FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Estimate	Request	Notional			
Budget Authority ($ in millions)	**2012**[1]	**2013**[2]	**2014**	**2015**	**2016**	**2017**	**2018**
NASA FY 2014	17,770.0	17,893.4	17,715.4	17,715.4	17,715.4	17,715.4	17,715.4
Science	5,073.7	5,115.9	5,017.8	5,017.8	5,017.8	5,017.8	5,017.8
Earth Science	1,765.7		1,846.1	1,854.6	1,848.9	1,836.9	1,838.1
Planetary Science	1,501.4		1,217.5	1,214.8	1,225.3	1,254.5	1,253.0
Astrophysics	648.4		642.3	670.0	686.8	692.7	727.1
James Webb Space Telescope	518.6		658.2	645.4	620.0	569.4	534.9
Heliophysics	644.9		653.7	633.1	636.8	664.3	664.6
Subtotal, Science	5,079.0	5,121.1	5,017.8	5,017.8	5,017.8	5,017.8	5,017.8
Less Rescissions	(5.3)	(5.3)					
Aeronautics	569.4	572.9	565.7	565.7	565.7	565.7	565.7
Subtotal, Aeronautics	569.9	573.4	565.7	565.7	565.7	565.7	565.7
Less Rescissions	(0.5)	(0.5)					
Space Technology	573.7	577.2	742.6	742.6	742.6	742.6	742.6
Subtotal, Space Technology	575.0	578.5	742.6	742.6	742.6	742.6	742.6
Less Rescissions	(1.3)	(1.3)					
Exploration	3,707.3	3,790.1	3,915.5	3,952.0	3,970.7	3,799.0	3,589.3
Exploration Systems Dev	3,002.0		2,730.0	2,789.8	2,801.5	2,818.3	2,819.5
Commercial Spaceflight	406.0		821.4	821.4	821.4	590.0	371.0
Exploration Research & Dev	303.0		364.2	340.8	347.8	390.7	398.7
Subtotal, Exploration	3,711.0	3,793.9	3,915.5	3,952.0	3,970.7	3,799.0	3,589.3
Less Rescissions	(3.7)	(3.7)					
Space Operations	4,184.0	4,249.1	3,882.9	4,014.9	3,996.2	4,167.9	4,377.6
Space Shuttle	599.3		0.0	0.0	0.0	0.0	0.0
International Space Station	2,789.9		3,049.1	3,169.8	3,182.4	3,389.6	3,598.3
Space & Flight Support	805.2		833.8	845.1	813.8	778.3	779.3
Subtotal, Space Operations	4,194.4	4,259.4	3,882.9	4,014.9	3,996.2	4,167.9	4,377.6
Less Rescissions	(10.4)	(10.4)					
Education	136.1	136.9	94.2	94.2	94.2	94.2	94.2
Subtotal, Education	138.4	139.2	94.2	94.2	94.2	94.2	94.2
Less Rescissions	(2.3)	(2.3)					
Cross Agency Support	2,993.9	3,012.2	2,850.3	2,850.3	2,850.3	2,850.3	2,850.3
Center Management & Ops	2,204.1		2,089.7	2,089.7	2,089.7	2,089.7	2,089.7
Agency Management & Ops	789.9		760.6	760.6	760.6	760.6	760.6
Subtotal, Cross Agency Support	2,994.0	3,012.3	2,850.3	2,850.3	2,850.3	2,850.3	2,850.3
Less Rescissions	(0.1)	(0.1)					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	Notional 2016	Notional 2017	Notional 2018
Construction & Environmental Compliance & Restoration[3]	494.5	401.9	609.4	440.9	440.9	440.9	440.9
Construction of Facilities	**455.0**		**533.9**	**365.4**	**365.4**	**365.4**	**365.4**
Environmental Compliance & Restoration	**45.0**		**75.5**	**75.5**	**75.5**	**75.5**	**75.5**
Subtotal, Construction & Environmental Compliance & Restoration	**500.0**	**407.4**	**609.4**	**440.9**	**440.9**	**440.9**	**440.9**
Less Rescissions	**(5.5)**	**(5.5)**					
Office of Inspector General[4]	38.3	38.2	37.0	37.0	37.0	37.0	37.0
Subtotal, Inspector General	**38.3**	**38.5**	**37.0**	**37.0**	**37.0**	**37.0**	**37.0**
Less Rescissions	**0.0**	**(0.3)**					
Less Rescission from Prior Appropriation Accounts	**(1.0)**	**(1.0)**					
NASA FY 2014	**17,770.0**	**17,893.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**

[1]*FY 2012 rescissions are pursuant to PL 112-55, Division B, sec 528(f).*

[2]*The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175). The FY 2012 and 2013 column also include rescissions to prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

[3]*Construction and Environmental Compliance and Restoration includes $15 million provided by the Disaster Relief Act, 2013 (P.L. 113-2) for Sandy storm recovery.*

[4]*Rescission of unobligated American Recovery and Reinvestments Act balances in the Office of Inspector General account pursuant to P.L. 111-203, the Dodd-Frank Wall Street Reform and Consumer Protection Act.*

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Estimate	Request	Notional			
Budget Authority ($ in millions)	**2012**[1]	**2013**[2]	**2014**	**2015**	**2016**	**2017**	**2018**
NASA FY 2014	**17,770.0**	**17,893.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**
Science	**5,073.7**	**5,115.9**	**5,017.8**	**5,017.8**	**5,017.8**	**5,017.8**	**5,017.8**
Earth Science	**1,760.5**	**5,115.9**	**1,846.1**	**1,854.6**	**1,848.9**	**1,836.9**	**1,838.1**
Earth Science Research	441.1	-	443.3	483.1	483.4	485.1	476.5
Earth Science Research & Analysis	333.3		328.7	337.8	339.2	342.7	327.7
Computing & Management	107.7		114.6	145.3	144.2	142.4	148.9
Earth Systematic Missions	880.9	-	787.5	811.2	861.9	839.1	833.3
Global Precipitation Measurement	87.9		60.3	18.7	19.6	14.2	15.3
Ice, Cloud, & land Elevation Satellite-II	130.5		140.7	106.4	90.4	27.1	14.1
Soil Moisture Active & Passive	214.2		88.3	74.9	15.9	11.3	11.3
Other Missions & Data Analysis	406.0		414.9	536.0	661.6	714.8	772.6
GRACE FO	42.3		83.4	75.3	74.3	71.7	20.0
Earth System Science Pathfinder	187.5	-	353.6	293.1	232.2	237.4	250.0
OCO-2	93.4		81.2	21.0	12.5	7.9	12.0
Venture Class Missions	53.6		212.7	208.5	166.9	190.0	201.7
Other Missions & Data Analysis	40.5		59.6	63.6	52.8	39.5	36.3
Earth Science Multi-Mission Operations	168.6	-	171.7	174.3	177.9	179.0	182.0
Earth Science Multi-Mission Operations	168.6		171.7	174.3	177.9	179.0	182.0
Earth Science Technology	51.2	-	55.1	56.2	55.1	56.1	56.1
Earth Science Technology	51.2		55.1	56.2	55.1	56.1	56.1
Applied Sciences	36.4	-	35.0	36.7	38.4	40.1	40.1
Pathways	36.4		35.0	36.7	38.4	40.1	40.1
Subtotal, Earth Science	**1,765.7**						
Less Rescissions	**(5.2)**						

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Planetary Science	**1,501.4**	**(0.0)**	**1,217.5**	**1,214.8**	**1,225.3**	**1,254.5**	**1,253.0**
Planetary Science Research	174.1	-	220.6	233.3	229.1	230.4	232.2
Planetary Science Research & Analysis	122.3		130.1	131.0	131.3	132.2	132.5
Other Missions & Data Analysis	27.4		46.0	74.5	70.2	70.3	71.8
Directorate Management	4.0		4.0	7.3	7.1	7.4	7.4
Near Earth Object Observations	20.4		40.5	20.5	20.5	20.5	20.5
Lunar Quest Program	140.0	-	17.7	0.0	0.0	0.0	0.0
Lunar Science	66.8		15.3	0.0	0.0	0.0	0.0
Lunar Atmosphere & Dust Environment Explorer	70.4		2.4	0.0	0.0	0.0	0.0
Surface Science Lander Technology	2.8		0.0	0.0	0.0	0.0	0.0
Discovery	172.6	-	257.9	268.2	242.3	187.5	215.0
InSight	42.1		193.3	175.2	116.5	15.2	10.6
Other Missions & Data Analysis	130.6		64.6	93.0	125.8	172.3	204.4
New Frontiers	143.7	-	257.5	297.2	266.5	151.0	126.2
OSIRIS-REx	99.8		218.7	244.1	204.4	30.9	21.1
Other Missions & Data Analysis	43.9		38.8	53.1	62.1	120.1	105.1
Mars Exploration	587.0	-	234.0	227.7	318.4	504.7	513.2
MAVEN	245.7		50.1	20.2	6.6	0.0	0.0
Other Missions & Data Analysis	341.4		183.9	207.6	311.8	504.7	513.2
Outer Planets	122.1	-	79.0	45.6	24.4	26.4	26.4
Outer Planets	122.1		79.0	45.6	24.4	26.4	26.4
Technology	161.9	-	150.9	142.8	144.7	154.4	140.0
Technology	161.9		150.9	142.8	144.7	154.4	140.0
Subtotal, Planetary Science	**1,501.4**						
Less Rescissions[5]	**(0.0)**						

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	Notional 2016	Notional 2017	Notional 2018
Astrophysics	**648.4**	**0.0**	**642.3**	**670.0**	**686.8**	**692.7**	**727.1**
Astrophysics Research	165.5	-	147.6	170.6	192.3	207.2	218.5
Astrophysics Research & Analysis	68.6		65.7	68.3	70.2	71.5	71.5
Balloon Project	31.6		32.9	32.8	34.2	34.3	34.3
Other Missions & Data Analysis	65.3		49.1	69.4	87.9	101.3	112.7
Cosmic Origins	239.9	-	228.0	216.5	193.1	196.7	194.1
Hubble Space Telescope	98.3		96.3	92.3	88.2	88.2	83.9
Stratospheric Observatory for Infrared Astronomy (SOFIA)	84.2		87.4	87.3	85.2	85.1	86.2
Other Missions & Data Analysis	57.4		44.3	36.9	19.7	23.4	24.0
Physics of the Cosmos	108.3	-	110.4	107.5	100.0	82.8	86.4
Other Missions & Data Analysis	108.3		110.4	107.5	100.0	82.8	86.4
Exoplanet Exploration	50.8	-	55.4	59.4	57.7	60.7	90.7
Other Missions & Data Analysis	50.8		55.4	59.4	57.7	60.7	90.7
Astrophysics Explorer	83.9	-	100.9	116.0	143.8	145.3	137.4
Other Missions & Data Analysis	83.9		100.9	116.0	143.8	145.3	137.4
James Webb Space Telescope	**518.6**	**0.0**	**658.2**	**645.4**	**620.0**	**569.4**	**534.9**
James Webb Space Telescope	518.6		658.2	645.4	620.0	569.4	534.9
James Webb Space Telescope	518.6		658.2	645.4	620.0	569.4	534.9

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Heliophysics	**644.8**	**(0.0)**	**653.7**	**633.1**	**636.8**	**664.3**	**664.6**
Heliophysics Research	166.7	-	195.7	163.0	167.5	172.1	174.1
Heliophysics Research & Analysis	32.9		33.5	33.9	34.0	33.9	33.9
Sounding Rockets	52.4		51.6	53.7	53.0	53.0	53.0
Research Range	20.1		21.0	21.3	21.6	21.7	21.7
Other Missions & Data Analysis	61.3		89.6	54.2	58.8	63.5	65.5
Living with a Star	196.3	-	216.2	277.7	332.6	353.9	374.4
Solar Probe Plus	52.6		104.8	137.1	229.3	213.5	329.7
Solar Orbiter Collaboration	19.7		55.5	97.3	68.2	100.0	6.7
Other Missions & Data Analysis	124.0		55.8	43.3	35.1	40.5	38.0
Solar Terrestrial Probes	216.0	-	146.6	68.7	48.9	50.1	27.9
Magnetospheric Multiscale	194.6		120.9	39.5	20.2	12.3	2.7
Other Missions & Data Analysis	21.4		25.8	29.2	28.7	37.8	25.2
Heliophysics Explorer Program	65.8	-	95.2	123.7	87.9	88.2	88.2
Other Missions & Data Analysis	65.8		95.2	123.7	87.9	88.2	88.2
Subtotal, Heliophysics	**644.9**						
Less Rescissions[5]	**(0.0)**						
Subtotal, Science	**5,079.0**	**5,121.1**	**5,017.8**	**5,017.8**	**5,017.8**	**5,017.8**	**5,017.8**
Less Rescissions	**(5.3)**	**(5.3)**					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Estimate	Request	Notional			
Budget Authority ($ in millions)	**2012[1]**	**2013[2]**	**2014**	**2015**	**2016**	**2017**	**2018**
Aeronautics	569.4	572.9	565.7	565.7	565.7	565.7	565.7
Aeronautics	569.4	572.9	565.7	565.7	565.7	565.7	565.7
Aviation Safety	80.1	-	80.0	80.3	81.5	82.4	82.5
Aviation Safety	80.1		80.0	80.3	81.5	82.4	82.5
Airspace Systems	92.7	-	91.5	91.5	91.9	92.4	92.4
Airspace Systems	92.7		91.5	91.5	91.9	92.4	92.4
Fundamental Aeronautics	186.3	-	168.0	166.9	163.4	160.1	159.7
Fundamental Aeronautics	186.3		168.0	166.9	163.4	160.1	159.7
Aeronautics Test	79.4	-	77.0	77.5	78.6	79.6	79.8
Aeronautics Test	79.4		77.0	77.5	78.6	79.6	79.8
Integrated Systems Research	104.2	-	126.5	126.8	127.4	128.2	128.4
Integrated Systems Research	104.2		126.5	126.8	127.4	128.2	128.4
Aeronautics Strategy & Management	27.2	-	22.7	22.7	22.8	22.9	22.9
Aeronautics Strategy & Management	27.2		22.7	22.7	22.8	22.9	22.9
Subtotal, Aeronautics	569.9	573.4	565.7	565.7	565.7	565.7	565.7
Less Rescissions	(0.5)	(0.5)					
Space Technology	573.7	577.2	742.6	742.6	742.6	742.6	742.6
Space Technology	573.7	578.5	742.6	742.6	742.6	742.6	742.6
Partnerships Development & Strategic Integration	29.5	-	34.1	34.3	34.4	34.5	34.6
Partnership Development & Strategic Integration	29.5		34.1	34.3	34.4	34.5	34.6
SBIR & STTR	171.6	-	186.4	192.0	200.4	211.6	211.6
SBIR & STTR	171.6		186.4	192.0	200.4	211.6	211.6
Crosscutting Space Technology Development	183.9	-	277.6	256.2	213.2	241.0	244.3
Crosscutting Space Technology Development	183.9		277.6	256.2	213.2	241.0	244.3
Exploration Technology Development	190.0	-	244.5	260.1	294.6	255.5	252.0
Exploration Technology Development	190.0		244.5	260.1	294.6	255.5	252.0
Subtotal, Space Technology	575.0	578.5	742.6	742.6	742.6	742.6	742.6
Less Rescissions	(1.3)	(1.3)					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Exploration	**3,707.3**	**3,790.1**	**3,915.5**	**3,952.0**	**3,970.7**	**3,799.0**	**3,589.3**
Exploration Systems Development	**3,001.6**	**0.0**	**2,730.0**	**2,789.8**	**2,801.5**	**2,818.3**	**2,819.5**
Orion Multi-Purpose Crew Vehicle	1,200.0	-	1,026.8	1,024.9	1,027.1	1,027.1	1,028.3
Crew Vehicle Development	1,159.8		993.5	997.8	1,001.8	1,001.3	1,002.6
MPCV Program Integration & Support	40.2		33.4	27.1	25.3	25.8	25.8
Space Launch System	1,497.5	-	1,384.9	1,356.5	1,360.2	1,354.4	1,345.4
Launch Vehicle Development	1,450.5		1,339.8	1,312.9	1,312.5	1,277.6	1,268.7
SLS Program Integration & Support	47.0		45.1	43.6	47.7	76.7	76.7
Exploration Ground Systems	304.5	-	318.2	408.4	414.2	436.8	445.8
Exploration Ground Systems	304.5		318.2	408.4	414.2	436.8	445.8
Subtotal, Exploration Systems Development	**3,002.0**						
Less Rescissions	**(0.4)**						
Commercial Spaceflight	**406.0**	**0.0**	**821.4**	**821.4**	**821.4**	**590.0**	**371.0**
Commercial Cargo	14.0	-	0.0	0.0	0.0	0.0	0.0
Commercial Orbital Transportation Services	14.0		0.0	0.0	0.0	0.0	0.0
Commercial Crew	392.0	-	821.4	821.4	821.4	590.0	371.0
Commercial Crew	392.0		821.4	821.4	821.4	590.0	371.0
Exploration Research & Development	**299.7**	**0.0**	**364.2**	**340.8**	**347.8**	**390.7**	**398.7**
Human Research Program	157.7	-	165.1	164.6	169.5	175.4	180.0
Human Research Program	157.7		165.1	164.6	169.5	175.4	180.0
Advanced Exploration Systems	145.3	-	199.0	176.2	178.3	215.3	218.7
Advanced Exploration Systems	145.3		199.0	176.2	178.3	215.3	218.7
Subtotal, Exploration Research & Development	**303.0**						
Less Rescissions	**(3.3)**						
Subtotal, Exploration	**3,711.0**	**3,793.9**	**3,915.5**	**3,952.0**	**3,970.7**	**3,799.0**	**3,589.3**
Less Rescissions	**(3.7)**	**(3.7)**					

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Space Operations	**4,184.0**	**4,249.1**	**3,882.9**	**4,014.9**	**3,996.2**	**4,167.9**	**4,377.6**
Space Shuttle	**596.2**	**(3.1)**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Space Shuttle Program	599.3	-	0.0	0.0	0.0	0.0	0.0
SPOC Pension Liability	515.0		0.0	0.0	0.0	0.0	0.0
Program Integration	60.5		0.0	0.0	0.0	0.0	0.0
Flight & Ground Operations	19.0		0.0	0.0	0.0	0.0	0.0
Flight Hardware	4.8		0.0	0.0	0.0	0.0	0.0
Subtotal, Space Shuttle	**599.3**						
Less Rescissions	**(3.1)**						
International Space Station	**2,789.9**	**0.0**	**3,049.1**	**3,169.8**	**3,182.4**	**3,389.6**	**3,598.3**
International Space Station Program	2,789.9	-	3,049.1	3,169.8	3,182.4	3,389.6	3,598.3
ISS Systems Operations & Maintenance	1,378.7		1,318.9	1,258.7	1,259.2	1,330.3	1,329.1
ISS Research	225.5		226.4	229.3	236.4	239.6	249.6
ISS Crew & Cargo Transportation	1,185.7		1,503.8	1,681.9	1,686.7	1,819.7	2,019.6

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Fiscal Year						
	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Space & Flight Support	**797.9**	**4,250.8**	**833.8**	**845.1**	**813.8**	**778.3**	**779.3**
21st Century Space Launch Complex	130.0	-	39.6	31.0	36.2	11.8	11.8
21st Century Space Launch Complex	130.0		39.6	31.0	36.2	11.8	11.8
Space Communications & Navigation	443.4	-	554.5	562.7	521.4	506.5	507.5
Space Communications Networks	355.6		435.9	412.0	415.5	416.3	416.5
TDRS Replenishment	15.4		41.2	71.2	28.6	0.0	0.0
Space Communications Support	72.3		77.4	79.5	77.4	90.2	91.0
Human Space Flight Operations	107.2	-	111.4	119.2	120.9	121.9	121.9
Human Space Flight Operations	107.2		111.4	119.2	120.9	121.9	121.9
Launch Services	81.0	-	80.5	84.9	87.6	90.0	90.0
Launch Services	81.0		80.5	84.9	87.6	90.0	90.0
Rocket Propulsion Test	43.6	-	47.8	47.3	47.7	48.0	48.0
Rocket Propulsion Testing	43.6		47.8	47.3	47.7	48.0	48.0
Subtotal, Space & Flight Support	**805.2**						
Less Rescissions	**(7.3)**						
Subtotal, Space Operations	**4,194.4**	**4,259.4**	**3,882.9**	**4,014.9**	**3,996.2**	**4,167.9**	**4,377.6**
Less Rescissions	**(10.4)**	**(10.4)**					
Education	**136.1**	**136.9**	**94.2**	**94.2**	**94.2**	**94.2**	**94.2**
Education	**136.1**		**94.2**	**94.2**	**94.2**	**94.2**	**94.2**
Aerospace Research. & Career Development	58.4	-	33.0	33.0	33.0	33.0	33.0
NASA Space Grant	40.0		24.0	24.0	24.0	24.0	24.0
EPSCoR	18.4		9.0	9.0	9.0	9.0	9.0
STEM Education & Accountability	80.0	-	61.2	61.2	61.2	61.2	61.2
Minority University Research Education Program	30.0		30.0	30.0	30.0	30.0	30.0
STEM Education & Accountability Projects	50.0		31.2	31.2	31.2	31.2	31.2
Subtotal, Education	**138.4**	**139.2**	**94.2**	**94.2**	**94.2**	**94.2**	**94.2**
Less Rescissions	**(2.3)**	**(2.3)**					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Estimate	Request	Notional			
Budget Authority ($ in millions)	**2012[1]**	**2013[2]**	**2014**	**2015**	**2016**	**2017**	**2018**
Cross Agency Support	**2,993.9**	**3,012.2**	**2,850.3**	**2,850.3**	**2,850.3**	**2,850.3**	**2,850.3**
Center Management & Operations	**2,204.1**	**0.0**	**2,089.7**	**2,089.7**	**2,089.7**	**2,089.7**	**2,089.7**
Center Management & Operations	2,204.1	-	2,089.7	2,089.7	2,089.7	2,089.7	2,089.7
Center Institutional Capabilities	1,707.2		1,622.4	1,622.4	1,622.4	1,622.4	1,622.4
Center Programmatic Capabilities	496.9		467.3	467.3	467.3	467.3	467.3
Agency Management & Operations	**789.8**	**3,012.2**	**760.6**	**760.6**	**760.6**	**760.6**	**760.6**
Agency Management	403.7	-	389.5	389.5	389.5	389.5	389.5
Agency Management	403.7		389.5	389.5	389.5	389.5	389.5
Safety & Mission Success	198.4	-	175.1	175.1	175.1	175.1	175.1
Safety & Mission Assurance	49.4		49.9	49.9	49.9	49.9	49.9
Chief Engineer	105.2		89.6	89.6	89.6	89.6	89.6
Chief Health & Medical Officer	4.7		4.3	4.3	4.3	4.3	4.3
Independent Verification & Validation	39.1		31.3	31.3	31.3	31.3	31.3
Agency IT Services	158.5	-	168.4	168.4	168.4	168.4	168.4
IT Management	14.6		17.6	17.6	17.6	17.6	17.6
Applications	67.8		56.0	56.0	56.0	56.0	56.0
Infrastructure	76.0		94.8	94.8	94.8	94.8	94.8
Strategic Capabilities Assets Program	29.3	-	27.6	27.6	27.6	27.6	27.6
Strategic Capabilities Assets Program	29.3		27.6	27.6	27.6	27.6	27.6
Subtotal, Agency Management & Operations	**789.9**						
Less Rescissions	**(0.1)**						
Subtotal, Cross Agency Support	**2,994.0**	**3,012.3**	**2,850.3**	**2,850.3**	**2,850.3**	**2,850.3**	**2,850.3**
Less Rescissions	**(0.1)**	**(0.1)**					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Construction & Environmental Compliance & Restoration[3]	**494.5**	**401.9**	**609.4**	**440.9**	**440.9**	**440.9**	**440.9**
Construction of Facilities	**449.7**	**402.1**	**533.9**	**365.4**	**365.4**	**365.4**	**365.4**
Institutional CoF	315.1	-	365.4	365.4	365.4	365.4	365.4
Institutional CoF	315.1		365.4	365.4	365.4	365.4	365.4
Science CoF	12.0	-	0.0	0.0	0.0	0.0	0.0
Science CoF	12.0		0.0	0.0	0.0	0.0	0.0
Exploration CoF	71.0	-	142.3	0.0	0.0	0.0	0.0
Exploration CoF	71.0		142.3	0.0	0.0	0.0	0.0
Space Operations CoF	56.9	-	26.2	0.0	0.0	0.0	0.0
Space Operations CoF	56.9		26.2	0.0	0.0	0.0	0.0
Subtotal, Construction & Environmental Compliance & Restoration	**455.0**						
Less Rescissions	**(5.3)**						
Environmental Compliance & Restoration	**44.8**	**(0.2)**	**75.5**	**75.5**	**75.5**	**75.5**	**75.5**
Environmental Compliance & Restoration	45.0	-	75.5	75.5	75.5	75.5	75.5
Environmental Compliance & Restoration	45.0		75.5	75.5	75.5	75.5	75.5
Subtotal, Environmental Compliance & Restoration	**45.0**						
Less Rescissions	**(0.2)**						
Subtotal, Construction & Environmental Compliance & Restoration	**500.0**	**407.4**	**609.4**	**440.9**	**440.9**	**440.9**	**440.9**
Less Rescissions	**(5.5)**	**(5.5)**					

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Inspector General[4]	**38.3**	**38.2**	**37.0**	**37.0**	**37.0**	**37.0**	**37.0**
Inspector General	**38.3**	**38.2**	**37.0**	**37.0**	**37.0**	**37.0**	**37.0**
IG Program	38.3	-	37.0	37.0	37.0	37.0	37.0
Inspector General	38.3		37.0	37.0	37.0	37.0	37.0
Subtotal, Inspector General	**38.3**	**38.5**	**37.0**	**37.0**	**37.0**	**37.0**	**37.0**
Less Rescissions	**0.0**	**(0.3)**					
Less Rescission from Prior Appropriation Accounts	**(1.0)**	**(1.0)**					
NASA FY 2014	**17,770.0**	**17,893.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**

Memorandum: NASA Pre- & Post-Rescission Totals

Budget Authority ($ in millions)	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	2016	2017	2018
Pre-Rescission Subtotal, NASA	**17,800.0**	**17,923.8**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**
Less Rescissions	**(30.0)**	**(30.3)**					
Post-Rescission Total	**17,770.0**	**17,893.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**	**17,715.4**

[1]*FY 2012 rescissions are pursuant to PL 112-55, Division B, sec 528(f).*

[2]*The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175). The FY 2012 and 2013 column also include rescissions to prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

[3]*Construction and Environmental Compliance and Restoration includes $15 million provided by the Disaster Relief Act, 2013 (P.L. 113-2) for Sandy storm recovery.*

[4]*Rescission of unobligated American Recovery and Reinvestments Act balances in the Office of Inspector General account pursuant to P.L. 111-203, the Dodd-Frank Wall Street Reform and Consumer Protection Act.*

[5]*Rescission amount for Planetary Science is $0.032M and Heliophysics is $0.026M. Amounts round to $0.0 million in table above.*

TABLE OF CONTENTS

OVERVIEW

SCIENCE

TABLE OF CONTENTS

TABLE OF CONTENTS

AERONAUTICS

SPACE TECHNOLOGY

TABLE OF CONTENTS

HUMAN EXPLORATION AND OPERATIONS

TABLE OF CONTENTS

EDUCATION

CROSS AGENCY SUPPORT

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION

TABLE OF CONTENTS

INSPECTOR GENERAL

SUPPORTING DATA

COMPARABILITY TABLES

PROPOSED APPROPRIATIONS LANGUAGE

REFERENCE

FY 2014 BUDGET REQUEST EXECUTIVE SUMMARY

OVERVIEW

Agency Summary

MESSAGE FROM THE ADMINISTRATOR

NASA is proud to play a leading role in ensuring America's preeminence in space exploration, technology, innovation, and scientific discovery. We are pleased to submit a budget request for 2014 that supports our goals to explore, discover, innovate, and inspire our Nation to reach greater heights while improving the lives of those on Earth.

This budget focuses on expanding America's capabilities in air and space through steady progress on new space and aeronautics technologies, continued success with commercial space partnerships, and far-reaching science programs to help us understand Earth and the universe in which we live. The budget keeps us competitive, opens the door to new destinations, and vastly increases our knowledge.

With American commercial partners now successfully and affordably resupplying the International Space Station with cargo launched from our shores by American companies, this budget ensures U.S. industry will soon begin cost-effectively flying astronauts to low Earth orbit, ending our reliance on other nations and opening up new commercial markets in space. The budget request for the Commercial Crew program provides resources at a level that will keep us on target to restore America's human space launch capability. It will ensure that we are flying missions by 2017, and that our astronauts are launching from U.S. soil on affordable spacecraft built by American companies.

The International Space Station remains the centerpiece of human exploration, and continues to help us understand how to live and work in space for the long term. It allows us to perform technology demonstrations and scientific research only possible in microgravity, all helping to improve life on Earth and plan for missions into deep space.

This budget enables significant progress toward the ambitious exploration objective that President Obama laid out in 2010: Send humans to an asteroid in 2025 and to Mars in the 2030s. Using critical national capabilities advanced by the Administration, such as game-changing technologies, detection of potentially hazardous asteroids, and the Space Launch System and Orion vehicles for human exploration beyond low Earth orbit, NASA will begin work on a first-of-its-kind asteroid retrieval mission.

This mission to identify, capture, redirect, and sample a small asteroid would mark an unprecedented technological feat that will raise the bar of what humans can do in space. And it would provide invaluable new data on the threats asteroids pose to our home planet and how they could be mitigated. Capturing and moving an asteroid integrates the best of our science, technology and human exploration operations and draws on the innovation of America's brightest scientists and engineers. It takes advantage of our hard work on the Space Launch System and Orion crew capsule and helps keep us on target to reach the President's goal of sending humans to Mars in the 2030s. NASA will plan and begin design of this mission in 2013. Progress will continue conditional on its feasibility and affordability.

Space Technology remains critical to our efforts, and this budget bolsters that priority. We are focusing on new capabilities such as solar sails and solar electric propulsion, green rocket propellants, laser communications and many others to make possible tomorrow's exploration.

NASA's ground-breaking science missions are reaching farther into the solar system, revealing unknown aspects of the universe and providing critical data about our home planet and threats to it. Spacecraft are speeding to Jupiter, Pluto, and the dwarf planet Ceres, while satellites peer into other galaxies, spot planets around other stars, and work to uncover the origins of the universe. The budget funds an amazing fleet of scientific spacecraft. The budget request will also support our study of Earth and its response to

MESSAGE FROM THE ADMINISTRATOR

natural or human-induced changes. On the heels of the most daring mission to Mars in history last year, this budget will provide funding to launch another mission to the Red Planet.

We also will continue making steady progress to develop and conduct critical tests on the James Webb Space Telescope, leading to its planned launch in 2018. The telescope will revolutionize our understanding of the universe, just as its predecessor the Hubble Space Telescope did.

NASA's innovative aeronautics research supports the U.S. aviation industry's efforts to maintain competiveness in the global market. Our research provides the flying public with flights with fewer delays, while also maintaining an outstanding safety level. NASA's breakthrough research into more efficient air traffic management and environmentally friendly aircraft helps U.S. air carriers operate their fleets more efficiently while reducing operating costs.

These critical efforts will contribute to a bright future for our Nation by stimulating the economy and creating more jobs, especially for the next generation of American scientists and engineers. The funding of cutting-edge aeronautics and space technology innovations, research, and development, will help fuel the Nation's economy for years to come and allow us to chart the next great era of space exploration.

NASA makes every effort to ensure that performance data are subject to the same attention to detail as is devoted to our scientific and technical research. With this in mind, I can provide reasonable assurance that the performance data included in the Annual Performance Report are reliable and complete. Any data limitations are documented explicitly in the performance report sections of this budget.

Charles F. Bolden, Jr.
NASA Administrator

BUDGET OVERVIEW

NASA has long been known for its willingness to take on big challenges and its "can-do" attitude. NASA put men on the moon and roving explorers on the surface of Mars. The Agency pursues fundamental research to reveal the mysteries of the universe and explain its origin. NASA, in collaboration with international partners, keeps astronaut crews safe and productive in a spacecraft laboratory more than 200 miles above Earth. Technology programs seek imaginative solutions to challenges of space flight, and help apply these findings to benefit life on Earth. With challenges and successes like these, NASA's ability to achieve is clear.

In FY 2014, NASA continues to apply this same confidence and resourcefulness to its current set of challenges. The Agency is ensuring that preliminary research, planning, prioritization, benefits analysis, and fiscal responsibility remain among core management considerations for each investment it makes. This rigor enables the Agency to continue work on its priority programs and accomplish core mission objectives despite uncertainties in current and future funding levels.

Maintaining milestones while facing funding uncertainty requires thoughtful planning, in-depth analysis, trade-off considerations, and data-driven decision making from management. NASA fully supports the Administration's commitment to transparency and "open" government, so NASA is improving the way it presents performance information. This year, the performance plan is presented in the context of longer-term as well as annual goals. The performance plan also includes several years of historical performance data and analyses of NASA's performance trends with increased emphasis on cost and schedule reporting.

In FY 2014, NASA begins development of a first-of-its-kind mission to encounter and move an asteroid. Across the Agency, scientists, mission managers, technologists, and operations specialists are developing a multi-segment mission that begins with accelerating our detection of near-Earth asteroids and the selection of a target for this mission. NASA will advance the Nation's ability to track and characterize these objects and then assess other factors that affect their movement. By doing so, NASA can better model their trajectories and develop various methods for mitigating threats, which ultimately improves the ability of our Nation and others to protect the planet from potential asteroid impacts.

Still in early design, the second segment of the mission is the detailed reconnaissance and capture of a small, non-threatening asteroid and redirecting it to a stable, non-Earth threatening orbit in the Earth-moon system. This mission segment would also demonstrate new advanced solar electric propulsion technologies, capable of generating the higher levels of thrust and power necessary to capture and redirect a large object. Instruments would enable close-up examination of the asteroid, validation of the target selection, and determine the best angle of approach to capture and manage the asteroid spin rate. The mission will benefit from the development of sensors and techniques from Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-Rex) mission. The requirement for this mission to attach to the entire asteroid will require unique and challenging adaptation of these instruments and techniques. NASA will also refine and adopt in its spacecraft designs new advances in a variety of areas, including lightweight materials, communication, data storage and transfer, and space navigation.

The final segment of the mission will focus on human exploration of the asteroid using the Orion Multi-Purpose Crew Vehicle (Orion MPCV). In this early mission for the Space Launch System and Orion MPCV, the crew will travel deeper into space than ever before to conduct advanced exploration and research with the target asteroid, and return samples of the asteroid to Earth.

BUDGET OVERVIEW

In designing this mission, NASA will leverage programs now in development, create innovative new capabilities, and assure affordability via an overall management strategy that draws deeply from the Agency's skilled workforce and applies varied acquisition and technology maturation processes from around the Agency. During 2013, NASA will plan and begin design of the mission, and progress is conditional on its feasibility and affordability. More information about the technical aspects of the missions can be found in the Science, Space Technology, and Exploration account sections of this document.

The FY 2014 budget request fully implements the deep space exploration program. This program makes possible future exploration—a drive that is so much a part of the human spirit. The program is on track for an uncrewed flight test of an early variant of the Orion MPCV in 2014, an uncrewed SLS/Orion MPCV test flight in 2017, and a first crewed flight by 2021. A crewed mission of Orion and SLS to rendezvous with the redirected asteroid would be an early use of this system in a journey beyond low Earth orbit.

The Space Launch System development process leverages proven rocket components in order to build a better next-generation vehicle. Through step-by-step design and demonstration, the rocket will be capable of lifting heavier and heavier loads. When complete, this new launch system will be capable of bringing an unprecedented 130 metric tons of payload to orbit. NASA is able to focus its human exploration resources on these goals because our commercial space partners are making into reality the vision of a competitive space industry. In 2012 (and again in 2013), Space Exploration Technologies (SpaceX) docked its Dragon spacecraft to the International Space Station, delivering supplies and then returning unneeded equipment to Earth. These historic missions proved the capability of commercial companies in providing ISS support services. NASA expects the Orbital Sciences Corporation (Orbital) developed Cygnus spacecraft to accomplish the same feat this spring, and still other companies are steadily progressing through readiness milestones. A strong U.S. commercial marketplace will provide safe, reliable, and cost-effective access to low Earth orbit for crew and cargo and lessen American reliance on foreign services. Step by step, this commercial space industry is becoming a reality.

FY 2014 will bring numerous advances in the Agency's study of Earth, sun, solar system, and deep space. Advances in remote sensing and data analysis are built into soon-to-be-deployed Earth Science missions that will allow unprecedented study of climate change and weather modeling and prediction. The James Webb Space Telescope remains on track for launch in 2018. Once operational, scientists will be able to look farther out into space than ever before, gaining new insights to the formation and evolution of stars and galaxies. A restructured Mars exploration program utilizes the data gained from Curiosity and other Mars assets and begins work on the next Mars rover that will be launched in 2020.

The proposed FY 2014 budget fully supports operations, safety, and scientific research on our unique laboratory in space, the International Space Station. The International Space Station continues to provide opportunities for conducting cutting-edge research in many areas, including biologic processes and technologic capabilities. The Agency is preparing for a yearlong human-crewed mission. Scientists will study the astronauts and how they adapt to the space environment over the duration of their mission. Insights gained from this mission will be essential for planning missions to Mars and to other points deeper in space. This knowledge will also inform Earth-based studies of bone density concerns, like osteoporosis. In FY 2014, the International Space Station will also host two Earth Science instruments that will provide important observations of wind speed and direction over the oceans, and atmospheric movement of pollution, dust, and smoke. The Center for the Advancement of Science in Space (CASIS), the research management organization for the ISS National Laboratory, continues to enable federal, academic, and commercial research activities. In 2014, CASIS will develop, issue, and manage competitive research solicitations, and develop new partnerships that leverage the unique microgravity environment of the ISS.

NASA's scientists, engineers, and technologists are examining plans for future exploration. They are following a technological "roadmap" to help them solve near and long-term challenges and potential barriers to exploration. To address more "near-term" needs, NASA will demonstrate several maturing technologies in FY 2014, including the flight of a cluster of eight small CubeSat spacecraft. This small network of orbiting instruments will demonstrate inter-unit communications and provide more complete data sets than one instrument operating alone. Demonstration is the final validation step necessary before NASA can incorporate improvements and upgrades into missions currently or soon to be in design and development.

Innovators are looking further ahead to the probable needs of missions 10 or 20 years away. They are applying, testing, and reworking cutting-edge research into potentially "game-changing" solutions that can accelerate a timeline, slash projected costs, or multiply science return. This work is not theoretical or highly conceptual. In fact, this practical work is ongoing in laboratories around the Nation. NASA makes progress in essential exploration technologies daily. Those technologies include: solar electric propulsion, learning to store and transfer fuel while in orbit, radiation protection, laser communications, high-reliability life support systems, and human and robotic interfaces. This is extraordinary work, with positive implications not only for exploration, but also for human health, quality of life, and the National economy.

The air travel and transportation industry is an important sector of the US economy. It is essential for conducting business and leisure activities throughout the globe. NASA's aeronautics investments continue to improve the safety and efficiency of air travel and produce technologies and tools that minimize the effect of that travel on the environment. In FY 2014, research continues in development of strong light-weight materials, drag reduction, and other means to reduce fuel burn.

NASA supports the President's goal to utilize existing resources to achieve improvements in science, technology, engineering, and mathematics, or STEM, education and instruction. In support of the Administration's FY 2014 STEM education plan, the Agency's education efforts will be fundamentally restructured into a consolidated education program funded through the Office of Education, which will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution. The best NASA education and public engagement programs from throughout the Agency will be awarded funding through a competitive process. The Agency will also make NASA's education assets available to a wider audience through the new STEM consolidation partners.

The budget request for the Education account includes continued funding for the National Space Grant College and Fellowship Program, the Experimental Program to Stimulate Competitive Research (EPSCoR), the Minority University Research and Education Program (MUREP), and the Global Learning and Observation to Benefit the Environment (GLOBE) project. These education investments link to NASA's research, engineering, and technology missions. Each of these investments provides unique NASA experiences and resources to students and faculty. Starting in FY 2014, mission-based K-12 education, public outreach, and engagement activities, traditionally funded within programmatic accounts, will be incorporated into the Administration's new STEM education paradigm in order to reach an even wider range of students and educators.

BUDGET OVERVIEW

In FY 2014, NASA takes steps to maintain and protect its resources, including personnel, equipment, and facilities. The Agency is completing transition of its former space shuttle workforce to one more focused on development instead of operations. NASA will increase its effort to defend against and mitigate effects of prevent cyber threats and other IT issues that hinder operations or security. Facilities maintenance will be prioritized. Today's investments in preventative repairs will reduce future costs of refurbishing or replacing infrastructure, prevent breakdowns and potential adverse impacts on the environment, prevent costly cleanup and resolution of problems, and generally sustain NASA core capabilities during the long term.

BUDGET HIGHLIGHTS

SCIENCE IS ANSWERING ENDURING QUESTIONS IN, FROM, AND ABOUT SPACE

NASA's Science account funds the development of innovative satellite missions and instruments to enable scientists to conduct research to understand Earth, the Sun, and planetary bodies in the solar system, and to unravel the mysteries of the universe. These discoveries will continue to inspire the next generation of scientists, engineers and explorers. The FY 2014 budget request for Science is $5,017.8 million.

The James Webb Space Telescope, a successor to the Hubble telescope, is fully funded within the FY 2014 budget request and is progressing well toward its launch in October 2018 within the cost baseline established in 2011. NASA is enhancing the asteroid detection capabilities of ground and space-based assets through a doubling of the resources in the Near Earth Object Observation program. In addition, development continues on the OSIRIS-REx mission, which will return and analyze asteroid material and pave the way for human exploration of an asteroid.

NASA continues to learn more about Earth. The Global Precipitation Mission will provide global precipitation observations every two to four hours. Astronauts will install the Stratospheric Aerosol and Gas Experiment III (SAGE III) on the International Space Station and it will begin measurements of ozone, water vapor, and other important trace gases in the upper troposphere and stratosphere. The IRIS mission will enable scientists to better understand how the solar atmosphere is energized. NASA continues its successful partnership on the Landsat program with the United States Geological Survey and will begin to explore strategies for how to continue this valuable series of land observations for many years to come. NASA will also assume the responsibility for key observations of the Earth's climate from the National Oceanic and Atmospheric Administration.

The next step in the exploration of Mars is the launch of the Mars Atmosphere and Volatile Evolution Mission (MAVEN) mission. MAVEN will explore the planet's upper atmosphere and interactions with solar wind. As noted above, a restructured Mars exploration program will utilize the data gained from Curiosity and other Mars assets and begin development of the next Mars rover, which will be launched in 2020. Advances in our understanding of the Moon continue with the launch of Lunar Atmosphere and Dust Environment Explorer (LADEE) in October 2013, which will provide detailed information about the lunar atmosphere, conditions near the surface and environmental influences on lunar dust during its five-month primary mission. A variety of other missions will provide new capabilities for observations in astrophysics(Stratospheric Observatory for Infrared Astronomy [SOFIA], Astro-H Soft X-Ray Spectrometer [SXS]); and advance our understanding of the Sun and its impact on the Earth (Magnetospheric Multiscale [MMS], Solar Probe Plus, Solar Orbiter Collaboration). Other missions will advance the Nation's capability to predict changes in climate, weather and natural hazards and inform decision-making to enhance our economic and environmental security (Soil Moisture Active-Passive [SMAP], Ice Cloud and land Elevation Satellite-II [ICESat-II], Gravity Recovery and Climate Experiment [GRACE-FO], and Surface Water and Ocean Topography [SWOT]).

AIR TRANSPORTATION FOR A CHANGING WORLD

NASA conducts aeronautics research to bring transformational advances in the safety, capacity, and efficiency of the air transportation system while minimizing negative impacts on the environment. The FY 2014 budget request for the Aeronautics Research Mission Directorate is $565.7 million.

Research from a recent Federal Aviation Administration report shows that civil aviation has accounted for $1.3 trillion in U.S. economic activity annually and helped employ over ten million people. In 2011, it provided the Nation with $47 billion toward a positive balance of trade. NASA builds on in this economic success by conducting research that, when transferred to the U.S. aviation industry, can help maintain competiveness in the global market. NASA develops cutting-edge technologies and demonstrates their feasibility to enable revolutionary new vehicle performance, dramatically more efficient operations, and assured safety levels for the nation's air transportation. These technologies will expand airspace capacity with more fuel-efficient flight planning, diminish delays on the ground and in the sky, reduce fuel consumption, reduce the overall environmental footprint of aviation, and continue to improve safety. In FY 2014, NASA will begin new research to streamline the process for certifying new composite materials for use in advanced aircraft. The goal of this project is to reduce the certification time line by a factor of four. This project will boost American industry and help maintain a U.S. global leadership in the field of composite materials and aircraft manufacturing. NASA will also complete flight tests of a wing equipped with an adaptive trailing edge designed to reduce weight and drag. This wing technology will lead to a reduction in fuel burn. Also in FY 2014, NASA will continue to conduct flight research of low-boom technology that is designed to reduce sonic booms enough to eliminate the barrier to overland civil supersonic flight.

SPACE TECHNOLOGY DELIVERS INNOVATION

Space Technology enables a new class of NASA missions by drawing on talent from the NASA workforce, academia, small businesses and the broader space enterprise to deliver innovative solutions that dramatically improve technological capabilities for NASA and the Nation. The FY 2014 budget request for Space Technology is $742.6 million to support a broad portfolio of technology development efforts that serve multiple customers.

NASA prepares for future technology needs by maturing new technologies and capabilities including: small spacecraft systems; entry technologies; robotics capabilities; optical communications; propulsion components; advanced manufacturing capabilities; radiation protection; and high-powered solar electric propulsion. These technologies are essential for progressing the Agency's science and human exploration missions. Space Technology successfully fabricated a 2.4-meter composite cryogenic propellant tank in FY 2012, and will scale this design up and test the 5.5-meter diameter tank, to enable lower mass rocket propellant tanks that will meet future needs, including for the Space Launch System. In FY 2014, Space Technology will also accelerate development of solar electric propulsion (SEP) technologies. SEP systems have broad applicability to science and human exploration missions, and several of the components (e.g., high-power solar arrays) are of potential benefit to the commercial satellite sector and other government agencies. NASA has identified a near-term infusion opportunity for this technology as propulsion for the robotic segment of a proposed asteroid retrieval mission. In addition, Space Technology will also see a flight demonstration of a cluster of eight CubeSats that will conduct coordinated space science observations, and high altitude tests of new full-scale parachute and drag devices designed to enable precise landing of higher-mass payloads on the surfaces of planets.

Space Technology will continue releasing a steady stream of new solicitations, tapping into the Nation's talent to ensure the availability of advanced technologies, and prioritize the technology gaps identified by the National Research Council in their review of the Space Technology Roadmaps. NASA contributes to the demands of larger national technology goals by investing in Space Technology.

BUDGET HIGHLIGHTS

EXPANDING HUMAN EXPLORATION OF THE SOLAR SYSTEM

Exploration ensures that the United States remains the leader in the human exploration of space. Activity within this account supports NASA's Human Exploration and Operations effort by developing systems and capabilities required for deep space exploration, and ensuring reliable and cost-effective crew access to low Earth orbit by U.S. commercial providers. The FY 2014 budget request for Exploration is $3,915.5 million.

The Exploration account invests in crew and cargo transportation to and beyond Earth orbit; research and countermeasures aimed at keeping astronauts healthy and functional during long-term missions; and technologies to advance capabilities, reduce launch mass, and minimize the cost of deep space missions. In FY 2014, NASA will finalize preparations for the first uncrewed exploration test flight of the Orion MPCV. This test will demonstrate the new Space Launch System design's spacecraft adapter, which connects the crew and launch vehicles.

NASA will mature capture mechanisms to redirect uncooperative targets and planning for an asteroid retrieval mission. The Agency will also begin fabrication of a next-generation spacesuit, which includes a more flexible design, is lightweight, and will be powered by an advanced battery system. In the Commercial Crew program, NASA's commercial partners will continue risk reduction and technical readiness testing. In addition, the Agency will begin to transition industry partners from Space Act Agreements to contracts to support the next phase of commercial crew transportation systems.

LIVING AND WORKING IN SPACE

Space Operations enables access to low Earth orbit, provides critical communication capabilities, and creates pathways for discovery and human exploration of space. Activity within this account supports NASA's Human Exploration and Operations effort with a robust collection of programs that ensure seamless execution of the Nation's human space flight goals. The FY 2014 budget request for Space Operations is $3,882.9 million.

As discussed above, a top Agency priority is exploitation of the ISS's research capability to advance science and technology, and improve our capacity to live and work in space. NASA will also upgrade and replace its aging communications suite to ensure future operational capability, including the launch of Tracking and Data Relay Satellite L, which will support the Agency's science missions as well as the International Space Station. The Agency plans propulsion testing of critical Space Launch System components, and commercial partners' engines at the Stennis Space Center.

NASA'S UNIQUE ASSETS MADE AVAILABLE TO SUPPORT THE NATION'S STEM EFFORTS

NASA Education's vision is to advance high-quality STEM education using NASA's unique capabilities. NASA's expertise, passion, and resources play a unique role in the Nation's STEM education portfolio. In support of the Administration's FY 2014 STEM education plan, NASA will restructure fundamentally the Agency's education efforts into a consolidated education program funded through the Office of Education, which will also lead the Agency's coordination with other Federal agencies in pursuit of the Administration's STEM education goals. The FY 2014 budget request for Education is $94.2 million.

In addition to managing the Space Grant, EPSCoR, MUREP, and GLOBE programs, NASA will consolidate the education functions, assets and efforts of the Aeronautics Research Mission Directorate, Science Mission Directorate and Human Exploration and Operations Mission Directorate into a single coordinated STEM Education and Accountability Project. This project will fund, on a competitive basis, the best education and public outreach efforts throughout the agency. NASA will also make its assets available to the National Science Foundation, Smithsonian Institution and Department of Education as they facilitate federal STEM education activities through the Administration's CoSTEM process for agency coordination, bringing NASA's inspirational activities to a broader audience. NASA will capitalize on the excitement of the Agency's mission to stimulate innovative solutions, approaches, and tools that inspire learner and educator interest and proficiency in STEM disciplines.

EXCELLENCE IN OPERATIONS FOR MISSION SUCCESS

Cross Agency Support and Construction and Environmental Compliance and Restoration provide the essential day-to-day technical and business operations required to conduct NASA's aeronautics and space activities. These missions support activities provide the proper services, tools, and equipment to complete essential tasks, protect and maintain the security and integrity of information and assets, and ensure that personnel work under safe and healthy conditions. The FY 2014 budget request for Cross Agency Support is $2,850.3 million. The request for Construction and Environmental Compliance and Restoration is $609.4 million.

In FY 2014, NASA will seek and implement additional operational efficiencies across the Agency. A savings campaign in support of the Administration's Campaign to Cut Waste enables the Agency to maximize its investments on mission priorities. Centers will increase reliability-centered maintenance and condition-based monitoring activities to provide early detection and correction of facility maintenance issues. NASA will modernize the information technology (IT) security assessment and authorization process, define metrics for measuring risk reduction, create dashboards for visualizing and communicating the Agency's cyber security posture, and expand security operations to provide early warning of cyber vulnerabilities. NASA has also implemented efficiencies in Center and Headquarters services, including facilities maintenance and repair, and IT services.

Construction and Environmental Compliance and Restoration will continue to manage the Agency's facilities with a focus on reducing infrastructure, implementing efficiency and high performance upgrades, and prioritizing repairs to achieve the greatest return on investment. In FY 2014, NASA continues to consolidate facilities to achieve greater operational efficiency, replacing old, obsolete, costly facilities with fewer, high performance facilities. Programmatic construction of facilities projects, such as the Modifications to Launch Complex 39-B at Kennedy Space Center, provide the specialized technical facilities required by the missions. NASA will decommission and continue preparations to dispose of property and equipment no longer needed for missions. To protect human health and the environment, and to preserve natural resources for future missions, environmental compliance and restoration projects will clean up pollutants released into the environment during past NASA activities.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

NASA'S WORKFORCE

NASA's workforce continues to be one of its greatest assets for enabling missions in space and on Earth. The Agency remains committed to applying this asset to benefit society, address contemporary environmental and social issues, lead or participate in emerging technology opportunities, collaborate and strengthen the capabilities of commercial partners, and communicate the challenges and results of Agency programs and activities. The civil service staffing levels proposed in the FY 2014 budget support NASA's scientists, engineers, researchers, managers, technicians, and business operations workforce. It includes civil service personnel at NASA Centers, Headquarters, and NASA-operated facilities. The mix of skills and distribution of workforce across the Agency is, however, necessarily changing.

NASA continues to adjust its workforce size and mix of skills to address changing mission priorities, with an emphasis on industry and academic partnerships, and a leaner fiscal environment. While a civil service workforce is critical for conducting mission-essential work in research and technology, some reduction to workforce levels is necessary. NASA will reduce the size of the civil service workforce by more than 250 full-time equivalents from FY 2013 to FY 2014, stabilizing the workforce at approximately 17,700 full-time equivalents. This decline addresses workforce at several Centers affected by changes in the human space flight portfolio and reflects changes in the Agency's staffing needs.

The Agency will apply the valued civil service workforce to priority mission work, adjusting the mix of skills where appropriate. Centers will explore cross-mission retraining opportunities for employees whenever possible, offer targeted buyouts in selected surplus skill areas, and continue to identify, recruit, and retain a multi-generational workforce of employees who possess skills critical to the Agency.

OPERATING EFFICIENTLY AND CUTTING WASTE

NASA continues to pursue cost savings throughout its operations. Savings targets comply with Executive Order 13576, *Delivering an Efficient, Effective and Accountable Government*, Executive Order 13589, *Promoting Efficient Spending,* and Office of Management and Budget Memorandum M-12-12 *Promoting Efficient Spending to Support Agency Operations*.

Reducing Contracts for Management Support Services

The FY 2014 budget request sustains the 15 percent reduction in management support services contracting that started in FY 2012. NASA has actually achieved a reduction of approximately 43 percent or $1.5 billion from FY 2010 levels in management support services contracting through June 2012, and has processes in place to ensure reductions do not go above 15 percent from the FY 2010 levels in FY 2014.

Data Center Consolidation

The FY 2014 budget request continues savings of approximately $460,000 from data center consolidation. NASA has reduced energy costs through more efficient use of existing conditioned spaces, employing best practices in room design, proper temperature settings, optimal rack and floor space densities, and lifecycle replacement of old and inefficient hardware.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

Reducing Administrative and Operational Expenses

Reducing administrative and operational expenses related to printing, reproduction, supplies and materials, advisory services, and travel will allow NASA to prioritize funding towards its science and engineering missions. The FY 2014 budget request sustains a minimum savings of $200 million in administrative costs, compared to FY 2010 levels.

Reducing Utility Costs

NASA has been working to reduce costs of energy, water, and other utilities. To reduce the energy burden, NASA is pursuing "green" building designs and renovations that make better use of natural light and temperatures, and replacing old and inefficient equipment with models that require less energy.

Reprioritizing Information Technology and Reinvesting to Improve Capabilities

The FY 2014 budget request realigns IT spending to increase emphasis on cybersecurity. Saving from reductions in IT services and reduced programmatic requirements will help offset the cost of additional security and cloud computing investments.

Minimizing the Risk of Improper Payments

The FY 2014 budget request demonstrates NASA's continued commitment to employ strong internal controls and processes to keep improper payments at extremely low levels. Results from the FY 2012 review of FY 2011 disbursements revealed no improper payments.

Identifying Lower Priority Program Activities

The main *Budget* volume of the President's Budget identifies lower-priority program activities, where applicable, as required under the Government Performance And Results Act-Modernization Act, 31 U.S.C. 1115(b)(10). To access the volume, go to: http://www.whitehouse.gov/omb/budget.

DELIVERING A 21ST CENTURY GOVERNMENT

Strengthening Cybersecurity

In FY 2014, NASA will increase investments in cybersecurity. These upgrades and improvements will address the Administration's priority of cybersecurity capabilities, including continuous monitoring, providing trusted Internet connections, and requiring strong authentication. The Agency will also implement specific improvements as recommended by NASA's Office of Inspector General. The planned work will correct high-risk deficiencies and vulnerabilities, restore aging and inefficient infrastructure, and promote proactive and preventative practices.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

Investing to Improve Efficiencies and Sustainability

NASA will also improve the operating efficiency of buildings by investing in utility meters and monitoring, HVAC, lighting and plumbing upgrades, and automated systems controllers that are based on occupancy.

Right-Sizing Infrastructure and Considering Repairs or Replacement

The FY 2014 budget request includes funding to reduce the Agency's footprint by replacing multiple aging, inefficient facilities with facilities that meet government Leadership in Energy and Environmental Design, or LEED, standards. NASA's proposed infrastructure investments focus on projects that are well-defined, aligned with the Agency's master plan, and build upon prior successful construction of facilities projects.

NASA presents the FY 2014 budget request in full-cost, where all project costs are allocated to the project, including labor funding for the Agency's civil service workforce. Note that budget figures in tables may not add because of rounding.

OUTYEAR FUNDING ASSUMPTIONS

At this time, funding lines beyond FY 2014 should be considered notional. In general, NASA accounts are held at the FY 2014 request level, adjusted for the amounts transferred to the construction account in FY 2014.

EXPLANATION OF FY 2012 AND FY 2013 BUDGET COLUMNS

FY 2012 and FY 2013 Columns

The FY 2012 Actual column in budget tables is consistent with the Agency spending plan (e.g. operating plan) control figures at the time of the budget release. Rescission amounts reflect the cancellation of a total of $30 million in prior year appropriations as directed in section 528(f) of P.L. 112-55, Division B, Commerce, Justice, Science, and Related Agencies Appropriations Act, 2012.

The FY 2013 Estimate column in budget tables displays at the account level, for reference, the Continuing Resolution (CR, P.L. 112-175) full-year rate for operations with the appropriation and rescission components reported separately; plus the Agency appropriation provided by the Disaster Relief Appropriations Act, 2013 (P.L. 113-2); and rescission of remaining unobligated balances of American Recovery and Reinvestment Act funds in the Office of Inspector General account pursuant to section 1306 of the Dodd-Frank Wall Street Reform and Consumer Protection Act (P.L. 111-203).

- The account level $30.0 million rescission component of the continuing resolution is the same as that for FY 2012 rescission of prior year appropriations except that rescissions applied to prior appropriation accounts in FY 2012 are applied to the Space Operations account in FY 2013. The adjustment was made because it was not clear whether the prior year appropriations account had sufficient balances to cancel. The total effect of the adjustment on the Space Operations account is $1.0 million.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

- Overall, the total FY 2013 full-year, direct budget authority provided to the Agency is $17,893.4 million, of which $17,878.8 million was provided by the continuing resolution; $15.0 million was provided by the Disaster Relief Appropriations Act, and $0.3 million was rescinded pursuant to the Dodd-Frank Act.

Comparability Adjustments

FY 2012 Actual and FY 2013 Estimate budget amounts have been adjusted to enable consistent programmatic comparisons to the FY 2014 budget request. These so-called comparability adjustments reflect movement of projects or activities and associated funding between programs, themes, or account and align to the structure of the FY 2014 budget request. This approach is essential to enabling year-to-year budget analysis. The Supporting Data section of the budget request includes a detailed crosswalk of non-comparable FY 2012 and FY 2013 budget figures and comparability adjustments to align to the FY 2014 budget structure.

Budget tables presented for themes, programs, and projects have been adjusted for comparability. When a rescission is presented, investments are subtotaled and the amount of the rescission to that account, program, or project, is shown. The subtotal minus the rescission amount results in the top column figure.

Theme, Program, and Project Tables

Budgets for themes, programs, and projects reflect scoring of rescissions, and they are adjusted for comparability. Detailed breakouts in Other Missions and Data projects are presented in the same manner.

Superstorm Sandy Supplemental Appropriations

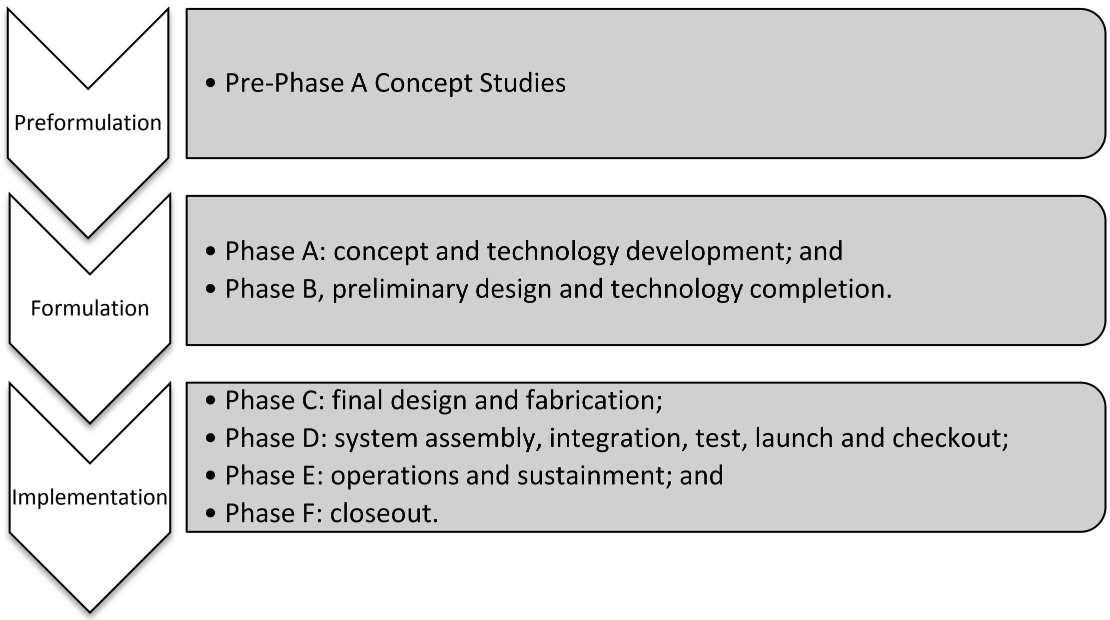
On January 29, 2013, Congress enacted P.L. 113-2, the Disaster Relief Appropriations Act, 2013. The Act provided $15.0 million dollars to NASA for Superstorm Sandy recovery activities. NASA is managing the appropriation in the Construction and Environmental Compliance and Restoration (CECR) account as part of its Institutional Construction of Facilities activity. The funding supplement is not called out specifically on the budget summary tables nor in the CECR account, theme, or program budget tables. NASA has added the supplement to the FY 2013 budget figure and provided a corresponding footnote on each relevant table.

EXPLANATION OF PROJECT SCHEDULE COMMITMENTS AND KEY MILESTONES

Project budget pages include current and significant planned project schedule commitments and key milestones. The milestone may differ for human-rated and robotic mission projects.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

Programs and projects follow their appropriate life cycle, which includes lifecycle phases; lifecycle gates and major events (including key decision points [KDPs]); and major lifecycle reviews. The lifecycle phases are segmented into three categories; pre-formulation, formulation and implementation.



Approval to proceed through the lifecycle gate is based on progress and performance, as assessed against an expected maturity level at each major lifecycle review. The key decision point is the event where the manager with decision authority determines the readiness of a project to progress to the next phase of the life cycle and establishes the content, cost, and schedule commitments for the ensuing phase(s).

For reference, a description of schedule commitments and milestones is listed below for projects in formulation and implementation. A list of common terms used in mission planning is also included.

Formulation

Formulation is NASA's period of initial planning for a new project and determination of how the proposed project will support the Agency's strategic goals. During formulation, a project is assessed for feasibility, completes development of concepts, and establishes high-level requirements and success criteria.

Formulation Milestone	Explanation
KDP A	The lifecycle gate at which the decision authority determines the readiness of a program or project to transition into Phase A and authorizes formulation of the project. Phase A is the first phase of formulation and means that: • The project addresses a critical NASA need; • The proposed mission concept(s) is feasible; • The associated planning is sufficiently mature to begin activities defined for formulation; and • The mission can likely be achieved as conceived.

System Requirements Review (SRR)	The lifecycle review in which the decision authority evaluates whether the functional and performance requirements are sufficiently defined for the system and represent achievable capabilities.
System Definition Review or Mission Definition Review	The lifecycle review in which the decision authority evaluates the credibility and responsiveness of the proposed mission/system architecture to the program requirements and constraints, including available resources. This review also determines whether the maturity of the project's mission/system definition and associated plans are sufficient to begin the next phase, Phase B.
KDP B	The lifecycle gate at which the decision authority determines the readiness of a program or project to transition from Phase A to Phase B. Phase B is the second phase of formulation and means that: • The proposed mission/system architecture is credible and responsive to program requirements and constraints, including resources; • The maturity of the project's mission/system definition and associated plans is sufficient to begin Phase B; and • The mission can likely be achieved within available resources with acceptable risk.
Preliminary Design Review (PDR)	The lifecycle review in which the decision authority evaluates the completeness/consistency of the planning, technical, cost, and schedule baselines developed during formulation. This review also assesses compliance of the preliminary design with applicable requirements and determines if the project is sufficiently mature to begin Phase C.

Implementation

Implementation occurs when Agency management establishes baseline cost and schedule commitments for projects at KDP C. The projects maintain the baseline commitment through the end of the mission. Projects are baselined for cost, schedule, and programmatic and technical parameters. Under implementation, projects are able to execute approved plans development and operations.

Implementation Milestone	Explanation
KDP C	The lifecycle gate at which the decision authority determines the readiness of a program or project to begin the first stage of development and transition to Phase C and authorizes the implementation of the project. Phase C is first stage of development and means that: • The project's planning, technical, cost, and schedule baselines developed during formulation are complete and consistent; • The preliminary design complies with mission requirements; • The project is sufficiently mature to begin Phase C; and • The cost and schedule are adequate to enable mission success with acceptable risk.
Critical Design Review (CDR)	The lifecycle review in which the decision authority evaluates the integrity of the project design and its ability to meet mission requirements. This review also determines if the design is appropriately mature to continue with the final design and fabrication phase.
System Integration Review (SIR)	The lifecycle review in which the decision authority evaluates the readiness of the project and associated supporting infrastructure to begin system assembly, integration, and test. The lifecycle review also evaluates whether the remaining project development can be completed within available resources, and determine if the project is sufficiently mature to begin the next phase.
KDP D	The lifecycle gate at which the decision authority determines the readiness of a project to continue in implementation and transition from Phase C to Phase D. Phase D is a second phase in implementation; the project continues in development and means that: • The project is still on plan; • The project continues to mature as planned; • The risk is commensurate with the project's payload classification; and • The project is ready for assembly, integration and test with acceptable risk within its Agency baseline commitment.
Launch Readiness Date (LRD)	The date at which the project and its ground, hardware, and software systems are ready for launch.

EXPLANATION OF BUDGET TABLES AND SCHEDULES

Other Common Terms for Mission Planning

Term	Definition
Decision Authority	The individual authorized by the Agency to make important decisions on programs and projects under their authority.
Formulation Authorization Document	The document that authorizes the formulation of a program whose goals will fulfill part of the Agency's Strategic Plan and Mission Directorate strategies. This document establishes the expectations and constraints for activity in the formulation phase.
Key Decision Point (KDP)	The lifecycle gate at which the decision authority determines the readiness of a program or project to progress to the next phase of the life cycle. The KDP also establishes the content, cost, and schedule commitments for the ensuing phase(s).
Launch Manifest	This list that NASA publishes (the "NASA Flight Planning Board launch manifest") periodically, which includes the expected launch dates for NASA missions. The launch dates in the manifest are the desired launch dates approved by the NASA Flight Planning Board, and are not typically the same as the Agency Baseline Commitment schedule dates. A launch manifest is a dynamic schedule that is affected by real world operational activities conducted by NASA and multiple other entities. It reflects the results of a complex process that requires the coordination and cooperation by multiple users for the use of launch range and launch contractor assets. Moreover, the launch dates are a mixture of "confirmed" range dates for missions launching within approximately six months, and contractual/planning dates for the missions beyond six months from launch. The NASA Flight Planning Board launch manifest date is typically earlier than the Agency Baseline Commitment schedule date to allow for the operationally driven delays to the launch schedule that may be outside of the project's control.
Operational Readiness Review	The lifecycle review in which the decision authority evaluates the readiness of the project to operate the flight system and associated ground system(s), in compliance with defined project requirements and constraints during the operations/sustainment phase of the project life cycle.
Mission Readiness Review or Flight Readiness Review (FRR)	The lifecycle review in which the decision authority evaluates the readiness of the project and supporting systems for a safe and successful launch and flight/mission.
KDP E	The lifecycle gate at which the decision authority determines the readiness of a project to continue in implementation and transition from Phase D to Phase E. Phase E is a third phase in implementation and means that the project and all supporting systems are ready for safe, successful launch and early operations with acceptable risk.
Decommissioning Review	The lifecycle review in which the decision authority evaluates the readiness of the project to conduct closeout activities. The review includes final delivery of all remaining project deliverables and safe decommissioning of space flight systems and other project assets.
KDP F	The lifecycle gate at which the decision authority determines the readiness of the project's decommissioning. Passage through this gate means the project has met its program objectives and is ready for safe decommissioning of its assets and closeout of activities. Scientific data analysis may continue after this period.

For further details, go to:

- NASA Procedural Requirement 7102.5E NASA Space Flight Program and Project Management Requirements: http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7120&s=5E
- NASA Procedural Requirement 7123.69 NASA Interim Directive (NID) to NPR 7123.1A - NASA Systems Engineering Processes and Requirements: http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001A_&page_name=main
- NASA Launch Services Web site: http://www.nasa.gov/directorates/heo/launch_services/index.html

SCIENCE

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	5073.7	5115.9	**5017.8**	5017.8	5017.8	5017.8	5017.8
Earth Science	1765.7	--	**1846.1**	1854.6	1848.9	1836.9	1838.1
Planetary Science	1501.4	--	**1217.5**	1214.8	1225.3	1254.5	1253.0
Astrophysics	648.4	--	**642.3**	670.0	686.8	692.7	727.1
James Webb Space Telescope	518.6	--	**658.2**	645.4	620.0	569.4	534.9
Heliophysics	644.9	--	**653.7**	633.1	636.8	664.3	664.6

SCIENCE

SCIENCE

Planetary Science

Astrophysics

James Webb Space Telescope

SCIENCE

Heliophysics

SCIENCE

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	5073.7	5115.9	**5017.8**	5017.8	5017.8	5017.8	5017.8
Earth Science	1765.7	--	**1846.1**	1854.6	1848.9	1836.9	1838.1
Planetary Science	1501.4	--	**1217.5**	1214.8	1225.3	1254.5	1253.0
Astrophysics	648.4	--	**642.3**	670.0	686.8	692.7	727.1
James Webb Space Telescope	518.6	--	**658.2**	645.4	620.0	569.4	534.9
Heliophysics	644.9	--	**653.7**	633.1	636.8	664.3	664.6
Subtotal	5079.0	5121.1	**5017.8**	5017.8	5017.8	5017.8	5017.8
Rescission of prior-year unob. balances**	-5.3	-5.3	**--**	--	--	--	--
Change from FY 2012	--	--	**-55.9**				
Percentage change from FY 2012	--	--	**-1.1 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Earth Science, Planetary Science, and Heliophysics pursuant to P.L. 112-55, Division B, sec. 528(f).*

From the vantage point of space, NASA captures breath-taking images of our world and the universe. These images advance our scientific understanding in a multitude of disciplines, but they also have the power to inform policy, influence action, and inspire learning.

NASA's Science Mission Directorate conducts scientific exploration enabled by the space observatories and space probes that view Earth from space, observe, and visit other bodies in the solar system, and gaze out into the galaxy and beyond. NASA's science programs seek answers to profound questions:

- How and why are Earth's climate and the environment changing?
- How and why does the Sun vary and affect Earth and the rest of the solar system?
- How do planets and life originate?
- How does the universe work, and what are its origin and destiny?
- Are we alone?

NASA uses the recommendations of the National Academies' decadal surveys for guidance in planning the future of its science programs. For over 30 years, decadal surveys have proven indispensable in establishing a broad national science community consensus on the state of the science, the highest priority science questions to be addressed, and actions that could be taken to address those priority science topics. NASA uses these recommendations to prioritize future flight missions, including space observatories and probes, as well as technology development and proposals for theoretical and suborbital supporting research. NASA must adapt science-based decadal survey recommendations to actual budgets, existing technological capabilities, national policy, partnership opportunities, and other programmatic factors.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The budget request includes a doubling of NASA's efforts to identify and characterize potentially hazardous near-Earth objects (NEOs). This increase in the budget reflects the serious approach NASA is taking to understand the risks of asteroid impacts to our home planet. It will also help identify potential targets for the future human mission to an asteroid.

The request also transfers responsibility from the Department of Energy to NASA for support of radioisotope power system development infrastructure. Beginning in FY 2014, DOE's Space and Defense Infrastructure subprogram is transitioning to a full cost recovery funding model. Funding to support this infrastructure is now included in NASA's budget request within the Planetary Science Technology program.

The budget request includes increases in Earth Science to begin work on land imaging capabilities beyond the Landsat Data Continuity Mission (to be renamed LandSat 8) that was successfully launched in February 2012. The request also includes funds for NASA to assume responsibility for several Earth measurements previously held by the National Oceanic and Atmospheric Administration (NOAA). NASA will begin study on continuing the long history of measurements of solar irradiance, atmospheric ozone, and Earth's radiation of energy to space. NASA Science will also steward the two Earth-observing instruments on NOAA's space weather mission, DSCOVR, or Deep Space Climate Observatory.

As part of the Administration's government-wide consolidation of Science, Technology, Engineering and Mathematics (STEM) education activities, described elsewhere in this document, Science will no longer fund STEM education activities. Instead, NASA's Office of Education will direct all of NASA's education funding, and ensure that Science's unique education skills and assets are effectively leveraged.

Building on the success of Curiosity's Red Planet landing, NASA announced plans for a robust multi-year Mars program. The program will include a new robotic science rover set to launch in 2020. The future rover development and design will be based on the Mars Science Laboratory (MSL) architecture that successfully carried the Curiosity rover to the Martian surface last summer. This will ensure mission costs and risks are as low as possible, and that the program can deliver a highly capable rover with a proven landing system. NASA will openly compete the specific payload and science instruments for the 2020 mission, following the Science Mission Directorate's established processes for instrument selection. The mission will advance the science priorities of the National Academies' 2011 Planetary Science decadal survey and respond to the findings of the Mars Program Planning Group established in 2012 to assist NASA in restructuring its Mars Exploration Program.

ACHIEVEMENTS IN FY 2012

The MSL Curiosity rover launched on November 26, 2011. Over 50 million people worldwide watched the dramatic entry, descent, and landing on Mars on August 6, 2012. Curiosity has begun its mission to investigate whether conditions on Mars have been favorable for microbial life, and whether the rocks could preserve clues about possible past life.

NASA also launched the Suomi National Polar-orbiting Partnership (NPP), the Nuclear Spectroscopic Telescope Array (NuSTAR), and the Van Allen Probes (formerly Radiation Belt Storm Probes) missions in FY 2012, all of which are meeting their science objectives.

In the last one and half years, five Science missions, including Juno, Gravity Recovery and Interior Laboratory, NPP, MSL, and Van Allen Probes, launched. None of these missions experienced cost growth in that timeframe. All except NPP and MSL were launched under their original baseline budget. NPP and MSL were originally baselined prior to many of the current program management improvements; adoption of these management practices as part of their rebaseline stabilized their cost and schedule performance. NuSTAR, the only other science mission launched in the last 1.5 years, experienced cost growth of about 2 percent. Seven space missions that remain in development are holding closely to their cost estimates. Those missions are:

- Interface Region Imaging Spectrograph (IRIS),
- Landsat Data Continuity Mission,
- Lunar Atmospheric Dust Environment Explorer (LADEE),
- Mars Atmosphere and Volatile EvolutioN (MAVEN),
- Global Precipitation Measurement (GPM),
- Magnetospheric MultiScale (MMS), and
- James Webb Space Telescope (JWST.)

The Orbiting Carbon Observatory 2 (OCO-2) is the only mission in development that has experienced significant cost growth, approximately three percent, since the FY 2013 budget request. That cost growth is due to selection of a more reliable and expensive launch vehicle. While significant risks remain in all projects yet to launch, as is always true when building scientific spacecraft, the excellent and unprecedented overall performance has prevented budgetary disruptions to other projects.

Recent scientific discoveries and societal applications of NASA-provided data are numerous. In Earth Science, data from NASA satellites helped researchers learn more about hurricanes and increase their predictability. NASA satellites also provided operational forecasters with valuable data on Tropical Storm Isaac, in near-real time. NASA’s Tropical Rainfall Measuring Mission satellite revealed that some areas within Isaac were dropping rainfall at a rate of 2.75 inches per hour.

In Planetary Science, observations from the Mars Curiosity rover of rounded pebbles embedded within rocky outcrops in Gale Crater provide concrete evidence that a stream once ran vigorously in this area. This is the first evidence of its kind.

In Astrophysics, the Wide-field Infrared Survey Explorer (WISE) mission has led to a bonanza of newfound supermassive black holes and extremely dust-obscured galaxies. Images from the telescope have revealed millions of dusty black hole candidates across the universe and about 1,000 even dustier objects than previously thought to be among the brightest galaxies ever found.

In Heliophysics, the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) spacecraft and the Solar Dynamics Observatory (SDO) measured the impact of a powerful solar flare on

Earth's upper atmosphere. The upper atmosphere puffed up like a marshmallow over a campfire, temporarily increasing the drag on low-orbiting satellites. Extra drag not only helps clear space junk out of Earth orbit, but it also decreases the lifetime of useful satellites by bringing them closer to re-entry.

These and many other scientific achievements are detailed in subsequent sections of this document.

WORK IN PROGRESS IN FY 2013

The Mars Curiosity rover is just one of nearly 60 operating science missions. The IRIS and LADEE missions are scheduled to launch in 2013, while work on other missions in development, such as MAVEN, GPM, MMS, and JWST, continues. The Ice, Cloud, and land Elevation Satellite 2 (ICESat-2), Soil Moisture Active/Passive (SMAP), OCO-2, and Solar Orbiter Collaboration missions completed formulation activities and started development. NASA will select new Heliophysics and Astrophysics Explorer missions to begin formulation in the spring of 2013.

NASA is establishing a 2020 Mars rover science definition team to further specify the scientific objectives for the mission, prior to the competition for science instruments.

NASA Science continues to support a diverse array of competed research activities, primarily selected through the yearly Research Opportunities in Space and Earth Sciences announcements.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The MAVEN, GPM, and OCO-2 missions, and the Stratospheric Aerosol and Gas Experiment III (SAGE III) ozone-measuring instrument for the International Space Station, are scheduled for launch in FY 2014. Work will accelerate on the 2020 Mars rover after NASA selects its science instruments. NASA science missions, data, and discoveries will continue to rewrite textbooks, excite the public, inspire children to pursue careers in STEM and demonstrate US leadership worldwide.

Themes

EARTH SCIENCE

From space, NASA satellites can view Earth as a planet and enable the study of it as a complex, dynamic system with diverse components: the oceans, atmosphere, continents, ice sheets, and life. The Nation's scientific community can thereby observe and track global-scale changes, connecting causes to effects. Scientists can study regional changes in their global context, as well as observe the role that human civilization plays as a force of change. Through partnerships with agencies that maintain forecasting and decision support systems, NASA improves national capabilities to predict climate, weather, and natural hazards, manage resources, and support the development of environmental policy.

The budget request continues to advance key elements of Earth Science program established in NASA's 2010 Climate Initiative. The first two Tier 1 decadal survey missions, SMAP, and ICESat-2, moved into development during FY 2013. The estimated cost of ICESat-2 has increased approximately $75 million above the formulation estimates of last year, because a plan to share the cost of a launch vehicle with an Air Force payload did not materialize. The Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission, to continue measurements of Earth's gravity field and the movement of water on its surface, has entered into formulation, in collaboration with Germany's space agency.

NASA is responding to the absence of the data that the Glory mission would have provided in two immediate ways. First, NASA has developed and is now deploying multiple aerosol polarimeters on research aircraft. Second, NASA is supporting and funding the Glory Science Team to analyze and use the data from the airborne polarimeters as well as additional work on measurements produced by the French POLDER polarimeter currently on orbit on the PARASOL satellite. These activities are providing data regarding the effect of airborne particles on climate change. NASA is also considering other activities as part of its longer-range planning.

The image above represents the flotilla of spacecraft that make continual land surface, biospheric, atmospheric, and oceanic observations of the Earth in order to study how its climate operates as a whole system and how it is changing over time.

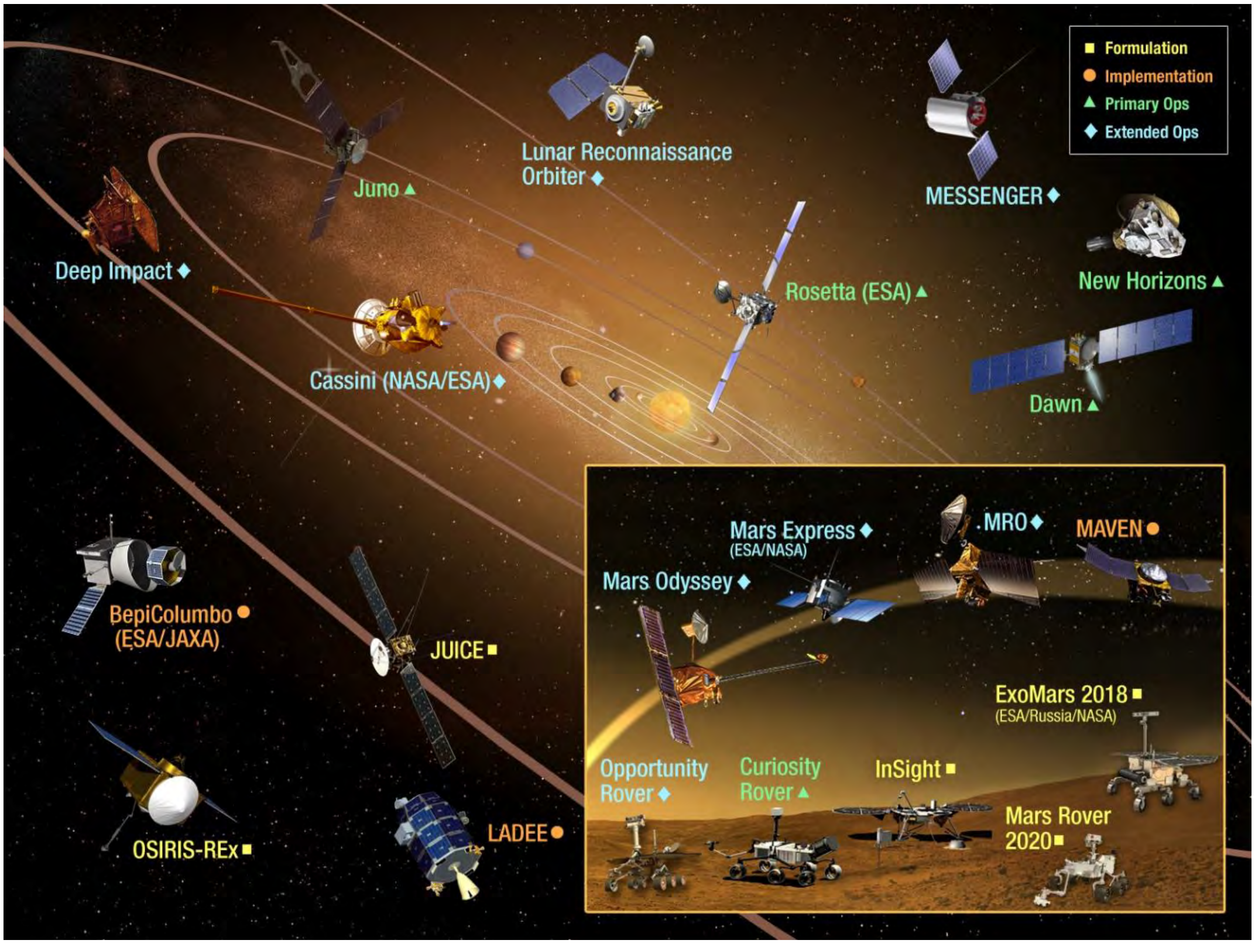
PLANETARY SCIENCE

To answer questions about the solar system and the origins of life, NASA sends robotic space probes to the Moon, other planets and their moons, asteroids and comets, and the icy bodies beyond Neptune. NASA is in the midst of a sustained investigation of Mars, launching a series of orbiters, landers, and rovers, with the long-term goal of eventual human exploration. NASA is operating spacecraft at Mercury and Saturn; is returning to Jupiter with the Juno mission (currently en route); has left the large asteroid Vesta and started on a journey to the largest asteroid Ceres with the Dawn mission; is completing humankind's first basic reconnaissance of the solar system by sending a mission (New Horizons) to fly by Pluto; and is preparing to return samples from an asteroid to Earth (OSIRIS-REx).

The budget request is consistent with the recommendations of the recent decadal survey, including a robust Mars program that retains the goal of sample return. The budget does not, and cannot at this time, accommodate any mission to orbit or land on Jupiter's moon Europa. However, NASA is participating in the European Space Agency's Jupiter Icy moons Explorer (JUICE) mission, which will provide valuable data on Europa and the other Galilean moons to the U.S. science community.

The budget request includes a doubling of NASA's efforts to identify and characterize potentially hazardous near Earth objects (NEOs). NASA will aggressively pursue an expanded observation program that will increase the detection and characterization of NEOs of all sizes by increasing the observing time on existing ground-based telescopes such as PanSTARRs.

To support future planetary missions in the 2020s and beyond, NASA is partnering with the Department of Energy for the production of plutonium-238. Small amounts of plutonium-238 have already been produced, and by optimizing the production process, it is estimated that 1.5 to 2 kilograms per year will be produced by 2018. This amount will be enough to meet NASA's projected needs for future planetary missions. The Science budget request fully funds this requirement. For the first time, NASA's request also includes $50 million to support the radioisotope power system development infrastructure through full-cost recovery mechanisms at the Department of Energy.



This legion of spacecraft represents US and International partnerships in pursuit of new discoveries. For real-time exploration of these missions in our Solar System visit: http://eyes.jpl.nasa.gov.

ASTROPHYSICS

Some of the greatest minds of the last century discovered wondrous things about the physical universe: the Big Bang and black holes, dark matter and dark energy, and the interrelated nature of space and time. Their theories challenge scientists and NASA to use observations from space to test conventional understanding of fundamental physics. Having measured the age of the universe, the scientific community now seeks to explore its ultimate extremes: its birth, the edges of space and time near black holes, and the mysterious dark energy filling the entire universe. Scientists have recently developed astronomical instrumentation sensitive enough to detect planets around other stars. With hundreds of extrasolar planets now known, scientists are using current NASA missions in conjunction with ground-based telescopes to seek Earth-like planets in other solar systems.

The budget request supports all current missions, an enhanced Explorer program, and most of the other core program recommendations of the recent decadal survey. NASA will also make a hardware contribution to the European Space Agency's Euclid mission. This collaboration has been endorsed by the

Astrophysics Subcommittee of the NASA Advisory Council, as well as the National Academies' Committee on Astronomy and Astrophysics. However, no funds will be available to begin development of any major new Astrophysics mission, such as the Wide-Field InfraRed Survey Telescope (WFIRST) and the possible use of the telescope assets made available to NASA, until after launch of JWST. For the next few years, activities on such missions will be limited to early mission studies and technology efforts, for a few million dollars annually.

The image above represents the flotilla of spacecraft and instruments that provide observations to help us understand how the universe works.

JAMES WEBB SPACE TELESCOPE

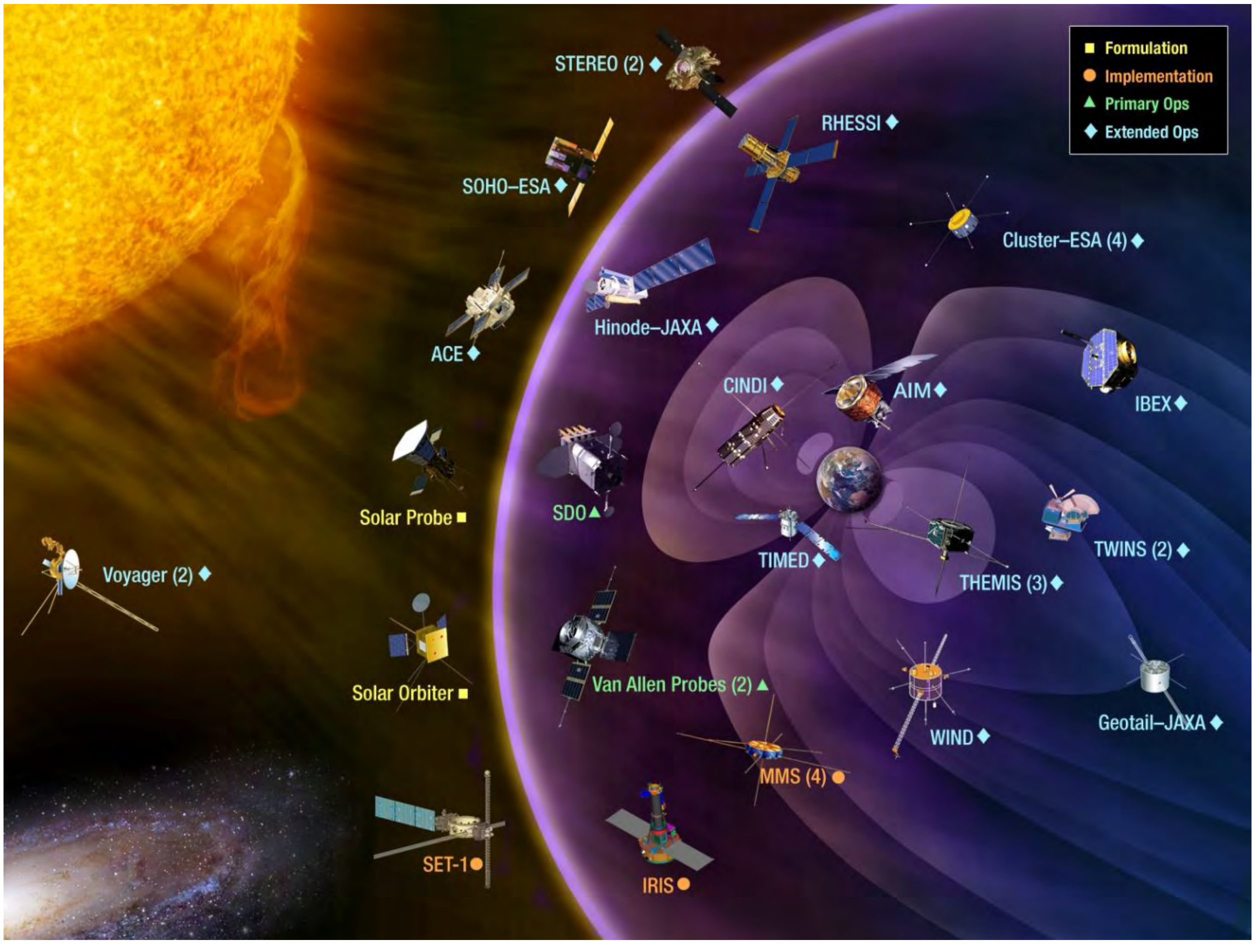
JWST is a large, space-based astronomical observatory. The mission is a logical successor to the Hubble Space Telescope, extending beyond Hubble's discoveries by looking into the infrared spectrum, where the highly red-shifted early universe must be observed, where relatively cool objects like protostars and protoplanetary disks strongly emit infrared light, and where dust obscures shorter wavelengths. JWST is fully funded towards its scheduled launch in October 2018, within the cost and schedule baseline established in 2011.

Lessons learned on JWST have led to changes in NASA project management practices that appear to have helped contain costs on other missions. In particular, the JWST Independent Comprehensive Review Panel recommended stronger cost and schedule analysis capabilities at NASA headquarters. The Science Mission Directorate performs monthly reviews of earned value where available and other project performance measures on all flight projects in phases B through D, or from preliminary design through launch. This increased emphasis from Headquarters has helped focus the attention of project managers on cost and schedule issues.

HELIOPHYSICS

The solar system is governed by the Sun, a typical small star midway through its life. The Sun's influence is wielded through its gravity, radiation, solar wind, and magnetic fields, all of which interact with the gravity, fields and atmospheres of Earth to produce space weather. Using a fleet of sensors on various spacecraft in Earth orbit and throughout the solar system, NASA seeks to understand how and why the Sun varies, how Earth responds to the Sun, and how human activities are affected. The science of heliophysics enables the predictions necessary to safeguard life and society on Earth and the outward journeys of human and robotic explorers.

The budget request supports the recommendations of the recent Heliophysics decadal survey. Following launch of MMS by March 2015, the largest part of the Heliophysics budget will be devoted to the Solar Probe Plus (SPP) project. NASA is strongly committed to SPP, which is expected to enter development in late FY 2014, in preparation for launch in July 2018. The budget also includes a new CubeSat project, which offers a low-cost option for enabling scientific discovery across the various Themes and disciplines in the Science Mission Directorate.



A fleet of Heliophysics spacecraft patrol the environment of our Earth, from its life-sustaining sun out to the edges of our solar system. They reveal a dynamic interconnected system within which our home planet is embedded and through which robotic and human explorers must journey.

EARTH SCIENCE RESEARCH

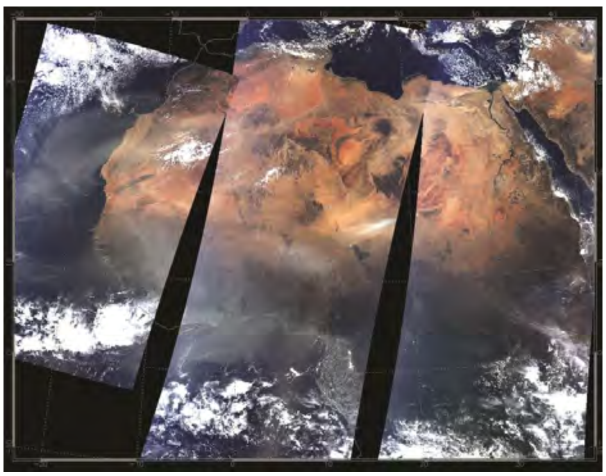
Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	1765.7	--	**1846.1**	1854.6	1848.9	1836.9	1838.1
Earth Science Research	441.1	--	**443.3**	483.1	483.4	485.1	476.5
Earth Systematic Missions	879.9	--	**787.5**	811.2	861.9	839.1	833.3
Earth System Science Pathfinder	183.3	--	**353.6**	293.1	232.2	237.4	250.0
Earth Science Multi-Mission Operations	168.6	--	**171.7**	174.3	177.9	179.0	182.0
Earth Science Technology	51.2	--	**55.1**	56.2	55.1	56.1	56.1
Applied Sciences	36.4	--	**35.0**	36.7	38.4	40.1	40.1

Earth Science

EARTH SCIENCE RESEARCH

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	441.1	--	**443.3**	483.1	483.4	485.1	476.5
Earth Science Research and Analysis	333.3	--	**328.7**	337.8	339.2	342.7	327.7
Computing and Management	107.7	--	**114.6**	145.3	144.2	142.4	148.9
Change from FY 2012	--	--	**2.2**				
Percentage change from FY 2012	--	--	**0.5 %**				



This is a composite image of a dust storm blowing off the coast of Morocco in the northwest corner of the African continent. The data was gathered by the MODIS (Moderate Resolution Imaging Spectroradiometer) instrument aboard the Terra satellite. Such data products are important tools in the study of land, ocean, and atmospheric processes and trends on local and global scales.

NASA's Earth Science Research program develops a scientific understanding of Earth and its response to natural or human-induced changes. Earth is a system, like the human body, comprised of diverse components interacting in complex ways. Understanding Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system is necessary in order to improve our predictions of climate, weather, and natural hazards.

The Earth Science Research program addresses complex, interdisciplinary Earth science problems in pursuit of a comprehensive understanding of the Earth system. This strategy involves six interdisciplinary and interrelated science focus areas, including:

- Climate Variability and Change: understanding the roles of ocean, atmosphere, land, and ice in the climate system and improving predictive capability for future evolution;
- Atmospheric Composition: understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition;
- Carbon Cycle and Ecosystems: quantifying, understanding, and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity;
- Water and Energy Cycle: quantifying the key reservoirs and fluxes in the global water cycle and assessing water cycle change and water quality;
- Weather: enabling improved predictive capability for weather and extreme weather events; and
- Earth Surface and Interior: characterizing the dynamics of the Earth surface and interior and forming the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events.

EARTH SCIENCE RESEARCH

NASA's Earth Science Research program pioneers the use of both space-borne and aircraft measurements in all of these areas. NASA's Earth Science Research program is critical to the advancement of the interagency US Global Change Research Program (USGCRP). NASA's Earth Science Research program also makes extensive contributions to international science programs such as the World Climate Research Programme.

EXPLANATION OF MAJOR CHANGES

NASA will use a modest increase in funding for Earth Science Research to support the Carbon Monitoring System (CMS) and to further integrate NASA products and capabilities with those of other US agencies and international entities. NASA seeks scientific and technical experts to shape and contribute to the next phase of development of a CMS. The Earth Science Education and Outreach Project has been discontinued, consistent with the Administration initiative to consolidate STEM education activities across all of the Agencies. NASA transferred the Global Learning and Observations to Benefit the Environment (GLOBE) activity from Earth Science to NASA’s Office of Education.

ACHIEVEMENTS IN FY 2012

NASA collaborated with other US agencies to conduct the Deep Convective Clouds and Chemistry Project. This field campaign explored the impact of large thunderstorms on the concentration of ozone and other substances in the upper troposphere.

In addition, NASA implemented the first phase of the Salinity Processes in the Upper Ocean Regional Study campaign aboard the research vessel Knorr. This study is designed to shed new light on the link between ocean salinity and shifts in global precipitation patterns. The suite of ocean instruments will complement data from NASA's salinity-sensing instrument aboard the Aquarius/ Satelite de Aplicaciones Cientificas-D (SAC-D) observatory.

WORK IN PROGRESS IN FY 2013

NASA’s Earth Science Research program will continue funding investigations in competitively selected projects in topics such as global impacts of urbanization and the physics of the ocean-ice interface. A number of funded studies on satellite calibration, which were initiated in FY 2012, constitute the first ever solicitation to compare NASA and non-NASA observing assets.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, in response to solicitations in Research Opportunities in Space and Earth Sciences 2013 (ROSES-13) and ROSES-12, NASA anticipates awarding over 200 new 3-year investigations.

EARTH SCIENCE RESEARCH

Program Elements

RESEARCH AND ANALYSIS

Research and Analysis is the core of the research program and funds the analysis and interpretation of data from NASA's satellites. This project funds the scientific activity needed to establish a rigorous base for the satellites' data and their use in computational models.

AIRBORNE SCIENCE

The Airborne Science project is responsible for providing manned and unmanned aircraft systems that further science and advance the use of satellite data. NASA uses these assets worldwide in campaigns to investigate extreme weather events, observe Earth system processes, obtain data for Earth science modeling activities, and calibrate instruments flying aboard Earth science spacecraft. NASA Airborne Science platforms support mission definition and development activities. For example, these activities include:

- Instrument development flights;
- Gathering ice sheet observations as gap fillers between missions (e.g., Operation IceBridge);
- Serve as technology test beds for Instrument Incubator Program (IIP) missions, and;
- Serve as the observation platforms for research campaigns, such as those that are competitively selected under the Sub-Orbital portion of Earth Venture.

The objectives of this project include:

- Conducting in-situ atmospheric measurement and remote sensing observations in support of scientific investigations;
- Demonstrating and exploiting the capabilities of autonomous aircraft for science investigations;
- Testing new sensor technologies in space-like environments; and
- Calibrating and validating space-based measurements and retrieval algorithms.

INTERDISCIPLINARY SCIENCE

Interdisciplinary Science includes science investigations, as well as calibration and validation activities, that ensure the utility of space-based measurements. In addition, it supports focused fieldwork (e.g., airborne campaigns) and specific facility instruments upon which fieldwork depends.

CARBON CYCLE SCIENCE TEAM

Carbon Cycle Science Team funds research on the distribution and cycling of carbon among Earth's active land, ocean, and atmospheric reservoirs.

EARTH SCIENCE RESEARCH

CARBON MONITORING SYSTEM

Carbon Monitoring System complements NASA's overall program in carbon cycle science and observations by producing and distributing products to the community regarding the flux of carbon between the surface and atmosphere, as well as the stores of carbon on the surface.

GLOBAL MODELING AND ASSIMILATION OFFICE

The Global Modeling and Assimilation Office creates global climate and Earth system component models using data from Earth science satellites and aircraft. Investigators can then use these products worldwide to further their research.

OZONE TRENDS SCIENCE

The Ozone Trends Science project produces a consistent, calibrated ozone record that can be used for trend analyses and other studies.

SPACE GEODESY

The Space Geodesy project provides global geodetic positioning and support for geodetic reference frames, which are necessary for climate change and geohazards research. Geodesy is the science of measuring Earth's shape, gravity and rotation, and how these change over time. The Space Geodesy project began in 2011 and is a Goddard Space Flight Center (GSFC) and Jet Propulsion Laboratory (JPL) partnership with participation from the Smithsonian Astrophysical Observatory and the University of Maryland.

FELLOWSHIPS AND NEW INVESTIGATORS

Fellowships and New Investigators supports graduate and early career research in the areas of Earth system research and applied science.

EARTH SCIENCE DIRECTED RESEARCH AND TECHNOLOGY

Earth Science Directed Research and Technology funds the civil service staff that work on emerging Earth Science flight projects, instruments, and research.

HIGH END COMPUTING CAPABILITY (HECC)

High End Computing Capability focuses on the Columbia and Pleiades supercomputer systems and the associated network connectivity, data storage, data analysis, visualization, and application software support. It serves the supercomputing needs of all NASA mission directorates and NASA-supported principal investigators at universities. The Science funding supports the operation, maintenance, and upgrade of NASA's supercomputing capability, while the Strategic Capabilities Assets Program provides oversight. The two systems, with approximately 117,500 computer processor cores, support NASA's aeronautics, human exploration, and science missions.

EARTH SCIENCE RESEARCH

SCIENTIFIC COMPUTING

The Scientific Computing project funds NASA's Earth Science Discover computing system, software engineering, and user interface projects at Goddard Space Flight Center, including climate assessment modeling. Scientific Computing supports Earth science modeling activities based on data collected by Earth science spacecraft. The system is separate from HECC, so it can be close to the satellite data archives at the Center. The proximity to the data and the focus on satellite data assimilation makes the Discover cluster unique in the ability to analyze large volumes of satellite data quickly. The system currently has approximately 31,400 computer processor cores.

DIRECTORATE SUPPORT

The Directorate Support project funds the Science Mission Directorate's institutional and crosscutting activities including: National Academies' studies, proposal peer review processes, printing and graphics, information technology, the NASA Postdoctoral Fellowship program, working group support, independent assessment studies, and other administrative tasks.

Program Schedule

Date	Significant Event
Q2/2014	ROSES-2014 solicitation (planned for solicitation release in spring of 2013)
	ROSES-2014 selection within six to nine months of receipt of proposals

Program Management & Commitments

Program Element	Provider
Research and Analysis	Provider: Various and defined in the acquisition strategy Lead Center: Headquarters (HQ) Performing Centers: All NASA Centers Cost Share Partners: United States Global Change Research Program (USGCRP) and Subcommittee on Ocean Science and Technology (SOST) agencies
Interdisciplinary Science	Provider: Various Lead Center: HQ Performing Centers: HQs, JPL, GSFC, ARC, DFRC, GRC, LaRC, MSFC, JSC Cost Share Partners: USGCRP and SOST agencies

EARTH SCIENCE RESEARCH

Carbon Monitoring System	Provider: Various and defined in the acquisition strategy Lead Center: HQ Performing Centers: JPL, GSFC, ARC Cost Share Partners: US Forest Service, Department of Energy (DOE), National Oceanic and Atmospheric Administration (NOAA)
Carbon Cycle Team	Provider: Various and defined in the acquisition strategy Lead Center: HQ Performing Centers: HQ, JPL, GSFC Cost Share Partners: USGCRP and SOST agencies
Ozone Trends Science	Provider: Various and defined in the acquisition strategy Lead Center: HQ Performing Centers: LaRC, GSFC Cost Share Partners: USGCRP and SOST agencies
Airborne Science	Provider: DFRC Lead Center: HQ Performing Centers: DFRC, ARC, GSFC,WFF Cost Share Partners: Federal Aviation Administration (FAA), Department of Defense (DoD), DOE, NOAA, National Science Foundation
High-End Computing Capability	Provider: ARC Lead Center: HQ Performing Center: ARC Cost Share Partners: DOE
Scientific Computing	Provider: GSFC Lead Center: HQ Performing Center: GSFC Cost Share Partners: DoD, DOE
Global Modeling and Assimilation Office	Provider: Various Lead Center: HQ Performing Center: GSFC Cost Share Partners: N/A
Fellowships and New Investigators	Provider: Various Lead Center: HQ Performing Centers: All NASA Centers Cost Share Partners: N/A

EARTH SCIENCE RESEARCH

Acquisition Strategy

The Earth Science Research program is implemented via competitively selected research awards. Research solicitations are released each year in the ROSES NASA Research Announcements. All proposals in response to NASA ROSES are peer reviewed and selected based on defined criteria. Selected proposals are funded with FY 2014 funding and two subsequent years in an effort to initiate research for about one-third of the program. The Earth Science Research program is based on full and open competition, and at least 90 percent of the funds of the program are competitively awarded to investigators from academia, the private sector, and NASA Centers.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Relevance	NASA Advisory Council Earth Science Subcommittee	2012	To review progress towards Earth Science objectives in the NASA Strategic Plan.	All six science focus areas were rated "green" as documented in the FY 2012 Performance and Accountability Report	2013; annually thereafter

EARTH SYSTEMATIC MISSIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	879.9	--	**787.5**	811.2	861.9	839.1	833.3
Global Precipitation Measurement (GPM)	87.9	--	**60.3**	18.7	19.6	14.2	15.3
Ice, Cloud, and land Elevation Satellite (ICESat-II)	130.5	--	**140.7**	106.4	90.4	27.1	14.1
Soil Moisture Active and Passive (SMAP)	214.2	--	**88.3**	74.9	15.9	11.3	11.3
GRACE FO	42.3	--	**83.4**	75.3	74.3	71.7	20.0
Other Missions and Data Analysis	406.0	--	**414.9**	536.0	661.6	714.8	772.6
Subtotal	880.9	--	**787.5**	811.2	861.9	839.1	833.3
Rescission of prior-year unob. balances*	-1.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-92.4**				
Percentage change from FY 2012	--	--	**-10.5 %**				

*Note: * Rescission of prior-year unobligated balances from Other Missions and Data Analysis pursuant to P.L. 112-55, Division B, sec. 528(f).*

An artist's conception shows the Surface Water Ocean Topography (SWOT) satellite, which entered the formulation phase in November, 2012. SWOT will make high-resolution, wide-swath altimetric measurements of the world's oceans and fresh water bodies to understand their circulation, surface topography, and storage. This multi-disciplinary, cooperative international mission, will produce science and data products that will allow for fundamental advances in the understanding of the global water cycle.

Earth Systematic Missions (ESM) includes a broad range of multi-disciplinary science investigations aimed at understanding the Earth system and its response to natural and human-induced forces and changes. Understanding these forces will help determine how to predict future changes, and how to mitigate or adapt to these changes.

The ESM program develops Earth-observing research satellite missions, manages the operation of these missions once on orbit, and produces mission data products in support of research, applications, and policy communities.

Interagency and international partnerships are a central element throughout the ESM program. Several of the on-orbit missions provide data products in near-real time for use by US and international meteorological agencies and disaster responders. Five of the on-orbit missions involve significant international or interagency collaboration in development. The Landsat Data Continuity Mission (LDCM), one of the ESM program's foundational missions, involves collaboration with the US Geological Survey. GPM is a partnership being developed in cooperation with the Japanese Aerospace Exploration Agency (JAXA), and the GRACE Follow-On (GRACE-FO) mission is a partnership between NASA and the German Space and Earth Science agencies.

EARTH SYSTEMATIC MISSIONS

EXPLANATION OF MAJOR CHANGES

The SWOT, GRACE-FO and SAGE III missions entered formulation and are now funded under separate budget lines. The request also includes funds for NASA to assume responsibility for several Earth measurements previously held by the National Oceanic and Atmospheric Administration (NOAA). NASA will begin study on continuing the long history of measurements of solar irradiance, atmospheric ozone, and Earth's radiation of energy to space. A newly created Land Imaging project will ensure continuity of Landsat land imaging data by funding the development of a sustained, space-based, global land imaging capability. The Landsat Data Continuity Mission (LDCM) recently entered operations after its successful launch on February 11, 2013 and is now funded under Earth Systematic Mission, Other Missions and Data Analysis.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	Prior	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	BTC	Total
FY 2014 President's Budget Request	638.4	87.9	91.4	**60.3**	18.7	19.6	14.2	15.3	0.0	945.8
2014 MPAR LCC Estimate	638.4	87.9	91.4	**60.3**	18.7	19.6	11.8	0.0	0.0	928.1
Formulation	349.2	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	349.2
Development/Implementation	289.2	87.9	91.4	**40.8**	0.0	0.0	0.0	0.0	0.0	509.3
Operations/Close-out	0.0	0.0	0.0	**19.4**	18.7	19.6	11.8	0.0	0.0	69.6
Change from FY 2012		--	--	**-27.6**						
Percentage change from FY 2012		--	--	**-31.4%**						

GPM data will reveal new information on hurricane eyewall development and intensity changes. It will also measure hazard-triggering rainfall events contributing to flooding and landslides, providing inputs to climate, weather, and land surface models for improved predictions.

PROJECT PURPOSE

The Global Precipitation Measurement (GPM) mission will advance the measurement of global precipitation. A joint mission with Japan Aerospace Exploration Agency, GPM will provide the first opportunity to calibrate measurements of global precipitation (including the distribution, amount, rate, and associated heat release) across tropical, mid-latitude, and Polar Regions.

The GPM mission has several scientific objectives:

- Advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques;
- Advance understanding of global water/energy cycle variability and fresh water availability;
- Improve climate prediction by providing the foundation for better understanding of surface water fluxes, soil moisture storage, cloud/precipitation microphysics and latent heat release in Earth's atmosphere;
- Advance numerical weather prediction skills through more accurate and frequent measurements of instantaneous rain rates; and
- Improve high-impact natural hazard event (flood and drought, landslide, and hurricanes) and fresh water-resource prediction capabilities through better temporal sampling and wider spatial coverage of high-resolution precipitation measurements.

For more information, go to: http://science.hq.nasa.gov/missions/earth.html.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

EXPLANATION OF MAJOR CHANGES

NASA re-phased the GPM budget for all years to better match project funding requirements.

PROJECT PARAMETERS

The NASA-provided elements of the GPM project include a core observatory spacecraft and a GPM Microwave Imager (GMI) instrument. The GMI instrument is a conically scanning radiometer that will provide significantly improved spatial resolution over the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager. JAXA will supply the second instrument, the Dual frequency Precipitation Radar (DPR), which will provide three-dimensional observation of rain and an accurate estimation of rainfall rate. The Core Observatory will leverage passive microwave measurements from other operating and planned "satellites of opportunity" by calibrating their measurements to its own. Given the prevalence of passive microwave instruments on operational and research satellite systems, the global sampling from this constellation of satellites will be robust providing frequent global mapping of precipitation. The spacecraft will be launched from Tanegashima Space Center, Japan on a JAXA-provided H-IIA launch vehicle in February 2014.

ACHIEVEMENTS IN FY 2012

The systems integration review was held in February 2012. NASA approved the GPM mission to begin the integration and test phase (Phase D) in April 2012.

WORK IN PROGRESS IN FY 2013

The observatory environmental testing is on track for completion in the fourth quarter of FY 2013 to prepare it for shipment to Japan for launch.

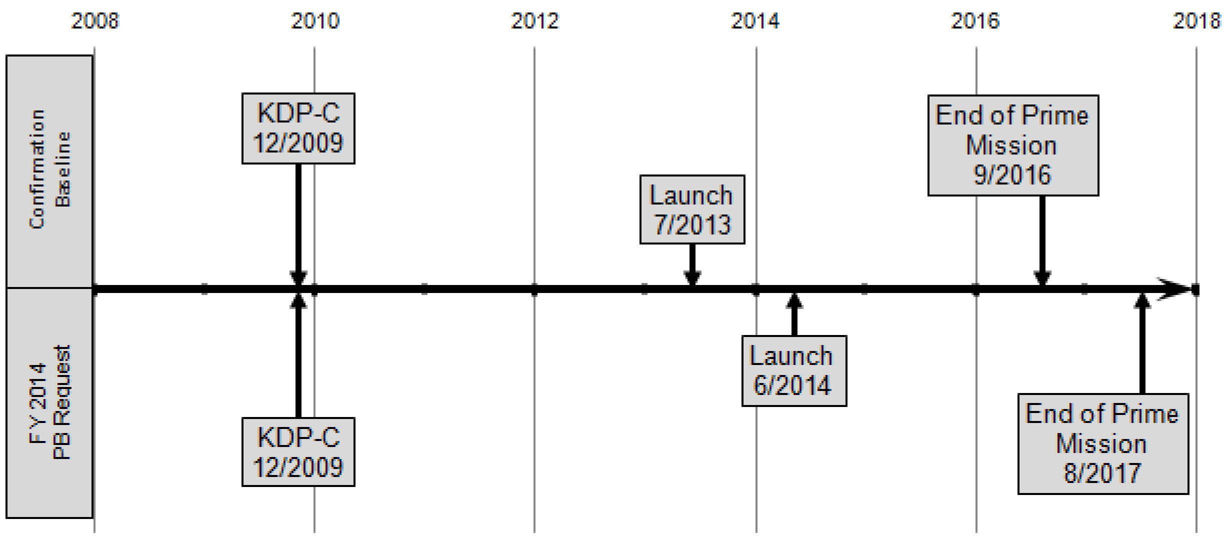
KEY ACHIEVEMENTS PLANNED FOR FY 2014

GPM will hold its operational and flight readiness reviews in advance of the planned launch in FY 2014.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES



Development Cost and Schedule

Due to the mission's critical international partnership and the desire to maintain continuity of the precipitation record established by the long-lived TRMM, NASA and JAXA will strive to launch GPM in February 2014. The GPM project has been directed to execute all necessary actions to accomplish the February 2014 launch. Consistent with NASA policies regarding commitments to time and schedule, the GPM launch will occur no later than June 2014.

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2010	555.2	70	2013	509.3	-8.3	LRD	Jul 2013	Jun 2014	11

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

Development Cost Details

Reductions in the Ground Systems, Science/Technology, and Other Direct Project Costs lines are due to the elimination of the Low-Inclination Observatory GMI-2 instrument, associated TDRSS communications subsystem, payload accommodation, ground system and operations costs in 2012. Increases in the Aircraft/Spacecraft and Systems Integration and Test (I&T) lines are due to spacecraft development issues and the extension of integration and testing activities supporting the replanned launch readiness date.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**555.2**	**509.3**	**-45.3**
Aircraft/Spacecraft	151.2	246.4	95.2
Payloads	91.2	90.9	-.3
Systems I&T	6.8	8.2	1.4
Launch Vehicle	1.5	1.6	.1
Ground Systems	30.5	27.5	-3.0
Science/Technology	28.4	24.2	-4.2
Other Direct Project Costs	245.6	110.4	-134.5

Project Management & Commitments

GSFC has project management responsibility. GPM is a constellation mission that will incorporate data from other precipitation missions from a consortium of international space agencies, including Centre National d'Etudes Spatiales (CNES), Indian Space Research Organization, NOAA, European Organisation for the Exploitation of Meteorological Satellites, and others.

Project Element	Description	Provider	Change from Baseline
Core Observatory	Provides platform for the GMI and JAXA-supplied DPR instruments	Provider: GSFC Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A	N/A
GMI instrument	Provides 13 microwave channels ranging in frequency from 10 gigahertz (GHz) to 183 GHz; 4 high frequency, millimeter-wave, channels	Provider: Ball Aerospace Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A	N/A

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

DPR instrument	Provides cross-track swath widths of 245 and 120 kilometers, for the Ku precipitation radar (KuPR) and Ka-band precipitation	Provider: JAXA Lead Center: N/A Performing Centers: N/A Cost Share Partners: JAXA	N/A
Low Inclination Observatory (LIO/GMI-2)	Provides platform for the second GMI instrument	Provider: Lead Center: Performing Centers: Cost Share Partners:	Descoped
Launch vehicle and services	H-IIA	Provider: JAXA Lead Center: N/A Performing Centers: N/A Cost Share Partners: JAXA	N/A
Ground System	Provides control of Core Observatory operations, science data processing, and distribution	Provider: GSFC Lead Center: GSFC Performing Center: GSFC Cost Share Partners: JAXA	N/A

Project Risks

Risk Statement	Mitigation
If: The total schedule reserve drops below the guideline (18 days), Then: The observatory environmental testing completion and shipment to the launch site could be delayed.	The project will optimize the schedule of testing activities to regain schedule reserve.

Acquisition Strategy

The GMI was selected through open competition in FY 2005.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
GMI	Ball Aerospace and Technologies Corp	Boulder, CO
GPM Core Spacecraft	GSFC	Greenbelt, MD

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	Feb 2012	System integration review	Project approved to begin integration and test	Oct 2013
Performance	SRB	Oct 2013	Operations readiness review to determine project readiness to operate the flight and ground systems	TBD	Jun 2014

CORRECTIVE ACTION PLAN AS REQUIRED BY SECTION 1203 OF NASA 2010 AUTHORIZATION ACT

On February 2, 2012, pursuant to Section 103(c) of P.L 109-155, NASA notified the Committee on Science, Space, and Technology of an anticipated schedule delay of more than six months, but that NASA did not expect this delay to cause the project to exceed its development cost baseline.

The NASA Associate Administrator approved a replan of the project with a new launch date of June 2014, an eleven-month delay compared to the January 2010 MPAR baseline. Based on the analysis conducted and progress to date against the new plan, the GPM project, barring a major test failure or some other significant unplanned event, has a high likelihood of completing its development on the cost and schedule presented.

ICESAT-2

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	Prior	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	BTC	Total
FY 2014 President's Budget Request	124.4	130.5	207.0	**140.7**	106.4	90.4	27.1	14.1	17.3	857.8
2014 MPAR LCC Estimate	124.4	130.5	207.0	**140.7**	106.4	90.4	27.1	14.1	17.3	857.8
Formulation	124.4	124.4	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	248.8
Development/Implementation	0.0	6.1	207.0	**140.7**	106.4	82.9	13.4	0.0	0.0	556.5
Operations/Close-out	0.0	0.0	0.0	**0.0**	0.0	7.5	13.7	14.1	17.3	52.6
Change from FY 2012		--	--	**10.2**						
Percentage change from FY 2012		--	--	**7.8%**						

ICESat-2 will use a multi-beam micropulse laser altimeter to measure the topography of the Greenland and Antarctic ice sheets as well as the thickness of Arctic and Antarctic sea ice. The satellite LIDAR also will measure vegetation canopy heights and support other NASA environmental monitoring missions. By discovering the anatomy of ice loss, researchers may be able to forecast how the ice sheets will melt in the future and what impact this will have on sea-levels.

PROJECT PURPOSE

The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) mission will serve as an ICESat follow-on satellite to continue the assessment of polar ice changes. ICESat-2 will also measure vegetation canopy heights, allowing estimates of biomass and carbon in above ground vegetation in conjunction with related missions, and allow measurements of solid earth properties.

ICESat-2 will continue to provide an important record of multi-year elevation data needed to determine ice sheet mass balance and cloud property information. It will also provide topography and vegetation data around the globe in addition to the polar-specific coverage over the Greenland and Antarctic ice sheets.

The ICESat-2 mission is a Tier 1 mission recommended by the National Academies. It entered formulation in FY 2010.

For more information, go to: http://icesat.gsfc.nasa.gov/icesat2.

EXPLANATION OF MAJOR CHANGES

During FY 2012, the mission lost its opportunity for a co-manifested launch with the US Air Force, thus necessitating the procurement of a dedicated launch vehicle. Based on the cost and schedule analysis of the ICESat-2 design, NASA established a launch readiness date of May 2017 at mission confirmation.

ICESAT-2

Formulation	Development	Operations

PROJECT PARAMETERS

The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation Lidar. ICESat-2 will continue the measurements begun with the first ICESat mission, which launched in 2003, and will improve upon ICESat by incorporating a micro-pulse multi-beam laser to provide dense cross-track sampling, improving elevation estimates over inclined surfaces and very rough (e.g., crevassed) areas and improving lead detection for above-water sea ice estimates.

ACHIEVEMENTS IN FY 2012

ICESat-2 successfully completed its system requirements review and preliminary design review. The Advanced Topographic Laser Altimeter System (ATLAS) instrument successfully completed preliminary design review as well. NASA officially released a request for launch services proposal to potential vendors.

WORK IN PROGRESS IN FY 2013

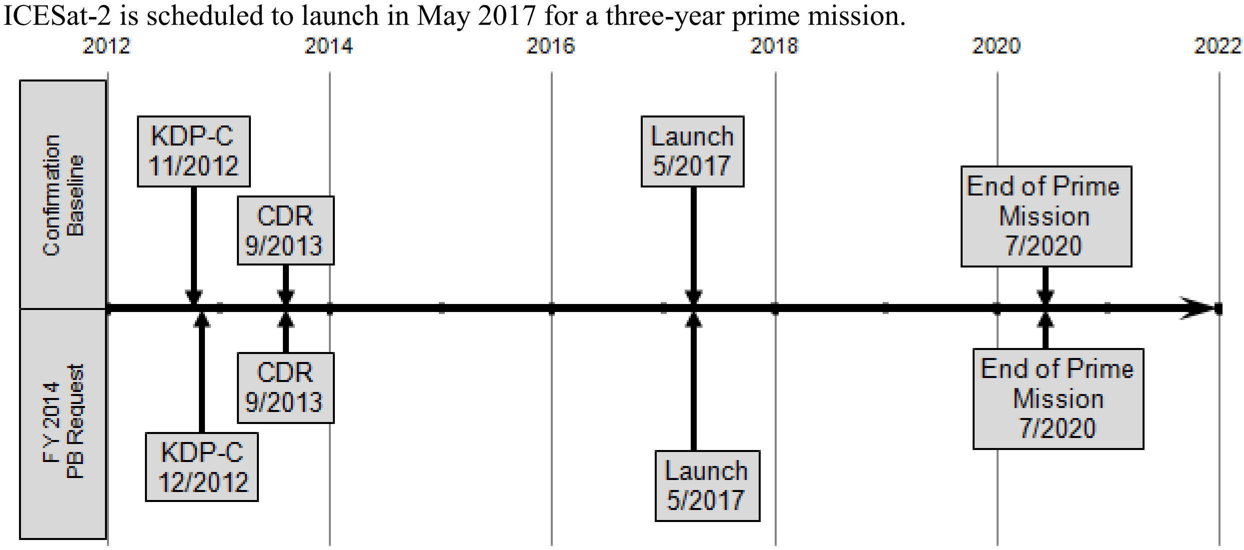
The mission successfully passed the KDP-C milestone and proceeded into the development phase in December 2012. The spacecraft will undergo its critical design review in late FY 2013.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Mission readiness testing for the ground system commences in June 2014. The Advanced Topographic Laser Altimeter System instrument will undergo its pre-environmental review in August 2014.

SCHEDULE COMMITMENTS/KEY MILESTONES

ICESat-2 is scheduled to launch in May 2017 for a three-year prime mission.



ICESAT-2

Formulation	Development	Operations

Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2013	558.9	70	2013	556.5	-0.4%	LRD	May 2017	May 2017	0

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

Development Cost Details

This is the first report of development costs for this mission.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**558.9**	**556.5**	**-2.4**
Aircraft/Spacecraft	77.8	77.8	None
Payloads	88.6	88.6	None
Systems I&T	18.5	18.5	None
Launch Vehicle	123.8	123.8	None
Ground Systems	35.3	35.3	None
Science/Technology	22.9	22.9	None
Other Direct Project Costs	192.0	189.6	-2.4

Project Management & Commitments

GSFC has project management responsibility for ICESat-2.

Project Element	Description	Provider	Change from Baseline
ATLAS Instrument	Advanced Topographic Laser Altimeter System	Provider: GSFC Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A	N/A

Formulation	Development	Operations

Spacecraft	Provides platform for the instrument	Provider: Orbital Sciences Corporation Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A	N/A
Ground System	Provides control of observatory operations, science data processing and distribution	Provider: Orbital Sciences Corporation Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A	N/A
Launch Vehicle	TBD	Provider: TBD Lead Center: N/A Performing Centers: KSC Cost Share Partners: N/A	N/A

Project Risks

Risk Statement	Mitigation
If: The launch vehicle development is delayed or mandates spacecraft changes for accommodation, Then: Mission cost will increase.	Launch vehicle procurement was initiated in October 2012. All spacecraft interface data were included in the Launch Vehicle Request For Proposal to allow proper accommodation.
If: The instrument hardware experiences development problems, Then: Instrument completion will be delayed.	Risk mitigation tasks have been implemented for the instrument throughout formulation. All components have achieved required maturity (technology readiness level-6) for this stage of development as a result.

Acquisition Strategy

The design and testing of the ATLAS instrument has been assigned to GSFC. The spacecraft vendor, Orbital Sciences Corporation, was competitively selected. The ground system element will be provided by the spacecraft vendor via a contract option. The launch services vendor selection is pending with authority to proceed currently anticipated for April 2013.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Ground System	Orbital Sciences Corporation	Dulles, VA
Spacecraft	Orbital Sciences Corporation	Gilbert, AZ

ICESAT-2

Formulation	Development	Operations

INDEPENDENT REVIEWS

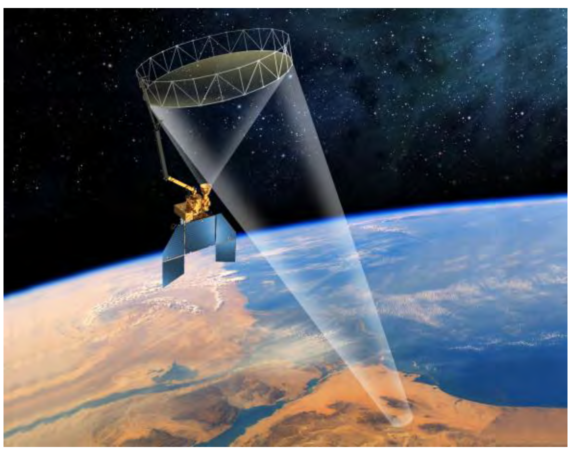
Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	Dec 2012	KDP-C	Mission was approved to enter development	Sep 2013
Performance	SRB	Sep 2013	Mission Critical Design Review	TBD	Dec 2016
Performance	SRB	Dec 2016	Flight Readiness Review	TBD	N/A

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	298.1	214.2	210.3	**88.3**	74.9	15.9	11.3	11.3	0.0	924.3
2014 MPAR LCC Estimate	298.1	214.2	210.3	**88.3**	74.9	15.9	11.3	1.7	0.0	914.6
Formulation	298.1	90.1	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	388.2
Development/Implementation	0.0	124.1	210.3	**88.3**	58.2	4.0	0.0	0.0	0.0	484.8
Operations/Close-out	0.0	0.0	0.0	**0.0**	16.6	11.9	11.3	1.7	0.0	41.6
Change from FY 2012		--	--	**-125.9**						
Percentage change from FY 2012		--	--	**-58.8%**						



SMAP has the potential to enable a diverse range of applications involving drought and flood estimation, agricultural productivity estimation, weather forecasting, climate modeling, and other factors affecting human health and security. For example, SMAP can benefit the emerging field of landscape epidemiology where direct observations of soil moisture can provide valuable information on vector population dynamics, such as identifying and mapping habitats for mosquitoes that spread malaria.

PROJECT PURPOSE

The Soil Moisture Active and Passive (SMAP) mission will provide a capability for global mapping of soil moisture with unprecedented accuracy, resolution, and coverage.

Future water resources are a critical societal impact of climate change, and scientific understanding of how such change may affect water supply and food production is crucial for policy makers. Uncertainty in current climate models result in disagreement on whether there will be more or less water regionally compared to today. SMAP data will help enable climate models to be brought into agreement on future trends in water resource availability.

SMAP science objectives are to acquire space-based hydrosphere state measurements over a three-year period to:

- Understand processes that link the terrestrial water, energy and carbon cycles;
- Estimate global water and energy fluxes at the land surface;
- Quantify net carbon flux in boreal landscapes;
- Enhance weather and climate forecast skill; and
- Develop improved flood prediction and drought monitoring capabilities.

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

The SMAP mission is one of four first-tier missions recommended by the National Academies. For more information, go to: http://smap.jpl.nasa.gov.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PARAMETERS

The SMAP observatory employs a dedicated spacecraft and will be launched into a near-polar, sun-synchronous orbit on an expendable launch vehicle. The SMAP baseline instrument suite includes radiometer and non-imaging synthetic aperture radar. The instruments are designed to make coincident measurements of surface emission and backscatter, with the ability to sense the soil conditions through moderate vegetation cover. Data will be acquired for a period of three years and a comprehensive validation program will be used to assess random errors and regional biases in the soil moisture and freeze/thaw estimates.

ACHIEVEMENTS IN FY 2012

SMAP successfully passed the KDP-C review in June 2012, and is now in the development phase of the mission. NASA completed the launch vehicle selection in July 2012.

WORK IN PROGRESS IN FY 2013

In FY 2013, SMAP will continue development activities and conduct the systems integration review to determine its readiness to begin integration activities.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

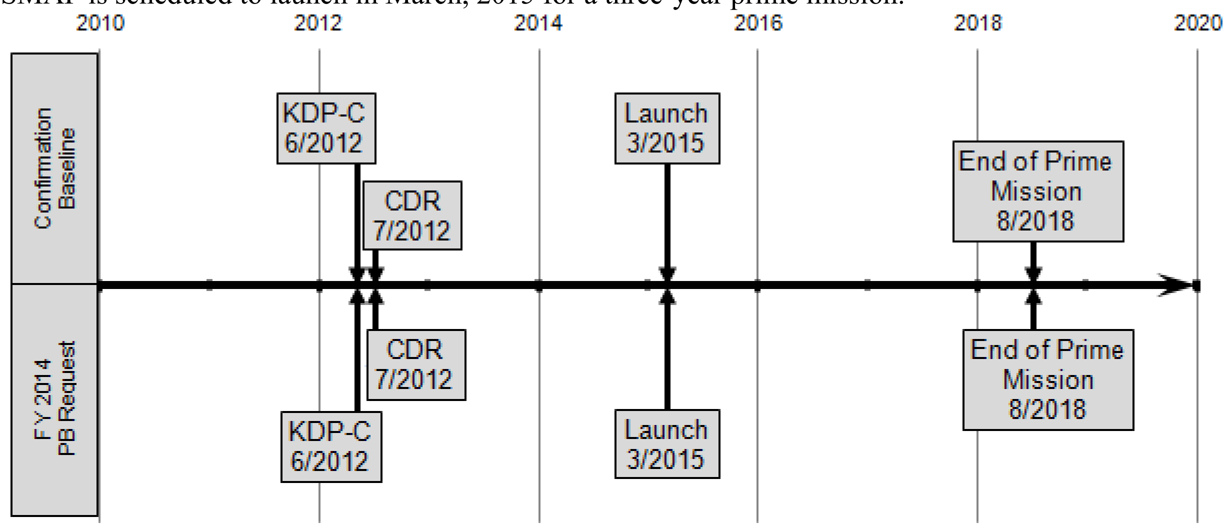
In FY 2014, SMAP will continue development and integration activities, targeting a launch in March, 2015.

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

SMAP is scheduled to launch in March, 2015 for a three-year prime mission.



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2013	485.7	>70	2013	484.8	-.02	LRD	Mar 2015	Mar 2015	None

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**485.7**	**484.8**	**-0.9**
Aircraft/Spacecraft	80.1	80.4	0.3
Payloads	59.7	60.9	1.2
Systems I&T	22.3	22.3	None
Launch Vehicle	123.6	123.6	None
Ground Systems	24.2	24.2	None
Science/Technology	8.9	8.9	None
Other Direct Project Costs	166.9	164.6	-2.3

Project Management & Commitments

JPL has project management responsibility for SMAP.

Project Element	Description	Provider	Change from Baseline
Spacecraft	Provides platform for the instruments	Provider: JPL Lead Center: JPL Performing Center: JPL Cost Share Partners: N/A	N/A
L-Band SAR	Combined with Radiometer, provides soil moisture measurements in the top 5 centimeters of soil through moderate vegetation cover	Provider: JPL Lead Center: JPL Performing Center: JPL Cost Share Partners: N/A	N/A
L-Band Radiometer	Combined with SAR, provides soil moisture measurements in the top 5 centimeters of soil through moderate vegetation cover.	Provider: GSFC Lead Center: JPL Performing Center: GSFC Cost Share Partners: N/A	N/A
Launch Vehicle	Delta II 7320-10C Launch System	Provider: ULA Lead Center: N/A Performing Centers: KSC Cost Share Partners: N/A	N/A

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: There is a late Launch Vehicle Interface Control Documentation (ICD) development, Then: It could cause a launch readiness delay.	Key interfaces required to support spacecraft design are being identified and priorities will be established to meet the need dates for each interface prior to the ICD delivery.
If: The accelerated Reflector Boom Assembly development schedule cannot be maintained, Then: There is a possibility of a launch readiness date delay.	RBA vendor has created an accelerated development schedule and plan to recover from delays caused by additional analysis and assessments needed to support multiple launch vehicle options. SMAP was required to carry these options prior to launch vehicle selection in July 2012. Additional resources are being added at both the Reflector Boom Assembly vendor and JPL to carry out this plan.

Acquisition Strategy

The SMAP mission was directed to JPL, where the radar and spacecraft are being produced as an in-house development, with the radiometer directed to GSFC also for in-house development. The key components, which are the deployable antenna/boom and instrument spin assemblies, were procured through open competition. The launch service was procured under the NASA Launch Services II Contract.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Spin Mechanism Assembly	The Boeing Company	El Segundo, CA
Reflector Boom Assembly (RBA)	Northrop Grumman Aerospace Systems	Carpinteria, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Senior Review Board	Jun 2012	KDP-C Milestone Review	Project approved to enter development	May 2013
Performance	Senior Review Board	May 2013	KDP-D Milestone Review	TBD	Aug 2014
Performance	Senior Review Board	Aug 2014	Flight readiness review	TBD	N/A

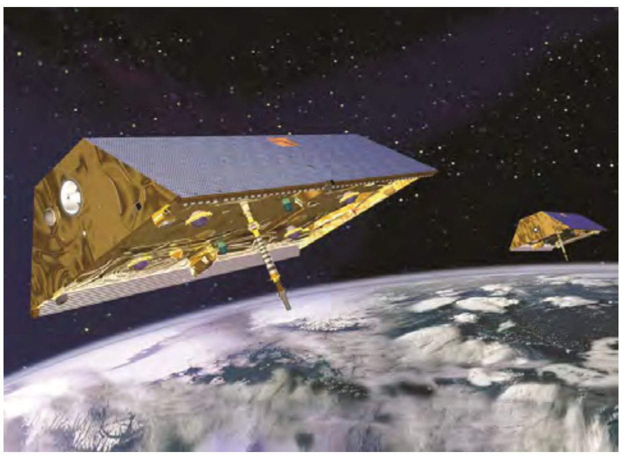
GRACE FOLLOW-ON

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	42.3	--	**83.4**	75.3	74.3	71.7	20.0
Change from FY 2012	--	--	**41.1**				
Percentage change from FY 2012	--	--	**97.2%**				

Note: Funding for GRACE-FO in the FY 2013 President's Budget was provided under the Decadal Survey Missions budget line. This is the first year in which a separate budget profile for this mission has been provided.



Since 2002, the Grace satellites have been making observations of changes in the Earth's gravity field to gain new insights into the dynamic processes in the planet's interior. The Grace-Follow On mission will continue with extremely precise measurements taken by the satellite pair (artist's conception shown), which will be used to generate an updated model of the Earth's gravitational field every 30 days. Along with other climate and geo-research efforts, data from Grace satellites will help scientists build an understanding of the Earth as an integral system.

PROJECT PURPOSE

The Gravity Recovery and Climate Experiment Follow-on (GRACE-FO) mission will allow scientists to gain new insights into the dynamic processes in Earth's interior, into currents in the oceans, and into variations in the extent of ice coverage. Data from the mission, combined with other existing sources of data, will greatly improve scientific understanding of glaciers, hydrology.

GRACE-FO will obtain the same extremely high-resolution global models of Earth's gravity field, including how it varies over time, as in the original GRACE mission (launched in 2002). The GRACE-FO data is vital to ensuring there is no gap in gravitational field measurements between the currently operating GRACE mission and the higher-capability GRACE-II recommended in the decadal survey. GRACE-FO includes a partnership with Germany.

EXPLANATION OF MAJOR CHANGES

GRACE-FO has entered into the detailed design phase formulation (Phase B) and a lifecycle cost range is now provided as part of the budget submission.

PROJECT PRELIMINARY PARAMETERS

The GRACE-FO observatory employs two dedicated spacecraft that will be launched into a near-circular polar orbit. As the two spacecraft orbit eEarth, slight variations in gravity will alter the spacecraft speed

GRACE FOLLOW-ON

Formulation	Development	Operations

and distance relative to each other. The speed and distance changes can be used to extrapolate and map Earth's gravitational pull.

The GRACE-FO instrument suite includes the Microwave Instrument (MWI), which accurately measures changes in the speed and distance between the two spacecraft. The accelerometer instrument measures all non-gravitational accelerations (e.g., air drag, solar radiation pressure, attitude control, thruster operation) of the GRACE-FO satellite(s). The Laser Ranging Interferometer is a technology demonstration and is a joint partnership between the US and Germany. The science data from GRACE mission will be used to generate an updated model of Earth's gravitational field approximately every 30 days for the 5-year lifetime of the mission.

ACHIEVEMENTS IN FY 2012

During 2012, GRACE-FO received approval to enter the detailed design phase of formulation, after successfully completing its key decision point (KDP) -A and KDP-B milestones in January 2012 and August 2012, respectively. The mission also completed system requirements and mission definition reviews in July 2012. GRACE-FO successfully completed the Interagency Coordination process for the use of a contributed, foreign-provided launch vehicle.

WORK IN PROGRESS IN FY 2013

A memorandum of understanding between NASA and Germany is being developed to codify international contributions (launch vehicle, operations, laser ranging instrument, ground data and science processing). The preliminary design reviews for the LRI and MWI instruments are scheduled for March and April 2013, respectively.

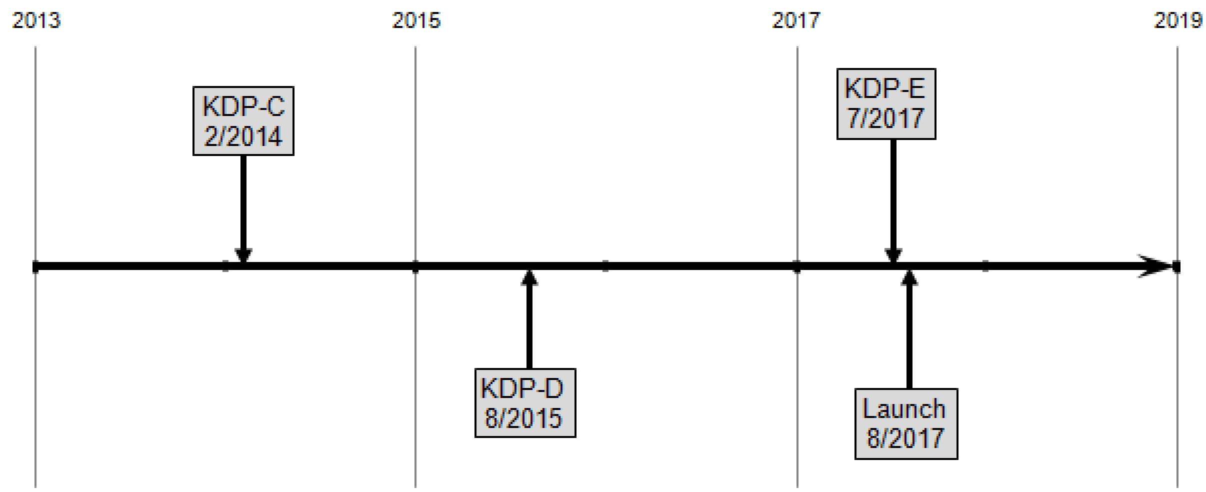
KEY ACHIEVEMENTS PLANNED FOR FY 2014

GRACE-FO will undergo its preliminary design review in January 2014. The confirmation review will occur in February 2014.

GRACE FOLLOW-ON

Formulation	Development	Operations

ESTIMATED PROJECT SCHEDULE



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Lifecycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Aug 2012	$404-$460	LRD	Aug 2017

GRACE FOLLOW-ON

Formulation	Development	Operations

Project Management & Commitments

GRACE-FO is managed through the Earth Systematic Missions Program at GSFC and implementation is assigned to JPL.

Element	Description	Provider Details	Change from Formulation Agreement
Spacecraft	Provides platform for the instruments.	Provider: Astrium GmbH (Germany) Lead Center: None Participating Center: JPL Cost Share Partners: None	N/A
Microwave Instrument (MWI)	Measures the distance between the spacecraft as a function of time	Provider: JPL Lead Center: JPL Participating Center: JPL Cost Share Partners: None	N/A
Accelerometers (ACC)	Measures all non-gravitational accelerations of the satellite(s)	Provider: French Office National d'Etudes et Recherches Aérospatiales (ONERA) Lead Center: None Participating Center: JPL Cost Share Partners: None	N/A
Laser Ranging Interferometer (LRI)	Heterodyne interferometric laser will measure the distance between the two spacecraft as a function of time	Provider: JPL and the German Research Centre for Geosciences (GFZ) Lead Center: None Participating Center: JPL Cost Share Partners: GFZ	N/A
Launch Vehicle	Delivers observatory into Earth orbit.	Provider: Germany Lead Center: None Participating Center: KSC Cost Share Partners: GFZ	N/A

Project Risks

Risk Statement	Mitigation
If: The development of a MOU to establish international contributions is delayed, Then: It could have a negative impact on project deadlines.	A draft memorandum of understanding is in work. NASA has developed a concept paper to begin discussions with GFZ. After completing the interagency coordination process for the use of a contributed, foreign-provided launch vehicle in November 2012, NASA will begin formal MOU negotiations with GFZ.

GRACE FOLLOW-ON

Formulation	Development	Operations

Acquisition Strategy

The acquisition strategy for GRACE-FO leveraged GRACE heritage by using sole source procurement to the same vendors for major components. All other mission components were built in-house or provided by international partners. All major acquisitions have been completed.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Spacecraft	Astrium	Germany
Microwave Instrument Ultra Stable Oscillator	Applied Physics Laboratory-Johns Hopkins University	Laurel, MD
Microwave Assemblies	Space Systems/Loral	Palo Alto, CA
Accelerometers	ONERA	France

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Standing Review Board	Aug 2012	KDP-B Milestone Review	Project approved to enter Phase B of formulation	Feb 2014
Performance	Standing Review Board	Feb 2014	KDP-C Milestone Review	To be determined (TBD)	Aug 2015
Performance	Standing Review Board	Aug 2015	KDP-D Milestone Review	TBD	Jul 2017
Performance	Standing Review Board	Jul 2017	Flight readiness review	TBD	N/A

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	404.9	--	**414.9**	536.0	661.6	714.8	772.6
Earth Systematic Missions Research	11.2	--	**12.1**	16.8	19.5	24.6	24.6
Ocean Surface Topography Science Team	6.3	--	**6.0**	6.1	6.3	6.4	6.4
Earth Observations Systems Research	27.3	--	**24.1**	24.5	25.3	25.5	25.5
Sage III	22.7	--	**27.3**	12.2	6.1	5.0	5.0
Decadal Survey Missions	43.7	--	**114.7**	157.0	237.2	276.2	289.7
Deep Space Climate Observatory	0.0	--	**9.9**	1.7	1.7	0.0	0.0
Land Imaging	0.0	--	**30.0**	84.0	94.8	117.9	117.9
Earth Science Program Management	34.9	--	**32.1**	32.4	29.4	30.3	30.5
Precipitation Science Team	7.2	--	**7.2**	7.4	7.5	7.7	7.7
Ocean Winds Science Team	4.7	--	**4.4**	4.5	4.6	4.7	4.7
Land Cover Science Project Office	1.5	--	**1.5**	1.6	1.6	1.6	1.6
Surface Water and Ocean Topography Mission	0.0	--	**20.0**	66.0	109.9	103.9	154.4
Quick Scatterometer	3.6	--	**3.7**	2.2	1.6	0.9	0.0
Tropical Rainfall Measuring Mission	9.4	--	**9.9**	10.1	10.7	5.1	5.1
Ocean Surface Topography Mission	1.1	--	**1.1**	1.1	1.2	1.2	1.2
Suomi NPP	6.0	--	**7.0**	6.7	6.3	6.3	6.3
Terra	29.8	--	**30.7**	31.2	30.6	31.1	30.1
Aqua	31.0	--	**31.7**	32.9	33.0	33.4	32.4
Aura	27.8	--	**25.5**	26.5	26.4	26.7	25.7
Active Cavity Radiometer Irradiance Monitor Satellite	1.3	--	**1.3**	1.4	1.4	1.4	1.4
Solar Radiation and Climate Experiment	5.3	--	**5.4**	3.3	2.4	1.3	0.0
Jason	4.5	--	**4.6**	2.9	2.0	1.1	0.0
Earth Observing-1	2.4	--	**2.5**	1.3	0.0	0.0	0.0
Ice, Cloud,and land Elevation Satellite	0.7	--	**0.0**	0.0	0.0	0.0	0.0
Landsat Data Continuity Mission	123.5	--	**2.2**	2.2	2.3	2.4	2.4
Subtotal	406.0	--	**414.9**	536.0	661.6	714.8	772.6
Rescission of prior-year unob. balances*	-1.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**10.0**				
Percentage change from FY 2012	--	--	**2.5 %**				

*Note: * Rescission of prior-year unobligated balances from Decadal Survey Missions pursuant to P.L. 112-55, Division B, sec. 528(f).*

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Earth Systematic Missions Other Missions and Data Analysis include operating missions and their science teams. Mission science teams define the scientific requirements for their respective missions and generate the algorithms used to process the data into useful data products. The research projects execute competitively selected investigations related to specific mission measurements.

Mission Planning and Other Projects

EARTH SYSTEMATIC MISSIONS RESEARCH

Earth Systematic Missions Research funds various science teams for the Earth Systematic missions. These science teams are composed of competitively selected individual investigators who analyze data from the missions to address the related science questions.

EARTH OBSERVATION SYSTEMS (EOS) RESEARCH

EOS Research funds science for the EOS missions, currently Terra, Aqua, Aura, Landsat, and ICESat missions. Individual investigators are competitively selected to undertake research projects that analyze data from specific missions. While overall the selected activities focus on science data analyses and the development of Earth system data records including climate data records relevant to NASA's research program, some funded activities continue algorithm improvement and validation for the EOS instrument data products.

Recent Achievements

A first measurement-based estimate of aerosol intercontinental transport to North America has been made using NASA mission and model data. It was estimated that about half of continental aerosol mass comes from overseas. Researchers use a variety of NASA data to understand better the climatic impacts of aerosols. Researchers have made progress in quantifying the impact of absorbing aerosol on monsoon circulation and the role of aerosol in convective cloud development.

DECADAL SURVEY MISSIONS

The Decadal Survey Missions project contains missions recommended by the National Academies' Earth Science decadal study, as well as a variety of climate change missions. All the missions within this project are either in a pre-Phase A (early formulation phase) or are still conducting mission concept studies. The current portfolio of missions includes Pre-Aerosol, Clouds, and ocean Ecosystem (PACE), Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS), GEOstationary Coastal and Air Pollution Events (GEO-CAPE), Aerosol Cloud Ecosystems (ACE), and Hyperspectral Infrared Imager (HyspIRI). The project also contains funding for a potential Earth Radar Mission.

Responsibility has been transferred to NASA for the sustained climate measurements that were to have

Formulation	Development	Operations

been made from the Total Solar Irradiance Sensor (TSIS-2), the Clouds and Earth's Radiant Energy System follow-on (CERES-C), and the limb soundings from the Ozone Mapping and Profiler Suite (OMPS-L), previously planned for NOAA's Joint Polar Satellite System (JPSS) series. NASA will begin studying the best options and approaches for economically conducting these earth observations, which are needed to monitor and study the Earth's climate system. NASA will study approaches to continue the 30 plus-year solar irradiance data record currently produced by the SORCE and ACRIMSAT missions, and the Total Solar Irradiance (TSI) Calibration Transfer Experiment (TCTE) instrument, a joint mission with NOAA. NASA will study approaches to continue the more than 25-year record of ozone measurements from the Ozone Mapping Profiler Suite. NASA will also study the implementation of the Earth radiation budget measurement currently conducted by the Clouds and Earth's Radiant Energy System (CERES) series of instruments. The CERES study will evaluate the continued system measurement requirements in combination and coordination with the other pre-formulation missions from the 2007 decadal survey, and will define an implementation approach that best achieve the measurement objectives.

Recent Achievements

The Orbiting Carbon Observatory-3 (OCO-3) and Surface Water Ocean Topography (SWOT) missions completed pre-formulation activities and were approved to enter Phase A. These mission budgets have now moved out of the Decadal Survey Missions line and have been established as separate projects. OCO-3 has been transferred to the Earth System Science Pathfinder (ESSP) program.

DEEP SPACE OBSERVATORY (DSCOVR)

The Deep Space Observatory mission is a multi-agency (NOAA, US Air Force, and NASA) mission planned for launch in 2014 with the primary goal of making unique space weather measurements from the Lagrange point L1. Lagrange point L1 is on the direct line between Earth and the Sun. NASA will complete the integration of the two Earth-observing instruments, the Earth Poly-Chromatic Imaging Camera (EPIC) and the National Institute of Standards and Technology (NIST) Advanced Radiometer (NISTAR) to the DSCOVR satellite. NASA will also develop and implement the necessary algorithms to enable the "Earth at noon" images from the satellite once on orbit.

SURFACE WATER OCEAN TOPOGRAPHY (SWOT)

The Surface Water and Ocean Topography mission will improve our understanding of the world's oceans and terrestrial surface waters. The mission, through broad swath altimetry, will make high-resolution measurements of ocean circulation, its kinetic energy, and its dissipation. These measurements will improve ocean circulation models leading to better prediction of weather and climate. The mission will also revolutionize knowledge of the surface water inventory on the continents by precise measurement of water levels in millions of lakes and water bodies and the discharge of all major rivers. This will allow for deeper understanding of the natural water cycle and the informed control of this resource.

The 2007 National Academies'decadal survey of Earth Science and the NASA's 2010 Climate Plan endorsed SWOT. The mission will complement the Jason oceanography missions, as well as other NASA

Formulation	Development	Operations

mission currently being developed to measure the global water cycle (GPM, SMAP, and GRACE-FO). NASA will partner with the French Centre National d'Etudes Spatiales (CNES) and the Canadian Space Agency to accomplish this mission.

Recent Achievements

The mission concept review was completed in September 2012. The KDP-A was completed in November 2012 and the project began formulation (Phase A).

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT III- (SAGE III)

SAGE III will provide global, long-term measurements of key components of Earth's atmosphere. The most important of these are the vertical distribution of aerosols and ozone from the upper troposphere through the stratosphere. In addition, SAGE III also provides unique measurements of temperature in the stratosphere and mesosphere and profiles of trace gases such as water vapor and nitrogen dioxide that play significant roles in atmospheric radative and chemical processes. These measurements are vital inputs to the global scientific community for improved understanding of climate, climate change and human-induced ozone trends.

To take these measurements, SAGE III relies upon the flight-proven designs used in the Stratospheric Aerosol Measurement (SAM I) and SAGE I and II instruments. SAGE III is scheduled to board one of NASA's first commercial SpaceX flights in 2015 for a ride to the International Space Station.

Recent Achievements

The SAGE III team completed instrument vibration testing in 2012.

LAND IMAGING

Unprecedented changes in land cover and land use have profound consequences for weather and climate change, crop monitoring and water management, carbon cycling and sequestration, and many other economic, health, and societal issues. The Landsat data series, begun in 1972, has provided the longest continuous record of changes in Earth's surface as seen from space and is the only satellite system that is designed and operated to repeatedly observe the global land surface at moderate resolution. Landsat data are available at no cost to those who work in agriculture, geology, forestry, regional planning, education, mapping, and global climate change research.

The successful launch of the NASA-US Geological Study (USGS) Landsat Data Continuity Mission (soon to be Landsat-8) mission in February 2013 enables near-term continuation of the 40-year Landsat record and avoids an immediate gap in land imaging data. In FY14 NASA will initiate the definition of a sustained, space-based, global land imaging capability for the nation, ensuring continuity following LDCM. Near-term activities led by NASA, in cooperation with USGS, will focus on studies to define the scope, measurement approaches, cost, and risk of a viable long-term land imaging system that will

Formulation	Development	Operations

achieve national objectives. Evaluations and design activities will include consideration of stand-alone new instruments and satellites, as well as potential international partnerships. It is expected that NASA will support the overall system design, flight system implementation, and launch of future missions, while USGS will continue to fund ground system development, post-launch operations, and data processing, archiving, and distribution.

EARTH SCIENCE PROGRAM MANAGEMENT

The Earth Science Program Management budget supports the ESM Program Office at GSFC, the Earth System Science Pathfinder Program Office at LaRC and the Earth Science Flight Project Office at JPL. This budget also supports:

- The GSFC conjunction assessment risk analysis function, which determines maneuvers required to avoid potential collisions between spacecraft and to avoid debris;
- The technical and management support for the international Committee on Earth Observation Satellites, which coordinates civil space-borne observations of Earth. Participating agencies strive to enhance international coordination and data exchange and to optimize societal benefit;
- NASA's efforts in support of the Big Data Research and Development Initiative, which will advance state-of-the-art core technologies needed to collect, store, preserve, manage, analyze, and share huge quantities of data; and
- The Independent Program and Assessment Office, which supports various project reviews for flight projects in Earth Science.

OCEAN SURFACE TOPOGRAPHY SCIENCE TEAM

Ocean Surface Topography Science Team uses scientific data to measure global sea surface height. The data is collected from the Ocean Surface Topography Mission (OSTM) and Jason satellites.

Recent Achievements

The team continues to publish actively using data from the OSTM and Jason satellites, with between 100 and 200 papers per year citing data from satellite altimeters. Recent highlights include papers explaining the temporary decline in global sea level that resulted from the 2011 La Niña event. This had such a dramatic impact on global rainfall patterns that water equivalent to half a centimeter of global sea level was transferred from the oceans to the continents.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

PRECIPITATION SCIENCE TEAM

The Precipitation Science Team uses scientific data received from the TRMM satellite to study weather and climate processes. This science team also supports improvements to the TRMM retrieval algorithms and the development of algorithms for the GPM mission.

Recent Achievements

The team has used TRMM's observations to greatly increase our understanding of the water cycle and the movement of heat that powers tropical cyclones and hurricanes. The team has also used GPM mission data to make significant progress in improving the estimation accuracy of rainfall rates.

OCEAN VECTOR WINDS SCIENCE TEAM

Ocean Vector Winds Science Team uses scientific data received from the Quick Scatterometer (QuikSCAT) satellite, which measures ocean surface wind vectors by sensing ripples caused by winds near the ocean's surface. From these data, scientists can compute wind speed and direction thus acquiring hundreds of times more observations of surface wind velocity each day than is possible from ships or buoys.

Recent Achievements

Scientists and researchers have used the QuikSCAT climate data set recently to provide an independent evaluation of the ability of climate models to reproduce decadal wind and wind stress observations. Although many features are reproduced by the models, significant differences still exist between models and observation. These studies will be incorporated in upcoming international climate change assessments.

LAND COVER PROJECT SCIENCE OFFICE (LCPSO)

The Land Cover Project Science Office maintains over 40 years of calibration records for the Landsat-1 through Landsat-7 series of satellites. The office also provides community software tools to make it easier for users to work with this data. In collaboration with USGS, LCPSO supports improvements in the Landsat-7 long-term acquisition plan and provision of preprocessed data sets for land-cover change analysis.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

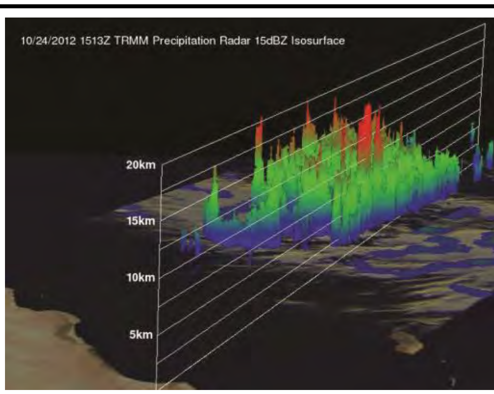
Operating Missions

QUICK SCATTEROMETER (QUIKSCAT)

The QuikSCAT mission carries the SeaWinds instrument, originally designed to measure ocean surface wind speed and direction under nearly all-weather conditions. Since the antenna stopped rotating in 2009, several years past its design life, the sensor has become the standard for cross-calibration with other ocean wind scatterometers, enabling both the continuation of the high-quality ocean winds dataset and the operational forecasts. QuikSCAT launched in 1999 and is currently in extended operations. The 2011 Earth Science senior review endorsed the QuikSCAT mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the QuikSCAT mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

The QuikSCAT project team completed the full mission reprocessing of the entire 10-year QuikSCAT dataset. The dataset from 1999 to2009 enables scientists beyond the traditional ocean vector wind community to conduct climate studies, such as assessing global carbon loss from Earth's forested areas. The cross-calibration efforts with the Indian Space Research Organization's OceanScat mission have been successful in extending the research-quality ocean wind vector dataset.



Most of the energy needed to drive global atmospheric circulation comes from evaporating water. As water vapor rises, it condenses into cloud clusters, thus releasing heat energy, with rainfall as the product of this release. To provide better climate modeling, the TRMM satellite measures rainfall as shown here, which shows data from the first tropical cyclone of 2012 over the Arabia Sea.

TROPICAL RAINFALL MEASURING MISSION (TRMM)

TRMM measures precipitation, clouds, and lightning over tropical and subtropical regions and extends our knowledge about how the energy associated with rainfall interacts with other aspects of the global climate. The TRMM sensor suite provides a three-dimensional map of storm structure, yielding information on rain intensity and distribution. TRMM launched in 1997. It is a joint mission with Japan. The 2011 Earth Science senior review endorsed the TRMM mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the TRMM mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

OTHER MISSIONS AND DATA ANALYSIS

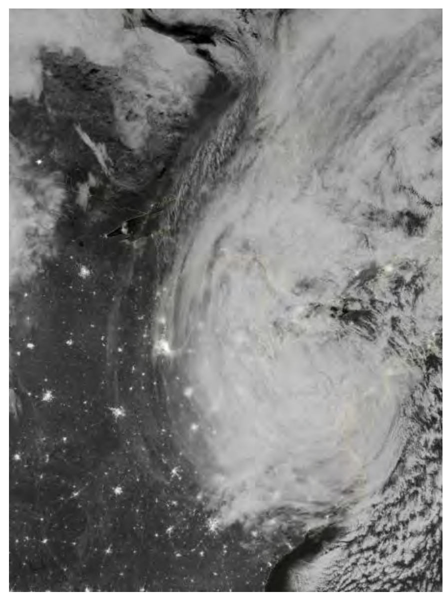
Formulation	Development	Operations

Recent Achievements

TRMM launched in 1997 and celebrated its 15th anniversary of operations in November 2012. In October 2012, TRMM passed above the first tropical cyclone of the year as it was forming in the Arabian Sea. TRMM data showed that rain at the surface was falling at a rate of up to 41 millimeters per hour (approximately1.6 inches per hour) in the forming tropical cyclone. Bands of thunderstorms were also wrapping tightly into a well-defined, low-level center of circulation. TRMM data was also used to create a 3-D image that showed the vertical structure of convective storms in the area. The image shows some towering convective storms were reaching heights of over 16 kilometers (approximately 9.9 miles).

OCEAN SURFACE TOPOGRAPHY MISSION (OSTM)

OSTM, or Jason-2, measures sea surface height and enables scientists to assess climate variability and change, and water and energy cycles. This mission is a follow-on mission to Jason, which launched in 2008 and recently completed its prime operations phase. OSTM is a joint mission with NOAA, Centre National d'Etudes Spatiales (CNES), and European Organisation for the Exploitation of Meteorological Satellites. The 2011 Earth Science senior review endorsed the OSTM mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the OSTM mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.



The Visible Infrared Imaging Radiometer Suite (VIIRS) on NASA/NOAA's Suomi NPP satellite captured this night-time view of Hurricane Sandy, taken 16 to 18 hours before the storm's landfall. The VIIRS instrument is one of five advanced instruments aboard Suomi NPP that provide observations to help us understand, monitor, and predict long-term climate change as well as short-term weather conditions.

Recent Achievements

OSTM produced important images of sea surface heights in the northeastern Gulf showing Hurricane Isaac's path in August 2012. The storm's track away from the Gulf's warmest waters helped to keep Isaac from intensifying rapidly, as Hurricanes Katrina and Rita did in 2005.

SUOMI NATIONAL POLAR ORBITING PARTNERSHIP (SUOMI NPP)

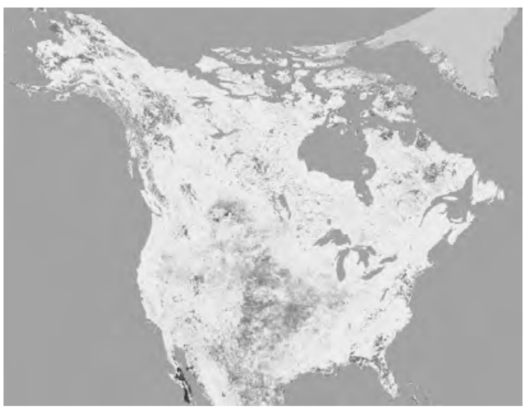
Suomi NPP launched in October 2011 to ensure critical continuity in the nation's operational meteorological measurements from the afternoon orbit. The five instruments on Suomi NPP provide visible and infrared multi-spectral global imagery, atmospheric temperature and moisture profiles, total ozone and stratospheric ozone

Formulation	Development	Operations

profiles, and measurements of Earth's radiation balance. In addition to a wide range of applications studies, the NASA science focus areas served by Suomi NPP include atmospheric composition, climate variability and change, carbon cycle, ecosystems, water and energy cycles, and weather.

Recent Achievements

The Suomi NPP mission was commissioned to begin operations in March 2012 and immediately began supporting the operational weather forecast system.



39% of the United States suffered severe drought conditions through August 2012. The browning and withering of vegetation in the central United States is clear in this vegetation anomaly map based on data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. The map contrasts plant health in August 2012 against the average conditions between 2002 and 2012. Gray areas show where plant growth was below normal.

TERRA

Terra is one of the Earth Observing System flagship missions. It enables a wide range of interdisciplinary studies of atmospheric composition, carbon cycle, ecosystems, biogeochemistry, climate variability and change, water and energy cycles, and weather. Terra launched in 1999 and is a joint mission with Japan and Canada. The 2011 Earth Science senior review endorsed the Terra mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the Terra mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

The Terra satellite produced important snow maps to help us understand the widespread drought in 2012. Snowpack maps help hydrologists and climate modelers determine how much water is available for irrigation and drinking.

AQUA

Aqua, another of the Earth Observing System flagship missions, also operates in the afternoon constellation of satellites, known as the A-Train. Aqua improves our understanding of Earth's water cycle and the intricacies of the climate system by monitoring atmospheric, land, ocean, and ice variables. Aqua launched in 2002 and is a joint mission with Brazil and Japan. The 2011 Earth Science senior review endorsed the Aqua mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the Aqua mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth

Formulation	Development	Operations

Science strategic plans.

Recent Achievements

In FY 2012, the Aqua team made significant progress towards recovering the Advanced Microwave Scanning Radiometer for EOS instrument. Aqua also supported the return of CloudSat into the A-Train constellation.

AURA

The Aura mission enables study of atmospheric composition, climate variability and weather by measuring atmospheric chemical composition, tropospheric/stratospheric exchange of energy and chemicals, chemistry-climate interactions, and air quality. Aura is also part of the A-Train. Aura launched in 2004. It is a joint mission with the Netherlands, Finland, and the United Kingdom. The 2011 Earth Science senior review endorsed the Aura mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the Aura mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

In FY 2012, a team of scientists used the Ozone Monitoring Instrument on NASA's Aura satellite to confirm major reductions in the levels of a key air pollutant generated by coal power plants in the eastern United States. The pollutant, sulfur dioxide, contributes to the formation of acid rain and can cause serious health problems. The scientists have shown that sulfur dioxide levels in the vicinity of major coal power plants have fallen by nearly half since 2005. The new findings, the first satellite observations of this type, confirm ground-based measurements of declining sulfur dioxide levels. The findings also demonstrate that scientists can potentially measure levels of harmful emissions throughout the world, even in places where ground monitoring is not extensive or does not exist.

ACTIVE CAVITY RADIOMETER IRRADIANCE MONITOR SATELLITE (ACRIMSAT)

The ACRIMSAT was launched in December 1999 to monitor total solar irradiance, which contributes to assessments of climate variability. ACRIMSAT data will be correlated with possible global warming data, ice cap shrinkage data, and ozone layer depletion data. It is theorized that as much as 25 percent of Earth's total global warming may be solar in origin, due to small increases in the Sun's total energy output since the last century. By measuring incoming solar radiation and correlating the radiation with measurements of ocean and atmosphere currents and temperatures, as well as surface temperatures, climatologists will be able to improve their predictions of climate and global warming over the next century.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

SOLAR RADIATION AND CLIMATE EXPERIMENT (SORCE)

The SORCE mission measures the total and spectral solar irradiance incident at the top of Earth's atmosphere. SORCE will provide state-of-the-art measurements of incoming X-ray, ultraviolet, visible, near-infrared, and total solar radiation in order to address long-term climate change, natural variability and enhanced climate prediction, and atmospheric ozone and Ultraviolet-B radiation. These measurements are critical to studies of the Sun, its effect on the Earth system, and its influence on humankind. SORCE launched in 2003 and is in extended operations. The 2011 Earth Science senior review endorsed the SORCE mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the SORCE mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

The SORCE mission successfully managed its degrading battery to maintain the Total Solar Irradiance record through 2012.

JASON

The Jason mission makes precise measurements of ocean height to support the study of ocean circulation and sea level rise. Jason enables oceanographers to monitor global ocean circulation, improve global climate predictions, and monitor events such as El Niño conditions and ocean eddies. Jason launched in 2001 and is a collaboration between NASA and the Centre National d'Études Spatiales (CNES). The 2011 Earth Science senior review endorsed the Jason mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the Jason mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

The Jason satellite experienced an error in computer memory in March 2012. The mission is still collecting valid oceanographic measurements, but the possibility of on-orbit failure increased. In accordance with international orbit debris standards, NASA and its partner CNES chose to move Jason to an alternate orbit that is also its eventual 'graveyard' orbit. A valuable new geodetic dataset will be collected in the new orbit, although temporal resolution of the oceanographic dataset will be reduced since Jason no longer flies with the OSTM mission. The new geodetic mission commenced May 2012.

EARTH OBSERVING-1 (EO-1)

The Earth Observing-1 (EO-1) satellite is an advanced land-imaging mission with relevance to various areas of Earth Science, including carbon cycle, ecosystems, biogeochemistry, and Earth surface and interior. EO-1 launched in 2000 and is in extended operations. The 2011 Earth Science senior review

Formulation	Development	Operations

endorsed the EO-1 mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the EO-1 mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

Data from instruments and sensors aboard EO-1 has enabled scientists and the international research community to observe evolving trends in Earth’s physical phenomena. EO-1 has identified located and imaged phenomena such as wildfires, volcanoes, floods and ice breakup with high-resolution instruments.

LANDSAT DATA CONTINUITY MISSION (LDCM)

The Landsat Data Continuity Mission is the eighth in the Landsat series of satellites that have been continuously observing Earth's land surfaces by recording data since 1972. This data is a key tool for monitoring climate change and has led to the improvement of human and biodiversity health, energy and water management, urban planning, disaster recovery and agriculture monitoring. This results in incalculable benefits to the US and global economies.

Recent Achievements

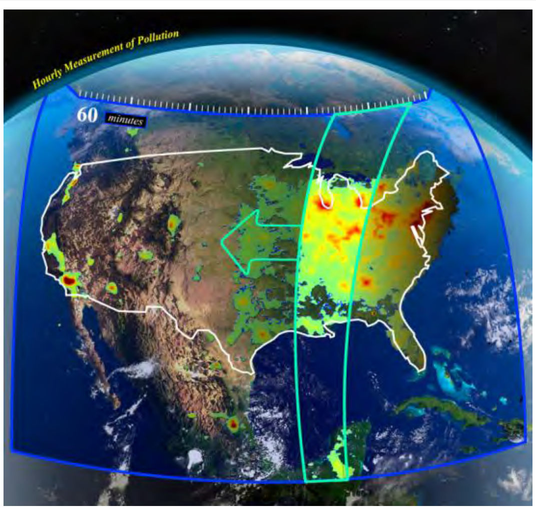
The LDCM satellite successfully launched into orbit on February 11, 2013. It will now go through a three-month on-orbit check-out phase. Afterwards, operational control will be transferred to NASA's mission partner, the Department of the Interior's USGS, and the satellite will be renamed Landsat 8. Data will be archived and distributed free over the internet from the Earth Resources and Science (EROS) center in Sioux Falls, South Dakota. Distribution of Landsat 8 data from the USGS archive is expected to begin within 100 days of launch.

EARTH SYSTEM SCIENCE PATHFINDER

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	183.3	--	**353.6**	293.1	232.2	237.4	250.0
OCO-2	93.4	--	**81.2**	21.0	12.5	7.9	12.0
Venture Class Missions	53.6	--	**212.7**	208.5	166.9	190.0	201.7
Other Missions and Data Analysis	40.5	--	**59.6**	63.6	52.8	39.5	36.3
Subtotal	187.5	--	**353.6**	293.1	232.2	237.4	250.0
Rescission of prior-year unob. balances*	-4.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**170.3**				
Percentage change from FY 2012	--	--	**92.9 %**				

*Note: * Rescission of prior-year unobligated balances from Other Missions and Data Analysis pursuant to P.L. 112-55, Division B, sec. 528(f).*



NASA's newly selected Earth Venture Class project, the Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission, will be led by a team that includes partnerships with NASA Centers, the Environmental Protection Agency, industry, academia and research organizations. TEMPO is aimed at tracking ozone, aerosols and other trace gases over North America to gauge how pollution affects climate change and air quality.

The Earth System Science Pathfinder (ESSP) program provides an innovative approach to Earth science research by providing frequent regular, competitively selected opportunities that accommodate new and emerging scientific priorities and measurement capabilities. This results in a series of relatively low-cost, small-sized investigations and missions. These missions are led by principal investigators whose scientific objectives support a variety of studies, including the atmosphere, oceans, land surface, polar ice regions, or solid Earth.

ESSP projects include space missions, space-based remote sensing instruments for missions of opportunity, and extended duration airborne science missions. The ESSP program also supports the conduct of science research utilizing data from these missions. ESSP projects often involve partnerships with other US agencies and/or international organizations. This portfolio of missions and investigations provides opportunity for investment in innovative Earth science that enhances NASA's capability for better understanding the current state of the Earth system.

EARTH SYSTEM SCIENCE PATHFINDER

EXPLANATION OF MAJOR CHANGES

The increase in the ESSP program line has been driven by the expected increase in the launch vehicle cost for the OCO-2 mission.

OCO-2

Formulation	Development	Operations

FY 2014 Budget

	Actual				Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	180.1	93.4	80.3	**81.2**	21.0	12.5	7.9	12.0		488.4
2014 MPAR LCC Estimate	180.1	93.4	80.3	**81.2**	21.0	11.3	0.2	0.0	0.0	467.5
Formulation	60.9	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	60.9
Development/Implementation	119.3	93.4	80.3	**74.1**	4.6	0.0	0.0	0.0	0.0	371.6
Operations/Close-out	0.0	0.0	0.0	**7.1**	16.4	11.3	0.2	0.0	0.0	35.0
Change from FY 2012		--	--	**-12.2**						
Percentage change from FY 2012		--	--	**-13.1%**						

This is an artist's concept of the OCO-2 satellite in orbit. OCO-2 is designed to make space-based measurements of atmospheric carbon dioxide (CO2) that will provide a bigger, clearer, more complete picture of global CO2. This enhanced understanding of CO2, an important greenhouse gas emitted by natural and man-made sources, is essential for improving predictions of future atmospheric CO2 increases and its impact on Earth's climate.

PROJECT PURPOSE

The Orbiting Carbon Observatory-2 (OCO-2) mission will monitor the concentration levels of atmospheric carbon dioxide (CO2), a critical component of Earth's atmosphere. Since the beginning of the industrial age, the concentration of CO2 has increased by about 38 percent. Scientific studies indicate that CO2 is one of several greenhouse gases that trap heat near Earth's surface. Most scientists have concluded that substantial increases in CO2 will generate an increase in the overall Earth's surface temperature, referred to as global warming. Historical records provide evidence of this trend.

The OCO-2 mission will play a significant role in understanding Earth's climate change. Through global coverage, spatial resolution, and accuracy of measurements, OCO-2 will provide a basis to characterize and monitor the geographic distribution of where CO2 is emitted (sources) and absorbed (sinks), and quantify associated variability.

EXPLANATION OF MAJOR CHANGES

The planned launch vehicle for the OCO-2 satellite was the Taurus XL. However, due to the failure of an identical launch vehicle carrying the Glory mission, NASA terminated the Taurus XL contract. NASA has since awarded a launch services contract to United Launch Alliance for a Delta II launch vehicle. The

OCO-2

Formulation	Development	Operations

OCO-2 budget has been rephased to account for the procurement of the new launch vehicle, and the LCC has been decreased to $467.5 million. The launch date has been delayed to February 2015.

PROJECT PARAMETERS

The OCO-2 spacecraft will carry three high-resolution grating spectrometers and fly in the A-train of Earth-observing satellites. The Observatory will acquire data in three different measurement modes. In "nadir mode", the instrument views the ground directly below the spacecraft. In "glint mode", the instrument tracks near the location where sunlight is directly reflected on Earth's surface. Glint mode enhances the instrument's ability to acquire highly accurate measurements, particularly over the ocean. In "target mode", the instrument views a specified surface target continuously as the satellite passes overhead. Target mode provides the capability to collect a large number of measurements over sites where ground based and airborne instruments also measure atmospheric CO2. The Observatory has a planned operational life of two years.

ACHIEVEMENTS IN FY 2012

JPL completed and tested the OCO-2 instrument, and subsequently shipped it to the prime contractor. NASA approved the project to begin integration (KDP-D). The instrument and spacecraft were safely integrated to form the OCO-2 spacecraft.

WORK IN PROGRESS IN FY 2013

NASA completed a re-baseline of the project budget and schedule in January 2013 to incorporate the new Delta-II launch vehicle costs and associated technical changes. The first observatory-level tests will be completed during 2013.

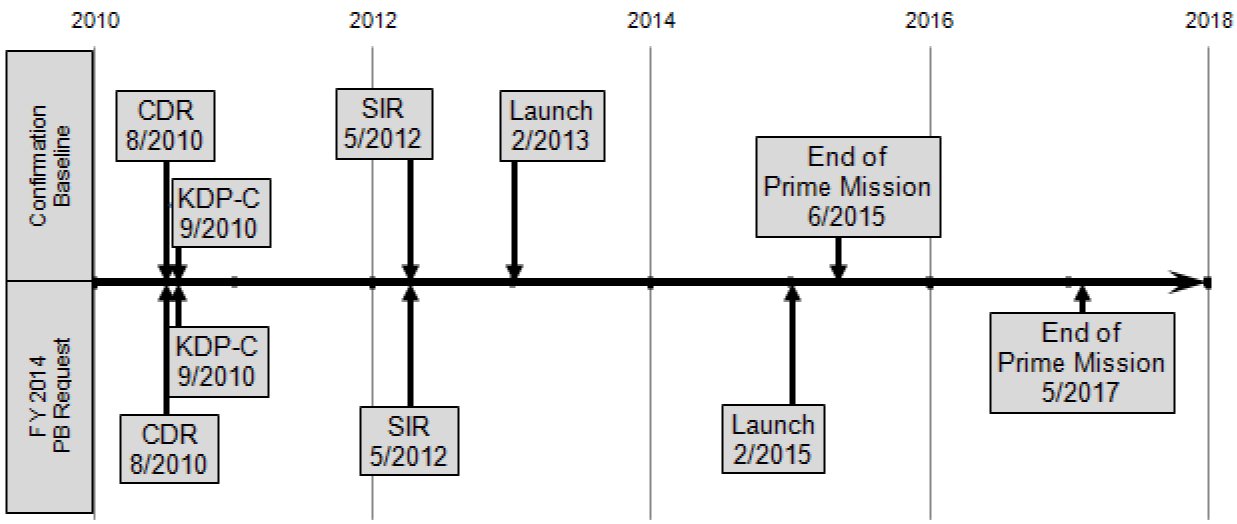
KEY ACHIEVEMENTS PLANNED FOR FY 2014

The project will complete the flight readiness review in 2014 in preparation for launch.

OCO-2

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2011	$249	70	2013	371.6M	49.2	LRD	Feb 2013	Feb 2015	24

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**249.0**	**371.6**	**122.6**
Aircraft/Spacecraft	42.0	68.3	26.3
Payloads	39.4	51.7	12.3

OCO-2

Formulation	Development	Operations

Systems I&T	2.4	5.6	3.2
Launch Vehicle	67.6	136.8	69.2
Ground Systems	7.5	8.8	1.3
Science/Technology	10	17.0	7.0
Other Direct Project Costs	80.1	83.4	3.3

Project Management & Commitments

JPL has project management responsibility for OCO-2.

Project Element	Description	Provider	Change from Baseline
OCO-2 instrument	Three high-resolution grating spectrometers will acquire precise measurements of atmospheric CO2.	Provider: JPL Lead Center: JPL Performing Center: JPL Cost Share Partners: N/A	N/A
Spacecraft	Provides platform for the instrument.	Provider: Orbital Sciences Corporation Lead Center: JPL Performing Center: JPL Cost Share Partners: N/A	N/A
Ground System	Provides mission operations for satellite.	Provider: Orbital Sciences Corporation Lead Center: JPL Performing Center: JPL Cost Share Partners: N/A	N/A
Launch Vehicle	Delta II launches observatory into Earth orbit.	Provider: United Launch Alliance Lead Center: KSC Performing Center: KSC Cost Share Partners: N/A	Original launch vehicle was Taurus XL

OCO-2

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The launch vehicle development is delayed or mandates spacecraft changes for accommodation, Then: Mission cost will increase.	The Project is monitoring launch vehicle development progress on a bi-weekly basis. The launch vehicle provider has subcontracted with a vibration isolation system design and fabrication company to possibly reduce dynamic loads to levels acceptable to the spacecraft.
If: Delivery of alternate Reaction Wheel Assemblies (RWAs) is delayed Then: Launch date could be delayed as much as 30 days	The alternate RWA supplier has been incentivized to deliver the assemblies on an expedited schedule and progress is being monitored on a bi-weekly basis. The Project will be implementing two-shift operations during Observatory I&T to absorb a delayed RWA delivery to the extent possible.

Acquisition Strategy

OCO-2 was procured as a single source selection from Jet Propulsion Laboratory in order to maintain the same configuration as the previous OCO mission.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Spacecraft	Orbital Sciences Corporation	Gilbert, AZ
Launch Vehicle	United Launch Alliance	Vandenberg Air Force Base, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	Jan 2013	Replan review of project plans to accommodate cost and schedule impacts of new launch vehicle.	New plan approved; project will continue development	Apr 2014
Performance	SRB	Apr 2014	Flight readiness review to determine project readiness to launch	TBD	N/A

OCO-2

Formulation	Development	Operations

CORRECTIVE ACTION PLAN AS REQUIRED BY SECTION 1203 OF NASA 2010 AUTHORIZATION ACT

Pursuant to Section 103(c) of the NASA Authorization Act of 2005, NASA notified the Committees of an anticipated schedule delay of more than six months and development cost exceeding 15 percent of the baseline on July 25, 2012 as a result of replacing the planned launch vehicle, the Taurus XL. NASA terminated the Taurus XL contract due to the failure of an identical launch vehicle carrying the Glory mission. NASA has since awarded a launch services contract to United Launch Alliance for a Delta II launch vehicle.

NASA completed an independent replan review in November 2012 of the OCO-2 Project to incorporate losses from the terminated Taurus-XL launch vehicle contract, new costs for the Delta-II launch vehicle, modifications to adapt the spacecraft and other systems to the new launch vehicle, and the associated delays for this launch service vendor change. The proposed replanned cost and schedule commitment are compliant with the 70% confidence level consistent with NASA policies. The proposed new mission plan has been presented to and approved by the NASA SMD Associate Administrator (AA) and Directorate Program Management Council (DPMC) on January 16, 2013, and the final mission cost and schedule will be included in the FY 2014 President's Budget Request.

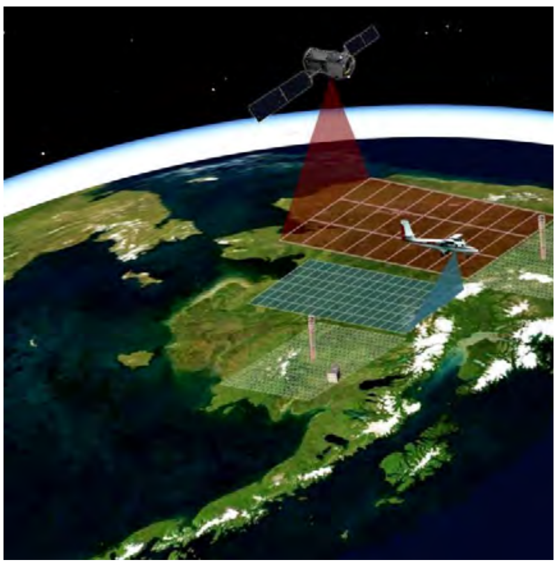
The current projected OCO-2 launch readiness date is February 2015, the development cost estimate is $371.6 and the lifecycle cost estimate (excluding extended operations) is $467.5 million.

VENTURE CLASS MISSIONS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	53.6	--	**212.7**	208.5	166.9	190.0	201.7
Change from FY 2012	--	--	**159.1**				
Percentage change from FY 2012	--	--	**296.8 %**				



Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) airborne observations over Alaska will be integrated with data from strategically located ground-based sites, as depicted in the artist concept. CARVE science fills a critical gap in Earth science knowledge on the fundamental elements of the complex Arctic biological-climatologic-hydrologic system.

PROJECT PURPOSE

NASA's Earth Venture Class projects provide frequent flight opportunities for high-quality Earth science investigations that are low cost and that can be developed and flown in five years or less. The investigations will be selected through open competitions to ensure broad community involvement and encourage innovative approaches. Successful investigations will enhance our capability to understand better the current state of the Earth system and to enable continual improvement in the prediction of future changes. Solicitations will alternate between space-borne and airborne/suborbital opportunities.

NASA established the Venture Class project in response to recommendations in the National Academies' report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*.

The current Venture Class missions include:

Earth Venture Suborbital -1 (EVS-1, selected in 2010) investigations include:

- Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) addresses the uncertainties in existing estimates by measuring soil moisture in the root zone of representative regions of major North American ecosystems;
- Airborne Tropical Tropopause Experiment (ATTREX) studies chemical and physical processes at different times of year from bases in California, Guam, Hawaii, and Australia;
- Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) collects an integrated set of data that will provide experimental insights into Arctic carbon cycling, especially the release of the important greenhouse gases such as carbon dioxide and methane;

VENTURE CLASS MISSIONS

Formulation	Development	Operations

- Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) improves the interpretation of satellite observations to diagnose near-surface conditions relating to air quality; and
- Hurricane and Severe Storm Sentinel studies hurricanes in the Atlantic Ocean basin using two NASA Global Hawks flying high above the storms for up to 30 hours.

Earth Venture Mission -1 (EVM-1, selected in 2012)
The Cyclone Global Navigation Satellite System (CYGNSS) will make accurate measurements of ocean surface winds throughout the life cycle of tropical storms and hurricanes, which could lead to better weather forecasting. CYGNSS data will enable scientists to probe from space key air-sea interaction processes that take place near the inner core of the storms, which are rapidly changing and play large roles in the genesis and intensification of hurricanes. The CYGNSS measurements also will provide information to the hurricane forecast community, potentially enabling better modeling to predict the strength of hurricanes as they develop. CYGNSS is currently in formulation and will launch in 2017.

CYGNSS's eight micro-satellite observatories will receive both direct and reflected signals from Global Positioning System (GPS) satellites. The direct signals pinpoint CYGNSS observatory positions, while the reflected signals respond to ocean surface roughness, from which wind speed is retrieved.

Earth Venture Instrument-1 (EVI-1)
The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument was selected in November, 2012. The instrument will be mounted on a commercial communications satellite in geostationary orbit and will monitor air pollutants over North America beginning in 2017. This is a first step toward what researchers hope will be a global network of pollution monitors in space.

EXPLANATION OF MAJOR CHANGES

CYGNSS and TEMPO were competitively selected from the EVM-1 and EVI-1competitions respectively, and their budgets have been moved into a separate project line within ESSP.

PROJECT PRELIMINARY PARAMETERS

The Earth Venture Class project consists of three different types of activities:

- Earth Venture Suborbital (EVS) are sustained suborbital science investigations. Each solicitation is capped at $150 million, and NASA will select multiple investigations within each call, individually cost capped at $30 million. The EVS solicitations will be made at four-year intervals;
- Earth Venture small Missions (EVM) are small space-based missions. Each solicitation is cost capped at $150 million. The EVM solicitations will be made at four-year intervals; and
- Earth Venture Instruments (EVI) are instruments to be flown on missions or platforms to be selected by NASA. Each solicitation is cost capped at $90 million. The EVI solicitations will be made at no more than 18-month intervals.

VENTURE CLASS MISSIONS

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2012

The EVM-1 Announcement of Opportunity proposals were reviewed and the winning proposal, CYGNSS, was selected in summer 2012.

WORK IN PROGRESS IN FY 2013

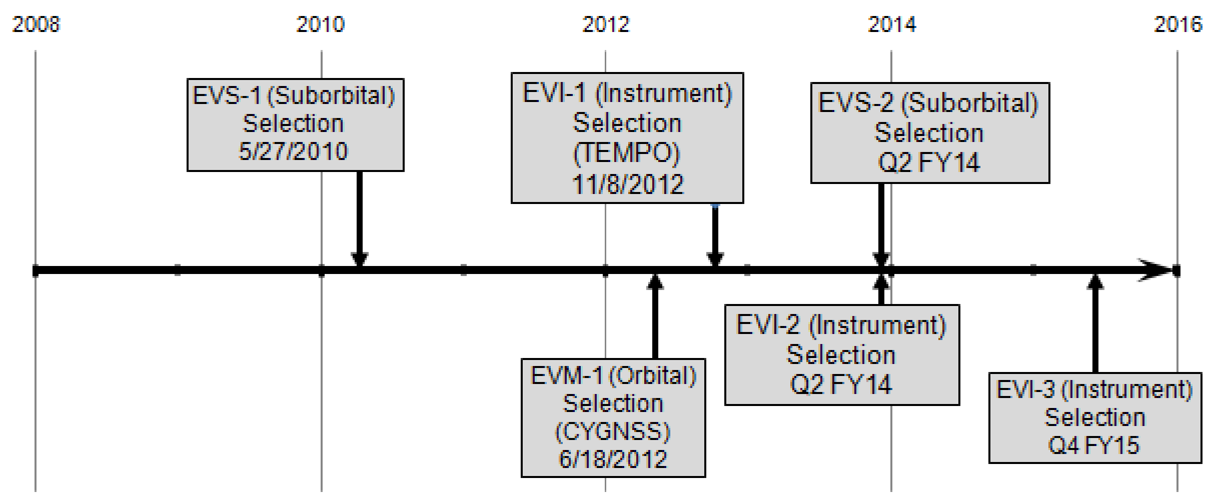
In FY 2013, NASA will produce results from all three types of the Earth Venture Class mission lines of competitive opportunities:

- Continue with the second year of science data from the EVS-1 investigations;
- Initiate the contracts and continue the formulation phase of the CYGNSS EVM-1 small mission;
- Evaluate and select the winning proposal from the EVI-1 call;
- Develop and release the next sub-orbital Venture call, EVS-2; and
- Develop the EVI-2 instrument call for release.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The five EVS-1 airborne science investigations will continue with their third year of field campaigns. The CYGNSS mission will complete formulation and move into implementation. The TEMPO selection will also make the transition from formulation into implementation. The second instrument call, EVI-2 will be completed with a selection, and the second suborbital call, EVS-2, will be completed and the investigations selected.

ESTIMATED PROJECT SCHEDULE



VENTURE CLASS MISSIONS

Formulation	Development	Operations

Project Management & Commitments

The Venture Class missions and investigations are managed within the ESSP program. Program management responsibility for implementation has been assigned to the ESSP Program Manager at LaRC.

Element	Description	Provider Details	Change from Formulation Agreement
EVS-1: AirMOSS	Soil Moisture	Provider: University of Michigan, JPL Lead Center: LaRC Participating Center: LaRC Cost Share Partners: N/A	N/A
EVS-1: ATTREX	Temporal changes in chemical and physical processes	Provider: ARC Lead Center: ARC Participating Center: ARC Cost Share Partners: N/A	N/A
EVS-1: CARVE	Arctic carbon cycling	Provider: JPL Lead Center: JPL Participating Center: JPL Cost Share Partners: N/A	N/A
EVS-1: DISCOVER-AQ	Air quality monitoring	Provider: LaRC Lead Center: LaRC Participating Center: LaRC Cost Share Partners: N/A	N/A
EVS-1: HS3	Hurricane and severe storms	Provider: GSFC, ARC Lead Center: GSFC, ARC Participating Centers: GSFC, ARC Cost Share Partners: N/A	N/A
EVM-1: CYGNSS	Ocean surface wind measurements	Provider: University of Michigan Lead Center: LaRC Participating Centers: LaRC, ARC Cost Share Partners: N/A	N/A
EVI-1: TEMPO	Air pollution monitoring	Provider: Smithsonian Astrophysical Observatory Lead Center: None Participating Centers: LaRC, GSFC Cost Share Partners: N/A	N/A

Formulation	Development	Operations

Acquisition Strategy

NASA anticipates issuing a solicitation for a Venture Class element at least once a year. NASA will award all Venture Class funds through full and open competition.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
CYGNSS - project management, development, integration and mission operations	Southwest Research Institute	San Antonio, TX

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	N/A	Determine readiness of CYGNSS to enter Phase B	TBD	
Performance	SRB	Jun 2013	CYGNSS preliminary design review	TBD	
Performance	SRB	Q1 FY14	CYGNSS critical design review	TBD	

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	36.3	--	**59.6**	63.6	52.8	39.5	36.3
Earth System Science Pathfinder Missions Research	14.0	--	**13.9**	14.2	14.6	14.8	14.8
Aquarius	4.2	--	**5.2**	5.2	5.3	5.4	5.4
Gravity Recovery and Climate Experiment	5.2	--	**5.0**	3.1	2.2	1.2	0.0
Cloudsat	10.5	--	**8.1**	4.9	3.5	2.0	0.0
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations	6.5	--	**6.7**	6.9	7.1	7.2	7.2
Orbiting Carbon Observatory-3	0.0	--	**20.8**	29.3	20.0	9.0	9.0
Subtotal	40.5	--	**59.6**	63.6	52.8	39.5	36.3
Rescission of prior-year unob. balances*	-4.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**23.3**				
Percentage change from FY 2012	--	--	**64.2 %**				

*Note: * Rescission of prior-year unobligated balances from Aquarius pursuant to P.L. 112-55, Division B, sec. 528(f).*

Earth System Science Pathfinder (ESSP) Other Missions and Data Analysis includes operating missions and mission-specific research. These innovative missions will provide Earth science to enhance understanding of the current state of the Earth system and to enable continual improvement in the prediction of future changes.

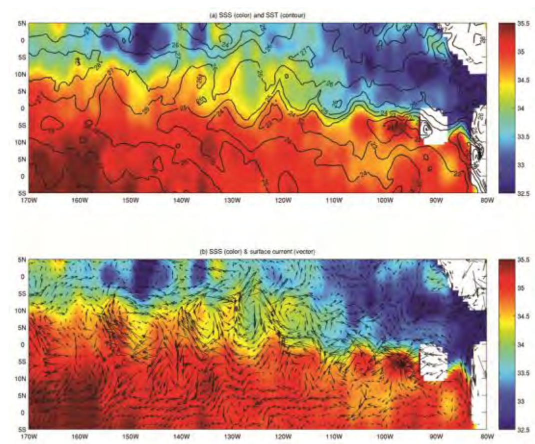
Mission Planning and Other Projects

ESSP MISSIONS RESEARCH

ESSP Missions Research provides funds for the science teams supporting ESSP operating missions. The science teams are comprised of competitively selected individual investigators who analyze data from the missions to address relevant science questions.

OCO-3

The Orbiting Carbon Observatory 3, or OCO-3, is a space instrument that will investigate important questions about the distribution of carbon dioxide on Earth as it relates to growing urban populations and changing patterns of fossil fuel combustion. NASA will develop and assemble the instrument using spare materials from Orbiting Carbon Observatory-2 and host the instrument on the International Space Station or another space-based platform. OCO-3 is currently in formulation.



The color shading in the panels in the figure above shows sea surface salinity on December 18, 2011. Derived from Aquarius measurements, this data shows the peaks and valleys of tropical instability waves in the eastern to central equatorial Pacific Ocean. Sea surface salinity is part of the many variables that contribute to a complete set of surface observations to study how global ocean circulation responds to climate change.

Operating Missions

AQUARIUS

The Aquarius spacecraft observes and models seasonal and year-to-year variations of sea-surface salinity and how these variations relate to changes in the water cycle and ocean circulation. The mission provides the first global observations of sea surface salinity, scanning the surface of Earth once every seven days. In its three-year mission life, Aquarius will collect as many sea surface salinity measurements as the entire 125-year historical record obtained from ships and buoys. The NASA-provided Aquarius instrument is flying on the Satellite for Scientific Applications-D (SAC-D) spacecraft, which is operated by the Argentine space agency, Comisión Nacional de Actividades Espaciales (CONAE). Aquarius launched in June 2011 and is currently in prime mission operations.

Recent Achievements

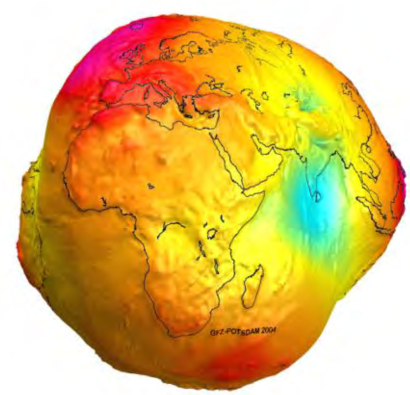
New research using salinity data from NASA's Aquarius instrument on the SAC-D observatory has given scientists an unprecedented look at a key factor involved in the formation of ocean waves in the tropical Pacific and Atlantic Oceans. Salinity was found to play an important role in the physics of these waves, and observations of their salinity are important to understanding them and their impacts on climate variability and prediction, and biogeochemistry.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

GRAVITY RECOVERY AND CLIMATE EXPERIMENT (GRACE)

GRACE measures minute changes in Earth's gravity field by measuring micron-scale variations in the separation between the two spacecraft that fly in formation 220 kilometers apart in low Earth orbit. Local changes in Earth's mass cause the variations in gravitational pull. GRACE has demonstrated a new paradigm of observations that utilizes ultra-small variations of Earth's gravity field (as small as one-billionth the surface force of gravity). With this capability, GRACE was the first mission to provide a comprehensive measurement of the monthly change in the ice sheets and major glaciers. GRACE has provided significant new information on changes in water resources within river basins and aquifers worldwide, and has measured the effects of major earthquakes around the world. NASA developed the twin GRACE satellites in collaboration with German Aero-Space Center, Deutsches Zentrum für Luft- und Raumfahrt (DLR), and launched in 2002.



The Earth as seen by the Gravity Recovery And Climate Experiment (GRACE) satellites. Color variations represent strong or weak gravitational fields. The data gives scientists a way to visualize global processes and geological changes over time, providing early warning of floods, crop failures, and aquifer depletion in remote corners of the globe.

The 2011 Earth Science senior review endorsed the GRACE mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the GRACE mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

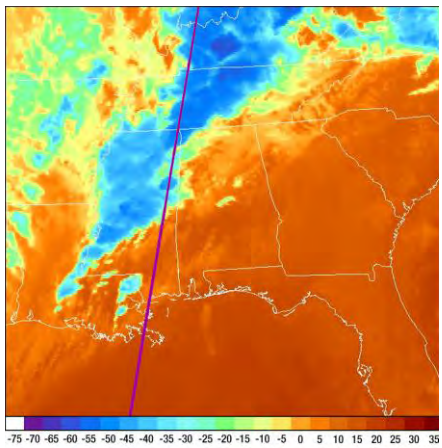
Recent Achievements

In 2012, a deep and persistent drought struck vast portions of the continental United States. Though there was some relief in the late summer, GRACE was able to show that the drought lingered in the underground water supplies that are often required for drinking and farming.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

CLOUDSAT



CloudSat made a nighttime overpass (approximately 0630 UTC) of the thunderstorms responsible for the tornadic outbreak over Kentucky, Tennessee, and Mississippi on Tuesday, February 5, 2008. This extensive tornado outbreak, which is responsible for more than 50 fatalities and billions of dollars in damage, occurred in the late evening and throughout the night of the 5th into the 6th of February.

CloudSat measures cloud characteristics to increase understanding of the role of clouds in Earth's radiation budget. This mission specifically provides estimates of the percentage of Earth's clouds that produce rain, provides vertically-resolved estimates of how much water and ice are in Earth's clouds, and estimates how efficiently the atmosphere produces rain from condensates. CloudSat is collecting information about the vertical structure of clouds and aerosols that other Earth-observing satellites do not collect. This data is improving models and providing a better understanding of the human impact on the atmosphere. Cloudsat launched in 2006. It is currently in extended operations. The 2011 Earth Science senior review endorsed the Cloudsat mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the Cloudsat mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

Recent Achievements

In October 2012, CloudSat's orbital path crossed over Hurricane Sandy, an estimated 137 miles to the west of the center of the storm. At the time, the hurricane was still over the Atlantic Ocean. The satellite sampled the vertical structure of the storm along a band of moderate precipitation stretching across New York to coastal North Carolina. The instrument measured maximum cloud top heights of up to 8 miles. The cloud top height data, combined with measurements of ice crystals, water droplets, and precipitation, will improve our understanding of the convective processes operating within this important storm system.

CLOUD-AEROSOL LIDAR AND INFRARED PATHFINDER SATELLITE OBSERVATION (CALIPSO)

CALIPSO provides data on the vertical structure of clouds, the geographic and vertical distribution of aerosols and detects sub visible clouds in the upper troposphere. CALIPSO also provides an indirect estimate of how much clouds and aerosols contribute to atmospheric warming. CALIPSO launched in 2006. It is in extended operations. The 2011 Earth Science senior review endorsed the CALIPSO mission for continued operations through 2013 and preliminarily through 2015. The next senior review will occur in 2013, and will re-evaluate the CALIPSO mission extension in terms of scientific value, national interest, technical performance, and proposed cost in relation to NASA Earth Science strategic plans.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

In FY 2012, a NASA-led study documented an unprecedented depletion of Earth's protective ozone layer above the Arctic the prior winter and spring, caused by an unusually prolonged period of extremely low temperatures in the stratosphere. To investigate the 2011 Arctic ozone loss, a team of international scientists analyzed several different measurements and data, including recent data from NASA's CALIPSO spacecraft. CALIPSO data helped scientists understand the ozone depletion they had observed the prior winter, and enabled them to predict future Arctic ozone loss.

EARTH SCIENCE MULTI-MISSION OPERATIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	168.6	--	**171.7**	174.3	177.9	179.0	182.0
Change from FY 2012	--	--	**3.1**				
Percentage change from FY 2012	--	--	**1.8 %**				

EOSDIS ingests, processes, archives and distributes data from a large number of Earth observing satellites. It consists of a set of processing facilities and Earth Science Data Centers distributed across the United States and serves hundreds of thousands of users around the world, providing hundreds of millions of data files each year.

The Earth Science Multi-Mission Operations (MMO) program acquires, preserves, and distributes observational data from operating spacecraft to support Earth Science focus areas. This is accomplished primarily by the Earth Observing System Data and Information System (EOSDIS), which has been in operations since 1994. EOSDIS acquires, processes, archives, and distributes Earth Science data and information products. These products are created from satellite data and arrive at the rate of more than four terabytes per day.

NASA Earth Science information is archived at eight Distributed Active Archive Centers (DAACs) and four disciplinary data centers located across the United States. The DAACs specialize by topic area, and make their data available to researchers around the world.

The MMO budget supports the science data Segment for Suomi NPP, and data archive and distribution for upcoming missions including OCO-2, SMAP, GPM and ICESAT-2. EOSDIS data centers also support Earth Science suborbital campaigns. A system plan for 2015 and beyond will take into account evolutionary needs for new missions being developed in response to the National Academies decadal survey. These investments will enable the system to keep technologically current, and incorporate new research data and services.

For more information, go to: http://www.science.nasa.gov/earth-science/earth-science-data/.

EXPLANATION OF MAJOR CHANGES

The budget request for FY 2014 includes increased support for Suomi NPP activities, and support for ICESAT-2. EOSDIS project management is working with decadal survey mission teams to understand their mission data characteristics and guide further improvements and system evolution. Support is also included for the Administration's Big Earth Data Initiative, a multi-agency effort to increase the discovery and utilization of earth science data for the Nation's societal and economic benefit.

EARTH SCIENCE MULTI-MISSION OPERATIONS

ACHIEVEMENTS IN FY 2012

NASA successfully completed the Evolution of EOSDIS Elements effort, which has increased efficiency and operability and increased data usability. EOSDIS expanded its capabilities to support the increasing suborbital campaign data, including IceBridge and the Earth Venture-1 campaigns.

WORK IN PROGRESS IN FY 2013

In response to the decadal survey, EOSDIS managers are building in more capabilities focused on the societal benefit use of our research data and information. In FY 2013, EOSDIS will provide data from the Moderate Resolution Imaging Spectroradiometer (MODIS), Atmospheric Infrared Sounder (AIRS), Microwave Limb Sounder (MLS) and Ozone Monitoring Instrument (OMI) instruments in near real time (less than 3 hours from observation) to various applications users. NASA will also ensure interoperability with other national and international earth science data systems, and recover data records from historical missions to extend the availability of key earth science parameters.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will continue to operate and maintain the EOSDIS, and all the accompanying infrastructure and functions. NASA also anticipates providing increased support for Suomi NPP activities, as well as ICESAT-2.

Program Elements

EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM (EOSDIS)

The EOSDIS project provides science data to a wide community of users, including NASA, Federal agencies, international partners, academia, and the public. EOSDIS provides users with the services and tools they need in order to use NASA's Earth science data in research and creation of models. EOSDIS archives and distributes data through standardized science data products, using algorithms and software developed by Earth Science investigators.

The EOSDIS project also funds research opportunities related to EOSDIS. Current programs include Advanced Collaborative Connections for Earth System Science (ACCESS) and Making Earth System data records for Use in Research Environments (MEaSUREs).

ACCESS projects increase the interconnectedness and reuse of key information-technology software and services in use across the spectrum of Earth science investigations. ACCESS also supports the deployment of data and information systems and services that enable the freer movement of data and information. ACCESS researchers develop needed tools and services to aid in measurable improvements to Earth science data access and usability.

Through the MEaSUREs activity, researchers investigate new types of sensors to provide three-dimensional profiles of Earth's atmosphere and surface. Emphasis is placed on linking data from multiple satellites, and then facilitating the use of this data in the development of comprehensive Earth system models.

EARTH SCIENCE MULTI-MISSION OPERATIONS

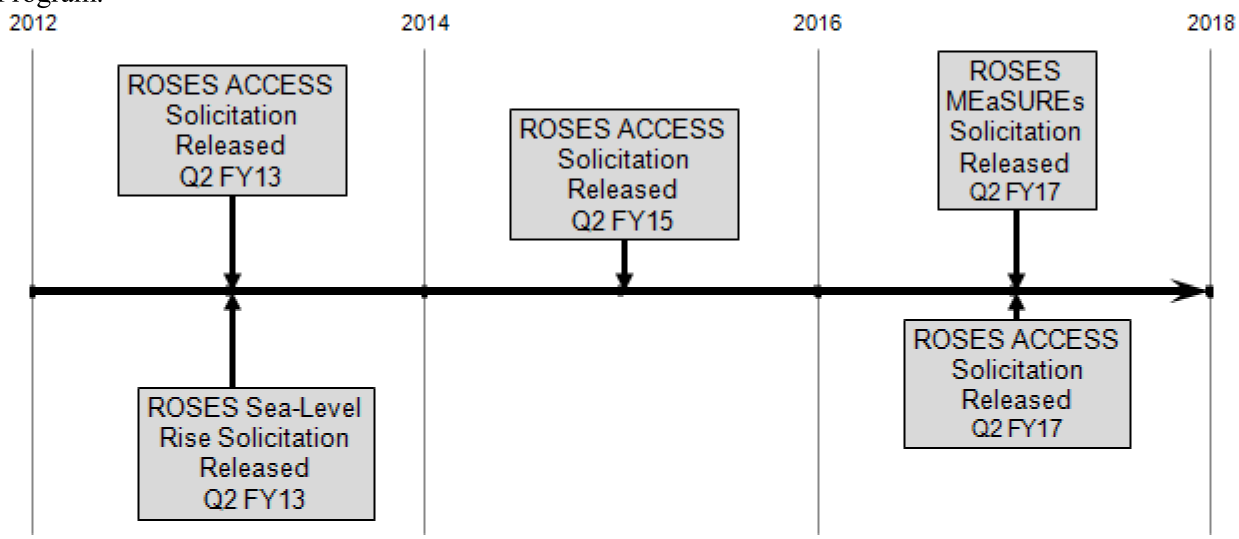
This project funds the Elements of EOSDIS Evolution, aimed at improving the efficiency and effectiveness of EOSDIS while reducing the cost. It also supports the eight nationwide DAAC installations that collect, disseminate, and archive Earth science data. Each DAAC focuses on a specific Earth system science discipline and provides users with data products, services, and data-handling tools unique to that specialty:

- The Alaska Synthetic Aperture Radar Facility, which collects data and information on sea ice, polar processes, and geophysics;
- The Goddard Space Flight Center Earth Sciences Data and Information Services Center, which collects information on atmospheric composition, atmospheric dynamics, global precipitation, ocean biology, ocean dynamics, and solar irradiance;
- The Langley Research Center DAAC, which collects data on Earth's radiation budget, clouds, aerosols, and tropospheric chemistry;
- The Land Processes DAAC, which collects land processes data;
- The National Snow and Ice Data Center, which collects snow and ice data, as well as information about the cryosphere and climate;
- The Oak Ridge National Laboratory DAAC, which collects data on biogeochemical dynamics and ecological data for studying environmental processes;
- The Physical Oceanography DAAC, which collects information on oceanic processes and air-sea interactions; and
- The Socioeconomic Data and Applications Center, covering population, sustainability, multilateral environmental agreements, natural hazards, and poverty.

EARTH SCIENCE MULTI-MISSION OPERATIONS

Program Schedule

MMO solicits research opportunities every two years for ACCESS and every five years for MEaSUREs. The new Sea-Level Rise solicitation will be released in coordination with the Earth Science Research Program.



Program Management & Commitments

The EOSDIS Project Office at GSFC has primary responsibility for day-to-day operations. DAACs are also co-located with other agencies [USGS-EDC Earth Resources Observation and Science (EROS) EDCEROS Data Center (EDC), DOE-Oak Ridge National Laboratory (ORNL)] and at the following universities: University of Alaska at Fairbanks, University of Colorado, and Columbia University.

Program Element	Provider
EOSDIS core system, and Evolution of EOSDIS upgrades	Provider: GSFC Lead Center: GSFC Performing Center: GSFC Cost Share Partners: N/A
Distributed Active Archive Centers (DAACs)	Provider: Various Lead Center: GSFC Performing Center: GSFC, LaRC, MSFC, JPL Cost Share Partners: N/A

EARTH SCIENCE MULTI-MISSION OPERATIONS

Acquisition Strategy

Research opportunities related to EOSDIS are available through NASA's ROSES announcements.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
EOSDIS Evolution & Development	Raytheon	Riverdale, MD

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	American Customer Satisfaction Index	2012	Survey current EOSDIS users to assess current status and improve future services	EOSDIS scored 77 out of 100, and has improved in all areas of usability and user satisfaction. As recommended by the 2011 report, the top priority drivers (product search, selection and order, and documentation) were the most improved.	2013, annually thereafter

EARTH SCIENCE TECHNOLOGY

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	51.2	--	**55.1**	56.2	55.1	56.1	56.1
Change from FY 2012	--	--	**3.9**				
Percentage change from FY 2012	--	--	**7.6 %**				

An Advanced Component Technology project designed, developed and built the multi-frequency antenna horn shown here and integrated it into a radiometer system prototype for use on the Surface Water Ocean Topography (SWOT) mission. This three-frequency microwave radiometer will improve measurement accuracy through the troposphere, the lower-most layer of the atmosphere where all meteorological phenomena (such as rain, hail, snow, clouds, etc.) occur. The capability to account for the high variability of water vapor distribution is the key factor in this technology.

Advanced technology plays a major role in enabling Earth research and applications. The Earth Science Technology Program (ESTP) enables previously infeasible science investigations; improves existing measurement capabilities; and reduces the cost, risk, and/or development times for Earth science instruments.

EXPLANATION OF MAJOR CHANGES

NASA has been increased funding for the Advanced Technology Initiatives project to support more robust technology space flight validation. This will help to reduce the cost and risk of new flight missions by providing more mature instruments.

ACHIEVEMENTS IN FY 2012

In FY 2012, NASA added 18 new investments to the ESTP program through the Advanced Information Systems Technology (AIST) project solicitation, and progress continued on tasks awarded in FY 2011 through the Advanced Component Technology (ACT) and the Instrument Incubator Project solicitations. During FY 2012, 40 percent of active technology projects advanced at least one technology readiness level, and many technologies were incorporated into science measurements, system demonstrations, or other applications. Overall, of the more than 600 activities completed in the portfolio, NASA has incorporated 37 into other missions, and has identified a path for future incorporation for an additional 43 percent.

WORK IN PROGRESS IN FY 2013

In FY 2013, ESTP will develop new remote-sensing and information systems technologies for infusion into future science missions and airborne campaigns. These technologies will enable or enhance measurements and data system capabilities. Instrument, component, and information technology activities awarded in prior solicitations will advance toward incorporation into decadal survey missions and NASA

Earth science deployments. Technology space flight validation awards made in FY 2013 will be in their first full year of development.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The program anticipates the release of both ACT and AIST solicitations during FY 2014, which will focus on technologies to enable future missions and help improve science data analysis.

Program Elements

INSTRUMENT INCUBATOR

This project develops instrument and measurement techniques at the system level, including laboratory breadboards and operational prototypes for airborne validation. Currently, 35 Instrument Incubator efforts are funded. For example, several instrument prototypes for measuring carbon dioxide are under development. Another effort is developing technologies that enable light measurement in across the spectrum from ultraviolet to visible to infrared. Instrument Incubator also supports the development of a unique type of Lidar that could one day be used to make 3-D wind measurements.

ADVANCED INFORMATION SYSTEMS TECHNOLOGY (AIST)

This project develops end-to-end information technologies that enable new Earth observation measurements and information products. The technologies help process, archive, access, visualize, communicate, and understand science data. Currently, AIST activities focus on three areas needed to support future Earth science measurements:

- Sensor System Support, which nurtures autonomy and rapid response in the sensing process to improve the science value of data;
- Advanced Data Processing, designed to enhance the information extracted from the data stream; and
- Data Services Management, whose investments manage the growing body of Earth science data.

ADVANCED TECHNOLOGY INITIATIVES (ATI)

This project enables development of critical component and subsystem technologies for instruments and platforms, mostly in support of the Earth science decadal survey. Current awards focus on areas such as space-qualified laser transmitters, passive optical technologies, and microwave and calibration technologies. Other awards support measurements of solar radiance, ozone, aerosols, and atmospheric gas columns for air quality and ocean color for coastal ecosystem health and climate emissions.

EARTH SCIENCE TECHNOLOGY

Program Schedule

Date	Significant Event
Q2/2014	ROSES-2014 solicitation
	ROSES-2014 selection no earlier than 6 months of receipt of proposals

Program Management & Commitments

The Earth Science Technology Program is implemented by the Earth Science Technology Office (ESTO), located at GSFC.

Program Element	Provider
Instrument Incubator	Provider: Various Lead Center: Performing Centers: GSFC, JPL, LaRC, GRC, DFRC Cost Share Partners: N/A
Advanced Information Systems	Provider: Various Lead Center: Performing Centers: GSFC, JPL, LaRC, ARC, GRC Cost Share Partners: N/A
Advanced Technology Initiatives	Provider: Various Lead Center: Performing Centers: GSFC, JPL, LaRC Cost Share Partners: N/A

Acquisition Strategy

NASA procures tasks primarily through full and open competition, such as through the ROSES announcements. Technology investments are competitively solicited from NASA Centers, industry, and academia.

EARTH SCIENCE TECHNOLOGY

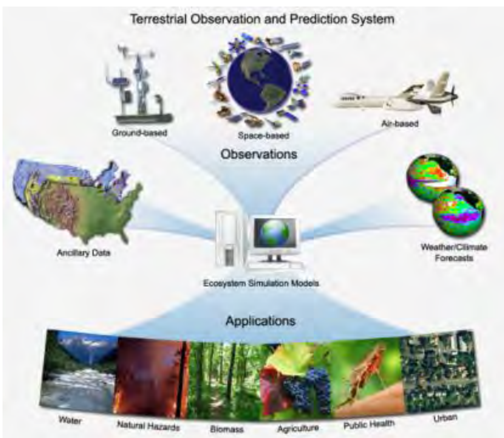
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	NASA Advisory Council Earth Science Subcommittee	2012	Review for success in infusion of new technologies and participation of universities in developing the new generation of technologists.	The committee was pleased with the technology program; it recommended focusing on reducing cost in missions and enabling specific measurements. Reports are available at esto.nasa.gov	2014, 2016, 2018

APPLIED SCIENCES

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	36.4	--	**35.0**	36.7	38.4	40.1	40.1
Change from FY 2012	--	--	**-1.4**				
Percentage change from FY 2012	--	--	**-3.8 %**				



The program supports applied research and decision-support projects in areas of national priority, such as Disasters, Health & Air Quality, Ecological Forecasting, and Water Resources. The Terrestrial Observation and Prediction System (TOPS) above, enables combinations of Earth satellite observations and Earth science model outputs to support analysis and improved decision-making.

The NASA Applied Sciences program leverages NASA Earth Science satellite measurements and new scientific knowledge to provide innovative and practical uses for public and private sector organizations. It also enables near-term uses of Earth science knowledge, discovers and demonstrates new applications, and facilitates adoption of applications by non-NASA stakeholder organizations.

Applied Sciences projects improve decision-making activities to help the Nation better manage its resources, improve quality of life, and strengthen the economy. NASA develops Earth science applications in collaboration with end-users in public, private, and academic organizations.

Examples of these applications include:

- Improved assessment of flooding and landslide conditions with the International Red Cross to plan mitigation and response activities;
- Improved wildfire smoke predictions with the US Forest Service to reduce downwind public exposure; and
- Advances in accuracy of volcanic ash advisories for airplane pilots with the National Weather Service and the Federal Aviation Administration.

The program ensures sustained use of these products in the decision-making process of user organizations. The program also encourages potential users to envision and anticipate possible applications from upcoming satellite missions and to provide input to mission development teams to increase the societal benefits of NASA missions.

EXPLANATION OF MAJOR CHANGES

None.

APPLIED SCIENCES

ACHIEVEMENTS IN FY 2012

The program initiated a new, phased approach to developing applications projects. Initially, numerous feasibility studies are supported for a year, and then a subset are selected to continue development. The program awarded 58 new activities under this approach in the areas of disasters, water resources, and wildfires. The Applied Sciences program also led the Earth Science Division's support of disaster response in 2012, by providing data on wildfires and Hurricane Isaac.

WORK IN PROGRESS IN FY 2013

In FY 2013, the program will increase its involvement in satellite mission planning by anticipating potential applications and supporting mission designs.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The program will get results from a set of applications feasibility studies in the areas of ecological forecasting and health. To increase focus on high-impact projects, the program will down select the studies and fund a subset in each area that will proceed to three-year implementation projects.

The program will issue new project solicitations in FY 2014, particularly to enable use of data from LDCM, GPM and SMAP satellites and to prepare applications for ICESat-2 missions. Initial results from decision-support projects in the areas of disasters, water resources, and wildfires will become available in FY 2014.

Program Elements

PATHWAYS

The Pathways project has two primary lines of business: Applications and Capacity Building. The Applications themes are Health and Air Quality, Disasters, Ecological Forecasting, and Water Resources. The Capacity Building elements focus on foreign and domestic activities to build skills and capabilities in uses of Earth observations, including international and economic development.

Program Schedule

Date	Significant Event
Q2/2014	ROSES-2014 solicitation
	ROSES-2014 selection no earlier than 6 months of receipt of proposals

Program Management & Commitments

The Applied Sciences Program is managed at NASA Headquarters.

Program Element	Provider
Pathways	Provider: Various Lead Center: HQ Performing Centers: GSFC, LaRC, SSC, JPL, MSFC, ARC Cost Share Partners: EPA, NOAA, US Department of Agriculture, USGS, National Park Service (NPS), US Fish and Wildlife Service (USFWS,) Centers for Disease Control (CDC), US Agency for International Development (USAID)

Acquisition Strategy

NASA bases the Earth Science Applied Science acquisitions on full and open competition. Grants are peer reviewed and selected based on NASA research announcements and other related announcements.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Relevance	Applied Sciences Analysis Group	Nov 2012	Review strategy and implementation. Annual reports to NASA Advisory Council from Earth Science Subcommittee.	TBD; report will be released Nov 2012	Oct 2013; annually thereafter

PLANETARY SCIENCE

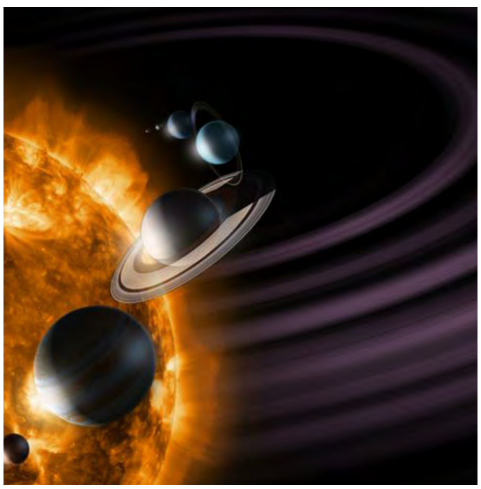
	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	1501.4	--	**1217.5**	1214.8	1225.3	1254.5	1253.0
Planetary Science Research	174.1	--	**220.6**	233.3	229.1	230.4	232.2
Lunar Quest Program	139.9	--	**17.7**	0.0	0.0	0.0	0.0
Discovery	172.6	--	**257.9**	268.2	242.3	187.5	215.0
New Frontiers	143.7	--	**257.5**	297.2	266.5	151.0	126.2
Mars Exploration	587.1	--	**234.0**	227.8	318.4	504.7	513.2
Outer Planets	122.1	--	**79.0**	45.6	24.4	26.4	26.4
Technology	161.9	--	**150.9**	142.8	144.7	154.4	140.0

Planetary Science

PLANETARY SCIENCE RESEARCH

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	174.1	--	**220.6**	233.3	229.1	230.4	232.2
Planetary Science Research and Analysis	122.3	--	**130.1**	131.0	131.3	132.2	132.5
Directorate Management	4.0	--	**4.0**	7.3	7.1	7.4	7.4
Near Earth Object Observations	20.4	--	**40.5**	20.5	20.5	20.5	20.5
Other Missions and Data Analysis	27.4	--	**46.0**	74.5	70.2	70.3	71.8
Change from FY 2012	--	--	**46.5**				
Percentage change from FY 2012	--	--	**26.7 %**				



This solar-system montage of the eight planets and four large moons of Jupiter in our solar system are set against a false-color view of the Rosette Nebula. Credit: NASA Planetary Photo Collection

Planetary Science Research program provides the scientific foundation for the Nation's use of the unique data sets returned from NASA missions exploring the solar system. It is also NASA's primary interface with university faculty and graduate students in this field and the research community in general. The program develops analytical and theoretical tools, as well as laboratory data to support analysis of flight mission data. These capabilities allow Planetary Science to answer specific questions about, and increase the understanding of, the origin and evolution of the solar system. The research program achieves this by supporting research grants solicited annually and subjected to a competitive peer review before selection and award.

The image to the left is a solar system montage of the eight planets and four large moons of Jupiter, set against a false-color view of the Rosette Nebula. Credit: NASA Planetary Photo Collection.

EXPLANATION OF MAJOR CHANGES

The budget request includes a doubling of NASA's efforts to identify and characterize potentially hazardous near-Earth objects (NEOs). NASA will prioritize partnerships and incentives that can enhance detection, characterization, and follow-up in the next few years. In addition to increasing understanding of the asteroid population, information gathered in this effort will support the proposed mission to retrieve an asteroid.

ACHIEVEMENTS IN FY 2012

The research program continued to curate and distribute solar system samples, or astromaterials, returned by NASA planetary missions such as Stardust, Genesis, and Hayabusa. The program also provided continued support for the Rosetta mission's arrival at comet Churyumov-Gerasimenko in 2014. The Robotics Alliance Project (RAP) selected 241 teams for receipt of the For Inspiration and Recognition of Science and Technology (FIRST) Robotics Student Competition 2012 Grant award.

Near Earth Object Observations (NEOO) surveyed about 95 percent of the known population of 1-kilometer and larger objects and has increased efforts for finding and characterizing smaller asteroids down to 140 meters in size. In FY 2012, the NEOO program found 919 more near-Earth asteroids, of which 82 are considered potentially hazardous to Earth.

WORK IN PROGRESS IN FY 2013

The research program is archiving and analyzing data from all active planetary missions. The NEOO program supports a network of search and characterization observatories and the data processing and analysis required to understand the near-Earth population of small bodies. In accordance with the findings and recommendations of the January 2010 National Academies study on the NEO hazard, NASA continues to:

- Analyze the small body data collected by NASA's Wide-field Infrared Survey Explorer (WISE) mission, and support increased follow-up and analysis of this data;
- Enable collection of NEO detection and characterization data by the United States Air Force's (USAF) Panoramic Survey Telescope and Rapid Reporting System (Pan-STARRS) and the newly commissioned Space Surveillance Telescope;
- Support the continued operation of planetary radar capabilities at NSF's Arecibo and NASA's Goldstone facilities; and
- Investigate both ground and space-based concepts for increasing capacity to detect, track and characterize NEOs of all sizes.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The Rosetta mission will arrive and orbit the Comet Churyumov-Gerasimenko.

Samples of asteroid Itokawa, collected by the Hayabusa mission, were allocated to researchers in the spring of 2012. The first samples were delivered to NASA in late 2011, and were available for research starting in spring 2012. The first results of their analysis, including study of space weathering and the search for organic matter, are expected in FY 2014.

In FY 2014 NASA will aggressively pursue an expanded NEO observation program that will increase the detection and characterization of NEOs of all sizes by increasing the observing time on ground-based telescopes such as PanSTARRs. In support of the future human mission to an asteroid, the Science Mission Directorate and the Human Exploration and Operations Mission Directorate will release a joint Announcement of Opportunity for a space-based NEO infrared telescope, to be flown as a hosted payload on a non-NASA geosynchronous spacecraft. This telescope would observe NEOs that either fly by or impact the Earth, prior to their encounter.

PLANETARY SCIENCE RESEARCH

Program Elements

RESEARCH AND ANALYSIS (R&A)

Planetary Science Research & Analysis provides the foundation for the formulation of new scientific questions and strategies for answering those questions. R&A develops new theories and instrumentation concepts that enable the next generation of flight missions. R&A supports research tasks in areas such as astrobiology and cosmochemistry; the origins and evolution of planetary systems; and the atmospheres, geology, and chemistry of the solar system's planets other than Earth.

DIRECTORATE MANAGEMENT

The Directorate Management project supports SMD-wide administrative and programmatic requirements. The Robotics Alliance Project is dedicated to increasing interest in science, technology, engineering, and mathematics disciplines among youth in the United States. Annual activities and events expose students to challenging applications of engineering and science. The Robotics Alliance Project supports national robotic competitions in which high school students team with engineering and technical professionals from government, industry, and universities to gain hands-on experience and mentoring.

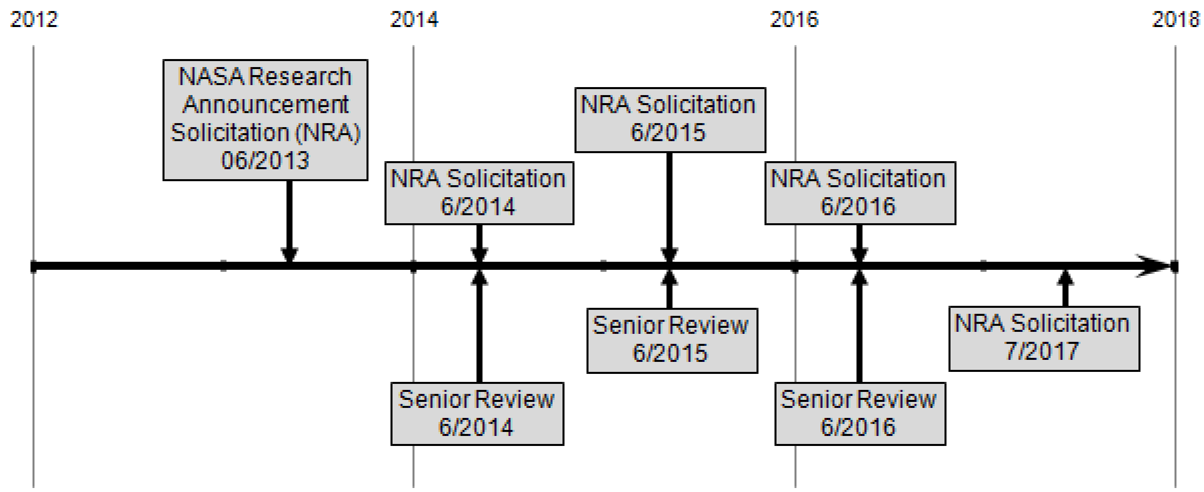
NEAR EARTH OBJECT OBSERVATIONS (NEOO)

The NEOO project was charged with detecting and tracking at least 90 percent of the near-Earth objects (NEOs), asteroids and comets that come within 1.3 astronomical units of the Sun. The NEOO project looks for NEOs that have any potential to collide with Earth and do significant damage to the planet. NEOs that could be viable targets for robotic and crewed exploration will also be discovered and characterized where possible.

For more information on the NEOO program, go to: http://neo.jpl.nasa.gov.

PLANETARY SCIENCE RESEARCH

Program Schedule



Program Management & Commitments

Program Element	Provider
R&A	Provider: NASA Lead Center: HQ Performing Centers: ARC, GRC, GSFC, JPL, JSC, LaRC, MSFC, HQ Cost Share Partners: N/A
NEOO	Provider: NASA Lead Center: HQ Performing Center: HQ, GSFC, JPL, ARC Cost Share Partners: NSF, USAF, Smithsonian Astrophysical Observatory (SAO)

PLANETARY SCIENCE RESEARCH

Acquisition Strategy

The Research and Analysis budget will fund competitively selected activities from the Research Opportunities in Space and Earth Sciences (ROSES) omnibus research announcement.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Planetary Science Subcommittee	2011	Review to assess goals and objectives of program.	Recommendation was to maintain a strong program consistent with the decadal survey.	To be determined (TBD)

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	27.4	--	**46.0**	74.5	70.2	70.3	71.8
Joint Robotics Program for Exploration	0.0	--	**10.0**	10.0	10.0	10.0	10.0
Planetary Science Directed Research & Technology	0.0	--	**0.0**	32.1	32.9	40.1	42.1
Planetary Data System	13.6	--	**13.7**	13.8	13.8	13.9	13.9
Astromaterial Curation	5.8	--	**5.8**	5.8	5.8	5.8	5.8
Rosetta	8.0	--	**16.5**	12.8	7.6	0.5	0.0
Change from FY 2012	--	--	**18.6**				
Percentage change from FY 2012	--	--	**67.9 %**				

Other Missions and Data Analysis includes supporting mission functions such as the Planetary Data Systems and the Astromaterials Curation as well as supporting the NASA portion of the European Space Agency (ESA) Rosetta mission.

Mission Planning and Other Projects

JOINT ROBOTICS PRECURSOR ACTIVITY

This activity funds research and analysis efforts in support of human spaceflight planning and robotic systems development. These precursor activities will characterize exploration environments, identify hazards, and assess resources, which will provide knowledge to inform the selection of future destinations, support the development of exploration systems, and reduce the risk associated with human exploration. NASA's Science Mission Directorate will jointly conduct many of these research and analysis activities with the Human Exploration and Operations Mission Directorate to maximize the benefit to both science and exploration objectives, as was done with the highly successful Lunar Reconnaissance Orbiter (LRO) mission.

PLANETARY SCIENCE DIRECTED RESEARCH AND TECHNOLOGY

This project funds the civil service staff that will work on emerging Planetary Science flight projects, instruments, and research. The workforce and funding will transfer to projects by the beginning of FY 2014.

OTHER MISSIONS AND DATA ANALYSIS

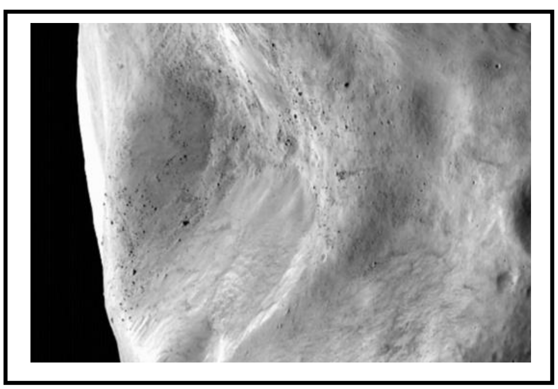
Formulation	Development	Operations

PLANETARY DATA SYSTEM

The Planetary Data System is the active data archive for NASA's Planetary Science theme. The Planetary Data System furthers NASA's Planetary Science goals by efficiently collecting, archiving, and making accessible digital data produced by, or relevant to, NASA's planetary missions, research programs, and data analysis. The archives include data products derived from a wide range of measurements, including imaging experiments, magnetic and gravity field measurements, orbit data, and various spectroscopic observations. All space-borne data from over 50 years of NASA-funded exploration of comets, asteroids, moons, and planets is publically available through the Planetary Data Systems archive.

ASTROMATERIAL CURATION

The Astromaterials Curation Facility at JSC is responsible for the curation of all extraterrestrial material under NASA control. Curation is an integral part of any sample return mission. It comprises initial characterization of new samples, preparation and allocation of samples for research and clean and secure storage for the benefit of current and future generations. Samples currently include Apollo lunar samples, Antarctic meteorites, and solar wind, comet, asteroid, and interplanetary dust particles, soil, and rocks.



Operating Missions

ROSETTA

Rosetta, an ESA/NASA comet rendezvous mission in operations phase that launched in March 2004, will enable scientists to look at some of the most primitive material from the formation of the solar system 4,600 million years ago. Rosetta will enable study of the nature and origin of comets, the relationship between cometary and interstellar material, and the implications of comets with regard to the origin of the solar system. The Rosetta spacecraft will be the first to undertake long-term exploration of a comet at close quarters. It comprises a large orbiter designed to operate for a decade at large distances from the Sun, and a small lander. Each of these elements carries a large number of scientific experiments and examinations designed to complete the most detailed study of a comet ever attempted. Rosetta will arrive at comet Churyumov-Gerasimenko in FY 2014.

LUNAR QUEST PROGRAM

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	139.9	--	**17.7**	0.0	0.0	0.0	0.0
Lunar Science	66.8	--	**15.3**	0.0	0.0	0.0	0.0
Lunar Atmosphere and Dust Environment Explorer	70.4	--	**2.4**	0.0	0.0	0.0	0.0
Surface Science Lander Technology	2.8	--	**0.0**	0.0	0.0	0.0	0.0
Subtotal	140.0	--	**17.7**	0.0	0.0	0.0	0.0
Rescission of prior-year unob. balances*	0	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-122.2**				
Percentage change from FY 2012	--	--	**-87.3 %**				

*Note: * Rescission of $0.032million of prior-year unobligated balances from Lunar Science pursuant to P.L. 112-55, Division B, sec. 528(f).Amounts rounds to $0.0 million in table above.*

The "Mighty Eagle," powered by hydrogen peroxide and guided by autonomous rendezvous and capture software, is shown descending gently from an altitude of 100 feet to a successful controlled landing. The Mighty Eagle will be used to mature the technologies needed to achieve scientific and exploration goals on the surface of the moon, asteroids, or other airless bodies with a new generation of small, smart, versatile robotic landers. The Mighty Eagle was developed for NASA by Marshall Space Flight Center and Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

Lunar Quest conducts scientific exploration of the Moon through research and analysis and through the development of small-to-medium satellites. Lunar Quest addresses the science priorities identified in the National Academies report, *The Scientific Context for Exploration of the Moon*.

EXPLANATION OF MAJOR CHANGES

The Lunar Quest program is being closed out as a separate program within Planetary Science after FY 2014.

ACHIEVEMENTS IN FY 2012

In summer of 2012, the Surface Science Lander Technology project conducted its second series of free-flight tests of a robotic lander. This series of flight tests successfully demonstrated that the autonomous guidance system could identify a target from a 30-meter altitude and guide a lander to a soft landing on a target 10 meters downrange.

The Lunar Reconnaissance Orbiter continued to acquire data about Earth's nearest celestial neighbor. Among other accomplishments, LRO results published in FY 2012:

- Quantified the abundance and distribution of surface ice at the lunar south pole, showing that surface frost may cover significant portions of some craters;
- Improved the age dating of lunar landforms by using crater counts from the new high-resolution LRO images;
- Identified widespread distribution of lunar pits and caverns, sites that are potential targets for future exploration; and
- Produced the first cosmic ray proton brightness map of the lunar surface.

WORK IN PROGRESS IN FY 2013

The Lunar Atmosphere and Dust Environment Explorer (LADEE) is continuing through the integration and testing phase. LRO operations are ongoing.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

LADEE is scheduled for launch and will complete operations in FY 2014.

Program Elements

LUNAR SCIENCE RESEARCH

The Lunar Science Research project enhances participation and collaboration within the lunar science community. It is composed of competed research and analysis opportunities that include:

- The NASA Lunar Science Institute, a virtual institute of geographically dispersed researchers and institutions;
- The Lunar Advanced Science and Exploration Research program, a lunar-only element in the annual ROSES competitive research announcement; and
- Lunar Data, which supports lunar data archives and distribution to the science community.

LUNAR MANAGEMENT

The Lunar Management Office, located at the Marshall Space Flight Center, provides the management oversight for all the missions in the Lunar Quest program.

LUNAR QUEST PROGRAM

Program Schedule

The Lunar Quest program will end shortly after the LADEE mission is complete, currently scheduled for FY 2014.

Date	Significant Event
11/13	LADEE Launch Readiness Date

Program Management & Commitments

Program Element	Provider
Lunar Science	Provider: HQ Lead Center: HQ Performing Centers: ARC, GSFC, MSFC, JPL, JSC Cost Share Partners: N/A

Acquisition Strategy

All major procurements are in place. No new awards are expected in FY 2014.

INDEPENDENT REVIEWS

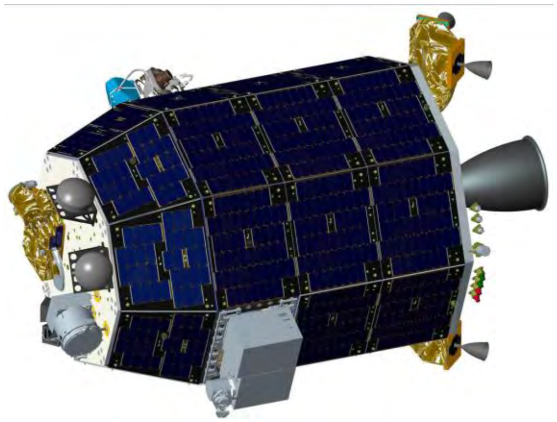
Review Type	Performer	Last Review	Purpose	Outcome	Next Review
LADEE Systems Integration Review (SIR)	Standing Review Board (SRB)	Aug-12	Delta SIR completed in Aug 2012. The purpose was to evaluate the readiness of the overall system to commence integration and test.	LADEE passed SIR and was approved to continue in Phase D	Late FY 2013

LUNAR ATMOSPHERE DUST AND ENVIRONMENT EXPLORER

Formulation	Development	Operations

FY 2014 Budget

	Actual				Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	148.6	70.4	41.4	**2.4**	0.0	0.0	0.0	0.0	0.0	262.9
2014 MPAR LCC Estimate	148.6	70.4	41.4	**2.4**	0.0	0.0	0.0	0.0	0.0	262.9
Formulation	79.5	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	79.5
Development/Implementation	69.1	70.4	36.6	**0.0**	0.0	0.0	0.0	0.0	0.0	176.1
Operations/Close-out	0.0	0.0	4.8	**2.4**	0.0	0.0	0.0	0.0	0.0	7.2
Change from FY 2012		--	--	**-70.0**						
Percentage change from FY 2012		--	--	**-99.4%**						



The National Academies report *The Scientific Context for Exploration of the Moon* lists studies of the pristine state of the lunar atmosphere and dust environment as two of eight major priorities for future lunar science missions. LADEE was developed to address these two priorities.

PROJECT PURPOSE

LADEE will determine the global density, composition, and time variability of the lunar atmosphere. LADEE will measure lunar dust and characterize the lunar atmosphere. Analysis of LADEE's data will broaden the scientific understanding of other planetary bodies with thin atmospheres. Additionally, LADEE will carry an optical laser communications demonstrator, provided by the Space Communications and Navigation program within Human Exploration and Operations, that will test laser communication from lunar orbit.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PARAMETERS

LADEE will deliver its science using three instrument packages. The Neutral Mass Spectrometer (NMS) will measure variations in the lunar atmosphere over multiple lunar orbits with the Moon in different space environments. The UV/Visible Spectrometer will determine the composition of the lunar atmosphere by analyzing light signatures of materials it finds. The Lunar Dust EXperiment (LDEX) will collect and analyze samples of any lunar dust particles in the tenuous atmosphere. The mission will test a first-of-its-kind spacecraft architecture called the "Modular Common Bus," developed by NASA as a flexible, low-cost, rapid-turnaround spacecraft for both orbiting and landing on the Moon and other deep space targets.

LUNAR ATMOSPHERE DUST AND ENVIRONMENT EXPLORER

Formulation	Development	Operations

In addition to three science instruments, LADEE will carry the Lunar Laser Communications Demonstration (LLCD), sponsored by the Human Exploration and Operations Mission Directorate. LLCD will demonstrate high-bandwidth optical communications from lunar orbit for the first time.

NASA will launch LADEE on a Minotaur V, procured by the Air Force, from NASA's Wallops Flight Facility. LADEE is an in-house development project, the first spacecraft to be built internally at Ames Research Center, and the first deep space planetary mission to be launched from Wallops Flight Facility.

ACHIEVEMENTS IN FY 2012

LADEE completed its System Integration Review in August 2012. All three science instruments were delivered and integrated on the spacecraft.

WORK IN PROGRESS IN FY 2013

The Lunar Laser Communications Demonstration was delivered and integrated on the spacecraft. NASA continues to work on spacecraft environmental testing, mission operations planning and staff training, and launch vehicle design and building. Ames Research Center will conduct the Electromagnetic Interference/Capability EMI/EMC testing, and a contractor in Southern California will perform the Acoustic and Vibration testing. Mission operations reviews are underway, as are launch vehicle development reviews.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

LADEE is scheduled to launch no later than November 2013. Data returned from the mission will be formatted and entered into the Planetary Data System. Scientists will use the data system to begin analysis.

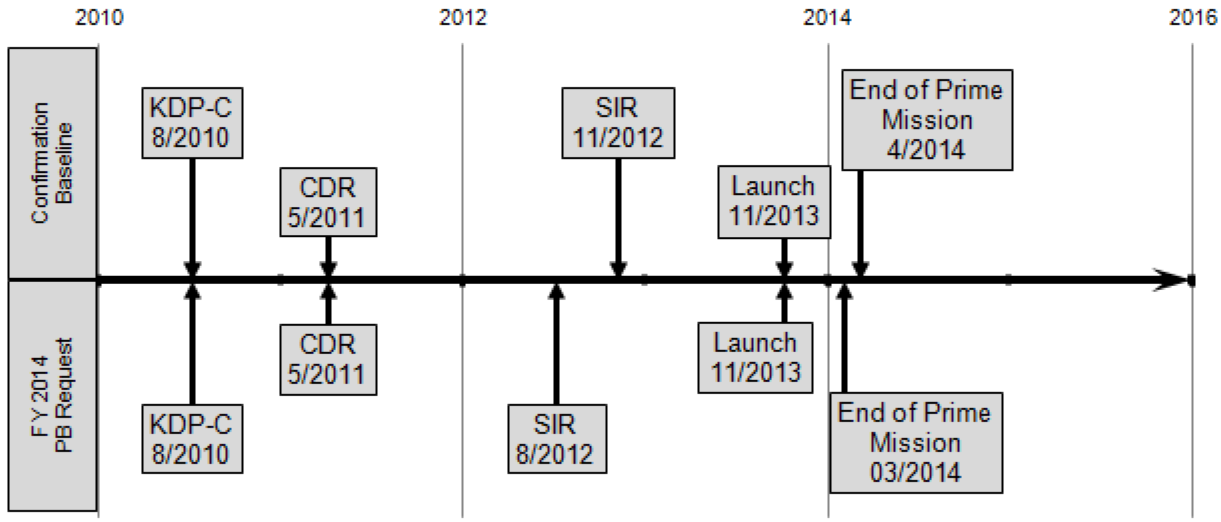
SCHEDULE COMMITMENTS/KEY MILESTONES

Milestone	Confirmation Baseline Date	FY 2014 PB Request Date
Key Decision Point C (KDP-C)	Aug 2010	Aug 2010
Critical Design Review (CDR)	May 2011	May 2011
System Integration Review (SIR)	Nov 2012	Aug 2012
Launch	Nov 2013	Nov 2013
End of Prime Mission	Apr 2014	Mar 2014

LUNAR ATMOSPHERE DUST AND ENVIRONMENT EXPLORER

Formulation	Development	Operations

Project Schedule



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2011	168.2	70	2013	176.1	4.5	LRD	Nov 2013	Nov 2013	0

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**168.2**	**176.1**	**7.9**
Aircraft/Spacecraft	34.8	52.2	17.4
Payloads	15	22.4	7.4

LUNAR ATMOSPHERE DUST AND ENVIRONMENT EXPLORER

Formulation	Development	Operations

Systems I&T	6.7	8.6	1.9
Launch Vehicle	45.7	57.8	12.1
Ground Systems	3.5	6.7	3.2
Science/Technology	0.8	.8	0.0
Other Direct Project Costs	61.7	27.5	-34.2

Project Management & Commitments

Ames Research Center (ARC) has project management responsibility.

Project Element	Description	Provider	Change from Baseline
Spacecraft	The LADEE spacecraft bus design, derived from the Modular Common Spacecraft Bus architecture	Provider: ARC Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	None
Neutral mass Spectrometer (NMS) Instrument	Will measure variations in the lunar atmosphere over multiple lunar orbits with the Moon in different space environments	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	None
UV Spectrometer Instrument	Will determine the composition of the lunar atmosphere by analyzing light signatures of materials it finds	Provider: ARC Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	None
Lunar Dust Experiment (LDEX) Instrument	Will collect and analyze samples of any lunar dust particles in the tenuous atmosphere	Provider: University of Colorado, Laboratory for Atmospheric and Space Physics (LASP) Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	None
Launch Vehicle	Minotaur V carrier rocket	Provider: USAF Lead Center: AF Performing Centers: Wallops Flight Facility Cost Share Partners: N/A	None

LUNAR ATMOSPHERE DUST AND ENVIRONMENT EXPLORER

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: There are schedule delays in the LLCD, Then: The launch readiness date could slip past the last launch window prior to the eclipse (October 21, 2013).	Determine when the decision will be made to fly without the LLCD, if need be.

Acquisition Strategy

All major acquisitions are in place.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
System Integration Review	Standing Review Board (SRB)	Aug 2012	Delta SIR completed in August 2012. The purpose was to evaluate the readiness of the overall system to commence integration and test.	LADEE passed SIR and was approved to continue in Phase D.	Late FY 2013

DISCOVERY

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	172.6	--	**257.9**	268.2	242.3	187.5	215.0
InSight	42.1	--	**193.3**	175.2	116.5	15.2	10.6
Other Missions and Data Analysis	130.6	--	**64.6**	93.0	125.8	172.3	204.4
Change from FY 2012	--	--	**85.3**				
Percentage change from FY 2012	--	--	**49.4 %**				

All completed Discovery missions have achieved ground-breaking science, each taking a unique approach to space exploration, doing what's never been done before, and driving new technology innovations.

NASA's Discovery program provides scientists the opportunity to dig deep into their imaginations and find innovative ways to unlock the mysteries of the solar system through missions to explore the planets, their moons, and small bodies such as comets and asteroids.

The Discovery program currently has four operational spacecraft: the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER), Deep Impact (in hibernation), Dawn, and the Gravity Recovery And Interior Laboratory (GRAIL). The program also has one instrument in operations: the Analyzer of Space Plasma and Energetic Atoms (ASPERA-3) on the ESA Mars Express mission; one flight mission in formulation: the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight); and one instrument in spacecraft integration: Strofio on the ESA BepiColombo mission to Mercury.

EXPLANATION OF MAJOR CHANGES

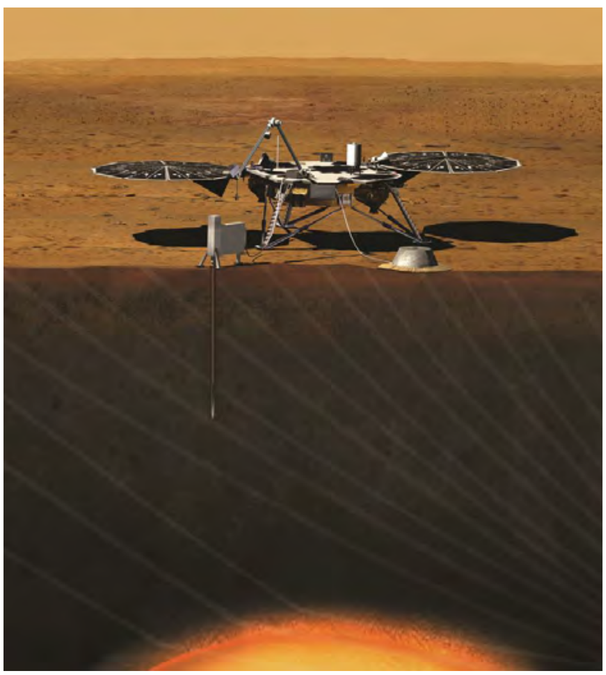
None.

INSIGHT

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	42.1	--	**193.3**	175.2	116.5	15.2	10.6
Change from FY 2012	--	--	**151.2**				
Percentage change from FY 2012	--	--	**359.1%**				



Scientists have determined the deep structure of only one planet — Earth. To obtain vital clues to how Mars formed, InSight will deploy a German-built drill nicknamed "The Mole" to pound 16 feet into the Martian crust for thermal measurements, as well as a sensitive French-built seismometer to detect "Marsquakes," and a US led experiment that will provide precise measurements of the planets rotation. Through these and other instruments, scientists will be able to deduce the deep structure of Mars, which is currently a mystery.

PROJECT PURPOSE

Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) is a Mars lander mission planned for launch in spring 2016. InSight is an investigation of the terrestrial planets that will address fundamental issues of planet formation and evolution with a study of the deep interior of Mars. This mission will seek to understand the evolutionary formation of rocky planets, including Earth, by investigating the crust and core of Mars. InSight will also investigate the dynamics of any Martian tectonic activity and meteorite impacts and compare this with like phenomena on Earth.

EXPLANATION OF MAJOR CHANGES

InSight was selected in August 2012 from the Discovery 2010 Announcement of Opportunity.

PROJECT PRELIMINARY PARAMETERS

InSight is planned to launch in March 2016, landing on Mars in September 2016. The InSight lander will be equipped with two science instruments that will conduct the first "check-up" of Mars in its more than 4.5 billion years, measuring its "pulse," or internal activity; its temperature; and its "reflexes" (the way the planet wobbles when it is pulled by the Sun and its moons). The science payload comprises two major instruments: the Seismic Experiment for Interior Structure (SEIS), which will take precise measurements of quakes and other internal activity on Mars to

INSIGHT

Formulation	Development	Operations

better understand the planet's history and structure, and the Heat Flow and Physical Properties Package (HP3), a self-penetrating heat flow probe that burrows up to 5 meters below the surface to measure how much heat is coming from Mars' core. In addition, the Rotation and Interior Structure Experiment (RISE) will use the spacecraft communication system to provide precise measurements of planetary rotation. InSight will spend roughly two years (720 Earth days or 700 "sols" Martian days) investigating the deep interior of Mars. The first science return is expected in October 2016. End of mission is planned for September 2018.

ACHIEVEMENTS IN FY 2012

Final down-select of the Discovery 2010 Announcement of Opportunity occurred in August 2012, allowing InSight to proceed into definition and preliminary design.

WORK IN PROGRESS IN FY 2013

During FY 2013, InSight will complete preliminary design and begin development.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

InSight will enter detailed design at the beginning of FY 2014 and expects to pass the critical design review before the end of FY 2014.

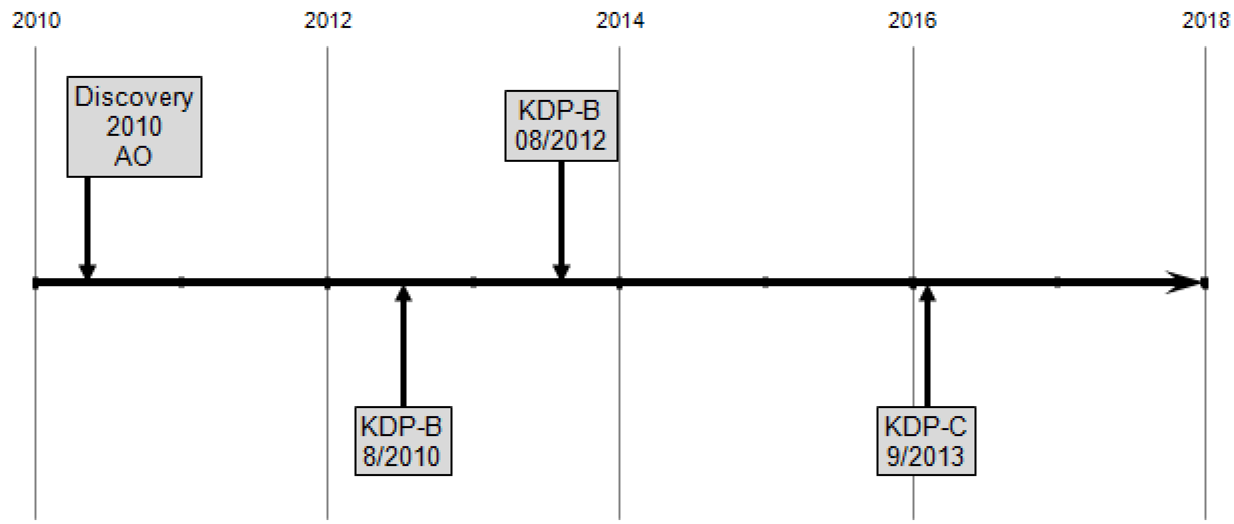
ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization	Discovery 2010 Announcement of Opportunity	N/A
KDP-B	Aug 2012	Aug 2012
KDP-C	Sep 2013	Sep 2013
Launch	Mar 2016	Mar 2016

INSIGHT

Formulation	Development	Operations

Project Schedule



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Aug 2012	678-760	Launch	Mar 2016 – Apr 2016

Project Management & Commitments

JPL will manage InSight and will provide systems engineering, safety and mission assurance, project scientists, flight dynamics, payload management, and mission system management.

Element	Description	Provider Details	Change from Formulation Agreement
Spacecraft	Similar in design to the Mars lander that the Phoenix mission used successfully in 2007	Provider: Lockheed Martin Lead Center: JPL Participating Centers: N/A Cost Share Partners: N/A	N/A

Formulation	Development	Operations

Seismic Experiment for Interior Structure (SEIS)	Will take precise measurements of quakes and other internal activity on Mars	Provider: Centre National d'Etudes Spatiales (CNES) Lead Center: JPL Participating Centers: N/A Cost Share Partners:	N/A
Heat Flow and Physical Properties Package (HP3)	A heat flow probe that will hammer 5m into the Martian subsurface (deeper than all previous arms, scoops, drills and probes) to measure heat emanating from the core	Provider: German Aerospace Center (DLR) Lead Center: JPL Participating Centers: N/A Cost Share Partners:	N/A
Rotation and Interior Structure Experiment (RISE)	Uses the spacecraft's communication system to provide precise measurements of planetary rotation	Provider: JPL Lead Center: JPL Participating Centers: N/A Cost Share Partners: N/A	N/A
Launch Vehicle	To be determined (TBD)	Provider: TBD Lead Center: KSC Participating Centers: JPL Cost Share Partners: N/A	N/A

Project Risks

Risk Statement	Mitigation
If: Growth of lander avionics and payload electronics continues to strain volume of thermal enclosure, Then: The heritage design of the thermal enclosure and aeroshell is at risk. The project cannot grow the size of the thermal enclosure.	Instrument teams are working to close trade studies that will establish the baseline for payload electronics configuration, and spacecraft team members are working closely with instrument teams to identify and analyze overall configuration options.
If: If Mars environment, entry conditions, or spacecraft behavior is not as anticipated, Then: Landing may not be successful.	Project will build comprehensive simulations of landing scenarios and test entry descent and landing systems, including independent verification of analysis. The project will be staffed with personnel who conducted previous successful Mars landings. Potential landing ellipses will be certified for elevation, slopes, and rock abundance. The project will use validated environmental models informed by atmospheric measurements from the previous three decades of observations at Mars.
If: Deployment of SEIS is not successful, Then: The science objectives will be compromised.	Extensive testing of deployments will be conducted in testbeds, including fault scenarios. Testbeds will also be available during mission operations to verify actual deployment moves, and ground verification will be deployed at each step during operations. Potential landing ellipses will be certified for elevation, slopes, and rock abundance.

INSIGHT

Formulation	Development	Operations

Acquisition Strategy

NASA selected the mission through a competitive Announcement of Opportunity.

MAJOR CONTRACTS/AWARDS

A contract with Lockheed Martin is in place for the flight system.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	N/A	N/A	TBD	Aug 2013

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	130.6	--	**64.6**	93.0	125.8	172.3	204.4
Discovery Future	19.2	--	**22.3**	55.0	92.2	138.9	176.2
Discovery Management	10.5	--	**11.8**	12.3	17.5	12.2	12.2
Discovery Research	15.4	--	**13.9**	14.1	15.2	15.6	15.6
Strofio	1.6	--	**1.3**	0.7	0.8	0.8	0.5
Gravity Recovery and Interior Laboratory	29.8	--	**0.0**	0.0	0.0	0.0	0.0
Dawn	14.3	--	**9.8**	11.0	0.1	4.8	0.0
MESSENGER	34.9	--	**4.9**	0.0	0.0	0.0	0.0
ASPERA-3	0.9	--	**0.6**	0.0	0.0	0.0	0.0
Deep Impact	4.0	--	**0.0**	0.0	0.0	0.0	0.0
Change from FY 2012	--	--	**-66.0**				
Percentage change from FY 2012	--	--	**-50.5 %**				

Other Missions and Data Analysis funds research and analysis, management activities, operations of active missions, and development of several minor missions. It includes missions of opportunity (e.g., the instruments Strofio and Analyzer of Space Plasma and Energetic Atoms (ASPERA-3)) with lifecycle costs to NASA of less than $35 million); operating missions (Dawn, MESSENGER, Deep Impact); missions whose operations have ceased but data analysis continues (GRAIL); competed research; funding for future mission selections; and program management activities.

Mission Planning and Other Projects

DISCOVERY RESEARCH

Discovery Research includes funding for the Discovery Missions Data Analysis program, which supports analysis of archived data from Discovery missions; Laboratory Analysis of Returned Samples, which supports analysis of material returned from sample collection missions and builds new instruments for use in terrestrial laboratories; and participating scientists for the MESSENGER, Dawn, and GRAIL missions. Discovery Research gives the research community access to samples and data and allows research to continue for many years after a mission has been completed. Scientists in the US planetary science community make research proposals that are competitively selected through peer review.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

Recent analysis of particles collected by the Stardust mission revealed material very similar to what is found in asteroids, which can only be explained if Jupiter formed as late as 3 million years after the solar system's birth.

DISCOVERY FUTURE MISSIONS

Discovery Future Missions provides funds for future Discovery flight missions to be selected via a competitive Announcement of Opportunity process. NASA recently selected InSight, the 12th mission of the Discovery program, as a result of the Discovery 2010 Announcement of Opportunity. NASA will release the next Announcement of Opportunity by early FY 2014.

DISCOVERY MANAGEMENT

Discovery Management provides for the management oversight of flight missions selected for the program, including support to standing review boards and external technical support as needed for the projects. It also supports the mission selection process through the development of Announcements of Opportunity and the establishment of independent panel reviews to evaluate mission proposals.

STROFIO

Strofio is a unique mass spectrometer that is part of the SERENA (Search for Esospheric Refilling and Emitted Natural Abundances) suite of instruments that will fly onboard the European Space Agency's BepiColombo spacecraft. Strofio will determine the chemical composition of Mercury's surface, providing a powerful tool to study the planet's geological history. Strofio is scheduled for launch in 2015.

Recent Achievements

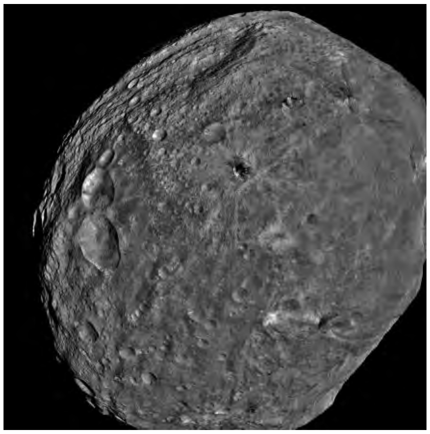
The Strofio Proto-Flight Model has been delivered to the University of Bern, where it has undergone instrument calibration with better than expected performance. The Strofio Proto-Flight Model will be assembled into the flight configuration in January for delivery to the Search for Esospheric Refilling and Emitted Natural Abundances (SERENA) instrument suite before mid-March 2013.

GRAVITY RECOVERY AND INTERIOR LABORATORY (GRAIL)

Launched in September 2011, the GRAIL mission was composed of two functionally identical spacecraft (called Ebb and Flow) that flew in tandem around the Moon to precisely measure and map variations in the Moon's gravitational field. The mission provided the most accurate global gravity field to date for any planet, including Earth. This detailed information will reveal differences in the density of the Moon's crust and mantle and will help answer fundamental questions about the Moon's internal structure, thermal evolution, and history of collisions with asteroids. This mission terminated in December 2012.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



Operating Missions

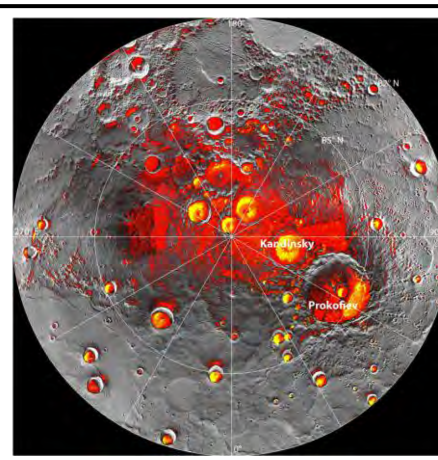
DAWN

Dawn is on a journey to the two oldest and most massive bodies in the main asteroid belt between Mars and Jupiter. By closely orbiting asteroid Vesta and the dwarf planet Ceres with the same set of instruments, Dawn has the unique capability to compare and contrast theses bodies, enabling scientists to answer questions about the formation and evolution of the solar system. Their surfaces are believed to preserve clues to the solar system's first 10 million years, along with alterations since that time, allowing Dawn to investigate both the origin and the current state of the main asteroid belt. Launched in September 2007, Dawn reached Vesta in July 2011, left in August 2012, and will arrive at Ceres in February 2015.

In the image above, Dawn mission data has revealed the rugged topography and complex textures of the asteroid Vesta's surface. Soon other pieces of data, such as the chemical composition, interior structure, and geologic age, will help scientists understand the history of this remnant protoplanet and its place in the early solar system. After a year orbiting Vesta, the Dawn spacecraft departed in August 2012 for the dwarf planet Ceres, where it will arrive in 2015.

Recent Achievements

The spacecraft completed its year-long orbital mission around Vesta in August 2012, and became the first spacecraft to break orbit from one object in the main asteroid belt and move on to a second, the dwarf planet Ceres.



MERCURY SURFACE, SPACE ENVIRONMENT, GEOCHEMISTRY, AND RANGING (MESSENGER)

The MESSENGER mission is a scientific investigation of the planet Mercury, the smallest and least explored of the terrestrial planets. It is the only rocky planet, besides Earth, to possess a global magnetic field. Understanding Mercury and the forces that have shaped it is fundamental to understanding the origin and evolution of the four rocky inner planets in our solar system. Launched in August 2004, MESSENGER entered Mercury's orbit in March 2011 for a one-year prime mission. The science return and health of the spacecraft

Formulation	Development	Operations

allowed approval of a one-year mission operations extension to March 2013. A second mission extension is now under consideration.

Recent Achievements

The International Academy of Astronautics (IAA) has awarded the 2012 Laurels for Team Achievement Award to the MESSENGER team. The award was presented September 30 at the opening ceremony of the 63rd International Astronautical Congress. The citation for MESSENGER's award reads, "To the team of scientists and engineers whose creativity and expertise made possible the development and operation of the MESSENGER Mission, the first to orbit Mercury, as a breakthrough in scientific solar system exploration. During its unprecedented one-year primary mission, this robotic explorer has provided an extraordinary, comprehensive scientific overview of the planet, its makeup, its exosphere and its magnetosphere, providing the text for a new and overdue chapter of humankind's knowledge of the smallest of the terrestrial planets. This unique achievement of technology was conducted by the JHU APL and accomplished with the collaboration of NASA."

ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (ASPERA-3)

ASPERA-3 is one of seven scientific instruments aboard the European Space Agency's Mars Express spacecraft launched in June 2003 that are performing remote sensing measurements designed to answer questions about the Martian atmosphere, structure, and geology. ASPERA-3 is measuring ions, electrons, and energetic neutral atoms in the outer atmosphere to reveal the number of oxygen and hydrogen atoms, (the constituents of water, interacting with solar wind and the regions where such interaction occurs. Mars Express is now on its third mission extension.

DEEP IMPACT

The Deep Impact mission was the first experiment to probe beneath the surface of a comet, attempting to reveal never-before-seen materials that would provide clues about the internal composition and structure of a comet. Deep Impact successfully completed its repurposed science missions, referred to as EPOXI, which has two components: Extrasolar Planet Observations and Characterization (EPOCh) and the Deep Impact Extended Investigation (DIXI). The spacecraft is still healthy and capable of remote observations. It will be put in hibernation to be available for opportunities such as the approaching Comet ISON.

NEW FRONTIERS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	143.7	--	**257.5**	297.2	266.5	151.0	126.2
Origins Spectral Interpretation Resource	99.8	--	**218.7**	244.1	204.4	30.9	21.1
Other Missions and Data Analysis	43.9	--	**38.8**	53.1	62.1	120.1	105.1
Change from FY 2012	--	--	**113.8**				
Percentage change from FY 2012	--	--	**79.2 %**				

The New Frontiers program seeks to contain total mission cost and development time and improve performance through the use of validated new technologies, efficient management, and control of design, development and operations costs while maintaining a strong commitment to flight safety. The program objective is to launch high-science-return planetary science investigations twice per decade.

The New Frontiers program explores our solar system with frequent, medium-class spacecraft missions. Within the New Frontiers program, possible mission destinations and the science goals for each competitive opportunity are limited to those identified by the National Academies as recommended science targets. These currently include: Venus In Situ Explorer, Saturn Probe, Trojan Tour and Rendezvous, the Comet Surface Sample Return, and Lunar South Pole-Aitken Basin Sample Return.

New Horizons will help us understand worlds at the edge of the solar system by making the first reconnaissance of Pluto and Charon, then visiting one or more Kuiper Belt Objects.

Juno is a mission to Jupiter that will significantly improve our understanding of the origin and evolution of the gas giant planet. This will help us better understand our entire solar system.

OSIRIS-REx will be the first mission to bring pristine samples from an asteroid to study and analyze on Earth. This will increase our understanding of planet formation and the origin of life. In addition to its science objectives OSIRIS-REx will improve our knowledge of:

- How to safely operate human and robotic missions in close proximity to a large NEO; and
- How the OSIRIS-REx spacecraft will alter the trajectory of a NEO through thruster exhaust impingement, gravitational attraction, and touch-and-go sample collection.

This knowledge will provide significant insight for both the future human mission to an asteroid, and for potential planetary defense strategies.

EXPLANATION OF MAJOR CHANGES

None.

ORIGINS SPECTRAL INTERPRETATION RESOURCE

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	99.8	--	**218.7**	244.1	204.4	30.9	21.1
Change from FY 2012	--	--	**118.9**				
Percentage change from FY 2012	--	--	**119.1%**				

Asteroids are leftovers formed from the cloud of gas and dust and the solar nebula that collapsed to form the Sun and the planets about 4.5 billion years ago. As such, they contain the original material from the solar nebula, which can tell scientists about the conditions of the solar system's birth. In sampling the near Earth asteroid designated 1999 RQ36 in 2019, OSIRIS-REx will be opening a time capsule from the birth of the solar system.

PROJECT PURPOSE

The OSIRIS-REx spacecraft will travel to a near-Earth carbonaceous asteroid (101955) 1999 RQ36, study it in detail, and bring back a sample (at least 60 grams or 2.1 ounces) to Earth. This sample will help with investigating planet formation and the origin of life, and the data collected at the asteroid will also aid in understanding asteroids that can impact Earth. This mission will measure the "Yarkovsky effect" on a potentially hazardous asteroid and measure the asteroid properties that contribute to this effect. By describing the integrated global properties of a primitive carbonaceous asteroid, this mission will allow for direct comparison with ground-based telescopic data of the entire asteroid population.

The Yarkovsky effect is a small force caused by the Sun on an asteroid, as it absorbs sunlight and re-emits that energy as heat. The small force adds up over time, but it is uneven due to an asteroid's shape, wobble, surface composition, and rotation. For scientists to predict an Earth-approaching asteroid's path, they must understand how the effect will change its orbit.

In addition to its science objectives OSIRIS-REx will improve our knowledge of: 1) how to safely operate human and robotic missions in close proximity to a large NEO and 2) how the OSIRIS-REx spacecraft will alter the trajectory of a NEO through thruster exhaust impingement, gravitational attraction, and touch-and-go sample collection. This knowledge will provide significant insight for both the future human mission to an asteroid, and for potential planetary defense strategies.

EXPLANATION OF MAJOR CHANGES

None.

ORIGINS SPECTRAL INTERPRETATION RESOURCE

Formulation	Development	Operations

PROJECT PRELIMINARY PARAMETERS

OSIRIS-REx will launch in September 2016, encountering the primitive, near-Earth asteroid designated (101955) 1999 RQ36 in October 2018. The mission will study the asteroid for about two years, globally mapping the surface from distances of 5 kilometers to 0.7 kilometers. The spacecraft cameras and instruments will photograph the asteroid and measure its surface topography, composition, and thermal emissions. Radio science will provide mass and gravity field maps. This information will help the mission team select the most promising sample site, from which it will collect and return to Earth at least 60 grams of pristine material from the target asteroid. The sample return will use a capsule similar to that which returned the samples of comet 81P/Wild on the Stardust spacecraft. This will allow the sample to return and land at the Utah Test and Training Range in 2023. The capsule will then be transported to Johnson Space Center (JSC) for processing by a dedicated research facility. Subsamples will be made available for research to the worldwide science community.

ACHIEVEMENTS IN FY 2012

OSIRIS-REx completed award of the industry and university contracts for the preliminary design and technology completion phase.

WORK IN PROGRESS

In March 2013, OSIRIS-REx will complete its preliminary design review (PDR) and begin mission development, entering its final design and fabrication phase (Phase C) by June 2013.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The project will complete its critical design review.

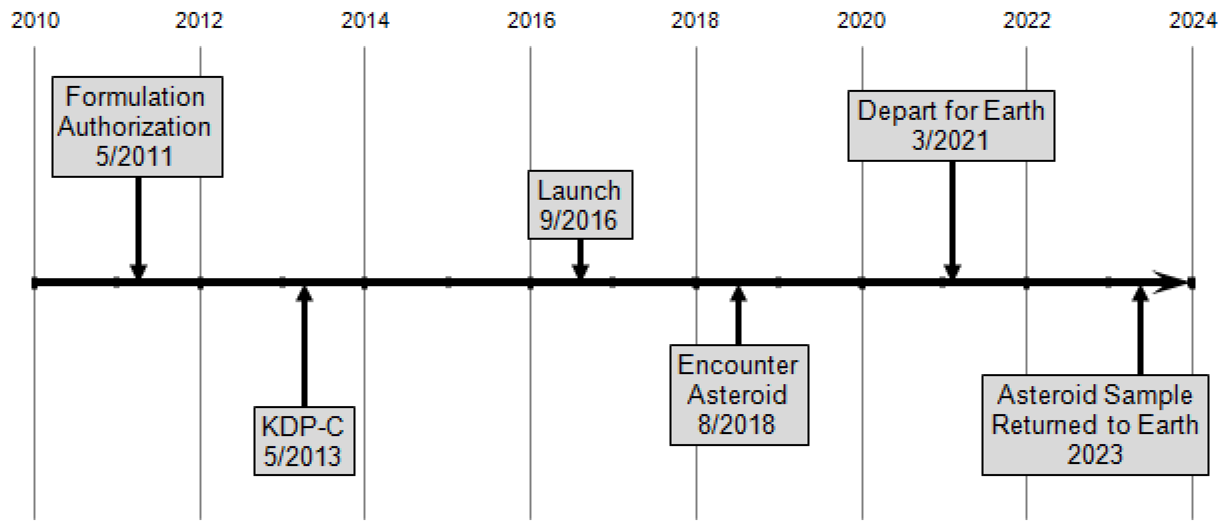
ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization	May 2011	May 2011
KDP-C	May 2013	May 2013
Launch	Sep 2016	Sep 2016
Encounter Asteroid	Aug 2018	Aug 2018
Asteroid Departure	Mar 2021	Mar 2021
Sample Earth Return	Sep 2023	Sep 2023

ORIGINS SPECTRAL INTERPRETATION RESOURCE

Formulation	Development	Operations

Project Schedule



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
May 2011	1085-1210	LRD	Mar 2016-Sep 2016

Project Management & Commitments

GSFC manages the OSIRIS-REx project and will provide systems engineering, safety and mission assurance, project scientists, flight dynamics, and the OSIRIS-REx Visible-Infrared Spectrometer (OVIRS) instrument. JSC will curate and manage the returned sample, and MSFC will manage the project under its New Frontiers Program Office. The University of Arizona will provide the principal investigator, science team coordination, Planetary Data Systems archiving, and the OSIRIS-REx Camera Suite (OCAMS) instrument.

ORIGINS SPECTRAL INTERPRETATION RESOURCE

Formulation	Development	Operations

Element	Description	Provider Details	Change from Formulation Agreement
Spacecraft	Solar energy charges lithium-ion batteries, which power the spacecraft. The Sample Return Capsule (SRC) is the same as used in the Stardust mission	Provider: Lockheed Martin Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Spacecraft Navigation	Radio science provides RQ36 mass and gravity field maps	Provider: KinetX Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
OSIRIS-REx Camera Suite (OCAMS)	Provides long-range acquisition of RQ36, along with global mapping, sample-site characterization, sample acquisition documentation, and sub-mm imaging	Provider: University of Arizona Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
OSIRIS-REx Laser Altimeter (OLA)	Provides ranging data; global topographic mapping; and local topographic maps of candidate sample sites	Provider: CSA Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: CSA	N/A
OSIRIS-REx Visible and IR Spectrometer (OVIRS)	Provides mineral and organic spectral maps and local spectral information of candidate sample sites	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
OSIRIS-REx Thermal Emission Spectrometer (OTES)	Provides mineral and thermal emission spectral maps and local spectral information of candidate sample sites	Provider: Arizona State University Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Launch Vehicle	Launch Vehicle	Provider: TBD Lead Center: KSC Performing Centers: GSFC Cost Share Partners: N/A	N/A

ORIGINS SPECTRAL INTERPRETATION RESOURCE

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: Ground performance and life testing of the guidance, navigation, and control lidar is insufficient to uncover latent defects in design or manufacturing, Then: There may be technical impacts related to reliability on orbit, affecting touch and go sampling success.	Close monitoring of subcontractor performance.
If: Maneuver design and/or execution uncertainties exceed requirements for a successful sampling touch and go, Then: The mission will not achieve the goal of collecting more than 60 grams of bulk regolith sample.	Refine preliminary design (e.g., ultrafine thrusters, onboard autonomy to adjust the checkpoint and matchpoint maneuvers to improve accuracy, additional camera head) to improve TAG accuracy.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Principal investigator/science team leadership, science operations, data archiving, and the OCAMS instrument	University of Arizona	Tucson, AZ
Spacecraft, sample acquisition mechanism, sample return capsule (SRC), integration/test, mission operations, and SRC	Lockheed Martin Space Systems Company	Denver, CO
Launch Vehicle & Services	To be completed through NASA Launch Services Program	To be determined through competition

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	SRB	N/A	Preliminary Design Review	TBD	Mar 2013
SRB	N/A	Critical Design Review	TBD	Apr 2014	

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	43.9	--	**38.8**	53.1	62.1	120.1	105.1
New Frontiers Management	2.7	--	**4.7**	4.9	5.9	5.8	6.0
New Horizons	26.5	--	**16.4**	26.8	18.5	4.6	0.0
Juno	14.4	--	**17.7**	21.4	29.5	33.4	19.5
New Frontiers Future Missions	0.0	--	**0.0**	0.0	8.2	76.3	79.7
New Frontiers Research	0.3	--	**0.0**	0.0	0.0	0.0	0.0
Change from FY 2012	--	--	**-5.1**				
Percentage change from FY 2012	--	--	**-11.6 %**				

New Frontiers Other Missions and Data Analysis supports operating New Frontiers missions (New Horizons, Juno), funding for future mission selections, and program management activities.

Mission Planning and Other Projects

NEW FRONTIERS FUTURE MISSIONS

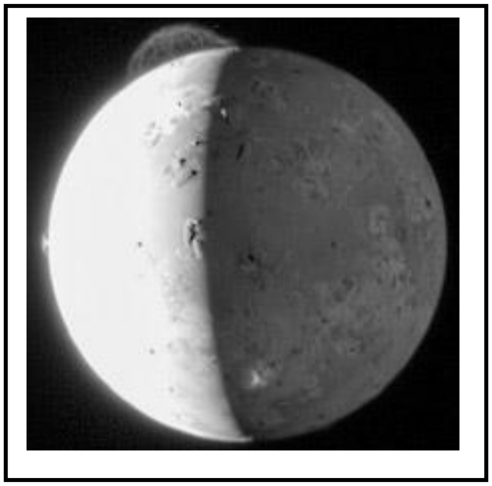
The New Frontiers Future Missions project provides funds for future space missions to be selected via a competitive Announcement of Opportunity process. The fourth announcement (NF-4) release for competition is currently planned for 2016.

NEW FRONTIERS MANAGEMENT

The New Frontiers Management Office, located at the Marshall Space Flight Center, provides the management oversight for all New Frontiers missions selected for the program. It also supports the mission selection process, through the development of Announcements of Opportunity and the establishment of independent panel reviews to evaluate mission proposals.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



Operating Missions

NEW HORIZONS

New Horizons is the first scientific investigation to obtain a close look at Pluto and its moons Charon, Nix, Hydra, P4 and P5. Scientists hope to find answers to basic questions about the surface properties, geology, interior makeup and atmospheres on these bodies, the last in the solar system to be visited by a spacecraft.

New Horizons launched on January 19, 2006. It will reach Pluto in July 2015. As part of an extended mission, the spacecraft will then venture deeper into the Kuiper Belt to study one or more of the icy mini-worlds in this region approximately two billion miles beyond Pluto's orbit.

To get to Pluto, which is three billion miles from Earth, in just 9.5 years, the spacecraft will fly by the dwarf planet and its five moons in 2015 at a velocity of about 27,000 miles per hour. The instruments on New Horizons will start taking data on Pluto and Charon months before it arrives. About three months from the closest approach, when Pluto and its moons are about 65 million miles away, the instruments will take images and spectra measurements and begin to make the first maps ever made of these intriguing bodies.

The New Horizons spacecraft will get as close as about 6,000 miles from Pluto and about 17,000 miles from Charon. During the half-hour when the spacecraft is closest to Pluto, it will take a variety of scientific observations, including close-up pictures in both visible and near-infrared wavelengths. These first images should depict surface features as small as 200 feet across and bring a plethora of new discoveries.

Recent Achievements

The New Horizons spacecraft has recently passed the halfway point between the orbits of Uranus and Neptune, zooming past another milepost on its historic trek to the planetary frontier. New Horizons has traveled more than 2.3 billion miles since launch. Pluto itself is 711 million miles (1.14 billion kilometers) away from the spacecraft, nearly eight times the distance between Earth and the Sun and closer to New Horizons than any other planet. The mission remains healthy and on course toward Pluto and the Kuiper Belt beyond.

The image above depicts the New Horizons spacecraft as it captured on Io the most detailed volcanic plume image ever seen. Io, with over 400 active volcanoes, is the innermost of the four largest moons around Jupiter and the most volcanically active object in the solar system.

Formulation	Development	Operations

JUNO

Juno will conduct an in-depth study of Jupiter, the most massive planet in the solar system. Juno's instruments will seek information from deep in Jupiter's atmosphere, enabling scientists to understand the fundamental processes of the formation and early evolution of the solar system. Juno was successfully launched on August 5, 2011 as scheduled and within the budget allocated for development of this mission.

During its approximately one-year mission, Juno, with its first-ever polar orbit, will complete 33 eleven-day-long orbits and will sample Jupiter's full range of latitudes and longitudes. From its polar perspective, Juno combines remote sensing observations to explore the polar magnetosphere and determine what drives Jupiter's remarkable auroras. Juno has an onboard camera to produce images to and it will provide unique opportunities to engage the next generation of scientists.

Recent Achievement

In February 2012, Juno successfully refined its flight path with the mission's first trajectory correction maneuver. It is the first of a dozen planned rocket firings that, over the next five years, will keep Juno on course for its rendezvous with Jupiter. The Juno spacecraft's thrusters fired for 25 minutes, consumed about 6.9 pounds (3.11 kilograms) of fuel and changed the spacecraft's speed by 3.9 feet, or 1.2 meters, per second.

MARS EXPLORATION

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	587.1	--	**234.0**	227.8	318.4	504.7	513.2
Mars Atmosphere & Volatile EvolutioN	245.7	--	**50.1**	20.2	6.6	0.0	0.0
Other Missions and Data Analysis	341.4	--	**183.9**	207.6	311.8	504.7	513.2
Change from FY 2012	--	--	**-353.1**				
Percentage change from FY 2012	--	--	**-60.1%**				

A mosaic of three Mastcam-100 images taken on sol 50 facing northeast. There is no sky visible in this view; occupying the distance is Gale's crater rim. Image Credit: NASA/JPL-Caltech/Malin Space Science Systems.

The Mars Exploration program seeks to understand whether Mars was, is, or can be, a habitable world and whether it ever supported life. As the most Earth-like planet in the solar system, Mars has a landmass approximately equivalent to the Earth's as well as many of the same geological features, such as riverbeds, past river deltas, and volcanoes. Mars also has many of the same "systems" that characterize Earth, such as air, water, ice, and geology that all interact to produce the Martian environment.

The four broad, overarching goals for Mars Exploration are to:

- Determine whether life ever arose on Mars;
- Characterize the climate of Mars;
- Characterize the geology of Mars; and
- Prepare for human exploration.

EXPLANATION OF MAJOR CHANGES

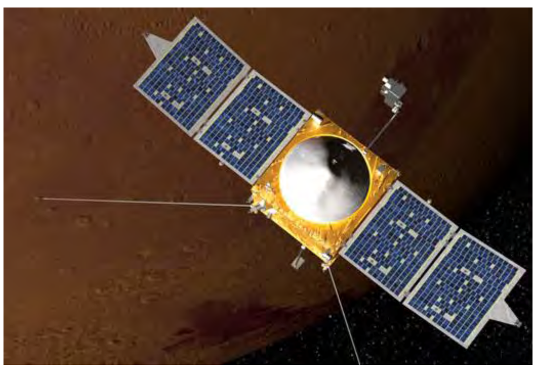
Building on the success of Curiosity's Mars landing, NASA announced plans for a robust multi-year Mars program, including a new robotic science rover set to launch in 2020. The future rover development and design will be based on the Mars Science Laboratory (MSL) architecture that successfully carried the Curiosity rover to the Martian surface in August 2012. This will ensure mission costs and risks are as low as possible, while still delivering a highly capable rover with a proven landing system. NASA will openly compete the specific payload and science instruments for the 2020 mission, following the Science Mission Directorate's established processes for instrument selection. The mission will advance the science priorities of the National Academies' 2011 Planetary Science decadal survey and respond to the findings of the Mars Program Planning Group, established in 2012, to assist NASA in restructuring its Mars Exploration program.

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	218.9	245.7	127.4	**50.1**	20.2	6.6	0.0	0.0	0.0	668.8
2014 MPAR LCC Estimate	218.9	245.7	127.4	**50.1**	20.2	6.6	0.0	0.0	0.0	668.8
Formulation	63.9	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	63.9
Development/Implementation	155.0	245.7	127.4	**22.3**	0.0	0.0	0.0	0.0	0.0	550.5
Operations/Close-out	0.0	0.0	0.0	**27.8**	20.2	6.6	0.0	0.0	0.0	54.5
Change from FY 2012		--	--	**-195.6**						
Percentage change from FY 2012		--	--	**-79.6%**						



After arriving at Mars in the fall of 2014, MAVEN will use its propulsion system to enter an elliptical orbit ranging 90 to 3,870 miles above the planet. The spacecraft's eight science instruments will take measurements for a full Earth year, obtaining critical measurements that the National Academy of Science listed high priority in their 2003 decadal survey on planetary exploration.

PROJECT PURPOSE

MAVEN will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses, to determine how the Mars atmosphere evolved through time. The mission will help answer long-standing questions regarding the loss of the Mars atmosphere, climate history, liquid water, and habitability. MAVEN will provide the first direct measurements ever taken to address key scientific questions about Mars' evolution. The MAVEN mission is part of NASA's Mars Scout program. Set to launch in 2013, the mission will explore the Mars upper atmosphere, ionosphere, and interactions with the Sun and solar wind. Scientists will use MAVEN data to determine the role that loss of volatile compounds (such as carbon dioxide, nitrogen dioxide, and water) from the Mars atmosphere to space has played through time, giving insight into the history of Mars' atmosphere and climate, liquid water, and planetary habitability. As with all Mars Exploration program orbiters, MAVEN will also carry an Electra radio for communications with rovers on the Mars surface.

EXPLANATION OF MAJOR CHANGES

None.

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

PROJECT PARAMETERS

The MAVEN project will deliver science using three instrument packages: a standalone neutral gas and ion mass spectrometer, capable of measuring thermal neutrals and ions; a standalone imaging ultraviolet spectrometer; and the Particles and Fields package, consisting of six instruments measuring ionospheric properties, energetic ions, solar wind and solar energetic particles, magnetic fields, and solar extreme ultraviolet irradiance.

ACHIEVEMENTS IN FY 2012

MAVEN completed the Systems Integration Review (SIR) in June 2012, and NASA approved it to enter Phase D in September 2012. In August 2012, a few weeks ahead of schedule, the MAVEN observatory began assembly, test, and launch operations. The Electra UHF radio was delivered to the observatory on time in August 2012.

WORK IN PROGRESS IN FY 2013

MAVEN is currently in the assembly, test, and launch operations phase, as it readies for shipment to Kennedy Space Center. This will be followed by integration with the launch vehicle in advance of launch in November 2013. The scientific instruments are in final testing, calibration, and preparation to ship to the spacecraft in Denver. The observatory, the spacecraft with the Electra radio and science instruments integrated, is on schedule to ship to Kennedy in August 2013. The Mission Operations Review was held in November 2012, and Operational and Flight Readiness Reviews are on schedule for the end of FY 2013.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

MAVEN is currently scheduled to launch in November 2013 after being shipped to the Kennedy Space Center late in FY 2013. MAVEN is expected to enter Mars orbit in FY 2015.

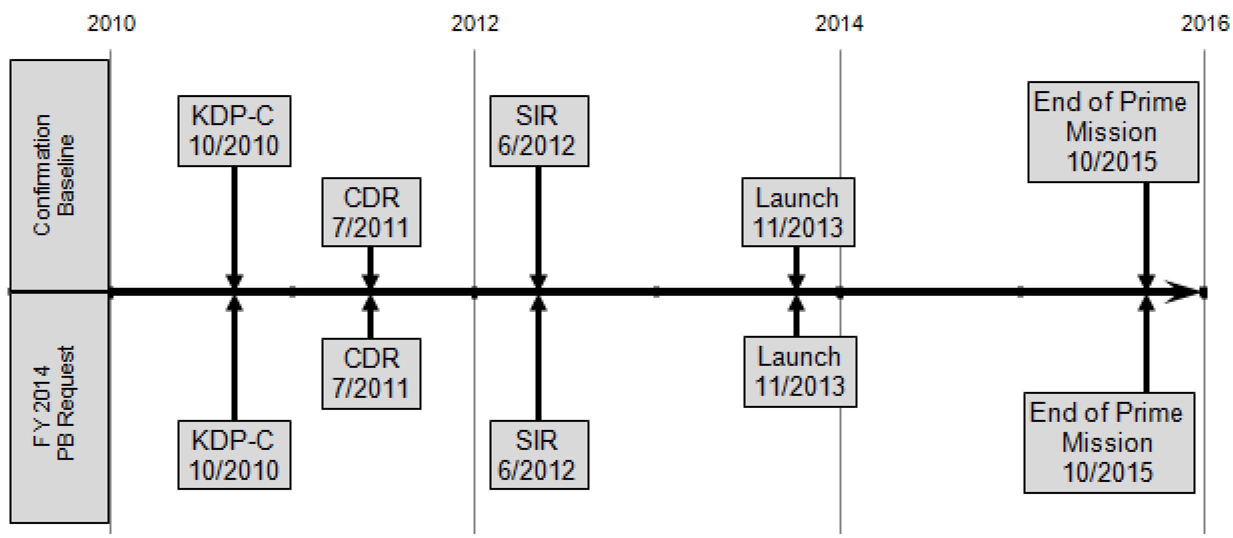
SCHEDULE COMMITMENTS/KEY MILESTONES

Milestone	Confirmation Baseline Date	FY 2014 PB Request Date
KDP-C	Oct 2010	Oct 2010
CDR	Jul 2011	Jul 2011
SIR	Jun 2012	Jun 2012
Launch	Nov 2013	Nov 2013
End of Prime Mission	Oct 2015	Oct 2015

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

Project Schedule



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2011	567.2	70	2013	550.5	-2.9%	LRD	Nov 2013	Nov 2013	0

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**567.2**	**550.5**	**-16.7**
Aircraft/Spacecraft	146.0	167.3	21.3
Payloads	51.1	59.9	8.8

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

Systems I&T	23.0	26.9	3.9
Launch Vehicle	187.0	168.7	-18.3
Ground Systems	5.2	16.2	11.0
Science/Technology	2.2	2.9	0.7
Other Direct Project Costs	152.7	108.5	-44.2

Project Management & Commitments

The MAVEN project is part of the Mars Exploration program managed for NASA by the Mars Program Office at JPL. The principal investigator for MAVEN is from the University of Colorado and has delegated the day-to-day management of the MAVEN project to NASA's Goddard Space Flight Center (GSFC).

Project Element	Description	Provider	Change from Baseline
Spacecraft	MRO heritage spacecraft bus and avionic suite, with cross strapping and monopropellant propulsion	Provider: Lockheed Martin Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Launch Vehicle	Atlas V launch vehicle and related launch services	Provider: ULA Lead Center: KSC Performing Centers: KSC Cost Share Partners: N/A	N/A
Neutral gas and ion mass spectrometer	Design, build, and deliver the instrument	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Magnetometer	Design, build, and deliver (part of the MAVEN Particle and Fields Instrument package)	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Imaging Ultraviolet Spectrometer	Design, build, and deliver remote sensing instrument package.	Provider: University of Colorado, LASP Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

Electra	Design, build, and deliver UHF Data Relay payload	Provider: JPL Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Supra Thermal Ion Composition	Design, build, and deliver (part of Particle and Fields Instrument package)	Provider: SSL Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Solar Energetic Particles	Design, build, and deliver UHF Data Relay payload	Provider: SSL Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Solar Wind Electron Analyzer	Design, build, and deliver UHF Data Relay payload	Provider: SSL Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Solar Wind Ion Analyzer	Design, build, and deliver the NGIMS instrument	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A
Lanamuir Probe and Waves and EUV	Design, build, and deliver UHF Data Relay payload	Provider: SSL Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	N/A

Project Risks

Risk Statement	Mitigation
If: Single point failures on the input of the HEPS card occur, Then: Permanent loss of spacecraft electrical power will result.	The project and GSFC Mission Assurance Office are identifying and understanding HEPS-specific manufacturing techniques; identifying all point failures to inspect during assembly to mitigate against shorts; developing a plan for insight/oversight of the 2013 MAVEN-specific HEPS card build; reviewing board requirements with an eye towards design robustness and remaining design requirements.

MARS ATMOSPHERE & VOLATILE EVOLUTION

Formulation	Development	Operations

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Spacecraft, flight system, integration and test, mission operations	Lockheed Martin Space Systems Company	Denver, CO
Launch vehicle and services	United Launch Alliance	Cape Canaveral, FL

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Standing Review Board (SRB)	Jul 2011	Critical Design Review	MAVEN passed CDR and was approved to continue to the next phase	Late FY 2013
Performance	SRB	Jun 2012	SIR Review	MAVEN passed SIR and was approved to continue to the next phase	Late FY 2013

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	341.4	--	**183.9**	207.6	311.8	504.7	513.2
Mars Research and Analysis	19.3	--	**19.5**	19.5	19.5	19.5	19.5
Mars Technology	5.0	--	**4.0**	4.0	4.0	4.0	4.0
Mars Mission Operations	1.8	--	**1.8**	1.9	1.9	1.9	1.9
Mars Extended Operations	0.0	--	**0.0**	82.3	91.3	97.3	93.3
Mars Future Missions	8.0	--	**10.7**	54.7	166.1	360.0	376.4
Mars Program Management	23.4	--	**15.5**	16.1	16.4	15.7	15.6
2011 Mars Science Lab	174.0	--	**47.1**	5.7	0.0	0.0	0.0
Mars Odyssey 2001	13.3	--	**12.8**	0.0	0.0	0.0	0.0
Mars Exploration Rover 2003	15.0	--	**14.7**	0.0	0.0	0.0	0.0
Mars Express	2.1	--	**2.2**	0.0	0.0	0.0	0.0
Mars Reconnaissance Orbiter 2005	39.9	--	**30.5**	0.0	0.0	0.0	0.0
Mars Organic Molecule Analyzer	12.6	--	**20.0**	20.0	10.0	5.0	1.0
2016 ExoMars Trace Gas Orbiter	27.1	--	**0.0**	0.0	0.0	0.0	0.0
ExoMars	0.0	--	**5.1**	3.4	2.6	1.3	1.4
Change from FY 2012	--	--	**-157.5**				
Percentage change from FY 2012	--	--	**-46.1 %**				

Mars Exploration Other Missions and Data Analysis currently includes five operating missions: 2001 Mars Odyssey, 2003 Mars Exploration Rover/Opportunity, Mars Express, 2005 Mars Reconnaissance Orbiter (MRO), and the 2011 Mars Science Laboratory (MSL) that successfully launched on November 26, 2011, and landed on August 6, 2012. Six non-mission components are also included: Mars Research and Analysis, Mars Technology, Mars Mission Operations, Mars Extended Operations, Mars Future Missions, and Mars Program Management. Also included are the Mars Organics Molecule Analyzer (MOMA) instrument to fly on ESA's 2018 ExoMars rover, and Electra radios flying on ESA's 2016 ExoMars Trace Gas Orbiter (EMTGO).

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Mission Planning and Other Projects

MARS RESEARCH AND ANALYSIS

Mars Research and Analysis (R&A) provides funding for research and analysis of Mars mission data in order to understand how geologic, climatic, and other processes have worked to shape Mars and its environment over time, as well as how they interact today. Specific investments include:

- Mars Fundamental Research program, which funds fundamental research in laboratory studies, field studies, or theoretical studies that inform researchers about Mars;
- Mars Data Analysis, which analyzes archived data collected on Mars missions;
- Critical Data Products, which provides data for the safe arrival, aero-maneuver, entry, descent, and landing at Mars; and
- MRO and MSL Participating Scientists programs for the MRO and MSL missions.

Data analysis through Mars R&A allows a much broader and objective analysis of the data and samples. It also allows research to continue for many years after the mission has been completed. Fundamental measurements and discoveries and testable hypotheses about the Martian environment are made through these programs.

Recent Achievements

The Mars R&A programs provided funding for more than 200 research projects, with more than 45 new awards in FY 2012, which included 3 new graduate student research fellowships. These projects increase our scientific understanding of Mars' geology and environment, and the results are disseminated through publication in the scientific literature. Mars R&A funded work to identify potential hazards and landing sites for future missions, including human missions.

MARS TECHNOLOGY

Mars Technology focuses on technological investments that lay the groundwork for successful future Mars missions, such as sample handling and processing technologies; entry, descent, and landing capabilities; and surface-to-orbit communications improvements (e.g. Electra).

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

Mars Technology completed three industry studies in FY 2012. These defined options for acquiring core samples and transferring them to a cache. The studies focused on their adaptability to various sizes and configurations of potential future missions.

MARS MISSION OPERATIONS

Mars Mission Operations provides management and leadership for the development and operation of Mars multi-mission systems for operations. Mars Mission Operations supports and provides common operational systems and capabilities at a lower cost and risk than having each Mars project produce systems individually.

MARS EXTENDED OPERATIONS

Mars Extended Operations provides funding to Mars Exploration program missions that have concluded their primary mission phase, thereby allowing for continued science operations and discoveries as long as the spacecraft and its instruments are healthy. Funding for mission extensions is allocated based on the findings of an annual, competitive Senior Review Board process. The review of each mission enables the Board to make recommendations for the allocation of the extended operations budget based on scientific merit and communications relay infrastructure needs.

MARS FUTURE MISSIONS

Mars Future Missions provides funds for the planning of future missions to Mars that build on scientific discoveries from past missions and incorporate the lessons learned from previous missions. The Mars Exploration program is working with the Human Exploration and Operations Mission Directorate (HEOMD) to define future robotic missions that support science and exploration requirements in an integrated strategy.

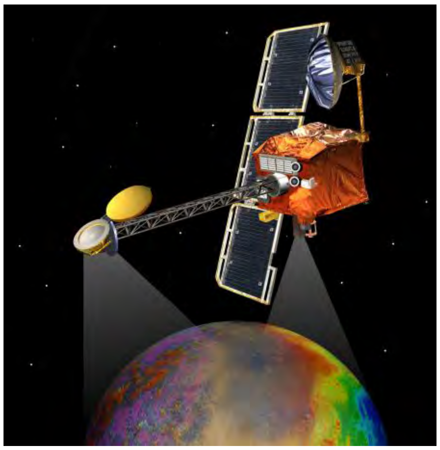
MARS PROGRAM MANAGEMENT

Mars Program Management provides for the broad-based implementation and programmatic management of the Mars Exploration program. Mars Program Management also supports independent panel reviews, studies regarding planetary protection, advanced mission studies and program architecture, program science, and telecommunications coordination and integration.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Operating Missions



2001 MARS ODYSSEY

2001 Mars Odyssey, currently in its fifth extended mission operations phase, is still in orbit around Mars. It continues to send information to Earth about Martian geology, climate, and mineralogy. Measurements by Odyssey have enabled scientists to create maps of minerals and chemical elements and identify regions with buried water ice. Images that measure the surface temperature have provided spectacular views of Martian topography. Mars Odyssey will continue critical long-term longitudinal studies of the Martian climate. Odyssey has served as the primary means of communications for NASA Mars surface explorers over the past decade and will continue that role for the Curiosity rover. The Odyssey orbiter continues to provide a communications relay for the Mars Exploration Rover "Opportunity." Transmitting over 95 percent of the data from the rover to Earth, Odyssey will support the rover throughout its extended mission. Just as they did for the 2003 rovers, scientists and engineers used the Mars Odyssey Spacecraft, as shown in the above image, to identify potential landing sites for the Curiosity rover.

Recent Achievements

2001 Mars Odyssey has become the longest lived Martian spacecraft in history (more than 11 years). Odyssey's longevity enables continued science, including the monitoring of seasonal changes on Mars from year to year and the most detailed global maps ever made of the planet. Odyssey served as the primary communication relay for the Mars Exploration Rover Opportunity and continues to be a key communications link for Mars Science Laboratory/Curiosity.

2003 MARS EXPLORATION ROVER

2003 Mars Exploration Rover Opportunity, which is currently on its eighth extended operations phase, continues to explore geological settings on the surface of Mars. It continues to expand understanding of the history and the geological processes that shaped Mars, particularly those involving water. Opportunity has trekked for 35 kilometers, or 21 miles, across the Martian surface, conducting field geology, making atmospheric observations, finding evidence of ancient Martian environments where intermittently wet and habitable conditions existed, and sending back to Earth nearly 175,000 spectacular, high-resolution images.

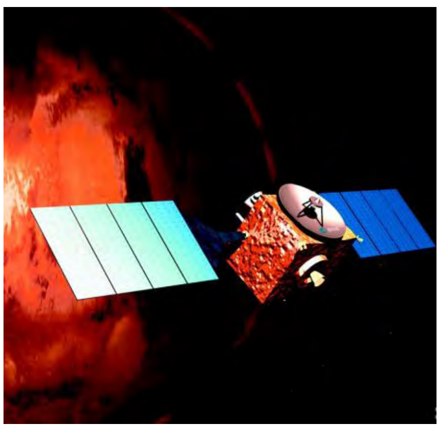
OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

Study of sulfate-rich sands at Eagle and Endurance Craters revealed evidence of playa lakes that repeatedly formed and evaporated. The sands within the lakes were subsequently reworked by water and wind, solidified into rock, and soaked by groundwater.

In August 2012, Opportunity achieved a significant milestone by arriving at Endeavour Crater, where the compositions of rocks vary in age from recent to ancient.

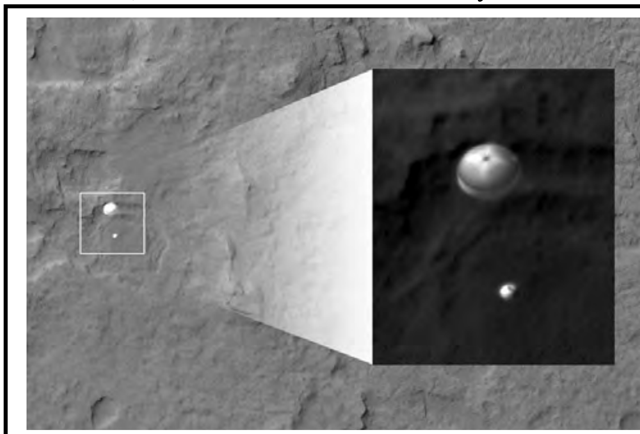


MARS EXPRESS

In the depiction to the left, the Mars Express mission is shown exploring the atmosphere and surface of Mars from polar orbit. Mars Express, currently in its third extended mission operations phase, is a European Space Agency mission that provides an understanding of Mars as a "coupled" system—from the ionosphere and atmosphere down to the surface and sub-surface. This mission addresses the climatic and geological evolution of Mars as well as the potential for life on the planet. NASA contributed components for the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) and ASPERA instruments aboard Mars Express and participates in the scientific analysis of mission data. Mars Express provides valuable context for the MAVEN mission by providing measurements of the upper Martian atmosphere and ionosphere during the solar maximum that occurs in FY 2013 to FY 2014.

Recent Achievements

This past year, the MARSIS instrument successfully observed the Northern Polar cap. These observations provided improved water estimates of water and enhanced understanding of the Martian ionosphere. This will provide valuable context for NASA's MAVEN mission, which will be launched in a year and arrive at Mars in September 2014. These measurements provide more insights into how the Martian atmosphere and ionosphere interact with the solar wind and how Mars may have lost its atmosphere.



2005 MARS RECONNAISSANCE ORBITER

2005 Mars Reconnaissance Orbiter (MRO), currently in its second extended operations phase, carries the most powerful camera ever flown on a planetary exploration mission. While previous cameras on other Mars orbiters were able to identify objects no smaller than a table, this camera is able to spot something as small as a chair. This capability provides not only a more detailed view of the geology and structure of Mars, but helps identify obstacles that could jeopardize the safety of future landers and rovers. MRO also carries a sounder to find subsurface water, an important consideration in selecting scientifically worthy landing sites for future exploration. Other science instruments on this spacecraft identify surface minerals and study how dust and water are transported in the Martian atmosphere. A second camera acquires medium-resolution images that provide a broader geological and meteorological context for more detailed observations from higher-resolution instruments. MRO will follow up on recent discoveries to determine the extent of ancient aqueous environments, reveal the 3-D structure and content of the polar ice deposits, characterize the episodic nature of great dust storms, and detect seasonal flows of liquid (probably briny) water on Mars today. As depicted in the image on the previous page, MRO is capturing unique views of Mars with the most powerful telescopic camera ever to orbit another planet. MRO also serves as a major installment of an "interplanetary Internet," a crucial service for future spacecraft to communicate back to Earth.

Recent Achievements

2005 MRO data reveals a growing collection of evidence indicating that the present surface of Mars is still geologically active. One of the most exciting discoveries is dark markings or streaks, 0.5 to 5 meters in width on steep slopes (greater than 25 degrees) that form and incrementally grow in late spring to summer, then fade or disappear in fall. They reform at nearly the same locations in multiple Mars years, extending down-slope from bedrock outcrops or rocky areas, and are often associated with small channels on equator-facing slopes in the southern hemisphere. The streaks grow in temperatures at which brines (waters that have high concentrations of dissolved minerals, largely salts) would be liquid.

MARS SCIENCE LABORATORY/CURIOSITY (MSL)

Mars Science Laboratory and its Curiosity rover, which successfully landed in August 2012, take a major step forward in Mars exploration, using a new entry, descent, and landing system; a long-duration rover; and ten payload instruments for definitive mineralogical and organics measurements. MSL is exploring and quantitatively assessing a local region on Mars as a potential habitat for life. MSL is twice as long and three times as heavy as the Mars Exploration Rover Opportunity. The Curiosity rover is collecting Martian soil and rock samples and analyzing them for organic compounds and environmental conditions that could have supported microbial life in the past or even now. MSL is the first planetary mission to use precision landing techniques, steering itself toward the Martian surface. This landing method enabled the rover to land in an area less than 20 kilometers in diameter, about one-sixth the size of previous landing zones on Mars. This international partnership mission uses components provided by the space agencies of Russia, Spain, and Canada.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

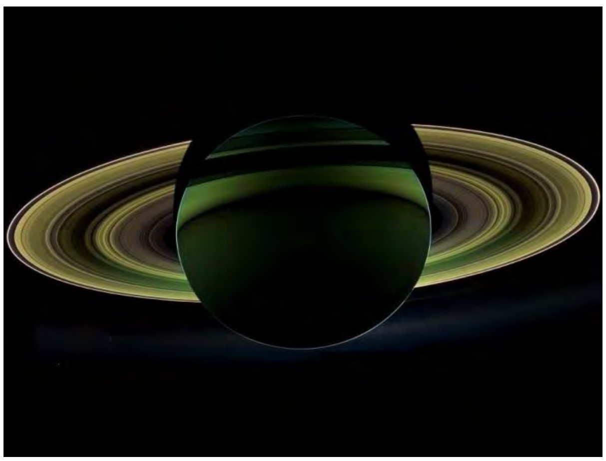
Recent Achievements

Upon landing, Curiosity completed a series of automated sequences to validate that all systems are operating as expected. The rover made its first drive into the scientifically rich landing zone prior to heading off towards the base of Mount Sharp in the middle of Gale Crater. It has already made incredible discoveries that have changed our understanding of Mars, such as evidence of vigorous, flowing streambed deposits on Mars and evidence of atmospheric loss.

OUTER PLANETS

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	122.1	--	**79.0**	45.6	24.4	26.4	26.4
Change from FY 2012	--	--	**-43.1**				
Percentage change from FY 2012	--	--	**-35.3 %**				



While the Cassini spacecraft was in Saturn's shadow, the cameras were turned toward Saturn and the sun so that the planet and rings are backlit. In addition to the visual splendor, this special, very-high-phase viewing geometry lets scientists study ring and atmosphere phenomena not easily seen at a lower phase. Taken when Cassini was closer to Saturn than a similar image in 2006, it shows more detail in the rings.

The Outer Planets program enables science investigations spanning the diverse geography and disciplines of the outer solar system. The strategic missions in this portfolio investigate a broad array of science disciplines with more depth than is possible for smaller, tightly focused missions in the Discovery and New Frontiers programs. The science discoveries made by these strategic missions provide answers to long-held questions and theories about the origin and evolution of outer planets.

EXPLANATION OF MAJOR CHANGES

NASA added Jupiter Icy Moons Explorer (JUICE; an ESA-led mission to Ganymede and the Jupiter system) as a program element, as identified in the FY 2012 Operating Plan.

ACHIEVEMENTS IN FY 2012

The Europa Study Team submitted its final report in response to the recommendation by the decadal survey to immediately examine ways to reduce the cost of the mission. The report outlined three mission concepts covering the diversity of possible mission types, including a lander, an orbiter, and a fly-by mission. The budget, however, does not, and cannot, accommodate any of these mission concepts at this time.

WORK IN PROGRESS IN FY 2013

In FY 2013, NASA and ESA are collaborating on JUICE payload recommendations. On February 21, 2013, following consultation with ESA, NASA announced the selection of one U.S.-led science instrument, plus hardware contributions for two European instruments. The selected teams are already beginning to work with ESA.

OUTER PLANETS

KEY ACHIEVEMENTS PLANNED FOR FY 2014

JUICE instruments development will continue based on the approved schedule.

Cassini will observe seasonal and temporal change in the Saturn system to understand: (1) hemispherically asymmetric behavior on Titan, (2) the role of sunlight in Enceladus plume activity, and (3) the origin of surprising asymmetry in Saturnian polar circulation.

Mission Planning and Other Projects

JUPITER ICY MOONS EXPLORER (JUICE)

NASA has committed to supporting US investigators and instruments on an ESA-led mission to Ganymede and the Jupiter system. Planned for launch in 2022, the mission has a tentative model payload of 11 scientific instruments, and will arrive at Jupiter in 2030.

OUTER PLANETS FLAGSHIP

The Outer Planets Flagship project is not funded in FY 2014. NASA is not able to support development of an Outer Planets Flagship mission in the foreseeable future. Instead, as described in the Mars Exploration Program section, available funding supports a future Mars program that is consistent with the first priority of the National Academies' decadal survey for planetary research.

OUTER PLANETS RESEARCH

Outer Planets Research increases the scientific return of current and past NASA outer planets missions, guides current mission operations (e.g., selecting Cassini imaging targets), and paves the way for future missions (e.g., refining landing sites on Titan, reconsidering the ice shell thickness on Europa). The competitive programs within the Outer Planets Research effort increase understanding of the origin and evolution of the outer solar system and broaden the science community’s participation in the analysis of data returned by Cassini, Galileo, New Horizons, and other missions.

Operating Missions

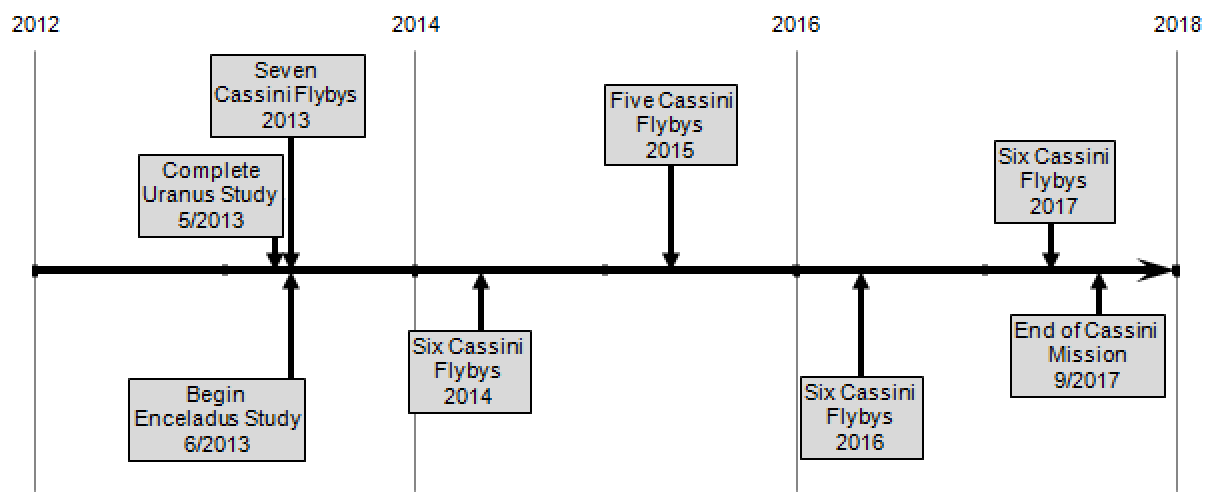
CASSINI

Cassini, in its extended operations phase, is a flagship mission in orbit around Saturn that has altered our understanding of the planet, its famous rings, magnetosphere, icy satellites, and particularly the moons Titan and Enceladus. It is exploring the Saturn system in detail, including its rings and moons. A major focus is Saturn’s largest moon, Titan, with its dense atmosphere, methane-based meteorology, and geologically active surface. The Solstice mission will observe seasonal and temporal change in the Saturn system, especially at Titan, to understand underlying processes and prepare for future missions. The

OUTER PLANETS

Solstice mission will continue to operate and conduct data analysis through September 2015, at which time it will undergo competitive Senior Review with all other PSD operating missions. Pending successful Senior Review in 2015, the mission will conclude in 2018, after another 155 revolutions around the planet, 54 flybys of Titan, and 11 flybys of Enceladus. In 2017, an encounter with Titan will change its orbit in such a way that, at closest approach to Saturn, it will be only 3,000 kilometers above the planet's cloud tops, and below the inner edge of the D ring. This sequence of approximately 15 "proximal orbits" will provide an opportunity for an entirely different mission for the Cassini spacecraft, investigating science questions never anticipated at the time Cassini was launched. Cassini completed its prime mission in July 2008, completed its Equinox extended mission in July 2010, and began the Solstice extended mission in October 2010. The Cassini mission will end when another encounter with Titan will send the Cassini probe into Saturn's atmosphere.

Program Schedule



Program Management & Commitments

Management responsibility for Cassini resides at JPL. Scientific mission priorities for the program and the research efforts reside within the Science Mission Directorate's Planetary Science Division.

The Cassini mission is a cooperative project of NASA, the ESA, and the Italian Space Agency.

Cassini is committed to continue delivery of science data until 2018, contingent upon health and status of the spacecraft.

Program Element	Provider
Outer Planets Research	Provider: HQ Lead Center: Performing Centers: Multiple Cost Share Partners: N/A
Cassini	Provider: JPL Lead Center: JPL Performing Center: JPL Cost Share Partners: The Italian Space Agency provided Cassini's high-gain communication antenna and the Huygens probe was built by ESA.

Acquisition Strategy

Outer Planets Research is included in the annual Research Opportunities in Space and Earth Sciences (ROSES) NASA Research Announcement (NRA). All major acquisitions and contracts for Cassini are in place.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Independent Review Board	Mar 2012	Review of the three Outer Planet (Europa) Flagship Mission concepts were found to have valuable science, acceptable implementation risks, and the costs were reduced in accordance with the Decadal survey recommendation.	The Europa Lander was found to have excessive cost and technical risks and not recommended for development.	Feb 2013

TECHNOLOGY

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	161.9	--	**150.9**	142.8	144.7	154.4	140.0
Change from FY 2012	--	--	**-11.0**				
Percentage change from FY 2012	--	--	**-6.8 %**				

Curiosity took this self-portrait which shows its Multi-Mission Radioisotope Thermoelectric Generator or MMRTG, essentially a nuclear battery that reliably converts heat from the natural decay of the radioisotope into electricity. Instead of the solar panels used on Spirit and Opportunity, this power source was selected to provide greater mission flexibility in accessing difficult or remote terrain and enable continuous operation in the dusty Martian environment and throughout its winter season. The heat is also distributed internally to maintain effective operating temperatures for its instruments and systems.

Planetary Science missions demand advances in both power and propulsion systems to enable successful trips to harsh environments, far distances from the Sun that cannot be easily solar powered, and missions with highly challenging trajectories and operations. To meet these needs, Planetary Science supports multi-mission capabilities and technology developments in key spacecraft systems, such as propulsion and power, and mission operations. The Planetary Science Technology program includes the In-Space Propulsion (ISP), Radioisotope Power Systems (RPS), Advanced Multi-Mission Operations System (AMMOS), and Plutonium projects.

EXPLANATION OF MAJOR CHANGES

To sustain the necessary capacity to meet future missions' power needs, the FY 2014 NASA budget request includes an additional $50 million to support radioisotope power system production infrastructure at the Department of Energy (DOE).

ACHIEVEMENTS IN FY 2012

The Radioisotope Power Systems (RPS) program continued to advance the development of the Advanced Stirling Radioisotope Generator (ASRG), completing the Delta Final Design Review process late in 2012. RPS made significant advances in alternate power sources for future missions. For example, the RPS program funded significant technology advances in advanced Stirling control systems and thermoelectric power conversion. The program also supported the first test of a heat-pipe cooled reactor for potential space applications, performed by Los Alamos National Lab with Stirling power converters supplied by NASA Glenn Research Center.

TECHNOLOGY

WORK IN PROGRESS IN FY 2013

The ASRG project team continues to solve design challenges and will complete two flight units for a mission to be launched in 2016 or later.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, RPS will complete an extended performance testing of the ASRG engineering unit and complete the development of a flight qualification unit to enable delivery of two ASRG flight units for a future flight opportunity. RPS will continue the development of advanced radioisotope thermoelectric generator couples by validating lifetime and four-couple module power. RPS will also fund DOE safety testing to verify safety models for solid upper stages.

The Technology program will assume responsibility for the funding of DOE's program, including its base infrastructure (see Program Elements below).

Program Elements

IN-SPACE PROPULSION (ISP)

ISP invests in high-priority technology areas such as the electric propulsion and aerocapture/Earth entry, descent, and landing technologies identified in the Planetary Science secadal survey. Main areas of emphasis include completing Earth Entry Vehicle heat shield micrometeoroid/orbital debris characteristics studies, preliminary design of a Multi-Mission Earth Entry Vehicle concept, and related technology developments; initiating thruster short-duration wear testing; and continuing other subsystem technology developments for the High Voltage Hall Accelerator thruster technology applicable to Earth Return Vehicles, transfer stages, and low-cost electric propulsion systems for Discovery-class missions.

RADIOISOTOPE POWER SYSTEMS (RPS)

The RPS program was chartered for implementation on March 24, 2011. The RPS program also funds crosscutting multi-mission activities to ensure that development, implementation, and approval of radioisotope power systems are ready when needed by the missions. This work includes the National Environmental Policy Act (NEPA) process development, multi-mission launch vehicle data book development, safety analysis, and testing. The program also assumes responsibility for performing RPS mission studies, sustaining needed RPS capabilities, and providing crosscutting launch approval activities. However, funds are not included within the RPS budget for the procurement of nuclear material required to support missions in formulation. RPS is structured to manage both the technology investments and systems development, such as the development and testing of the ASRG. The program transitions acquisition of flight units to a mission-specific user.

TECHNOLOGY

DOE RADIOISOTOPE POWER SYSTEM INFRASTRUCTURE

A new project has been established to ensure that NASA supports the DOE radioisotope power system production infrastructure. Beginning in FY 2014, the DOE Space and Defense Infrastructure subprogram is transitioning to a full cost recovery funding model. Funding to support this infrastructure is now included in NASA's budget request. NASA is currently the only user of radioisotope power systems. If additional users for radioisotope power systems emerge in future years, NASA will work with DOE to determine an equitable funding arrangement. NASA will review the currently available infrastructure at DOE, identify the capabilities needed, and provide those requirements to DOE.

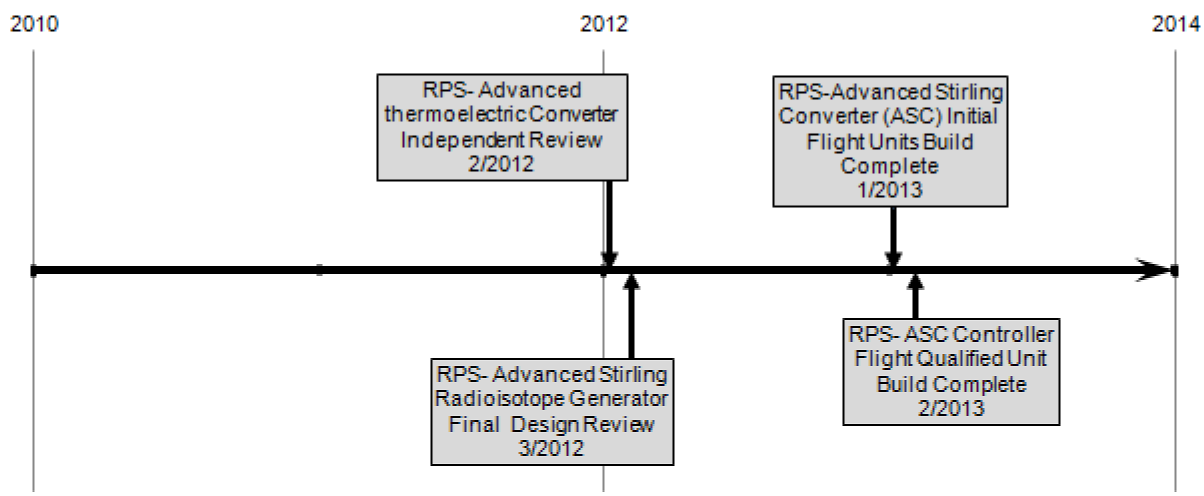
ADVANCED MULTI-MISSION OPERATION SYSTEM (AMMOS)

AMMOS provides multi-mission operations, navigation, design, and training tools for Planetary Science flight missions and invests in improved communications and navigation technologies. The AMMOS project will continue to provide and develop multi-mission software tools for spacecraft navigation and mission planning throughout FY 2014. In addition, AMMOS will pursue complementary collaborations with the Agency's crosscutting Space Technology program.

PLUTONIUM

NASA and DOE have begun implementing a Plutonium (Pu-238) Supply Project to restart domestic production under a DOE Pu-238 production program. NASA continues to work with DOE to assess the need and schedule for plutonium supplies to respond to the diminishing inventory of Pu-238 available to NASA missions from past US production and material purchased from Russia. Based on the studies of the Planetary decadal survey mission set, NASA revalidated the need for Pu-238 production to support NASA missions, as current inventory will be exhausted by scheduled missions within the next decade.

Program Schedule



Program Management & Commitments

Program Element	Provider
ISP	Provider: GRC Lead Center: GRC Performing Centers: GRC, MSFC, JPL, LaRC, ARC, GSFC Cost Share Partners: N/A
RPS	Provider: GRC Lead Center: GRC Performing Center: GRC, JPL, KSC Cost Share Partners: Department of Energy
AMMOS	Provider: JPL Lead Center: JPL Performing Center: JPL Cost Share Partners: None
Plutonium	Provider: Department of Energy Lead Center: HQ Performing Center: GRC Cost Share Partners: None
DOE RPS Infrastructure	Provider: Department of Energy Lead Center: HQ Performing Center: HQ Cost Share Partners: None

Acquisition Strategy

Technology activities are solicited using the ROSES NASA Research Announcement, and selections are made using a competitive, peer-reviewed process. DOE completed an acquisition for ASRG flight system development: Lockheed Martin for RPS. Jet Propulsion Laboratory provides management and the navigation and space communication software tools.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Advanced Stirling Radioisotope Generator (ASRG)	Department of Energy Lockheed Martin	Idaho National Laboratory, Los Alamos National Lab, Oak Ridge National Lab, Denver CO
Mars Ascent Vehicle	ATK Lockheed Martin Northrop Grumman	Elkton, MD Denver, CO Los Angeles, CA

TECHNOLOGY

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Relevance	National Academies	Dec 2010	Assessing the restart and sustainment of domestic production of radioisotope heat source material for deep space and other exploration missions. Assessing the development of and standards for flight certification of ASRG for flagship and other missions.		TBD
Performance	SRB/IPAO	Sep 2010	Program Implementation Review.	Based on the program readiness and SRB recommendation, subsequent Agency approval was granted to the RPS program on Dec 9, 2010, by the Agency Program Management Council.	Sep 2012

ASTROPHYSICS

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	648.4	--	**642.3**	670.0	686.8	692.7	727.1
Astrophysics Research	165.5	--	**147.6**	170.6	192.3	207.2	218.5
Cosmic Origins	239.9	--	**228.0**	216.5	193.1	196.7	194.1
Physics of the Cosmos	108.3	--	**110.4**	107.5	100.0	82.8	86.4
Exoplanet Exploration	50.8	--	**55.4**	59.4	57.7	60.7	90.7
Astrophysics Explorer	83.9	--	**100.9**	116.0	143.8	145.3	137.4

Astrophysics

ASTROPHYSICS RESEARCH

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	165.5	--	**147.6**	170.6	192.3	207.2	218.5
Astrophysics Research and Analysis	68.6	--	**65.7**	68.3	70.2	71.5	71.5
Balloon Project	31.6	--	**32.9**	32.8	34.2	34.3	34.3
Other Missions and Data Analysis	65.3	--	**49.1**	69.4	87.9	101.3	112.7
Change from FY 2012	--	--	**-17.9**				
Percentage change from FY 2012	--	--	**-10.8 %**				

A research balloon is inflated for launching a science payload in Antarctica. Large unpiloted helium balloons provide NASA with an inexpensive means to place payloads into a space environment. Scientific ballooning has contributed significantly to NASA's science program, both directly with science coming from measurements made by balloon-borne instruments, and indirectly by serving as a test platform on which instruments have been developed that were subsequently flown on NASA space missions.

The Astrophysics Research program analyzes the data from NASA missions to understand astronomical events such as the explosion of a star, the birth of a distant galaxy, or the nature of planets circling other stars. The program also enables the early development of new technologies for future missions, and suborbital flights of experimental payloads on balloons and sounding rockets.

The program facilitates basic research for scientists to test their theories, and to understand how they can best use data from NASA missions to develop new knowledge about the cosmos.

EXPLANATION OF MAJOR CHANGES

The reduction from the FY 2013 request reflects the consolidation of STEM education funds within the Department of Education, the National Science Foundation, and the Smithsonian Institution as part of an Administration initiative. It also reflects the transfer of funding for Keck Single Aperture observations to the Keck Operations project in the Exoplanet Exploration program, to consolidate funding for Keck, without any reduction in content. Funding has also been allocated to other programs for the extension of nine selected operating missions, consistent with the 2012 Senior Review.

ACHIEVEMENTS IN FY 2012

NASA chose a first cohort of fellows of the Nancy Grace Roman Technology Fellowship in FY 2012; proposals for a second cohort are now pending. This fellowship was created in 2011 in Astrophysics to develop early career researchers, who could lead future astrophysics flight instruments, projects, and missions.

Consistent with Decadal Survey recommendations, total funding for the competed research programs was increased roughly nine percent from the level in FY 2011. The program maintained its emphasis on suborbital payloads and on enhancing development of key technologies for use in future missions.

The Balloon project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to space flight application. NASA conducted nine scientific balloon launches during four campaigns from the United States, Sweden, and Antarctica. A successful test of an 18.8 million cubic foot super-pressure balloon was carried out in Sweden; when fully developed this capability will allow months-long flights. Tests of an advanced pointing system and a high altitude student mission flew successfully. The student mission carried 11 payloads while involving 62 students from 11 institutions in 10 States and Puerto Rico.

WORK IN PROGRESS IN FY 2013

A robust competed research program is ongoing. NASA is introducing a new competed research program, the Theory and Computational Astrophysics Networks, as a joint program with the Astronomical Sciences Division of the National Science Foundation. The joint program will offer three-year awards for networked teams distributed across multiple distinct institutions, which address key challenges in theoretical astrophysics that are of a scale and complexity that require sustained, multi-institutional collaborations. This new program is in response to a recommendation in the 2010 Astrophysics Decadal Survey, which identified these key challenges: Why is the cosmic expansion accelerating? What were the first objects to light up the cosmos, and when did they do it? How do black holes grow? How do planets form? How does a star explode as a supernova?

NASA launched three long-duration balloons from Antarctica in December 2012. The goal was to measure the cosmic rays that fill the Milky Way, to understand the origin of these, the most energetic particles in the universe, and to map the tiny fluctuations in the cosmic microwave background that give clues to how matter and energy were distributed at the earliest times, forming the seeds of the largest cosmic structures that we observe today. Data analysis from these missions is ongoing.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will continue a robust competed astrophysics research program, with emphasis on suborbital payloads and on development of key technologies for use in future missions. NASA will also pursue new work to confirm the nature of Kepler exoplanet candidates and explore the nature of planets circling other stars.

The Balloon project plans to support one domestic and two foreign campaigns, including the Long Duration Balloon Antarctic Campaign and many conventional flights from Fort Sumner, New Mexico.

ASTROPHYSICS RESEARCH

Program Elements

RESEARCH AND ANALYSIS

This project supports basic research, solicited through NASA's annual Research Opportunities in Space and Earth Sciences (ROSES) announcements. NASA solicits investigations relevant to Astrophysics over the entire range of photon energies, gravitational waves, and particles of cosmic origin. Scientists and technologists from a mix of disciplines review proposals and provide findings that underlie NASA's merit-based selections.

Astrophysics Research and Analysis solicits detector and technology development for instruments that may be candidates for future space flight opportunities and science and technology investigations using sounding rockets, high-altitude balloons, and similar platforms. The first step in developing a novel technology for future NASA missions is to show that it can work in the laboratory. A new type of scientific instrument is often flown first on a stratospheric balloon mission or on a sounding rocket flight that takes it briefly outside Earth's atmosphere. Instruments for balloons and sounding rockets are not as costly as those for an orbital mission, and experimenters can build them quickly to respond to unexpected opportunities. The experimenter usually retrieves the equipment after the flight, so that novel instruments can be tested, improved, and flown again. These suborbital flights are important for training the next generation of scientists and engineers to better compete and to maintain US leadership in science, engineering, and technology. The project also supports small experiments to be flown on the International Space Station, laboratory astrophysics, and limited ground-based observations.

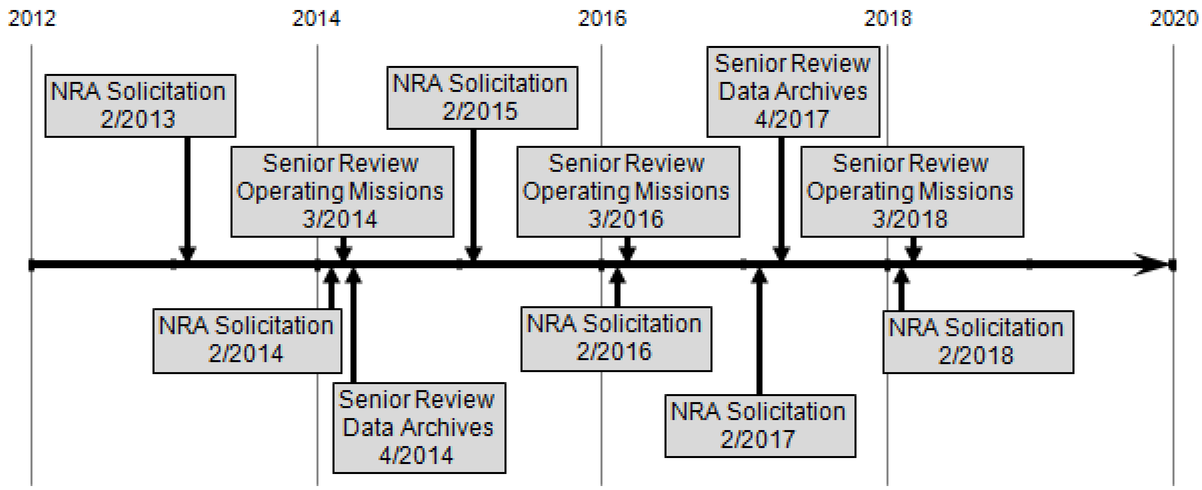
The Astrophysics Theory Program solicits basic theory investigations needed to interpret data from NASA's space astrophysics missions and to develop the scientific basis for future missions. Astrophysics Theory topics include formation of stars and planets; supernova explosions and gamma-ray bursts; the birth of galaxies; dark matter, dark energy and the cosmic microwave background.

BALLOON PROJECT

The Balloon project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to space flight application. Balloon experiments cover a wide range of disciplines in astrophysics, solar, and heliospheric physics, as well as Earth upper-atmosphere chemistry. Observations from balloons have even detected echoes of the Big Bang and probed the earliest galaxies. The Balloon project continues to work to increase balloon size and enhance capabilities, including an accurate pointing system to allow high quality astronomical imaging and a super-pressure balloon that maintains the balloon's integrity at a high altitude to allow much longer flights.

ASTROPHYSICS RESEARCH

Program Schedule



Program Management & Commitments

Program Element	Provider
Research and Analysis Project	Provider: All NASA Centers Lead Center: HQ (SMD) Performing Centers: All Cost Share Partners: None
Balloon Project	Provider: WFF Lead Center: GSFC and WFF Performing Center: WFF, HQ, MSFC Cost Share Partners: None

Acquisition Strategy

NASA issues solicitations for competed research awards each February through ROSES. Panels of scientists conduct peer reviews on all proposals. A Senior Review process reviews all missions in extended operations phase every two years, and all data archives every three years.

ASTROPHYSICS RESEARCH

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Balloon Management	Physical Science Laboratory, New Mexico State University (managing Columbia Scientific Balloon Facility, which is a government owned, contractor operated facility)	Palestine, TX and other balloon launch sites

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Archives Senior Review Panel	2011	A comparative evaluation of Astrophysics data archives.	Recommended improvements in archives	2014
Quality	Astrophysics Research Program Review Panel	2011	Review of competed research projects.	panel praised scope and impact of programs	TBD
Quality	Mission Senior Review Panel	2012	A comparative evaluation of Astrophysics operating missions.	ranking of missions, citing strengths and weaknesses	2014, 2016, 2018

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	65.3	--	**49.1**	69.4	87.9	101.3	112.7
Astrophysics Directed Research & Technology	0.0	--	**0.0**	5.4	12.3	14.3	20.5
Keck Single Aperture	2.3	--	**0.0**	0.0	0.0	0.0	0.0
Contract Administration, Audit, and Quality Assurance Services	13.7	--	**13.9**	14.0	14.5	14.5	14.5
Education and Public Outreach	12.9	--	**0.0**	0.0	0.0	0.0	0.0
Astrophysics Senior Review	0.0	--	**0.0**	13.9	24.5	35.8	41.0
Astrophysics Data Program	16.4	--	**17.0**	17.0	17.6	17.6	17.6
Astrophysics Data Curation and Archival Research	20.0	--	**18.2**	19.1	19.1	19.1	19.1
Change from FY 2012	--	--	**-16.2**				
Percentage change from FY 2012	--	--	**-24.8 %**				

The Astrophysics Research program prepares for the next generation of missions through both theoretical research and applied technology investigations. This program uses data from current missions and suborbital science investigations to advance NASA's science goals. One of these is to create new knowledge as explorers of the universe, and to use that knowledge for the benefit of all humankind.

Mission Planning and Other Projects

DIRECTED RESEARCH AND TECHNOLOGY

This project funds the civil service staff that will work on emerging Astrophysics projects, instruments and research.

CONTRACT ADMINISTRATION, AUDIT AND QUALITY ASSURANCE SERVICES

This project provides critical safety and mission product inspections and contract audit services from the Defense Contract Management Agency and Defense Contract Audit Agency, respectively. It also provides for supplier contract assurance audits, assessments, and surveillance by the NASA Contract Assurance Services Program.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

ASTROPHYSICS SENIOR REVIEW

The Astrophysics Senior Review project enables extension of the life of current operating missions. Every other year, the Astrophysics division conducts a senior review to do comparative evaluations of all operating missions that have successfully completed or are about to complete their prime mission operation phase. The senior review ratings help NASA determine which missions will receive funding for extended operations. Consistent with the 2012 Senior Review, NASA transferred funds previously held in this project to Spitzer, Planck, Chandra, Fermi, XMM, Kepler, Hubble Space Telescope, Swift, and Suzaku. The next senior review will take place in the spring of 2014.

ASTROPHYSICS DATA ANALYSIS PROGRAM

The Astrophysics Data Analysis Program (ADAP) solicits research that emphasizes the analysis of NASA space astrophysics data archived in the public domain at one of NASA's Astrophysics Data Centers. The size and scope of the archival astronomical data available to ADAP researchers grew dramatically, including data from such major strategic missions as Spitzer and Kepler. As these data are already bought and paid for, every dollar invested in archival research using this data brings additional value to the Nation's investment in the NASA Mission. The steady increase in the program budget in coming years is designed to ensure continued, effective use of this scientific resource as data holdings continue to grow from current operating missions such as Kepler, Fermi, Hubble Space Telescope, and Chandra.

Recent Achievements

The number of proposals submitted to ADAP has tripled over the last several years, reflecting a dramatic increase in demand for the data from NASA's space astrophysics missions. The increased utilization of these data supported by ADAP plays a crucial role in realizing the full scientific potential of NASA's missions. In 2012, the program received nearly 300 proposals in response to its annual solicitation. Of those, 90 proposals spanning the field of Astrophysics and exploiting the full range of NASA's archival data holdings were ultimately selected for funding. Topics include:

- Continued analysis of the data from Kepler and Spitzer to study planets around other stars and around pairs of stars;
- Mining the data from the WISE infrared survey to search for variable stars and to explore the structure of our own Milky Way and of other galaxies;
- Combining Hubble Space Telescope images and X-ray observations to measure the dark matter content in massive clusters of galaxies;
- Using X-ray observations to study how one star in a close binary can pour gas onto another; and
- How material is "swallowed" by massive black holes at the centers of galaxies.

ASTROPHYSICS DATA CURATION AND ARCHIVAL RESEARCH (ADCAR)

The Astrophysics Data Centers constitute an ensemble of archives that receives processed data from individual missions and makes them accessible to the scientific community. After the completion of a

Formulation	Development	Operations

mission, the relevant, active, multi-mission archive takes over all data archiving activities. ADCAR covers the activities of the Astrophysics Data Centers and NASA's participation in the Virtual Astronomical Observatory. Priorities from the FY 2011 Archival Senior Review have been implemented in FY 2012 and beyond. For example, the NASA Exoplanet Archive will provide value-added science to the Kepler mission by disseminating the Kepler data and serve as a clearinghouse for the follow-up ground-based observations required to confirm the nature of the Kepler exoplanet candidates.

Recent Achievements

The Astrophysics Data Centers are tackling challenges and opportunities presented by a tremendous growth of content. New analysis tools have been developed to support NASA's participation in Planck, the European Space Agency (ESA) mission that will make the most sensitive measurements yet of the cosmic microwave background. New tools for Spitzer have allowed observers to measure the light from planets around other stars and to infer their atmospheric composition and thermal profiles. Queries and data retrieval from the NASA Extragalactic Database (NED) grew by 10 to 25 percent over FY 2012, with server hits exceeding 6 million per month. The Astrophysics Data System project doubled its full-text coverage of both the current and historical astronomy literature (now over 2.5 million papers). In summary, over one thousand refereed publications used data from all the Astrophysics archives in 2012.

COSMIC ORIGINS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	239.9	--	**228.0**	216.5	193.1	196.7	194.1
Hubble Space Telescope (HST)	98.3	--	**96.3**	92.3	88.2	88.2	83.9
Stratospheric Observatory for Infrared Astronomy (SOFIA)	84.2	--	**87.4**	87.3	85.2	85.1	86.2
Other Missions And Data Analysis	57.4	--	**44.3**	36.9	19.7	23.4	24.0
Change from FY 2012	--	--	**-11.9**				
Percentage change from FY 2012	--	--	**-5.0 %**				

This Spitzer image of Messier 78 shows two nebulae carved out of dark dust clouds in Orion. Spitzer's infrared eyes penetrate the dust, revealing the glowing interiors of the two nebulae. A string of baby stars that have yet to burn their way through their natal shells can be seen as pinpoints on the outside of the nebula.

Other Missions and Data Analysis supports the Spitzer Space Telescope, the scientific applications of which continue to expand, as well as NASA's partnership with ESA on the groundbreaking Herschel mission. Spitzer was used to confirm the Hubble Constant, which relates a distant galaxy's apparent velocity to its distance from Earth to within four percent. Herschel revealed the presence of large quantities of water in the proto-stellar disks from which new stars and planetary systems form. Many more discoveries are expected over the next several years as data from both observatories are analyzed.

Mission Planning and Other Projects

COSMIC ORIGINS PROGRAM MANAGEMENT

Cosmic Origins program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

COSMIC ORIGINS STRATEGIC RESEARCH AND TECHNOLOGY (SR&T)

Cosmic Origins SR&T supports Hubble fellowships, program-specific research and advanced technology development efforts such as the Strategic Astrophysics Technology solicitation issued in FY 2012. In addition, funding supports the study of a future ultraviolet/optical space capability, and Hubble disposal mission planning.

COSMIC ORIGINS FUTURE MISSIONS

This funds early concept studies (pre-Phase A) for future Cosmic Origins missions, in accordance with the NASA strategic plan.

Operating Missions

SPITZER SPACE TELESCOPE

The Spitzer Space Telescope, launched in 2003 as the final element of NASA's series of Great Observatories, is now in extended operations. Spitzer is an infrared telescope using two channels of the Infrared Array Camera instrument to study exoplanet atmospheres, early clusters of galaxies, near-Earth asteroids, and a broad range of other phenomena. Spitzer completed its cryogenic mission in FY 2009, and warm operations have been extended through FY 2014. The 2014 Senior Review may recommend extending the mission beyond 2014.

Recent Achievements

During FY 2012, a team led by an astronomer from the Carnegie Observatories used Spitzer to confirm the expansion rate of the universe to within four percent. A team led by a Massachusetts Institute of Technology scientist reported the first measurement of the temperature of a rocky, Earth-like planet orbiting another star. Another team, led by an astronomer from Johns Hopkins University, used data from both Spitzer and Hubble to discover the most distant known galaxy, observed as it existed when the universe was only four percent of its current age.

HERSCHEL SPACE OBSERVATORY

The Herschel Space Observatory is a collaborative mission with ESA that launched on May 14, 2009. Herschel can detect the coldest and dustiest objects in space, such as cool cocoons where stars form and dusty galaxies bulking up with new stars. It has the largest single mirror ever built for a space telescope and it collects long wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed key technologies to two instruments onboard Herschel, and also hosts US astronomer access to data through the NASA Herschel Science Center. Herschel's on-board supply of helium will expire in the middle of FY 2013, after which the focus of the mission will turn to analysis of the vast stores of data already obtained.

Recent Achievements

During FY 2012, the Herschel Space Observatory continued to have a major impact on a wide range of critical astronomical questions. Herschel provided data on filament-like structures in the interstellar medium, highlighting the role that these structures play in the formation of new stars and the evolution of galaxies. Spectroscopic data revealed the presence of large quantities of water in proto-stellar disks from which new stars and planetary systems form. Herschel data also supported the theory that the Earth's oceans may have originated from comets impacting Earth, early in the history of the solar system.

COSMIC ORIGINS

EXPLANATION OF MAJOR CHANGES

The FY 2014 budget request includes a $5.4 million increase from the FY 2013 estimate to extend Spitzer operations through 2015.

HUBBLE SPACE TELESCOPE OPERATIONS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	98.3	--	**96.3**	92.3	88.2	88.2	83.9
Change from FY 2012	--	--	**-2.0**				
Percentage change from FY 2012	--	--	**-2.0%**				

Hubble's Wide Field Camera 3 recently captured this image of the interacting pair of galaxies Arp 273 in the constellation Andromeda, roughly 300 million light-years away from Earth. The shapes suggest that the smaller galaxy actually dived deep, but off-center, through the larger galaxy whose mass is about five times greater. Hubble discoveries have revolutionized nearly all areas of current astronomical research from planetary science to the origins of the universe.

One of NASA's most successful and long-lasting science missions, the Hubble Space Telescope, has beamed hundreds of thousands of images back to Earth, shedding light on many of the great mysteries of astronomy. It has helped scientists determine the age of the universe, the identity of quasars, and the existence of dark energy. Hubble launched in 1990 and is currently in an extended operations phase. The fourth servicing mission, completed in 2009, added new batteries, gyros, and instruments to extend its life even further into the future.

The Cosmic Origins program is studying concepts to dispose of Hubble safely after its mission has concluded. The timing for the disposal mission will be determined by the status of the observatory and the orbital conditions that would lead to orbital decay and reentry.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Hubble’s Wide Field Camera 3 observed a new class of extra-solar planet, dubbed a "water world,” as spectral analysis showed that planet GJ1214b is enshrouded by a thick, steamy atmosphere. High precision observations of the motion of the Andromeda Galaxy (M31) revealed that our own Milky Way galaxy and Andromeda are destined for a head-on collision in about four billion years. Three physicists, including one from the Space Telescope Science Institute, were presented with the Nobel Prize in December 2011 for the discovery of the recent acceleration in the expansion of the universe, a discovery to which Hubble made a key contribution. And finally, Hubble passed an exceptional milestone in December 2011 with the publication of the 10,000th peer-reviewed publication based on Hubble data.

HUBBLE SPACE TELESCOPE OPERATIONS

Formulation	Development	Operations

WORK IN PROGRESS IN FY 2013

In FY 2013 and beyond, NASA will support mission operations, systems engineering, software maintenance, ground systems support, and guest observer science grants. Work continues on mission life extension initiatives, such as optimizing the use of the gyroscopes.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Cycle 22 science observations will be selected. Similar to other recent competitions for Hubble observing time, NASA expects requested observational orbits to outnumber the available orbits by a factor of six to one, indicating that Hubble remains one of the world's preeminent astronomical observatories.

Project Management & Commitments

Element	Description	Provider Details	Change from Formulation Agreement
Observatory Operation	Provides safe and efficient control and utilization of Hubble, maintenance and operation of its facilities and equipment, as well as creation, maintenance, and utilization of Hubble operations processes and procedures	Provider: Lockheed Martin Lead Center: GSFC Participating Centers: GSFC Cost Share Partners: None	
Science management	Evaluates proposals for telescope time and manages the science program.	Provider: STScI/AURA Lead Center: GSFC Participating Centers: GSFC Cost Share Partners: ESA	

Acquisition Strategy

All new grant and research selections are made competitively.

HUBBLE SPACE TELESCOPE OPERATIONS

Formulation	Development	Operations

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Observatory Operation	Lockheed Martin	Littleton, CO
Science management	Space Telescope Science Institute/AURA	Baltimore, MD

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Senior Review	2012	Determine if mission operations should be extended, and if approved, extend science operations	Approved to continue operations	2014, 2016, 2018

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Prior	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018	BTC	Total
FY 2014 President's Budget Request	892.2	84.2	85.5	**87.4**	87.3	85.2	85.1	86.2	1506.1	2999.3
2014 MPAR LCC Estimate	892.2	84.2	85.5	**87.4**	87.3	85.2	85.1	86.2	1506.1	2999.3
Formulation	35.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	35.0
Development/Implementation	857.2	84.2	85.5	**87.4**	13.5	0.0	0.0	0.0	0.0	1127.8
Operations/Close-out	0.0	0.0	0.0	**0.0**	73.8	85.2	85.1	86.2	1506.1	1836.4
Change from FY 2012		--	--	**3.2**						
Percentage change from FY 2012		--	--	**3.8%**						

NASA is developing SOFIA as a world-class airborne observatory that will complement the Hubble, Spitzer, Herschel and the James Webb Space Telescope. SOFIA's ability to return to earth after each flight also makes it an outstanding laboratory for developing and testing new astronomical instrumentation and detector technology throughout its lifetime.

PROJECT PURPOSE

SOFIA is a unique airborne astronomical observatory, capable of observing a wide variety of astronomical objects and phenomena. SOFIA will investigate star birth and death and the formation of new planetary systems; it will identify complex molecules in space; and it will observe planets, comets, and asteroids in our solar system, as well as nebulae and dust in galaxies.

The infrared light of these objects is only partially visible from the ground due to water vapor in the Earth's atmosphere. However, at high altitudes, the telescope is above most of the water vapor allowing better observation of these astronomical objects. During its 20-year expected lifetime, SOFIA will be capable of enabling "Great Observatory" class astronomical science. SOFIA's reconfigurability and flexibility ensures the integration of cutting edge technology and the ability to address emerging scientific questions. SOFIA will soon be NASA's only far-infrared mission, as Spitzer's cryogens have been depleted and Herschel's cryogens will be exhausted by mid-FY 2013. It is the only mid-infrared mission until JWST becomes operational.

EXPLANATION OF MAJOR CHANGES

None.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

PROJECT PARAMETERS

SOFIA is designed as a highly modified Boeing 747SP aircraft with a large open-port cavity aft of the wings, housing a 2.5 meter telescope optimized for infrared/sub-millimeter wavelength astronomy. SOFIA will operate in flight at 41,000 feet, and at full operational capability will have four instruments, with additional instruments available later. At its peak operational tempo, SOFIA will conduct 960 research hours per year.

ACHIEVEMENTS IN FY 2012

SOFIA's early science led directly to the publication of more than 30 scientific papers. The project made significant progress toward completion of comprehensive upgrades to the observatory, including improved telescope performance. The comprehensive upgrades included modernization of the cockpit avionics (including navigation systems, visual displays, and other systems), upgrades to the Mission Control and Communications System (power distribution system, data distribution and archiving systems, audio systems, etc.), improvements to the Cavity Environmental Control System, and modification of other critical platform elements.

NASA selected the upgraded High-resolution Airborne Wideband Camera (HAWC+) as SOFIA’s second-generation instrument.

WORK IN PROGRESS IN FY 2013

SOFIA is implementing the final phases of observatory upgrades. In parallel, it is commissioning first generation instruments, while also performing observations in support of Cycle 1 science investigations, and initiating the development of a second generation instrument.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

SOFIA will continue to work toward demonstration of full operational capability, defined as full science operational capability with four instruments, which NASA has committed to achieve by December 2014. Cycle 1 science will be completed by December 2013; Cycle 2 science will begin soon thereafter; and Cycle 3 selections will occur late in FY 2014. In addition, NASA will initiate a series of maintenance tasks required to maintain the aircraft in safe and reliable operating condition.

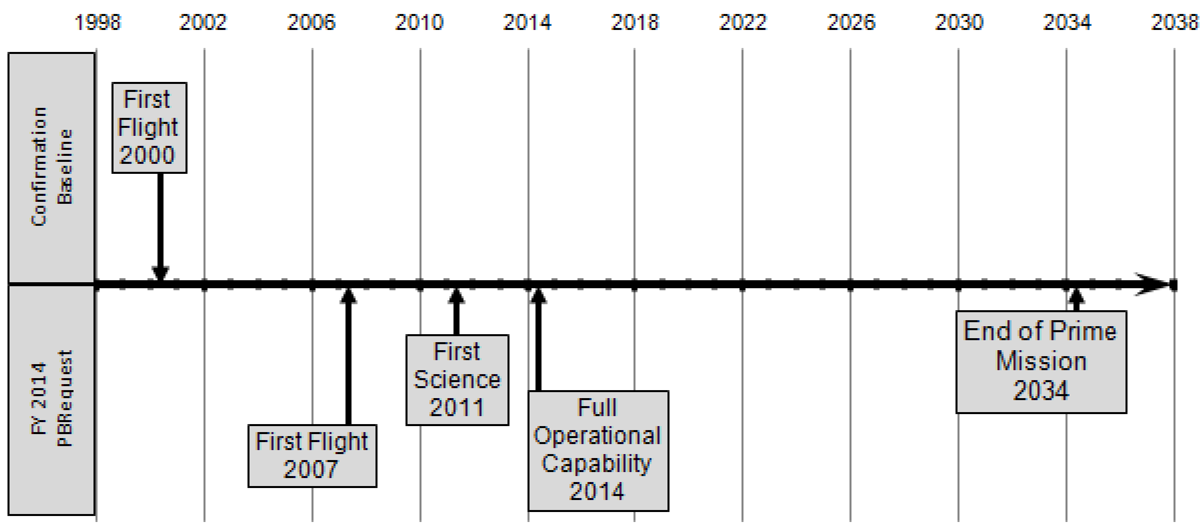
STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

SOFIA began Early Science flights in 2011 and will reach full operational capability by December 2014.

Project Schedule



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2007	919.5	70	2013	1127.8	22.7	FOC	Dec 2013	Dec 2014	12

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

Development Cost Details

Additional funds were added to the development budget to preserve the new instrument selection schedule and science hours and to fund risk reduction activities. Risk reduction activities previously planned for operations were moved into development. The SOFIA milestone Full Operational Capability (FOC) has been redefined as the capability to provide full science operational capability with four available instruments.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	919.5	1,127.8	208.3
Aircraft/Spacecraft	657.7	775.4	117.7
Science/Technology	199.6	227.4	27.8
Other Direct Project Costs	62.2	125.0	62.8

Project Management & Commitments

The overall SOFIA project and SOFIA airborne system is managed by DFRC. SOFIA science is managed by ARC.

Project Element	Description	Provider	Change from Baseline
Platform	Refurbished Boeing 747SP modified to accommodate telescope	Provider: DFRC/L3 Lead Center: DFRC Performing Centers: DFRC Cost Share Partners: DLR/DSI	No
Science Operations Center	Science operations center will schedule observations, and manage data acquisition and processing	Provider: ARC/USRA Lead Center: ARC Performing Centers: ARC Cost Share Partners: DLR/DSI	No
Telescope	2.5 meter diameter, dual mirror	Provider: Germany-DLR/DSI Lead Center: DFRC Performing Centers: DFRC Cost Share Partners: DLR/DSI	No

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

Flight Operations	Flight crew, maintenance, and fuel	Provider: DFRC/CSC DynCorp Lead Center: DFRC Performing Centers: DFRC Cost Share Partners: DLR/DSI	No
High-speed Photometer for Occulations (HIPO)	Simultaneous high-speed time-resolved imaging photometry at two optical wavelengths	Provider: Lowell Observatory Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	No
First Light Infrared Test Experiment Camera (FLITECAM)	Large field-of-view, narrow-and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 micrometers	Provider: UCLA Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	No
FORCAST	Large field-of-view, narrow-and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 micrometer	Provider: Cornell University Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	No
Echellon-Cross-Echelle Spectrograph (EXES)	Echelon spectrometer,5-28 microns R=105,104, or 3000	Provider: ARC Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	No
High-resolution Airborne Wideband Camera (HAWC)	Far-infrared bolometer camera, 50-240 microns	Provider: University of Chicago Lead Center: ARC Performing Centers: ARC Cost Share Partners: N/A	Yes (HAWC will be upgraded to HAWC+ before being delivered to SOFIA)
German Receiver for Astronomy at Terahertz Frequencies (GREAT)	Infrared heterodyne spectrometer 60 to 200 microns	Provider: Germany - DLR/DSI Lead Center: ARC Performing Centers: ARC Cost Share Partners: DLR/DSI, Max-Plank-Institute	No
Field Imaging Far-Infrared Line Spectrometer (FIFI-LS)	Imaging spectrometer 42 to 210 microns	Provider: Germany - DLR/DSI Lead Center: ARC Performing Centers: ARC Cost Share Partners: DLR/DSI, University of Stuttgart	No

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

Upgraded High-resolution Airborne Wideband Camera (HAWC+)	HAWC far-infrared camera to be upgraded with the addition of polarimetry capability and new state-of-the-art detectors	Provider: JPL, GSFC Lead Center: ARC Performing Centers: JPL, GSFC Cost Share Partners: N/A	Yes (new selection)

Project Risks

Risk Statement	Mitigation
If: Telescope image quality goals cannot be met, Then: Some planned science observations will not be possible.	Appointed the joint US- German SOFIA Pointing Optimization Team to study telescope pointing performance and make recommendations for improvements. Installed active mass dampers on telescope to reduce image jitter. Upgraded the Focal Plane Imager (guide camera) with new and significantly more sensitive detectors.
If: Primary mirror is damaged due to handling mishaps, Then: Observatory will be inoperable during mirror repair and/or replacement.	Completed the move of the Mirror Coating Facility from the Science Operations Center (Moffett Field, CA) to Aircraft Operations Facility (Palmdale, CA). This will allow coating to take place at home base of Observatory. Also developed water and snow cleaning techniques to preserve telescope optical characteristics as long as possible without recoating. Implementing a contamination control program.

Acquisition Strategy

All major contracts have been awarded.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Platform	L3 Communications	Waco, TX
Cavity Door Drive System	MPC Products Corporation	Skokie, IL
Aircraft Maintenance Support	CSC DynCorp	El Segundo, CA
Science Operations	University Space Research Association	Columbia, MD

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Operations Optimization Review Team (OORT) Evaluation	Operations Optimization Review Team	Nov 2011	Evaluate plans and processes for the operational phase and identify any means of improving efficiency	Program has implemented recommendations to improve scientific productivity, crew safety, and operational efficiency.	N/A
Program Implementation Review (PIR)	SRB	N/A	Assess program performance and review progress against Full Operational Capability milestone	N/A	May 2013
Program Implementation Review (PIR)	SRB	May 2013	Evaluate Observatory performance against Level 1 requirements and instrument interfaces. Review overall operational efficiency of observatory	N/A	May 2015

CORRECTIVE ACTION PLAN AS REQUIRED BY SECTION 1203 OF NASA 2010 AUTHORIZATION ACT

SOFIA is an airborne observatory that will study the universe in the infrared spectrum. These infrared observations allow scientists to study the dust between stars, the formation of stars and new solar systems, the chemistry of the universe, and the deep universe where the most distance galaxies are seen in infrared light. SOFIA will host a complement of scientists, computer engineers, graduate students, and educators on nightlong research missions. SOFIA will be a major factor in the development of observational techniques and of new instrumentation and in the education of young scientists and teachers in the discipline of infrared astronomy.

NASA and DLR, Germany's Aerospace Research Center and Space Agency, are working together to construct SOFIA, a Boeing 747SP aircraft which was modified by L3 Communications Integrated Systems to accommodate a 2.5 meter reflecting telescope. SOFIA will be the largest airborne observatory in the world and will make observations that are impossible for even the largest and highest of ground-based telescopes. SOFIA will operate at 41,000 feet using U.S. and German instruments and flights will last, on average, six to eight hours.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

Formulation	Development	Operations

2010 Issues	Corrective Action Plan
Issue 1: Definition of Full Operational Capability Current Status: The Full Operational Capability milestone requirements have been revised to emphasize science instrument observational capability (4 science instruments), the overall program has been replanned in terms of schedule (no change in Full Operational Capability date, however), and the NASA Agency Program Management Council has approved the replan.	Programmatic: Review of the definition of the Full Operational Capability milestone technical requirements by the independent Standing Review Board resulted in a finding that the original definition (800 flight hours per year) was an improper definition in that insufficient science emphasis was contained in the definition. Therefore, the definition of Full Operational Capability was revised to focus on science instrument capability (the requirement was revised to four available science instruments, consistent with the Major Program Annual Report definition), and the overall program was replanned around that definition. The replanned program plan was approved by the NASA Agency Program Management Council (APMC) on October 6, 2010. This did not cause a change in the externally-committed FOC date of December 2014, but does emphasize science in the definition.
Issue 2: Late delivery of Cavity Door Drive System Current Status: The cavity door drive system controller and actuator was delivered and integrated in the SOFIA observatory, and flight testing to clear the full flight envelope has been completed. This permits the continuation of SOFIA system testing, leading up to the first science flights in December 2010.	Programmatic: Late delivery of software that operates the telescope observation doors on the aircraft resulted in later-than-planned initiation of open door flight testing and science observation. NASA stationed representatives at Woodward’s facility to support and oversee the vendor until delivery of the cavity controller and actuator.

OTHER MISSIONS AND DATA ANALYSIS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	57.4	--	**44.3**	36.9	19.7	23.4	24.0
Cosmic Origins Program Management	4.1	--	**2.6**	2.6	2.7	2.8	2.9
Cosmic Origins Supporting Research & Technology	10.2	--	**12.8**	13.1	13.3	18.6	19.2
Cosmic Origins Future Missions	1.0	--	**0.4**	1.6	1.0	1.0	2.0
SIRTF/Spitzer	17.8	--	**16.3**	14.2	0.0	0.0	0.0
Herschel	24.3	--	**12.2**	5.5	2.7	1.0	0.0
Change from FY 2012	--	--	**-13.1**				
Percentage change from FY 2012	--	--	**-22.8 %**				

This Spitzer image of Messier 78 shows two nebulae carved out of dark dust clouds in Orion. Spitzer's infrared eyes penetrate the dust, revealing the glowing interiors of the two nebulae. A string of baby stars that have yet to burn their way through their natal shells can be seen as pinpoints on the outside of the nebula.

Other Missions and Data Analysis supports the Spitzer Space Telescope, the scientific applications of which continue to expand, as well as NASA’s partnership with ESA on the groundbreaking Herschel mission. Spitzer was used to confirm the Hubble Constant, which relates a distant galaxy’s apparent velocity to its distance from Earth to within four percent. Herschel revealed the presence of large quantities of water in the proto-stellar disks from which new stars and planetary systems form. Many more discoveries are expected over the next several years as data from both observatories are analyzed.

Mission Planning and Other Projects

COSMIC ORIGINS PROGRAM MANAGEMENT

Cosmic Origins program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

COSMIC ORIGINS STRATEGIC RESEARCH AND TECHNOLOGY (SR&T)

Cosmic Origins SR&T supports Hubble fellowships, program-specific research and advanced technology development efforts such as the Strategic Astrophysics Technology solicitation issued in FY 2012. In addition, funding supports the study of a future ultraviolet/optical space capability, and Hubble disposal mission planning.

COSMIC ORIGINS FUTURE MISSIONS

This funds early concept studies (pre-Phase A) for future Cosmic Origins missions, in accordance with the NASA strategic plan.

Operating Missions

SPITZER SPACE TELESCOPE

The Spitzer Space Telescope, launched in 2003 as the final element of NASA's series of Great Observatories, is now in extended operations. Spitzer is an infrared telescope using two channels of the Infrared Array Camera instrument to study exoplanet atmospheres, early clusters of galaxies, near-Earth asteroids, and a broad range of other phenomena. Spitzer completed its cryogenic mission in FY 2009, and warm operations have been extended through FY 2014. The 2014 Senior Review may recommend extending the mission beyond 2014.

Recent Achievements

During FY 2012, a team led by an astronomer from the Carnegie Observatories used Spitzer to confirm the expansion rate of the universe to within four percent. A team led by a Massachusetts Institute of Technology scientist reported the first measurement of the temperature of a rocky, Earth-like planet orbiting another star. Another team, led by an astronomer from Johns Hopkins University, used data from both Spitzer and Hubble to discover the most distant known galaxy, observed as it existed when the universe was only four percent of its current age.

HERSCHEL SPACE OBSERVATORY

The Herschel Space Observatory is a collaborative mission with ESA that launched on May 14, 2009. Herschel can detect the coldest and dustiest objects in space, such as cool cocoons where stars form and dusty galaxies bulking up with new stars. It has the largest single mirror ever built for a space telescope and it collects long wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed key technologies to two instruments onboard Herschel, and also hosts US astronomer access to data through the NASA Herschel Science Center. Herschel's on-board supply of helium will expire in the middle of FY 2013, after which the focus of the mission will turn to analysis of the vast stores of data already obtained.

Recent Achievements

During FY 2012, the Herschel Space Observatory continued to have a major impact on a wide range of critical astronomical questions. Herschel provided data on filament-like structures in the interstellar medium, highlighting the role that these structures play in the formation of new stars and the evolution of galaxies. Spectroscopic data revealed the presence of large quantities of water in proto-stellar disks from which new stars and planetary systems form. Herschel data also supported the theory that the Earth's oceans may have originated from comets impacting Earth, early in the history of the solar system.

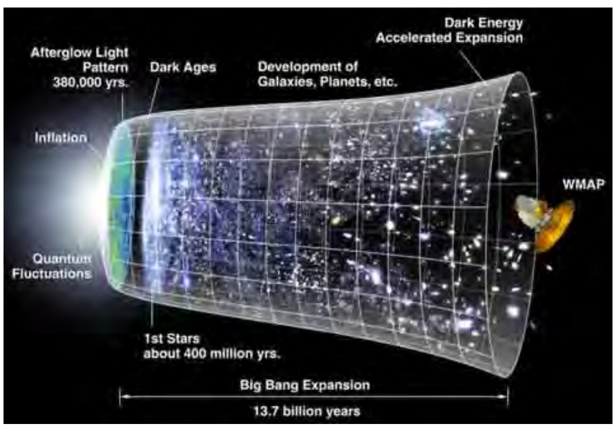
EXPLANATION OF MAJOR CHANGES

The FY 2014 budget request includes a $5.4 million increase from the FY 2013 estimate to extend Spitzer operations through 2015.

PHYSICS OF THE COSMOS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	108.3	--	**110.4**	107.5	100.0	82.8	86.4
Change from FY 2012	--	--	**2.1**				
Percentage change from FY 2012	--	--	**1.9 %**				



This diagram reveals changes in the rate of expansion since the universe's birth 15 billion years ago. The discovery that the expansion of space is accelerating presents one of the most important scientific problems of our time. The implication that the universe is dominated by an unknown entity, now called "dark energy," that counters the attractive force of gravity, may revolutionize our understanding of cosmology and fundamental physics.

The universe can be viewed as a laboratory that enables scientists to study some of the most profound questions at the intersection of physics and astronomy. How did the universe begin? How do matter, energy, space, and time behave under the extraordinarily diverse conditions of the cosmos? The Physics of the Cosmos (PCOS) program incorporates cosmology, high-energy astrophysics, and fundamental physics projects that address central questions about the nature of complex astrophysical phenomena such as black holes, neutron stars, dark matter and dark energy, cosmic microwave background, and gravitational waves.

The operating missions within the PCOS program are beginning to provide answers to the fundamental questions above. Scientists using data from the Fermi mission are trying to determine what composes mysterious dark matter, which will help explain how black holes accelerate immense jets of material to nearly the speed of light. The Planck mission is observing the earliest moments of the universe and is providing a high-resolution map of the cosmic microwave background. X-Ray Multi-Mirror Mission (XMM)-Newton has helped scientists solve cosmic mysteries, including enigmatic massive black holes. The Chandra mission continues to reveal new details of celestial X-ray phenomena, such as the collisions of clusters of galaxies that directly detect the presence of dark matter, and has unveiled a population of faint, obscured massive black holes that may provide the early seeds for galaxy formation and growth since the birth of the universe nearly 14 billion years ago.

PCOS includes a vigorous program to develop of technologies necessary for the next generation of space missions to address the science questions of this program.

For more information, see: http://nasascience.nasa.gov/about-us/smd-programs/physics-of-the-cosmos.

PHYSICS OF THE COSMOS

EXPLANATION OF MAJOR CHANGES

The European Space Agency (ESA) selected Euclid, a dark energy mission, for implementation beginning in 2012 with a launch readiness date in 2020. NASA will provide the detector components for the infrared instrument in return for US membership on the Euclid Science Team, Euclid Consortium, and early access to Euclid data.

The FY 2014 budget request is $ 110.4 million, an increase from the FY 2013 estimate. The increase supports NASA's participation in Euclid, and the extension of the Chandra and Planck missions per the 2012 Senior Review of Operating Missions.

The Fermi budget request is $10.2 million less than the FY 2013 estimate. This will be accommodated by eliminating the FY 2014 Guest Observer selections and taking advantage of operational efficiencies with minimal risk to spacecraft and data.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	108.3	--	**110.4**	107.5	100.0	82.8	86.4
Physics of the Cosmos Supporting Research & Technology	13.3	--	**15.3**	14.9	16.4	19.3	20.8
Physics of the Cosmos Program Management	3.0	--	**2.7**	2.8	2.8	2.9	3.0
Physics of the Cosmos Future Missions	0.3	--	**0.0**	1.0	1.0	1.0	2.0
Euclid	1.0	--	**15.1**	9.3	3.7	4.0	5.0
Planck	7.1	--	**6.2**	4.1	0.0	0.0	0.0
Fermi Gamma-ray Space Telescope	25.3	--	**14.3**	18.6	20.7	0.0	0.0
Chandra X-Ray Observatory	56.4	--	**55.0**	55.8	55.4	55.6	55.6
XMM-Newton	2.1	--	**1.9**	1.0	0.0	0.0	0.0
Change from FY 2012	--	--	**2.1**				
Percentage change from FY 2012	--	--	**1.9 %**				

The FY 2014 budget supports NASA's participation in Euclid, and the extension of the Chandra and Planck missions per the 2012 Senior Review of Operating Missions.

Mission Planning and Other Projects

PCOS SUPPORTING RESEARCH AND TECHNOLOGY

PCOS Supporting Research and Technology supports Einstein Fellowships and program-specific research and early technology development efforts to prepare for the next generation of PCOS space missions. The Space Technology (ST)-7 project is developing enhanced thrusters, which are scheduled for launch in 2015 on the ESA Laser Interferometer Space Antenna (LISA) Pathfinder mission. These new thrusters will be able to apply thrust equivalent to the weight of a single grain of sand, enabling ESA to conduct the LISA gravitational experiment in a truly weightless environment.

Recent Achievements

The PCOS program released its inaugural Program Annual Technology Report. This report summarizes the status of technology development funded by the program in FY 2012 and describes the prioritization of future technology needs. A copy of the report can be found at: http://pcos.gsfc.nasa.gov/technology/2012_PCOS_PATR_Final_101612.pdf.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

PCOS PROGRAM MANAGEMENT

PCOS program management provides programmatic, technical, and business management, as well as program science leadership.

PCOS FUTURE MISSIONS

PCOS Future Missions funding supports future mission concept studies.

EUCLID

NASA is collaborating on Euclid, an ESA mission selected as part of ESA's Cosmic Visions program in June 2012 and scheduled for launch in 2020. Euclid seeks to investigate the accelerated expansion of the universe, the so-called "dark energy," using a Visible Instrument (VIS) and a Near Infrared Spectrometer and Photometer (NISP) instrument, as well as ground-based data. Responsibility for developing the two instruments and the Science Data Centers rests with the Euclid Consortium, comprised of over 950 scientists and engineers from over 50 institutes in Europe, the United States, and Canada. In the Euclid mission, NASA contributes flight detector subsystems for the NISP instrument in exchange for membership in the Euclid Science Team and Consortium and competed science opportunities for US investigators.

Operating Missions

PLANK

Planck's objective is to analyze, with the highest accuracy ever achieved, the remnants of the radiation that filled the universe immediately after the Big Bang. Planck enables scientists to address fundamental questions, such as the initial conditions for the evolution in the universe, the overall geometry of space, the rate at which the universe is expanding, and the nature and amount of the constituents of the universe. Planck, launched in May 2009, is an ESA-led telescope with substantial NASA contributions.

FERMI

The Fermi Gamma-ray Space Telescope has explored the most extreme environments in the universe from black holes to gamma-ray bursts and expanded knowledge of their high-energy properties. Fermi data are answering long-standing questions across a broad range of topics, including solar flares, the origin of cosmic rays, and the nature of dark matter. Fermi, a NASA mission with strong international and Department of Energy involvement, launched in June 2008.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

CHANDRA

Launched in 1999, Chandra is transforming our view of the universe with its high quality X-ray images, providing unique insights into violent events and extreme conditions such as explosions of stars, collisions of galaxies, and matter around black holes. Chandra enables observations of the Bullet Cluster of galaxies that provide direct evidence for the existence of dark matter. In addition, studies of clusters of galaxies using Chandra data have greatly strengthened the case for the existence of dark energy. Chandra observations of the remains of exploded stars, or supernovas, have advanced our understanding of the behavior of matter and energy under extreme conditions. Chandra has also discovered and studied hundreds of supermassive black holes in the centers of distant galaxies.

Recent Achievements

Astronomers have used NASA's Chandra X-ray Observatory to find evidence that the Milky Way galaxy is embedded in an enormous halo of hot gas that extends for hundreds of thousands of light years. The estimated mass of the halo is comparable to the mass of all the stars in the galaxy.

XMM-NEWTON

XMM-Newton provides unique data for studies of the fundamental processes of black holes and neutron stars. It studies the evolution of chemical elements in galaxy clusters and the distribution of dark matter in galaxy clusters and elliptical galaxies. XMM-Newton, an ESA-led mission with substantial NASA contributions, launched in December 1999. NASA provides the U.S. Guest Observer Facility at GSFC.

EXOPLANET EXPLORATION

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	50.8	--	**55.4**	59.4	57.7	60.7	90.7
Exoplanet Exploration Strategic Research and Technology	18.4	--	**22.2**	26.0	26.1	34.3	34.3
Exoplanet Exploration Program Management	5.6	--	**4.6**	5.4	5.5	5.6	5.7
Exoplanet Exploration Future Missions	1.5	--	**1.2**	2.0	1.2	14.2	44.4
Kepler	19.6	--	**18.7**	18.0	18.3	0.0	0.0
Keck Operations	3.2	--	**5.8**	6.0	6.1	6.1	6.2
Large Binocular Telescope Interferometer	2.0	--	**2.9**	2.0	0.5	0.5	0.0
Keck Interferometer	0.4	--	**0.0**	0.0	0.0	0.0	0.0
Change from FY 2012	--	--	**4.6**				
Percentage change from FY 2012	--	--	**9.1 %**				

Humankind stands on the threshold of a voyage of unprecedented scope and ambition, promising insight into some of the most timeless questions: Are we alone? Is Earth unique, or are planets like ours common? One of the most exciting new fields of research within the NASA Astrophysics portfolio is the search for planets, particularly Earth-like planets, around other stars.

During the last 15 years, astronomers have discovered over 770 planets orbiting nearby stars. Many of these planets are gas giants, similar in size to the four outer planets in our solar system, and orbit much closer to their parent stars than do the giant planets in our system. NASA's Exoplanet Exploration program is advancing along a path of discovery leading to a point where scientists can directly study the atmospheres and surface features of habitable, rocky planets, like Earth, around other stars in the solar neighborhood.

The 2009 launch of the Kepler mission, NASA's first mission dedicated to the study of extrasolar planets, ushered in a new chapter in the search for planets around other stars. From its unique vantage point of space, Kepler can detect much smaller planets than even the most powerful ground-based telescopes. Kepler provided data showing us that small planets are more abundant than giant planets. By the end of its mission, Kepler will establish how common habitable, Earth-sized planets are in the galaxy.

NASA aims to develop systems that will allow scientists to take the pivotal step from identifying an exoplanet as Earth-sized, to determining whether it is truly Earth-like, and possibly even detecting if it bears the fingerprints of life. Such an ambitious goal includes significant technological challenges. An important component of the Exoplanet Exploration effort is a robust technology development program with the goal of enabling a future direct detection mission.

EXOPLANET EXPLORATION

The discovery of Kepler-35b and another twin sun planet, Kepler-34 b, was announced Jan. 11, 2012. The two discoveries represent a new class of circumbinary planets, and may help astronomers estimate how many of such binary stars possess planets. Scientists say the two planets are also extremely close to the habitable zones of their parent stars. This illustration shows Kepler-35 b, a Saturn-size planet, around its pair of sun-size stars. Credit: Lynette Cook

For more information, see: http://exep.jpl.nasa.gov/.

EXPLANATION OF MAJOR CHANGES

Following the Senior Review of Astrophysics Missions in 2012, NASA approved an extension of the Kepler mission through at least 2015. The extension will expand on and improve the statistical census of planetary sizes and orbits begun during the prime mission, in particular extending that census to obtain robust measurements of the frequency of Earth-sized, rocky planets in the habitable zones of Sun-like stars.

The FY 2014 budget request is $55.4 million, a $13.8 million increase from the FY 2013 estimate ($41.6 million), to support the Kepler extension as a result of senior review and an increase to Keck Operations as a result of Keck Single Aperture observations moving from research.

ACHIEVEMENTS IN FY 2012

The Exoplanet program completed development of the Large Binocular Telescope Interferometer (LBTI). The Kepler mission successfully completed its prime mission phase in November and has begun an extended mission that will add as many as four years to the lifetime of the mission. Scientists analyzing data from the Kepler mission announced the discovery of Kepler-47b and -47c, the first transiting circumbinary system, multiple planets orbiting two suns. Researchers at Massachusetts Institute of Technology, NASA, and elsewhere have detected a planet that appears to be evaporating under the blistering heat of its parent star. The scientists infer that a long tail of debris, much like the tail of a comet, is following the planet, and that this tail may tell the story of the planet's disintegration.

WORK IN PROGRESS IN FY 2013

The Exoplanet Program continues to support competitively-selected technology development to advance key technologies that will enable a future space mission to separate the feeble reflected light of an exoplanet from the overwhelming glare of its parent star, and analyze that light for clues to the planet's characteristics. Commissioning activities for LBTI continue, with the achievement of full operational capability anticipated in 2013. The program is standing up Science and Technology Definition Teams to develop a set of mission concepts for a potential future mission that would be executable within the program's projected budget profile.

EXOPLANET EXPLORATION

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The Large Binocular Telescope Interferometer will begin regular operation with the first full year of key project observations. Operation of the Kepler mission will continue, creating the potential for the first detection of an Earth-sized planet in the habitable zone of a Sun-like star.

Mission Planning and Other Projects

EXOPLANET EXPLORATION STRATEGIC RESEARCH AND TECHNOLOGY

Exoplanet Exploration Strategic Research and Technology supports the prestigious Sagan Postdoctoral Fellowships, program-specific scientific research, and technology development activities that support and enable future Exoplanet Exploration missions.

In FY 2012, NASA supported approximately 15 competitively-selected technology development projects and 17 Sagan fellows. The selected technology development projects all focus on advancing technologies for separating the feeble reflected light of an exoplanet from the overwhelming glare of its parent star so that it can be analyzed for clues to the planet's nature. Those technologies will one day enable the ultimate goal of NASA's Exoplanet Exploration Program: a future mission capable of imaging and measuring the spectra of habitable, Earth-like exoplanets in the solar neighborhood. In 2013, NASA will continue to work on technologies for future telescopes.

EXOPLANET EXPLORATION PROGRAM MANAGEMENT

Exoplanet Exploration program management provides programmatic, technical, and business management, as well as program science leadership. The program management coordinates, supports and tracks the progress of the program's numerous technology development tasks, and oversees the program's diverse portfolio of projects, including LBTI, Kepler, and the NASA Exoplanet Science Institute.

EXOPLANET EXPLORATION FUTURE MISSIONS

Exoplanet Exploration Future Missions funding supports the execution of the exoplanet mission science and technology definition teams, and ultimately the formulation, development, and implementation of a future Exoplanet Exploration flight mission.

Operating Missions

KEPLER

Kepler, launched in March 2009, is specifically designed to survey the distant stars in this region of the Milky Way galaxy to detect and characterize rocky planets in or near the "habitable zone" of their host star. The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface. As time progresses, smaller planets with longer orbital periods emerge from the data.

KECK OPERATIONS

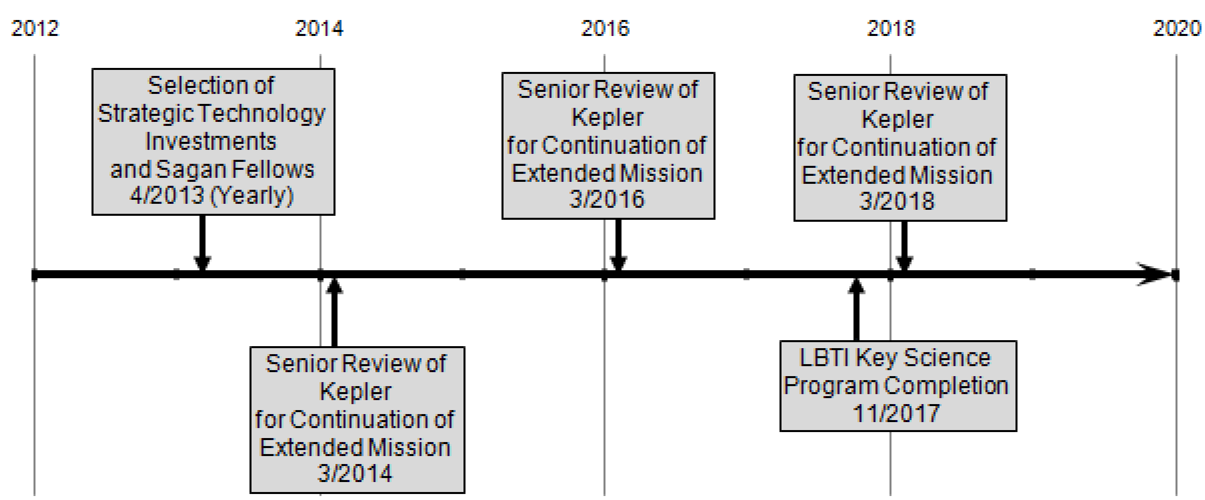
Keck Operations is the NASA portion of the Keck Observatory partnership. NASA uses its share of observing time in support of all Astrophysics science programs. Observation time is competed, selected, and managed by the NASA Exoplanet Science Institute. A significant portion of the observing time has been awarded to studies of potential planets identified by Kepler.

NASA is transferring the budget for Keck Single Aperture (KSA) in the Research Program to Keck Operations within the Exoplanet Exploration program to consolidate all Keck funding. KSA manages NASA time on the 10-meter, ground-based Keck telescopes by issuing proposal solicitations, conducting peer reviews, communicating selections for investigations, and providing support to observers. KSA also manages the Keck archives for the High Resolution Echelle Spectrometer (HIRES) and the Near Infrared Spectrometer (NIRSPEC) instruments. HIRES primarily measures the radial velocity data used to find and characterize exoplanets and NIRSPEC is a general-purpose near-infrared spectrometer widely used by Keck observers.

LARGE BINOCULAR TELESCOPE INTERFEROMETER

The Large Binocular Telescope Interferometer (LBTI) is the NASA portion of the Large Binocular Telescope partnership. LBTI is designed to allow high contrast, high spatial resolution infrared imaging of the dust clouds around nearby stars. The system surveys nearby stars for dust and debris disks that may hamper the detection of planets around those stars. This information will be crucial for designing future space observatories capable of detecting and characterizing those planets.

Program Schedule



EXOPLANET EXPLORATION

Program Management & Commitments

JPL manages the Exoplanet Exploration Program.

Program Element	Provider
Kepler	Provider: JPL Lead Center: ARC Performing Centers: ARC Cost Share Partners: None
Keck Observatory	Provider: Caltech and University of California Lead Center: JPL Performing Center: None Cost Share Partners: Various private entities
LBTI	Provider: University of Arizona Lead Center: JPL Performing Center: None Cost Share Partners: University of Arizona

Acquisition Strategy

NASA will make technology awards in response to annual NRAs released in ROSES-2013 solicitations.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Kepler	Ball Aerospace Corp.	Boulder, CO

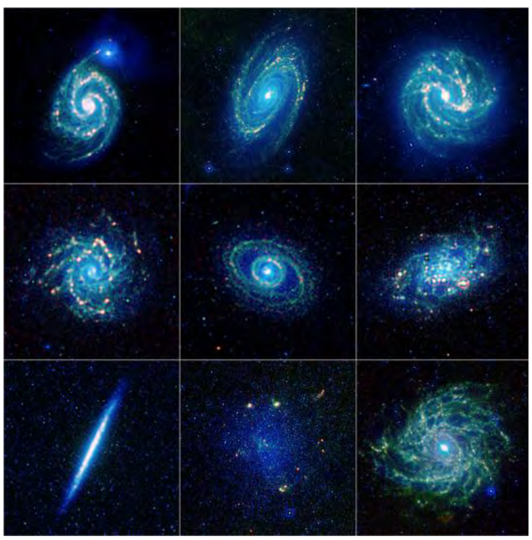
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Senior Review	2012	Determine which mission operations should be extended	Ranking of missions, citing strengths and weaknesses	2014, 2016, 2018

ASTROPHYSICS EXPLORER

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	83.9	--	**100.9**	116.0	143.8	145.3	137.4
Other Missions and Data Analysis	83.9	--	**100.9**	116.0	143.8	145.3	137.4
Change from FY 2012	--	--	**17.0**				
Percentage change from FY 2012	--	--	**20.3 %**				



A collection of galaxy specimens from the Wide-field Infrared Survey Explorer (WISE) mission showcases galaxies of several types.

The Astrophysics Explorer program provides frequent flight opportunities for world-class astrophysics investigations using innovative and streamlined management approaches for spacecraft development and operations. The program is highly responsive to new knowledge, new technology, and updated scientific priorities by launching smaller missions that can be conceived and executed in a relatively short development cycle. Priorities are based on an open competition of concepts solicited from the scientific community. The program emphasizes missions that can be accomplished under the control of the scientific research community within constrained mission life-cycle costs.

Standard Explorer missions cost up to $200 million in total, excluding launch services. Small Explorers (SMEX) may cost about half that, excluding launch services. Explorer missions of opportunity (MO) have a total NASA cost of under $60 million and may be of several types. The most common are partner MOs, investigations that are part of a non-NASA space mission. These missions are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. Other possible types are new science missions using existing spacecraft and small complete missions. NASA intends to solicit proposals for missions of opportunity associated with each announcement of opportunity issued for Explorer and SMEX investigations, and perhaps more frequently.

For more information on Explorer missions, see http://explorers.gsfc.nasa.gov/missions.html.

EXPLANATION OF MAJOR CHANGES

NASA informed Congress in the FY 2012 Operating Plans that the Gravity and Extreme Magnetism Small Explorer (GEMS) mission was terminated prior to entering development because of projected cost growth. The decrease in the FY 2014 estimate, compared to the FY 2013 budget run out, reflects that termination.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	83.9	--	**100.9**	116.0	143.8	145.3	137.4
Astro-H	16.2	--	**1.3**	0.9	0.9	0.0	0.0
Astrophysics Explorer Future Missions	2.7	--	**86.0**	105.8	130.9	137.9	133.4
Astrophysics Explorer Program Management	5.6	--	**7.0**	3.5	6.8	7.4	4.0
Wide-Field Infrared Survey Explorer	4.5	--	**0.2**	0.0	0.0	0.0	0.0
SWIFT	4.3	--	**4.8**	5.0	5.1	0.0	0.0
Suzaku	0.3	--	**0.3**	0.3	0.0	0.0	0.0
Nuclear Spectroscopic Telescope Array	15.6	--	**1.3**	0.4	0.0	0.0	0.0
Galaxy Evolution Explorer	0.5	--	**0.0**	0.0	0.0	0.0	0.0
Gravity and Extreme Magnetism	33.2	--	**0.0**	0.0	0.0	0.0	0.0
Wilkinson Microwave Anistropy Probe	1.0	--	**0.0**	0.0	0.0	0.0	0.0
Change from FY 2012	--	--	**17.0**				
Percentage change from FY 2012	--	--	**20.3 %**				

Astrophysics Explorers Other Missions and Data Analysis includes funding for small missions in development (Astro-H), operating missions (NuSTAR, Swift, Suzaku), and funding for future mission selections and program management functions. The Wide-Field Infrared Survey Explorer mission is no longer operational, and data archival activities will cease after FY 2014.

Mission Planning and Other Projects

ASTRO-H (SXS)

NASA is providing a High-Resolution Soft X-Ray Spectrometer (SXS) instrument to Japan, for a 2015 launch onboard the Japanese Astro-H –IIA spacecraft. The SXS instrument is a cryogenically cooled high-resolution X-ray spectrometer that will allow the most detailed studies of a wide range of astronomical systems from nearby stars to distant active galaxies. Using this unprecedented capability, the mission will conduct a number of fundamental studies, including tracing the growth history of the largest structures in the universe, obtaining insights into the behavior of material in extreme gravitational fields, determining the spin of black holes, probing shock acceleration structures in clusters of galaxies, and investigating the detailed physics of black hole jets.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

ASTROPHYSICS EXPLORER FUTURE MISSIONS

Astrophysics Explorer Future Missions funding supports future astrophysics Explorer missions and missions of opportunity through concept studies and selections.

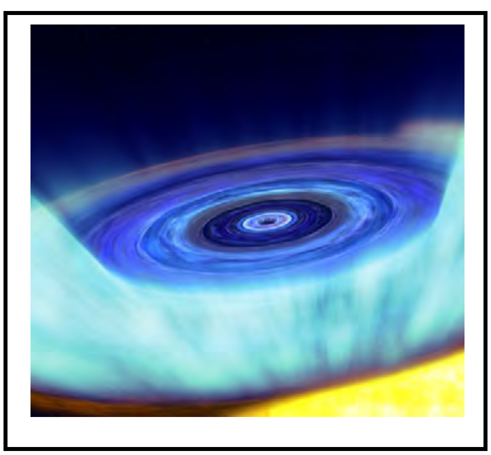
The four missions selected under the 2011 Announcement of Opportunity will undergo review and down-selection in the spring of 2013. NASA will select one of the two Explorer missions: First Infrared Exoplanet Spectroscopy Survey Explorer (FINESSE) or Transiting Exoplanet Survey Satellite (TESS). NASA will select one of the two Missions of Opportunity: Galactic/Xgalactic Ultra long duration balloon Spectroscopic Stratospheric THz Observatory (GUSSTO) or Neutron star Interior Composition ExploreR (NICER).

ASTROPHYSICS EXPLORER PROGRAM MANAGEMENT

Astrophysics Explorer program management provides programmatic, technical, and business management of ongoing missions in formulation and development.

THE WIDE-FIELD INFRARED SURVEY EXPLORER (WISE)

WISE is a Medium Explorer class mission that launched in December 2009. It has surveyed the entire sky in four mid-infrared bands and mapped it with better sensitivity than previous infrared all-sky surveys. During its mission, WISE identified the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. Its legacy is a rich database that will enable astronomers to address questions posed by the Cosmic Origins program. WISE ended its prime mission in October 2010, after which NASA continued to use it for observing asteroids until February 2011, when the satellite was turned off and placed into dormant mode. Data analysis activities are funded through FY 2014.



Operating Missions

SWIFT

Swift is a multi-wavelength space-based observatory that studies the position, brightness, and physical properties of gamma-ray bursts. Swift is a Medium Explorer class mission that launched in 2004 and is now in extended mission operations.

The image to above shows the "white dwarf collision." The Swift Accretion Disk shows how material from a companion star accumulates in a disk around the black hole (blue) and how large amounts of high-energy radiation (green) are released when changes in the accretion state lead to a sudden flow of material

OTHER MISSIONS AND DATA ANALYSIS

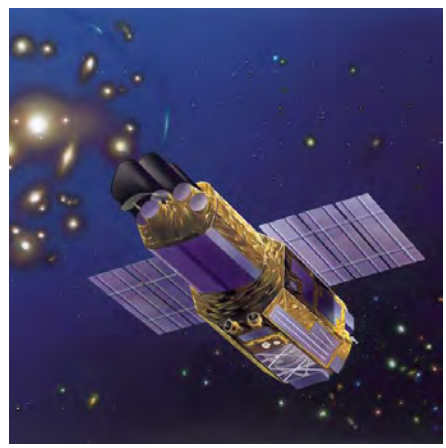
Formulation	Development	Operations

to the inner parts of the disk, marking the onset of an X-ray Nova.

Recent Achievements

Swift continues to observe gamma-ray bursts at a rate of around 90 per year, as well as non-gamma-ray burst targets. Swift studies using X-ray and ultraviolet observations provided new insights into the elusive origins of Type Ia supernovae. The lack of X-rays from a combined sample of 53 nearby supernovae Ia showed that supergiant stars, and even sun-like stars in a later red giant phase, likely aren't present in the host binaries. No ultraviolet emission was detected from the interaction of the outgoing supernovae shock with its companion, suggesting that the companion to the white dwarf is either a small star similar to our sun or another white dwarf.

SUZAKU



Suzaku is Japan's fifth X-ray astronomy mission, which launched in July 2005 and is now in extended mission operations. It was developed at the Institute of Space and Astronautical Science of Japan Aerospace Exploration Agency (ISAS/JAXA) in collaboration with US (NASA and the Massachusetts Institute of Technology) and Japanese institutions. NASA provides software to analyze Suzaku data and operates a Guest Observer Facility for US observers.

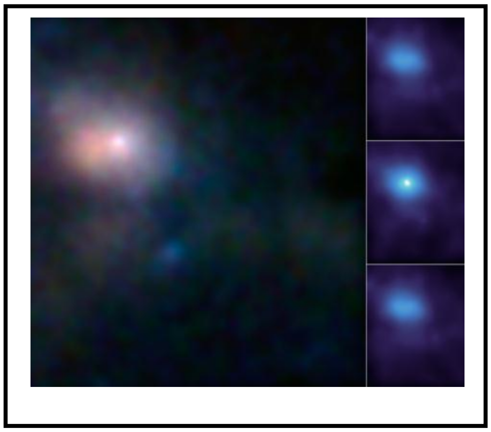
This image is an artist conception of the Suzaku X-ray Observatory in orbit. The universe holds an enormous number of extremely energetic objects like neutron stars, active and merging galaxies, black holes, and supernovae. Astronomers hope Suzaku will help answer several important questions: When and where are the chemical elements created? What happens when matter falls onto a black hole? How does nature heat gas to X-ray emitting temperatures?

RECENT ACHIEVEMENTS

Using Suzaku's state-of-the-art X-ray imaging/spectroscopy instrumentation, scientists took the first-ever measurement of the Doppler shift of X-rays emitted by two clusters of galaxies in the process of merging into a single larger cluster, called Abell 2256. The direct observation of this process, which will take several hundred million years, provided valuable new information on the formation of structure in the universe, one of the most pressing scientific issues in present-day astrophysics.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

The NuSTAR mission launched in June 2012 and has begun its two-year mission, which enables scientists to locate massive black holes in other galaxies, locate and examine the remnants of collapsed stars in our galaxy, observe selected gamma-ray sources, and observe any new supernovae in the local group of galaxies. NuSTAR's key science products are sensitive X-ray survey maps of the celestial sky. NuSTAR offers opportunities for a broad range of science investigations, ranging from probing cosmic ray origins and studying the extreme physics around collapsed stars, to mapping micro flares on the surface of the Sun. NuSTAR also performs follow-up observations to discoveries made by Chandra and Spitzer scientists, and NuSTAR research teams collaborate with those using Fermi to make simultaneous observations. Initial science findings since launch include the X-ray observations of: in-falling matter into the 4 million solar mass black hole located at the center of the Milky Way galaxy (Sagittarius A*), charged particle dynamics in the interior of the Cassiopeia A supernova remnant located about 11,000 light-years away in our Milky Way galaxy, and two intermediate size black holes (i.e., black holes that are 10 times brighter than stellar-mass black holes) within another galaxy (IC342) that is 7 million light-years away. The NuSTAR mission will complete its prime mission in August 2014.

NuSTAR has captured these first, focused views of the supermassive black hole, called Sagittarius A*, at the center of our Milky Way Galaxy. In the image above, taken in infrared light, the brightest white dot is the hottest material closest to the black hole. The series at right shows a flare caught by NuSTAR over two days in July. At the peak of the flare (middle panel) the black hole was consuming and heating matter to temperatures up to 100 million degrees Celsius (180 million degrees Fahrenheit).

JAMES WEBB SPACE TELESCOPE

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	518.6	627.6	**658.2**	645.4	620.0	569.4	534.9

James Webb Space Telescope

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

FY 2014 Budget

	Actual				Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	3468.8	518.6	627.6	**658.2**	645.4	620.0	569.4	534.9	1112.5	8755.4
2014 MPAR LCC Estimate	3528.9	530.6	627.6	**658.2**	645.4	620.0	569.4	534.9	1112.5	8827.5
Formulation	1800.1	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	1800.1
Development/Implementation	1728.8	530.6	627.6	**658.2**	645.4	620.0	569.4	534.9	275.5	6190.4
Operations/Close-out	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	837.0	837.0
Change from FY 2012		--	--	**139.6**						
Percentage change from FY 2012		--	--	**26.9%**						

Note: The 2012 MPAR Project Cost Estimate includes $72.1 million for Construction of Facilities (CoF) funds in FY 2010 to FY 2012 which are budgeted in the CECR account. The life cycle cost (including CoF funds) is $8.828 billion.

The first six flight-ready James Webb Space Telescope primary mirror segments are prepped to begin final cryogenic testing at GSFC. A total of 18 segments will form the telescope's primary mirror for space observations. Engineers began final cryogenic testing to confirm that the mirrors will respond as expected to the extreme temperatures of space prior to integration into the telescope's permanent housing structure.

PROJECT PURPOSE

The James Webb Space Telescope (JWST) is a large, space-based astronomical observatory. The mission is a logical successor to the Hubble Space Telescope, extending beyond Hubble's discoveries by looking into the infrared spectrum, where the highly red-shifted early universe must be observed, where relatively cool objects like protostars and protoplanetary disks emit infrared light strongly, and where dust obscures shorter wavelengths.

The four main science goals are:

- Search for the first galaxies or luminous objects formed after the Big Bang;
- Determine how galaxies evolved from their formation until now;
- Observe the formation of stars from the first stages to the formation of planetary systems; and
- Measure the physical and chemical properties of planetary systems and investigate the potential for life in those systems.

While Hubble greatly improved knowledge about distant objects, its infrared coverage is limited. Light from distant galaxies is redshifted out of the visible part of the spectrum into the infrared by the expansion

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

of the universe. By examining light redshifted beyond Hubble's sight, with more light-collecting area than Hubble and with near to mid-infrared-optimized instruments, JWST will observe objects farther away and further back in time. JWST will explore the poorly understood epoch when the first luminous objects in the universe came into being after the Big Bang. The focus of scientific study will include the first light of the universe, assembly of galaxies, origins of stars and planetary systems, and origins of the elements necessary for life.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PARAMETERS

JWST is an infrared optimized observatory that will conduct imaging and spectrographic observations in the 0.6 to 27 microns wavelength range and will be 100 times more capable than Hubble is. The 6.5-meter primary mirror consists of 18 actively controlled segments that, along with the rest of the telescope optics and instruments, are passively cooled to about 40 degrees Kelvin by a multilayer sunshield the size of a tennis court. JWST will launch from Kourou, French Guiana, on an Ariane 5 rocket supplied by the European Space Agency. JWST will operate in deep space about one million miles from Earth.

JWST's instruments include the Near Infrared Camera (NIRCam), Near Infrared Spectrograph (NIRSpec), Mid Infrared Instrument (MIRI), and the Fine Guidance Sensor (FGS).

NIRCam takes images with a large field of view and high resolution, over the wavelength range of 0.6 to 5 micrometers. NIRCam also aligns and focuses the optical telescope.

NIRSpec can obtain simultaneous spectra of more than 100 objects in a single exposure, over the wavelength range of 0.6 to 5 micrometers.

MIRI takes wide-field images and narrow-field spectra, over the wavelength range of 5 to 28 micrometers. MIRI operates at about seven degrees Kelvin, which an on-board cooling system makes possible.

FGS is a camera that guides star acquisition and provides fine pointing control. The sensor operates over a wavelength range of 1 to 5 micrometers.

For more information, go to http://www.jwst.nasa.gov.

ACHIEVEMENTS IN FY 2012

As planned in the JWST rebaseline, the FGS and MIRI instruments were successfully tested in cryogenic vacuum conditions and qualified for spaceflight, and they arrived at NASA's Goddard Space Flight Center (GSFC). The project also successfully completed the following significant and technically

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

challenging developments and tests:

- Cryogenic vacuum testing on all flight primary mirrors to confirm precision optical shape under cryogenic conditions;
- Fabrication of the flight primary mirror backplane support structure, a very complex composite structure, to an exacting shape necessary to hold the primary mirrors ;
- The telescope tower, also a precision composite structure;
- Extensive modifications of the NASA Johnson Space Center Chamber A to add, for the first time, cryogenic testing capabilities; and
- Fabrication of the critical center of curvature optical assembly, a critical element of precision testing of the flight optical system in the NASA Johnson Space Center Chamber A.

WORK IN PROGRESS IN FY 2013

In FY 2013, the NIRCam and NIRSpec instruments will arrive at GSFC. The project will integrate the FGS and MIRI instruments into the Integrated Science Instrument Module (ISIM); initiate the ISIM risk reduction cryogenic vacuum test; complete the aft optical assembly and the wing structure of the primary mirror backplane support structure; and complete Build 1.1 of the Wave Front Sensing & Control Software. Also, the project will continue the fabrication of the Optical Telescope Element (OTE) backplane support structure, initiated in FY 2012, hold the sunshield manufacturing readiness review, conduct reviews necessary before the ISIM risk reduction cryogenic test, and initiate work on build 3 of the common command and telemetry system.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The President's FY 2014 budget request provides the full level of funding required to keep JWST on schedule for a 2018 launch.

NASA will complete the critical design review of the spacecraft bus; initiate the second cryogenic vacuum test on the Integrated Science Instrument Module; complete modification of the primary mirror gear motors; and begin integration of the pathfinder secondary mirror support structure with the struts.

SCHEDULE COMMITMENTS/KEY MILESTONES

NASA plans to launch JWST in October 2018 to begin a five-year prime mission. The following timeline shows the development agreement schedule per the rebaseline plan from September 2011.

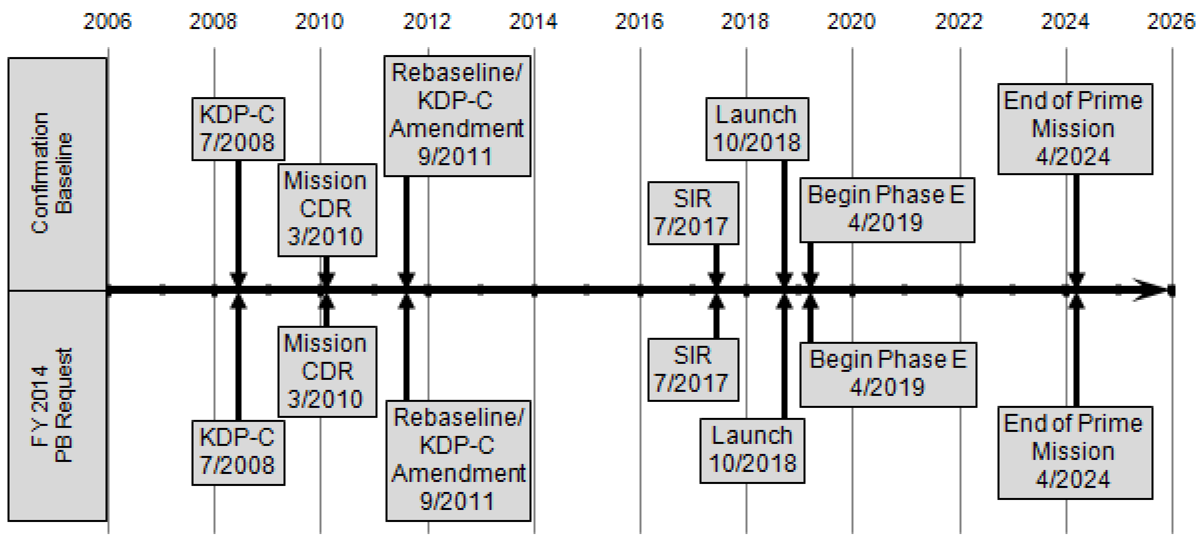
Milestone	Confirmation Baseline Date	FY 2014 PB Request Date
KDP-C	Jul 2008	Jul 2008
Mission CDR	Mar 2010	Mar 2010
Rebaseline/KDP-C Amendment	Sep 2011	Sep 2011
SIR	Jul 2017	Jul 2017
Launch	Oct 2018	Oct 2018

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

Begin Phase E	Apr 2019	Apr 2019
End of Prime Mission	Apr 2024	Apr 2024

Project Schedule



Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2012	6,197.9	66	2013	6,190.4	-0.1%	LRD	Oct 2018	Oct 2018	0

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	6,197.9	6,190.4	-7.5
Aircraft/Spacecraft	2,955.0	3,053.4	98.4
Payloads	695.1	752.7	57.6
Systems I&T	288.4	290.6	2.2
Launch Vehicle	0.9	0.9	0.0
Ground Systems	652.3	560.0	-92.3
Science/Technology	42.7	43.0	0.3
Other Direct Project Costs	1,563.5	1,490.0	-73.5

Project Management & Commitments

NASA Headquarters is responsible for JWST program management. GSFC is responsible for JWST project management.

Project Element	Description	Provider	Change from Baseline
Observatory	Includes Optical Telescope Element, spacecraft, sunshield, observatory assembly integration and testing, and commissioning. The observatory shall be designed for at least a five year lifetime. Northrop Grumman Aerospace Systems has the lead for the OTE, sunshield, spacecraft bus, and selected assembly, integration, and testing activities.	Provider: Northrop Grumman Aerospace Systems (NGAS) and GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Mission management and system engineering	Includes management of all technical aspects of mission development, and system engineering of all components	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

Integrated Science Instrument Module (ISIM)	Contains the science instruments and FGS. Provides structural, thermal, power, command and data handling resources to the science instruments and FGS	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Near Infrared Camera (NIR Cam) Instrument	Operates over the wavelength range of 0.6 to 5 microns, and optimized for finding first light sources	Provider: University of Arizona, Lockheed Martin Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Near Infrared Spectrometer (NIRSpec)	Operates over the wavelength range 0.6 to 5 microns with three observing modes	Provider: ESA Lead Center: ESA Performing Centers: None Cost Share Partners: ESA	None
Mid-Infrared Instrument (MIRI)	Operates over the wavelength range 5 to 27 microns, providing imaging, coronagraphy, and spectroscopy	Provider: ESA, University of Arizona, JPL Lead Center: GSFC Performing Centers: JPL, ARC Cost Share Partners: ESA	None
Fine Guidance	Provides scientific target pointing information to the observatory's attitude control sub-system	Provider: CSA Lead Center: CSA Performing Centers: None Cost Share Partners: CSA	None
Launch vehicle and launch operations	Ariane 5 Evolution Cryotechnique-Type A	Provider: ESA Lead Center: ESA Performing Centers: None Cost Share Partners: ESA	None
Ground control system and science operations and control center	Includes mission operations and science operations center	Provider: Space Telescope Science Institute Lead Center: GSFC Performing Centers: None Cost Share Partners: None	None

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The spacecraft bus mass estimate is higher than the system allocation to the spacecraft bus, Then: Design changes would be required to reduce spacecraft bus mass.	The spacecraft bus developer (NGAS) will complete analysis and design work to reduce spacecraft bus mass, prior to the spacecraft bus critical design review.
If: NIRCam and/or NIRSpec instrument delivery changes schedule to a later date, Then: Changes to the ISIM integration and test plan, flow and schedule will be required.	The ISIM integration and test plan, flow, and schedule were adjusted in October 2012 to accommodate the updated estimate delivery dates for NIRCam and NIRSpec instruments.

Acquisition Strategy

All major contracts have been awarded.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Science and Operations Center	Space Telescope Science Institute	Baltimore, MD
NIRCam	University of Arizona; Lockheed Martin	Tucson, AZ Palo Alto, CA
Observatory	NGAS Ball Aerospace ITT Alliant Techsystems	Redondo Beach, CA Boulder, CO Rochester, NY Edina, MN
Near Infrared Detectors	Teledyne Imaging Systems	Camarillo, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Standing Review Board (SRB)	Apr 2010	Critical Design review	Determined mission design is mature and recommended a more in depth review of the integration and testing plan.	N/A
Quality	Test Assessment Team	Aug 2010	Evaluate plans for integration and testing. See the full report at http://www.jwst.nasa.gov/publications.html	The team recommended several changes to test plan.	N/A

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

Other	Independent comprehensive Review Panel	Oct 2010	Determine the causes of cost growth and schedule delay on JWST, and estimate the launch date and budget, including adequate reserves.	The report made 22 recommendations covering several areas of management and performance	N/A
Other	Aerospace Corp	Apr 2011	Analysis of alternatives	Determined that JWST design was still the best value to achieve the primary scientific objectives of the mission.	N/A
Other	SRB	May 2011	Review technical, cost, and schedule plans	The SRB proposed rebaselined project technical, cost, and schedule plans and made recommendations to Agency.	N/A
Performance	NASA Headquarters Office of Evaluation	Jun 2012	Replan assessment review	A review assessed progress against replan.	N/A
Performance	SRB	N/A	Spacecraft Critical Design Review		Dec 2013
Performance	SRB	N/A	OTIS Pre-Environmental Review		Jun 2016
Performance	SRB	N/A	Spacecraft Element Readiness Review		Apr 2016
Performance	SRB	N/A	Systems Integration Review		Jul 2017
Performance	SRB	N/A	Flight Readiness Review		Sep 2018

JAMES WEBB SPACE TELESCOPE

Formulation	Development	Operations

CORRECTIVE ACTION PLAN AS REQUIRED BY SECTION 1203 OF NASA 2010 AUTHORIZATION ACT

NASA informed Congress by letters dated October 28, 2010, April 21, 2011, and October 24, 2011, that JWST had experienced a significant cost overrun and schedule delay. NASA has addressed the root causes of the overrun and delays vigorously, and has rebaselined the project with an executable budget and schedule. On April 21, 2011, NASA transmitted the final report of the Independent Comprehensive Review Panel (ICRP). NASA's detailed response to the ICRP included recommendations to correct past problems, reduce the risk of future cost growth and schedule delays, and improve JWST performance.

The current projected JWST launch readiness date is October 2018, the development cost estimate is $6.190 billion, and the life cycle cost estimate is $8.827 billion. The revised JWST cost and schedule incorporates 13 months of schedule reserve within the planned funding for development.

The following table describes the issues that NASA addressed during the rebaseline of JWST in 2011.

2010 Issues	Corrective Action Plan
Issue 1: Cost and schedule overrun Current Status: Revised cost and schedule baseline has been approved by the Agency and sent to Congress. Subsequent to the submission of the revised baseline to Congress, Congress approved the FY 2012 NASA appropriation and included the funding required to support the revised development cost and schedule baseline, and included language capping JWST formulation and development costs at $8 billion.	Programmatic: NASA revised the program management structure, with the creation of a NASA Headquarters program office reporting programmatically to the NASA Associate Administrator. NASA also increased visibility and communication at both the Agency and Center levels. Technical: No action required Cost: Bottom-up review resulted in a revised life cycle cost estimate of $8.827 billion. This estimate is consistent with the 66 percent joint confidence level with a cost confidence level that is significantly higher than the 80 percent recommended by the ICRP. Schedule: Bottom-up review resulted in a revised development schedule, with launch in October 2018. The revised schedule incorporates 13 months of funded schedule reserve.
Issue 2: Testing concerns Current Status: Findings from the Independent Test Assessment Team have been incorporated into the plans for testing within the JWST integration and test phase and within the revised development cost and schedule baseline.	To address testing concerns from the mission CDR, NASA chartered an independent Test Assessment Team to conduct a review of plans for environmental and functional testing. The findings of this review have now been incorporated into the plans for testing within the JWST integration and test phase and the revised development cost and schedule baseline.

HELIOPHYSICS

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	644.9	--	**653.7**	633.1	636.8	664.3	664.6
Heliophysics Research	166.7	--	**195.7**	163.0	167.5	172.1	174.1
Living with a Star	196.3	--	**216.2**	277.7	332.6	353.9	374.4
Solar Terrestrial Probes	216.0	--	**146.6**	68.7	48.9	50.1	27.9
Heliophysics Explorer Program	65.8	--	**95.2**	123.7	87.9	88.2	88.2

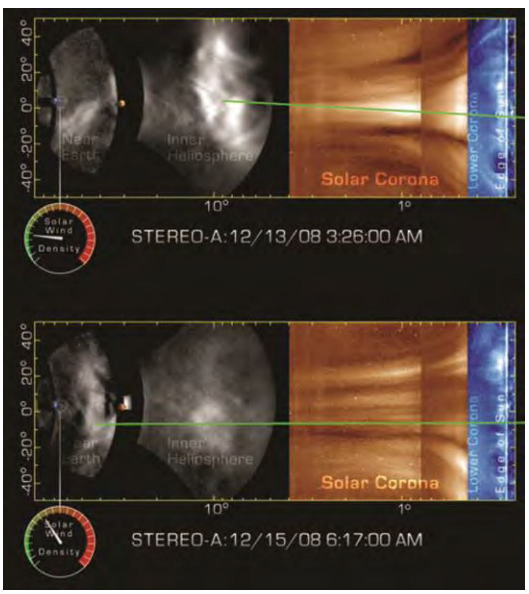
Heliophysics

HELIOPHYSICS RESEARCH

FY 2014 Budget

	Actual				Notional		
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	166.7	--	**195.7**	163.0	167.5	172.1	174.1
Heliophysics Research and Analysis	32.9	--	**33.5**	33.9	34.0	33.9	33.9
Sounding Rockets	52.4	--	**51.6**	53.7	53.0	53.0	53.0
Research Range	20.1	--	**21.0**	21.3	21.6	21.7	21.7
Other Missions and Data Analysis	61.3	--	**89.6**	54.2	58.8	63.5	65.5
Subtotal	166.7	--	**195.7**	163.0	167.5	172.1	174.1
Rescission of prior-year unob. balances*	0	--	**--**	--	--	--	--
Change from FY 2012	--	--	**29.0**				
Percentage change from FY 2012	--	--	**17.4 %**				

** Rescission of $0.026 million of prior-year unobligated balances in Sounding Rockets pursuant to P.L. 112-55, Division B, sec. 528(f). Amount rounds to $0.0 million in table above.*



Coronal Mass Ejections (CME) are billion-ton clouds of solar plasma ejected from the sun at speeds up to 3 million miles per hour. Newly reprocessed images from NASA's STEREO-A spacecraft allow scientists to trace the anatomy of the December 2008 CME as it moves from the Sun to the Earth (from right to left in the images) and changes on its journey (upper to lower panels). This work identifies the origin and structure of the material that impacted Earth, and it connects the image data directly with measurements on Earth at the time of impact.

Heliophysics seeks to understand the Sun and its interactions with Earth and the solar system. The goal of the Heliophysics Research program is to understand the Sun, heliosphere, and planetary environments as a single connected system and to answer these fundamental questions about this system's behavior.

What causes the Sun to vary?

How do Earth and the heliosphere respond to the Sun’s changes?

What are the impacts on humanity?

The Heliophysics Research program advances knowledge of solar processes and also the interaction of solar plasma and radiation with Earth, the other planets and the Galaxy. By analyzing the connections between the Sun, solar wind, planetary space environments, and our place in the Galaxy, we are uncovering the fundamental physical processes that occur throughout the Universe. Understanding the connections between the Sun and its planets will allow us to improve predictions on the impacts of solar variability on humans, technological systems, and even the presence of life itself. For more information, go to:

HELIOPHYSICS RESEARCH

http://science.nasa.gov/about-us/smd-programs/heliophysics-research/.

EXPLANATION OF MAJOR CHANGES

The request reflects the movement of the budgets for the operational Advanced Composition Explorer (ACE) and Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) missions to the Heliophysics Explorer program, which originally funded their development. The request also reflects movement of the budget for the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) mission to the Solar Terrestrial Probes program. These transfers increase the consistency of the budget structure, without affecting the projects in any way. A new Space Weather Research to Operations project has been created, consolidating several small ongoing efforts, totaling about $300K per year, which support non-NASA space weather operational forecasters. A new CubeSat project offers a low-cost option for enabling scientific discovery across the various themes and disciplines in the Science Mission Directorate.

ACHIEVEMENTS IN FY 2012

Heliophysics research findings in FY 2012 have demonstrated that the Solar Terrestrial Relations Observatory (STEREO)-A spacecraft cameras are capable of taking images that could improve space weather predictions. Direct imaging of plasma clouds was very difficult, but the spacecraft's wide-angle cameras detect ordinary sunlight scattered by free-floating electrons in plasma clouds. Newly released processed images from cameras on the STEREO-A spacecraft reveal detailed features in a large Earth-directed coronal mass ejection in late 2008, connecting the original magnetized structure in the Sun's corona to the intricate anatomy of the interplanetary storm as it hit the planet three days later. These STEREO-A observations pinpointed not only the arrival time of the coronal mass ejection, but also its mass. The brightness of the cloud enabled researchers to calculate the cloud's gas density throughout the structure and compare it to direct measurements by other NASA spacecraft. When this technique is applied to future storms, forecasters will be able to say with confidence whether Earth is about to be hit by a small or large cloud, and where on the Sun the material originated.

The Sounding Rocket project launched 21 sounding rockets, supporting eleven science investigations, three test vehicle and technology demonstrations, and two educational projects. Notable science achievements include the Anomalous Transport Experiment, which required 5 separate rockets to be launched 80 seconds apart to study the upper level jet stream on multiple scales. The jet stream is a region of significant electrical turbulence that adversely affects satellite and radio communications.

WORK IN PROGRESS IN FY 2013

NASA is introducing a newly restructured competed research program in response to the National Research Council of the National Academies' 2012 Decadal Survey. In direct response to the Diversify, Realize, Integrate, Venture, Educate (DRIVE) initiative in the Decadal Survey, the Heliophysics Grand Challenges program will in the future support large principle investigator-proposed team efforts that require a critical mass of expertise to make significant progress in understanding complex heliophysical processes with broad importance. The new Heliophysics Technology and Instrument Development for Science program will support development of new instrument concepts, and laboratory measurements of relevant atomic and plasma parameters for all of Heliophysics. One recent selection will conduct micro-dust impact experiments in a vacuum chamber with surfaces resembling spacecraft hardware. This way the team will understand better the signals picked up by the STEREO antennas currently interpreted as stemming from dust impacts in space.

KEY ACHIEVEMENT PLANNED FOR FY 2014

The budget request supports a flight program of up to 24 sounding rocket flights, with 1 to 2 campaign deployments. (Poker Flat, Norway and/or Australia are envisioned as potential locations for the deployments). The Peregrine motor design will be completed and verified in up to three test flights, for subsequent release to industry.

In FY 2014, in response to solicitations in Research Opportunities in Space and Earth Sciences 2013 (ROSES-13) and ROSES-12, NASA anticipates awarding over 85 new 3-year investigations.

Program Elements

HELIOPHYSICS RESEARCH AND ANALYSIS

This project supports basic research, solicited through NASA's annual ROSES announcements. NASA solicits investigations relevant to Heliophysics in several broad areas that include:

- Understanding the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments;
- Exploring the fundamental physical processes of space plasma systems; and
- Studying the solar wind.

Geospace Science and Solar and Heliospheric Physics element solicits basic theory investigations needed to interpret data from NASA's heliophysics missions, and to develop the scientific basis for future missions. The Low Cost Access to Space element solicits investigations and new instrument concepts to be flown on sounding rockets or balloons, as well as preparation of payloads.

Other research elements include Heliophysics Technology and Instrument Developments and Heliophysics Guest Investigators.

NASA occasionally releases special solicitations to take advantage of research opportunities that arise from recent launches or other significant opportunities. Heliophysics Research and Analysis funds scientific investigations based on suborbital platforms such as balloons or sounding rockets, and maintains some of the vital communications infrastructure at Wallops Flight Facility.

SOUNDING ROCKETS

The Sounding Rockets project provides low-cost, sub-orbital access to space in support of space and Earth sciences research and technology development sponsored by NASA and other users by providing payload development, launch vehicles, and mission engineering services.

HELIOPHYSICS RESEARCH

RESEARCH RANGE

The Research Range Services (RRS) project provides operations support, maintenance, and engineering for the Wallops Launch Range and instrumentation. The range and instrumentation support suborbital, orbital, and aircraft missions conducted on behalf of NASA and the Department of Defense at the Wallops Flight Facility and at remote sites around the world. New work includes support for Commercial Resupply Services missions, NASA technology missions, unmanned aerial vehicle flights, and commercial launch and flight projects.

The range instrumentation includes meteorological, telemetry, radar, command, launch and range control centers, and optical systems. RRS mobile assets provide range services at other ranges and remote locations around the world.

Program Schedule

NASA implements the Heliophysics Research program via competitively selected research. Research solicitations are released each year in the Research Opportunities in Space and Earth Sciences NASA Research Announcement (ROSES NRA), typically aiming to initiate research for about one-third of the program, given the selected projects are typically three-year awards. Therefore, NASA will allocate FY 2014 funds to first year projects from ROSES-2013 selections, second year of projects from ROSES-2012 selections, and third year of projects from ROSES-2011 selections.

Date	Significant Event
Q2 FY14	ROSES-2014 solicitation - February 2014
Q3 FY14	Review of all Proposals Submitted to Heliophysics ROSES Elements
Apr 2014	Senior Review of Data Archives
Apr 2015	Senior Review of All Operating Missions

Program Management & Commitments

Program Element	Provider
Research and Analysis	Provider: NASA/HQ Lead Center: SMD-Heliophysics Division Performing Centers: GSFC, MSFC, JPL, LaRC, JSC Cost Share Partners: None

Sounding Rockets and Research Range	Provider: GSFC Lead Center: SMD Performing Center: GSFC Cost Share Partners: None
Science Data and Computing	Provider: GSFC Lead Center: SMD Performing Center: GSFC Cost Share Partners: None
Heliophysics Operating Missions	Provider: GSFC, JPL, MSFC Lead Center: HQ Performing Center: GSFC, JPL, MSFC Cost Share Partners: None

Acquisition Strategy

All new acquisitions are based on full and open competition. Proposals are peer-reviewed and selected from the annual NASA Research Opportunities in Space and Earth Sciences (ROSES) announcement. Universities, government research laboratories, and industry partners throughout the United States participate in research and analysis projects. The Heliophysics operating missions and instrument teams were previously selected from NASA Announcements of Opportunity. NASA evaluates the allocation of funding among the operating missions bi-annually through the Heliophysics Senior Review. Universities, government research labs, and industry partners throughout the United States participate in science data and computing technology research projects.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Sounding Rocket Operations	Orbital Sciences Corp., Dulles VA	Various

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Mission Senior Review Panel	Apr 2010	A comparative evaluation of Heliophysics operating missions. A report ranking the operating missions to be released	Report released in July 2010. Assessed missions singly, and as part of a greater whole	Apr 2013

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	61.3	--	**89.6**	54.2	58.8	63.5	65.5
Science Planning and Research Support	5.7	--	**6.3**	6.5	6.6	6.7	6.8
Directed Research & Technology	13.5	--	**37.8**	3.4	6.9	11.4	13.3
Space Weather Research to Operations	0.0	--	**0.3**	0.4	0.4	0.4	0.4
SOLAR Data Center	0.7	--	**1.0**	1.0	1.0	1.0	1.0
Data & Modeling Services	3.8	--	**3.2**	3.2	3.0	3.0	3.0
Space Physics Data Archive	1.4	--	**2.0**	2.0	2.0	2.0	2.0
Guest Investigator Program	10.4	--	**8.2**	7.2	8.0	8.0	8.0
Community Coordinated Modeling Center	2.0	--	**1.5**	1.4	1.4	1.4	1.4
Science Data & Computing	1.7	--	**2.1**	2.0	2.0	2.0	2.0
Space Science Mission Ops Services	10.1	--	**11.0**	11.3	11.6	11.7	11.7
CubeSat	0.0	--	**5.0**	5.0	5.0	5.0	5.0
Voyager	5.3	--	**5.3**	5.3	5.5	5.4	5.4
Solar and Heliospheric Obervatory	2.0	--	**2.2**	1.9	1.9	1.9	1.9
WIND	2.0	--	**2.2**	2.2	2.2	2.2	2.2
GEOTAIL	0.2	--	**0.2**	0.2	0.2	0.2	0.2
CLUSTER-II	2.5	--	**1.2**	1.2	1.2	1.2	1.2
Change from FY 2012	--	--	**28.3**				
Percentage change from FY 2012	--	--	**46.2 %**				

NASA accumulates, archives, and distributes data collected by the Heliophysics System Observatory, a fleet of operating spacecraft. Combining the measurements from all of these observing platforms enables interdisciplinary science across the vast spatial scales of our solar system. This collective asset enables the data, expertise, and research results to directly contribute to fundamental research on solar and space plasma physics and to the national goal of real-time space weather prediction. NASA teams support day-to-day mission operations, a guest investigator program for data analysis and to advance the state of space science and space weather. NASA conducts community-based projects to provide evaluations of the ability of research models to forecast weather disturbance information of value to industry and government agencies, in preparation for transition to operations. Heliophysics data centers archive and distribute the collected science data from operating missions in the Living With a Star (LWS), Solar Terrestrial Probes (STP), and Explorers programs.

Space observations spark space science progress, which also provides the “ground truth” to test simulations, models, and predictions. "Ground truth" has come to mean making the kinds of measurements that would validate a theory. It is essential to properly record, analyze, release, document, and rapidly turn space observations into scientific results. NASA funds projects that facilitate a smooth data flow: the Solar Data Center, Sun-Earth Connection Data and Modeling Services, the Space Physics

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Data Archive, Science Data and Computing, and Space Science Mission Operations Services. These projects undergo a competitive senior review process with the level of support adjusted regularly, according to the anticipated scientific productivity and mission maintenance requirements.

For more information, go to: http://science.nasa.gov/about-us/smd-programs/heliophysics-research/.

Mission Planning and Other Projects

SCIENCE PLANNING AND RESEARCH SUPPORT

This project supports NASA's participation in proposal peer review panels, decadal surveys and National Research Council studies.

DIRECTED RESEARCH AND TECHNOLOGY

This project funds the civil service staff that will work on emerging science projects, instruments, and research.

SOLAR DATA CENTER

The Solar Data Center provides mission and instrument expertise to enable high-quality analysis of solar physics mission data. It provides leadership for community-based, distributed development efforts to facilitate identifying and accessing solar physics data, including ground-based coordinated observations residing in the Virtual Solar Observatory. The center also provides a repository for software used to analyze these data. The Virtual Solar Observatory (VSO) is a software system linking together distributed archives of solar data into a unified whole, along with data search and analysis tools.

DATA & MODELING SERVICES

This project supports missions in extended operations and missions transitioning to decommissioning to better prepare their data holdings for long-term archival curation. This project also provides for the creation of higher-level data products, which are of significant use to the science community and not funded during the prime mission. Higher level data products are data that combine results of multiple missions and/or instruments. This project is competed through the annual Research Opportunities in Space and Earth Science competitive announcement.

SPACE PHYSICS DATA ARCHIVE

The Space Physics Data Facility ensures long-term data preservation and online access to non-solar heliophysics science data. It operates key infrastructure components for the Heliophysics Data

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Environment including inventory and web service interfaces to systems and data. It also provides unique enabling science data services.

GUEST INVESTIGATOR PROGRAM

The Guest Investigator program is intended to maximize the return from currently operating Heliophysics missions by supporting studies of the current science goals of these missions. These highly competitive research investigations use data from multiple spacecraft, as appropriate, and investigations addressing global system problems are strongly encouraged, as Heliophysics is, by its nature, the investigation of a large-scale, complex, connected system.

COMMUNITY COORDINATED MODELING CENTER (CCMC)

The Community Coordinated Modeling Center is a multi-agency partnership to enable, support, and perform the research and development for next-generation heliophysics and space weather models. The center provides the United States and international research community access to modern simulations to enable "runs on demand," using models to study solar events in near-real time. This allows the comparison of observational data and model parameters during or shortly after solar activity, incorporating more precise boundary conditions into the models, thereby making them more accurate. This latter function has important implications for human space flight and the societal impacts of space weather phenomena.

SCIENCE DATA AND COMPUTING

This project preserves NASA's science data assets by working with all space science data archives, missions, and investigators. Science Data and Computing provides the space science community with stewardship, guidance, and support so that data made available to the research community is well documented to provide independent usability. As a repository making unique data and metadata available, Science Data and Computing participates in Virtual Observatory development efforts to assist in the practical evolution of those concepts.

SPACE SCIENCE MISSION OPERATIONS SERVICES

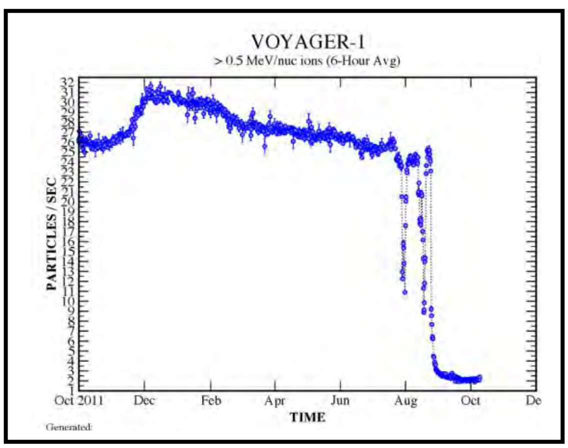
Space Science Mission Operations Services manages the GSFC Space Science missions on-orbit operations. Services include consistent processes for missions operated at GSFC, Johns Hopkins University Applied Physics Laboratory, Orbital Sciences Corporation, Pennsylvania State University, University of California at Berkeley, and Bowie State University. Space Science Mission Operations Services also sustains an operational infrastructure for current and future missions.

SPACE WEATHER RESEARCH TO OPERATIONS

NASA takes theoretical models produced from a variety of sources, and in conjunction with real data from missions, assesses the accuracy of the models to be able to predict a space weather event. NASA provides the results of these tests to agencies that are responsible for operational predictions to the public.

CUBESATS

A new CubeSat project offers a low-cost option for enabling scientific discovery across the various themes and disciplines in the Science Mission Directorate. CubeSats are very small spacecraft, as small as a few inches square, that can be launched as secondary ("tag-along") payloads, on either orbital or sub-orbital rockets. At costs that can be less than $1 to $2 million per satellite and with rapid development cycles, CubeSats are now a viable frequent flight opportunity for rapid innovation in science and technology. CubeSats will address space technology and exploration systems development needs, will extend important hands-on experience to undergraduate and graduate students, and will leverage exploratory and systematic science observations at a minimal cost. CubeSats have the potential to reduce technology risk in early stage TRL development before infusing these technologies into less risk-tolerant, more expensive, NASA missions. NASA plans to offer CubeSat Pilot-1 investigations as part of the SMD ROSES-13 announcement, and select multiple CubeSat investigations as part of the SMD award announcement in FY 2014. The CubeSats would be delivered approximately 24 months after award, and at least one CubeSat would be targeted to launch by 2016.



Operating Missions

VOYAGER

The Voyager Interstellar Mission is exploring the interaction of the heliosphere with the local interstellar medium. The Voyager Interstellar mission is making the first in situ observations of the region outside the heliosphere. Voyager 1 is about 120 astronomical units (AU), or 120 times Earth's distance from the Sun, and traveling at a speed of 3.6 AU per year. Voyager 2 is about 100 AU from the Sun and traveling at a speed of about 3.3 AU per year. Spacecraft power is expected to be adequate for currently operating instruments through 2020; a subset of those instruments could operate through 2025.

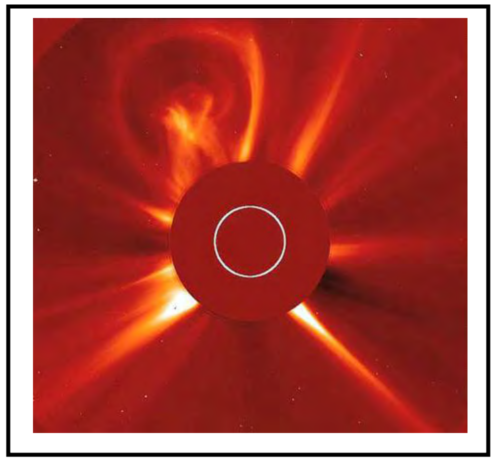
Recent Achievements

Data obtained from Voyager 1 over the last year reveal that the wind of charged particles streaming out from the Sun has calmed, and the solar system's magnetic field has piled up, or increased in density at the heliospheric bow shock. Voyager has been measuring energetic particles that originate from inside and outside the solar system. The intensity of these energetic particles has been declining since Voyager 1

Formulation	Development	Operations

moved into the region. The particles were found to be half as abundant or less as they were during the previous five years, with multiple sharp drops occurring in 2012. The image above reflects what Voyager 1 observed. Voyager 1 has now entered, by direct measurement, a region of physical processes never observed before.

SOLAR AND HELIOSPHERIC OBSERVATORY (SOHO)



SOHO combines remote sensing of the Sun and the consequences of solar activity with measurements of the space environment near the L1 Lagrangian point, about a million miles from Earth toward the Sun. SOHO is the main source of near-real time solar data for space weather predictions. The Large Angle and Spectrometic Coronagraph on SOHO is a unique instrument resource on the Sun-Earth line that is critically important to the Nation's space weather architecture. This instrument helps scientists understand coronal mass ejections, which are large bursts of plasma from the Sun that can impact Earth, and their effect on interplanetary space.

Recent Achievements

On August 20, 2012, the Sun ejected a bulbous coronal mass ejection resembling a light bulb. This ejection had a thin outer edge and a bright, glowing core at its center. Scientists find this unusual shape of interest because it displayed rare magnetic field structure not often seen at such large scales and has not been seen in a number of years. The image to the left reflects what SOHO observed.

WIND

The Wind spacecraft studies the solar wind and its impact on the near Earth environment. It addresses wave-particle interaction processes in the space environment, the evolution of solar transients in the heliosphere, and the geomagnetic impact of solar activity. Wind performs in situ studies using unique capabilities, such as three-dimensional particle distributions over a wide range of energies, and delivery at higher time resolution than available from any other mission.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

This year, new Wind observations provided evidence for anacceleration and heating mechanism in multiple space environments. Observations of space plasmas with a mix of fast and slow-moving particles have consistently shown evidence of relaxation, which means that the particle speeds become more uniform, even though the particles themselves do not collide to make this happen. For over 50 years, theorists have proposed that electromagnetic waves could replace collisions as a mechanism to increase the temperature of the system. Recent Wind spacecraft observations provide the first direct evidence of particle acceleration by electromagnetic waves.

GEOTAIL

Geotail enables scientists to assess data on the interaction of the solar wind and the magnetosphere. July 24, 2012 marked the 20th anniversary of the launch of Geotail, and its instruments continue to function, sending back crucial information about how aurora form, how energy from the Sun funnels through near Earth space, and the ways in which magnetic field lines move and rebound creating explosive bursts that rearrange the very shape of our magnetic environment. The Geotail mission is a collaborative project undertaken by the Japanese Institute of Space and Astronautical Science and NASA.

CLUSTER-II

Cluster uses four spacecraft to make direct measurements of the particles trapped in Earth's magnetic field. By varying spacecraft separations during repeated visits to regions, Cluster can measure the small-scale fluctuations in interplanetary space. One of the interactions studied is the acceleration of plasma in the magnetotail during substorms. The magnetotail is a large reservoir of both solar wind and ionospheric particles that, under some circumstances, releases a large quantity of particles towards Earth. Both mechanisms—particles entering the polar cusps and the substorms—produce aurorae when the participating particles, electrons and ions, hit the neutral gas of the atmosphere. When these particles are particularly energetic they can have a dramatic effect on human activities, disrupting electrical power and telecommunications or causing serious anomalies in the operation of satellites, especially those in geostationary orbit.

Cluster is a joint European Space Agency and NASA project, part of ESA's Horizons 2000 program.

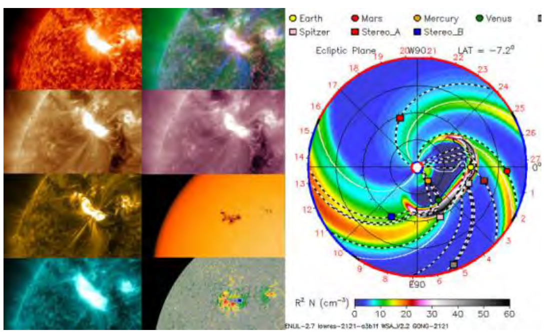
Recent Achievements

In 2012, a new study showed that it is easier for the solar wind to penetrate Earth's magnetic environment, or magnetosphere, than scientists had previously thought. For the first time, scientists directly observed the presence of waves in the solar wind, called Kelvin-Helmholtz waves, that can help transfer energy into near Earth space under circumstances that previous theories had predicted would not happen.

LIVING WITH A STAR

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	196.3	--	**216.2**	277.7	332.6	353.9	374.4
Solar Probe Plus	52.6	--	**104.8**	137.1	229.3	213.5	329.7
Solar Orbiter Collaboration	19.7	--	**55.5**	97.3	68.2	100.0	6.7
Other Missions and Data Analysis	124.0	--	**55.8**	43.3	35.1	40.5	38.0
Change from FY 2012	--	--	**19.9**				
Percentage change from FY 2012	--	--	**10.1 %**				



Sunspot AR1429 unleashed a powerful X5-class solar flare and propelled a massive CME toward Earth on March 7, 2012, starting off the "St. Patrick Day Storms." NASA's Solar Dynamics Observatory recorded the flare at multiple extreme ultraviolent wavelengths. Solar flare strength is ranked using five categories: A, B, C, M and X, with X-class the most powerful. This system resembles the Richter scale in that each category is 10 times stronger than the one before it. The categories are broken into subsets from 1 to 9, but only X-class flares can go higher than 9. The most powerful solar flare on record occurred in 2003, estimated to be X28 on the solar flare scale.

The Living with a Star program targets specific aspects of the coupled Sun-Earth-planetary system that affect life and society and enables robotic and human exploration of the solar system. LWS provides a predictive understanding of the Sun-Earth system, the linkages among the interconnected systems, and specifically of the space weather conditions at Earth and the interplanetary medium. LWS products measure and therefore may mitigate impacts to technology associated with space systems, communications and navigation, and ground systems such as power grids. Its products improve understanding of ionizing radiation, which has human health implications on the International Space Station and high-altitude aircraft flight, as well as operations of future space exploration with and without human presence. Its products improve the definition of solar radiation for global climate change, surface warming, and ozone depletion and recovery.

For more information, go to: http://science.nasa.gov/about-us/smd-programs/living-with-a-star/.

EXPLANATION OF MAJOR CHANGES

None.

SOLAR PROBE PLUS

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	52.6	--	**104.8**	137.1	229.3	213.5	329.7
Change from FY 2012	--	--	**52.2**				
Percentage change from FY 2012	--	--	**99.2%**				

To test the survivability of the high temperatures and intense particle fluxes they will encounter, the Thermal Protection System ceramic coating was subjected to 1600 degrees Celcius in a furnace setting and the expected mission solar flux using plasma lamps. This is to test the optical performance and survivability of the ceramic material on the carbon-carbon surface. In addition, the project has completed ion exposure using a linear accelerator at 150 percent of the expected mission radiation exposure. In all testing, the system survived with no problems.

PROJECT PURPOSE

Solar Probe Plus (SPP) will explore the Sun's outer atmosphere, or corona, as it extends out into space. At 3.7 million miles from the surface of the Sun, closer than any other spacecraft, SPP will repeatedly obtain direct in situ coronal magnetic field and plasma observations and white-light remote sensing observations in the region of the Sun that carries the solar wind and creates space weather. SPP's findings will revolutionize knowledge and understanding of coronal heating and of the origin and evolution of the solar wind, answering critical questions in heliophysics that have been ranked as the top priority by the last decadal survey.

Its seven year prime mission lifetime will permit observations to be made over a significant portion of a solar cycle. SPP will enable direct sampling of plasma, enabling observations that could not previously be accomplished in any other way. These observations will allow heliophysicists to verify and discriminate between a broad range of theory and models that describe the Sun's coronal magnetic field and the heating and acceleration of the solar wind. SPP will enable NASA to characterize and forecast the radiation environment in which future space explorers will work and live.

For more information about SPP, go to: http://nasascience.nasa.gov/missions/solar-probe.

EXPLANATION OF MAJOR CHANGES

None.

SOLAR PROBE PLUS

Formulation	Development	Operations

PROJECT PRELIMINARY PARAMETERS

SPP's first closest approach to the Sun occurs three months after launch, at a heliocentric distance of 35 solar radii. Over the next several years, successive Venus gravitational assists will gradually lower the spacecraft's closest approach to the Sun to less than 10 solar radii. July 2018 is the earliest possible launch date within funding guidelines and technology capability. After launch, SPP will orbit the Sun 24 times, gradually "walking in" toward the Sun with each pass. The closest points of each orbit come well within the path of Mercury, the closest planet to the Sun. On the final three orbits, SPP will fly to within 3.7 million miles of the Sun's surface. That is about seven times closer than the current record holder for a close solar pass, the Helios Spacecraft. SPP will sample the solar wind as it evolves with rising solar activity toward an increasingly complex structure

ACHIEVEMENTS IN FY 2012

The project successfully completed the Mission Design Review in November 2011 and proceeded into preliminary design.

WORK IN PROGRESS IN FY 2013

The project will generate mission, instrument, and spacecraft requirements and designs, and hold system and sub-system requirements reviews during FY 2013.

SPP is designing and fabricating hardware for the technical readiness level (TRL)-6 (near final version of new technology tested in real-life conditions) demonstrations of all technology items. Engineers are focusing on the thermal protection system and its support structure, the solar array cooling system, the high temperature portion of the solar array, and the solar limb sensors.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, SPP plans to complete a static firing of the STAR48GXV motor. This motor is a new development for the upper stage of the launch vehicle. The static firing will effectively demonstrate the motor concept and provide the engineering data necessary for follow-on work to develop the motor.

SPP will conduct TRL-6 testing and analysis for all enabling technologies including the Thermal Protection System (TPS), the high temperature solar array and its cooling system. A series of subsystem-level preliminary design reviews will follow these TRL-6 demonstrations. TRL-6 consists of a system/subsystem model or prototype demonstration in a relevant environment. In January of FY 2014, the SPP project will complete its mission-level Preliminary Design Review. In March of FY 2014, SPP will start its implementation phase.

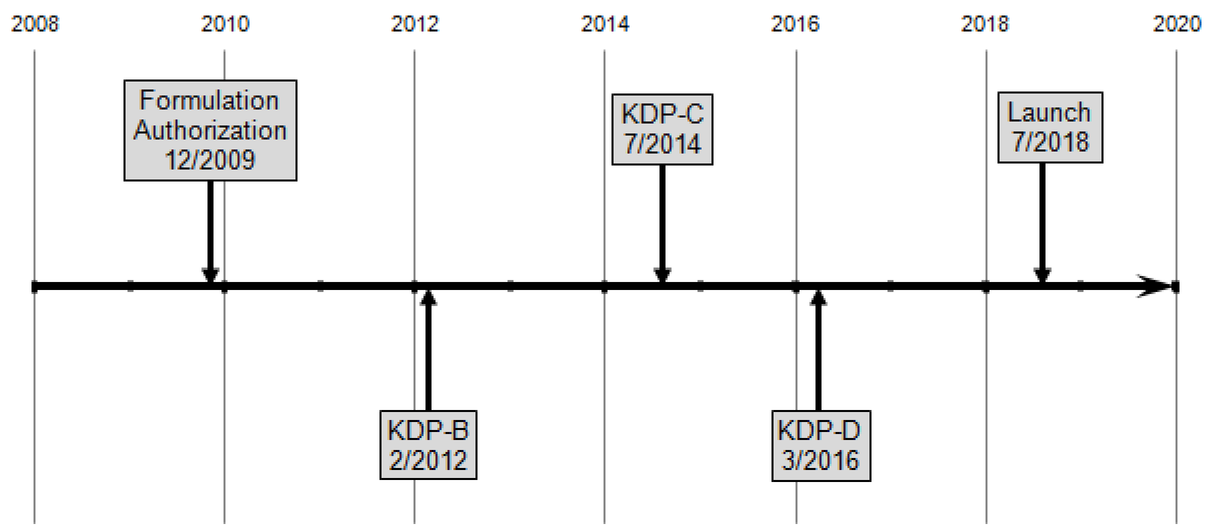
SOLAR PROBE PLUS

Formulation	Development	Operations

ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization	Dec 2009	Dec 2009
KDPB	Feb 2012	Feb 2012
KDPC	Jul 2014	Mar 2014
KDPD	Mar 2016	Mar 2016
Launch	Jul 2018	Jul 2018

Project Schedule



SOLAR PROBE PLUS

Formulation	Development	Operations

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Lifecycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Jan 2012	1,233-1,439	Launch Readiness	Jul 2018

Project Management & Commitments

Goddard Space Flight Center provides program management and science management. The John Hopkins University Applied Physics Laboratory (JHU-APL) manages the project.

Element	Description	Provider Details	Change from Formulation Agreement
Expendable Launch Vehicle	Deliver the spacecraft to operational orbit	Provider: TBD Lead Center: JHU-APL Participating Centers: LSC Cost Share Partners: N/A	None
Ground Systems	Receive science and telemetry data from spacecraft, command spacecraft, and distribute science data to investigator teams	Provider: JHU-APL Lead Center: N/A Participating Centers: N/A Cost Share Partners: N/A	None
Spacecraft	Transport instruments to science destination, operate instruments, and modify orbit, including several Venus gravity assists	Provider: JHU-APL Lead Center: N/A Participating Centers: N/A Cost Share Partners: N/A	None
Instruments	Provide in situ measurements and remote observations of the Sun	Provider: NASA funded investigators Lead Center: JHU-APL Participating Centers: N/A Cost Share Partners: N/A	None

SOLAR PROBE PLUS

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The thermal protection system (TPS) design does not meet launch load requirements, Then: The mass may increase to accommodate loads, or a different design option may be required.	The SPP project is currently assessing an early coupled loads analysis that Kennedy Space Center provided in late October 2012. As expected, predicted launch loads dropped. The SPP project is currently assessing the impact of this result. Additionally, the SPP project is performing sub-scale testing and analysis in key areas. Results from these tests and analyses will influence the design. Management will consider the risk mitigated after testing of the full-scale prototype.

Acquisition Strategy

Principal Investigators (PIs) selected through the announcement of opportunity will build science instruments. JHU-APL will build the spacecraft, and will competitively procure the spacecraft subassemblies, components, and parts. The ground system components will be defined during the formulation phase and requirements will be defined by the project. GSFC will manage the operations contracts.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Phase-B formulation	JHU-APL	Laurel, MD

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
MDR	SRB	Nov 2011	Gate Review for KDP-B	Successful, project moved to early design	Jan 2014

SOLAR ORBITER COLLABORATION

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	19.7	--	**55.5**	97.3	68.2	100.0	6.7
Change from FY 2012	--	--	**35.8**				
Percentage change from FY 2012	--	--	**181.7%**				

Note: The KDP-C for this project was scheduled on March 28, 2013. Data is as of February 2013

Solar Orbiter will venture closer to the Sun than any previous mission. The spacecraft will also carry advanced instrumentation that will help untangle how activity on the sun sends out radiation, particles and magnetic fields that can affect Earth's magnetic environment. This can cause aurora, or potentially damage satellites, interfere with GPS communications, or even Earth's electrical power grids.

PROJECT PURPOSE

The NASA and European Space Agency (ESA) Solar Orbiter Collaboration (SOC) mission will provide measurements that will give NASA better insight on the evolution of sunspots, active regions, coronal holes, and other solar features and phenomena. The instruments will explore the near Sun environment to improve the understanding of the origins of the solar wind streams and the heliospheric magnetic field, the sources, and acceleration mechanisms, and transport processes of solar energetic particles, and the evolution of coronal mass ejections in the inner heliosphere. To achieve these objectives, SOC will make in situ measurements of the solar wind plasma, fields, waves, and energetic particles and imaging/spectroscopic observations close enough to the Sun such that they are still relatively unprocessed. SOC will provide close-up views of the Sun's polar regions and its far side. SOC will tune its orbit to the direction of the Sun's rotation to allow the spacecraft to observe one specific area for much longer than currently possible.

ESA provides the spacecraft and operations, the ESA member states provide the majority of the instruments, and NASA provides the launch vehicle and two science investigations/instruments: Solar and Heliospheric Imager and the Heavy Ion Sensor. In return for its contributions, NASA will have access to the entire science mission data set.

For more information about SOC, go to: http://nasascience.nasa.gov/missions/solar-orbiter.

SOLAR ORBITER COLLABORATION

Formulation	Development	Operations

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

A NASA-provided launch vehicle will place the ESA-provided SOC spacecraft into an inner heliospheric orbit around the Sun, with its closest approach ranging from 0.23 to 0.38 astronomical units and the farthest distance from 0.73 to 0.88 astronomical units. In the first phase of mission operations, SOC will orbit around the Sun's equator at about the same rate as the Sun's rotation. In the second phase, it will perform a Venus gravity assist between each rotation around the Sun. Each gravity assist will increase the Solar Orbiter inclination with respect to the Sun's equator so that the inclination will reach 27.5 degrees by the end of prime mission operations. This will enable the instruments to image the polar regions of the Sun clearly for the first time and make key measurements that will advance our understanding of the solar dynamo and the polarity reversal of the global magnetic field. The inclination will increase to 34 degrees by the end of the three-year extended mission allowing better insight into the polar regions.

ACHIEVEMENTS IN FY 2012

The Solar-Heliospheric Imager instrument completed its preliminary design review in June 2012.

WORK IN PROGRESS IN FY 2013

NASA has begun development of the Solar-Heliospheric Imager science instrument and the Heavy Ion Sensor, which will continue through FY 2013.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will complete the majority of development in preparation for delivery of the instruments to ESA in FY 2015.

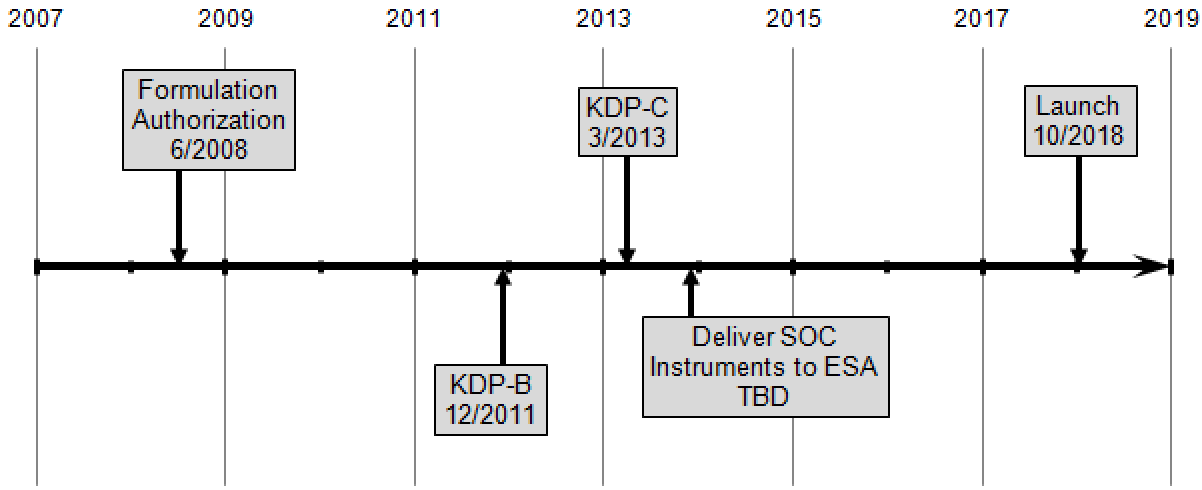
ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
KDP-C	Jan 2013	Mar 2013
Launch	Jan 2017	Oct 2018

SOLAR ORBITER COLLABORATION

Formulation	Development	Operations

Project Schedule



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Dec 2011	371-424	Launch Readiness	Jan 2017-Oct 2018

Project Management & Commitments

GSFC has program management responsibility for the Living With a Star program and the Solar Orbiter Collaboration project. All instruments provided by the United States are procured through an Announcement of Opportunity.

Element	Description	Provider Details	Change from Formulation Agreement
Solar Orbiter Heliospheric Imager (SoloHi)	Measures the solar wind formations, shock disturbance, and turbulence	Provider: Naval Research Lab Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: N/A	None

SOLAR ORBITER COLLABORATION

Formulation	Development	Operations

Heavy Ion Sensor	Measures the range of heavy ion energies, charge states, masses, and elevation angles as part of the United Kingdom-provided Solar Wind Analyzer instrument suite	Provider: Southwest Research Institute Lead Center: GSFC Performing Centers: None Cost Share Partners: N/A	None
Expendable Launch Vehicle	Launch vehicle	Provider: TBD Lead Center: N/A Performing Centers: KSC Cost Share Partners: N/A	None

Project Risks

Risk Statement	Mitigation
If: Aggressive instrument delivery schedule is maintained by ESA, Then: NASA will not be able to meet the planned delivery schedule.	New instrument delivery and integration dates will be negotiated with ESA and project management risk resources will be used to cover the period of delay.
If: ESA hardware delivery for launch is delayed, Then: NASA launch vehicle and development costs will increase.	Monitor ESA's progress during its hardware development and plan to cover ESA schedule overruns.

Acquisition Strategy

The instruments and science investigations were selected from an Announcement of Opportunity. The launch vehicle is being competitively selected through the NLS-2 contract.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Launch Vehicle	United Launch Alliance	KSC, FL
SoloHI	Naval Research Lab	Washington, DC
Heavy Ion Sensor	Southwest Research Institute	Austin, TX

SOLAR ORBITER COLLABORATION

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
All	SRB	Dec 2011	Assess readiness for KDP-B	Successful	N/A
Instrument	SRB	Oct 2012	Assess readiness for PDR	Successful	N/A
All	SRB	N/A	Assess readiness for CDR		Nov 2013

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	124.0	--	**55.8**	43.3	35.1	40.5	38.0
Balloon Array for Radiation-Belt Relativ	1.6	--	**1.5**	0.3	0.0	0.0	0.0
LWS Space Environment Testbeds	0.5	--	**0.6**	0.1	0.0	0.0	0.0
LWS Science	15.0	--	**17.2**	17.5	17.5	17.5	17.5
LWS Program Management and Future Missions	4.0	--	**8.7**	7.5	8.1	13.4	10.9
Van Allen Probes	86.1	--	**13.8**	8.4	0.0	0.0	0.0
Solar Dynamics Observatory	16.7	--	**14.1**	9.5	9.5	9.5	9.5
Change from FY 2012	--	--	**-68.2**				
Percentage change from FY 2012	--	--	**-55 %**				

The Living with a Star Other Missions and Data Analysis budget includes operating LWS missions, a science research program, program management, and limited funding for missions to be launched in the next decade.

Future LWS missions are strategically defined and prioritized by the National Academies' Heliophysics Decadal Surveys, the last of which was issued in August 2012.

For more information, go to the LWS program at: http://lws.gsfc.nasa.gov/.

Mission Planning and Other Projects

THE BALLOON ARRAY FOR RBSP RELATIVISTIC ELECTRON LOSSES (BARREL)

BARREL is a balloon-based mission of opportunity to augment the measurements of the Van Allen Probes, formerly Radiation Belt Storm Probes, or RBSP, mission. The balloon array will make its observations in conjunction with the Van Allen spacecraft, so that direct comparisons of data can be made. There are two campaigns of five to eight long-duration balloons aloft simultaneously (over one month) to provide measurements of the spatial extent of relativistic electron precipitation and to allow an estimate of the total electron loss from the radiation belts. The first campaign is scheduled for January of 2013 and the second campaign is scheduled for January of 2014.

Recent Achievements

In FY 2012, BARREL completed the build of 25 balloon payloads in support of the first of the two campaigns, as well as the completion, test and verification of the ground system that will monitor and control the balloons and payloads, and collect data for analysis.

SPACE ENVIRONMENT TESTBEDS

The Space Environment Testbeds project will perform flight and ground investigations to characterize the space environment and its impact on hardware performance in space. It will fly as a piggyback payload on the US Air Force Deployable Structures Experiment (DSX) mission. DSX will be launched on the SpaceX Falcon Heavy Rocket in mid-2015.

Recent Achievements

Workmanship comprehensive performance testing was completed in June 2012, and DSX was put into storage until DMSP-19 is ready to launch.

LWS SCIENCE

Understanding space weather and improving the capability to address problems, such as predicting geomagnetic storms, pose two major challenges for the research community. First, research must couple traditionally separate disciplines in NASA's Heliophysics division, such as solar-heliospheric and geospace physics. Second, to be truly successful, research must also demonstrate how results would enable an operational capability, such as the generation of forecasts for geomagnetic storms. LWS Science addresses these challenges. A community-based steering committee provides advice on priorities for future LWS Science investigations, and focus teams comprised of selected investigators in particular areas have been set up. The LWS Science team addresses these challenges through three main approaches:

It builds infrastructure--The infrastructure component includes funding to train the next generation of heliophysics experts, to conduct a Heliophysics graduate-level summer school, to develop graduate course content, and to support a limited number of space weather postdoctoral positions at universities and government laboratories.

It addresses scientific needs--Funds permit the LWS program to tackle large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and identify how this new understanding will have a direct impact on life and society. The aforementioned community-based steering committee provides advice on which areas should be focused on each year, and teams are assembled from peer-reviewed proposals, that individually address pieces of the problem but collectively, as a team, tackle the whole scientific need.

It develops strategic capabilities--Funds allow areas of science focus that have reached level of maturity to be integrated into scientific and operational deliverables (e.g. models or tools) broadly useful to the larger community in Universities, Government laboratories, industry and the military.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

Recent LWS-supported research has shown that the Sun's atmosphere, or corona, is full of magnetic waves generated by the boiling convection of the solar interior. Observing the motions of the ionized gas in the corona enables scientists to determine how much of the magnetic wave energy gets converted into heat. In open regions of the corona called coronal holes, the heated atmosphere boils into space in the form of high-speed solar wind streams. Such high-speed streams can cause aurorae and other space weather effects, even in the absence of large explosive events on the Sun.

Another study used Solar Dynamics Observatory observations to predict when sunspots will emerge from inside the Sun. Yet another study using data from the observatory have shown a new "late phase" of solar flares, extending the duration and increasing the energy released in solar flares. These results are significant to understand the causes of space weather

PROGRAM MANAGEMENT AND FUTURE MISSIONS

Program Management and Future Missions provide the resources required to manage the planning, formulation, and implementation of all Living With a Star missions. The office resolves technical and programmatic issues and risks, monitors and reports on progress, and is responsible for achieving overall LWS cost and schedule goals. Additionally, Future Missions supports the program's strategic planning for addressing the recommendations of the heliophysics decadal survey and the pre-formulation activities for missions that are not yet approved as projects.

Operating Missions

VAN ALLEN PROBES (FORMERLY RADIATION BELT STORM PROBES)

The Van Allen Probes mission will help scientists understand the Sun's influence on Earth and near Earth space by studying Earth's radiation belts on various scales of space and time. The two spacecrafts' instruments will observe the fundamental processes that energize and transport radiation belt electrons and ions in Earth's inner magnetosphere, the area in and around Earth's radiation belts. These observations will provide new knowledge on the dynamics and extremes of the radiation belts that are important to all technological systems that fly in and through geospace. The mission will enable an understanding, ideally to the point of predictability, of how populations of relativistic electrons and penetrating ions in space form or change in response to variable inputs of energy from the Sun.

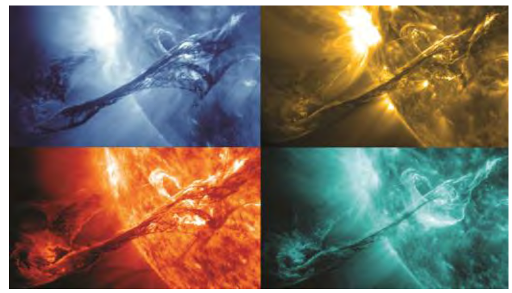
Recent Achievements

The twin spacecraft launched in August 2012, is meeting its science objectives to better understand Earth's radiation belts.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

SOLAR DYNAMICS OBSERVATORY (SDO)



Launched on February 11, 2010, the Solar Dynamics Observatory seeks to understand the Sun's influence on Earth and near Earth space by studying the solar atmosphere on small scales of space and time and in many wavelengths simultaneously. The observatory enables scientists to determine how the Sun's magnetic field is generated and structured and how stored magnetic energy is converted and released in the form of solar wind, energetic particles, and variations in the solar irradiance. It collects data to help elucidate how solar activity is created and how space weather emerges as a product of that activity. Measurements of the interior of the Sun, the Sun's magnetic field, the hot plasma of the solar corona, and the irradiance that creates Earth's ionosphere are the primary data products. Currently in its prime operations phase, SDO's images and spectra are key sources of data at solar science conferences and further advances knowledge of the Sun.

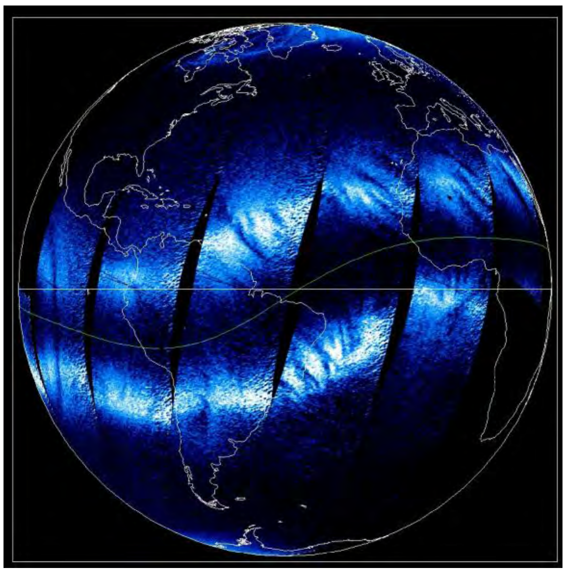
Recent Achievements

On August 31, 2012, a long filament of solar material that had been hovering in the Sun's atmosphere, the corona erupted. The coronal mass ejection traveled at over 900 miles per second. The ejection did not travel directly toward Earth, but did connect with Earth's magnetic environment, or magnetosphere, with a glancing blow causing aurora to appear on the night of Monday, September 3. The observatory was able to detect the source of the cone and follow its path into the heliosphere, helping to further understanding of an important mechanism that transports energy from the Sun. The image above reflects SDO's observations. Four images of a filament on the Sun are shown in various wavelengths of light. Starting from the upper left and going clockwise, they represent light in the: 335,171,304 and 131 Angstrom wavelengths. Since each wavelength generally corresponds to solar material at a particular temperature, scientists can compare images like this to observe how the material moves during an eruption.

SOLAR TERRESTRIAL PROBES

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	216.0	--	**146.6**	68.7	48.9	50.1	27.9
Magnetospheric Multiscale (MMS)	194.6	--	**120.9**	39.5	20.2	12.3	2.7
Other Missions and Data Analysis	21.4	--	**25.8**	29.2	28.7	37.8	25.2
Change from FY 2012	--	--	**-69.4**				
Percentage change from FY 2012	--	--	**-32.1 %**				



The Earth's night-time ionosphere displaying spatial structures of various scales (caused by small and large-scale waves emanating upward from the troposphere). Such plasma bubbles and dropouts greatly affect communication and navigation. This program continues to make important contributions to the understanding of many of the processes that link the Earth's upper atmosphere and ionosphere system.

Solar Terrestrial Probes focuses on understanding the fundamental physics of the space environment, from the Sun to Earth, other planets, and beyond to the interstellar medium. STP provides insight into the fundamental processes of plasmas (fluid of charged particles) inherent in all astrophysical systems. STP missions focus on processes such as the variability of the Sun, the responses of the planets to those variations, and the interaction of the Sun and solar system. STP missions are strategically defined and investigations are competitively selected. These missions allow the science community an opportunity to address important research focus areas and make significant progress in understanding fundamental physics.

For more information, go to the STP program at: http://stp.gsfc.nasa.gov.

EXPLANATION OF MAJOR CHANGES

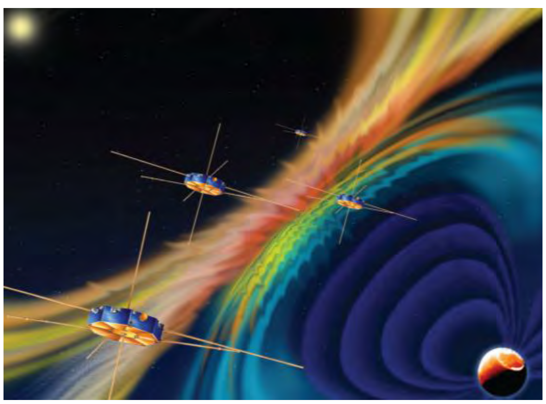
There are no programmatic changes. The decrease in FY 2014 from the FY 2013 budget request reflects the restoration of funding to the Astrophysics Explorer program, as anticipated in the FY 2012 operating plan of June 20, 2012. The STP program now carries the budget for the Thermosphere, Ionosphere, and Mesophere Energetics and Dynamics (TIMED) mission. This transfer increases the consistency of NASA's budget structure, without affecting the project in any way.

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	**Prior**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**BTC**	**Total**
FY 2014 President's Budget Request	507.6	194.6	183.3	**120.9**	39.5	20.2	12.3	2.7	0.0	1081.1
2014 MPAR LCC Estimate	507.6	194.6	183.3	**120.9**	39.5	20.2	12.3	2.7	0.0	1081.1
Formulation	172.9	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	172.9
Development/Implementation	334.7	194.6	183.3	**120.9**	23.3	0.0	0.0	0.0	0.0	856.8
Operations/Close-out	0.0	0.0	0.0	**0.0**	16.2	20.0	12.3	2.7	0.0	51.4
Change from FY 2012		--	--	**-73.7**						
Percentage change from FY 2012		--	--	**-37.9%**						



An artist concept shows the MMS spacecraft flying through the dayside magnetic interaction region where the Sun's and Earth's magnetic fields come together. The four MMS spacecraft will fly in a tetrahedron formation, which enables the best possible measurements to identify the temporal and spatial energetic processes taking place. The scientific instruments carried onboard will rapidly measure the involved electric and magnetic fields and the tenuous, electrically charged gases or plasma. What is learned here will be extended to the Sun's atmosphere and throughout the cosmos as scientists seek to understand particle heating and acceleration throughout space.

PROJECT PURPOSE

The Magnetospheric MultiScale mission investigates how the Sun's and Earth's magnetic fields connect and disconnect, explosively transferring energy from one to the other, a process that occurs throughout the universe, known as magnetic reconnection. MMS will use Earth's magnetosphere as a laboratory to study the microphysics of magnetic reconnection, a fundamental plasma-physical process that converts magnetic energy into heat and the kinetic energy of charged particles. In addition to seeking to solve the mystery of the small-scale physics of the reconnection process, MMS will also investigate how the energy conversion that occurs in magnetic reconnection accelerates particles to high energies and what role plasma turbulence plays in reconnection events. Magnetic reconnection, particle acceleration, and turbulence occur in all astrophysical plasma systems, but can be studied in situ only in the solar system and most efficiently in Earth's magnetosphere, where these processes control the dynamics of the geospace environment and play an important role in the phenomena known as space weather.

For more information about MMS, go to: http://science.nasa.gov/missions/mms/.

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

EXPLANATION OF MAJOR CHANGES

The decrease in FY 2014 from the FY 2013 budget request reflects the restoration of funding to the Astrophysics Explorer program, as anticipated in the FY 2012 Operating Plan of June 20, 2012.

PROJECT PARAMETERS

The MMS mission comprises four identically instrumented spacecraft that measure particles, fields, and plasmas. The MMS instrument payload will measure electric and magnetic fields and the plasmas found in the regions where magnetic reconnection occurs. Fast, multi-point measurements will enable dramatically revealing direct observations of these physical processes. A near-equatorial orbit will explore how Sun-Earth magnetic fields reconnect in Earth's neighborhood. The four spacecraft will fly in a tetrahedron formation that allows them to observe the 3-D structure of magnetic reconnection. The separation between the observatories will be adjustable over a range of 10 to 400 kilometers during science operations in the area of interest. The mission design life is two years.

ACHIEVEMENTS IN FY 2012

NASA conducted the Systems Integration Review in August 2012. The project passed its KDP-D milestone in September 2012. The project delivered the science instruments for the first observatory and built and assembled the first spacecraft in FY 2012.

WORK IN PROGRESS IN FY 2013

Integration is underway for the first fully populated observatory, which includes spacecraft and instruments, is underway. The second spacecraft and science payload are being integrated. NASA will complete environmental testing of all four observatories and conduct vibration testing of the stack of four observatories.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will complete environmental testing of all four observatories and conduct vibration testing of a stack of 3 observatories and one mass model. The project will pack and ship all four observatories to the Kennedy Space Center and start launch processing by the end of FY 2014.

MAGNETOSPHERIC MULTISCALE (MMS)

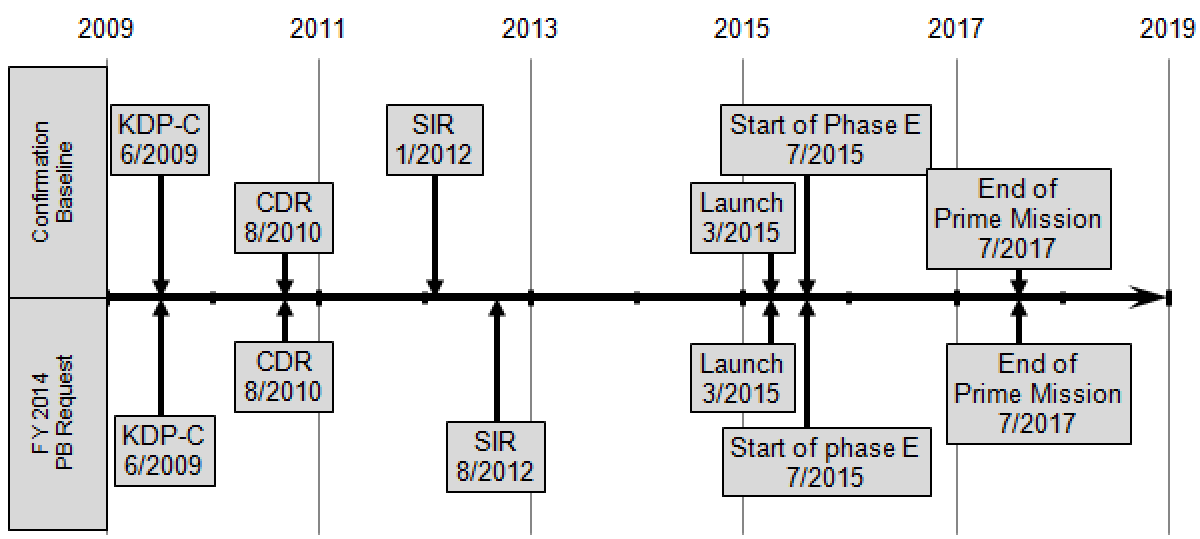
Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

The MMS mission will launch on the Atlas V 421 vehicle from Cape Canaveral Air Force Station in Florida no later than March 2015.

Milestone	Confirmation Baseline Date	FY 2014 PB Request Date
KDP-C	Jun 2009	Jun 2009
CDR	Aug 2010	Aug 2010
SIR	Jan 2012	Aug 2012
Launch	Mar 2015	Mar 2015
Start of Phase E	Jul 2015	Jul 2015
End of Prime Mission	Jul 2017	Jul 2017

Project Schedule



MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2010	857.3	70	2013	856.8	-0.1	Launch Readiness	Mar 2015	Mar 2015	0

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

Development Cost Details

Spacecraft costs increased due to increased requirements for personnel, increased parts costs, increased environmental test costs and the requirement for a clean room when the planned facilities were not available. Payload increases are attributed to a foreign partner decreasing its contribution to the Spin-plane Double Probe electric field instrument, fluctuation in foreign exchange rate for purchase of a major instrument component, and cost growth for Fast Plasma Investigation, Hot Plasma Composition Analyzer, and Central Instrument Data Processor. NASA realized some savings due to reduced launch costs. The United Launch Alliance (ULA) team was able to reduce the cost of mission unique engineering by using fleet-wide system upgrades for MMS. Integration and Test (I&T) costs have been reduced by increasing the testing performed at the system and subsystem level prior to delivery to the Observatory and Constellation I&T activity.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	**857.4**	**856.8**	**-0.6**
Aircraft/Spacecraft	169.0	244.1	75.1
Payloads	131.9	193.4	61.5
Systems I&T	55.3	46.0	-9.3
Launch Vehicle	194.2	184.4	-9.8
Ground Systems	19.1	29.3	10.2
Science/Technology	19.9	22.5	2.6
Other Direct Project Costs	268	137.2	-130.8

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Project Management & Commitments

The STP Program Office at GSFC has program management responsibility for the MMS project.

Project Element	Description	Provider	Change from Baseline
Electric fields instrument	Provide measurements of electric fields (time resolution 1ms) and magnetic fields (time resolution 10ms)	Provider:University of New Hampshire Lead Center:GSFC Performing Centers:GSFC Cost Share Partners:Austria	None
Fast Plasma Investigation	Provide plasma wave measurements (electric vector to 100 KHz)	Provider:GSFC Lead Center:GSFC Performing Centers:GSFC Cost Share Partners:Japan	None
Energetic Particle Detectors	Provide high-resolution measurement of energetic particles	Provider:JHU-APL Lead Center:GSFC Performing Centers:GSFC Cost Share Partners:None	None
Hot Plasma Composition Analyzers	Three-dimensional measurements of hot plasma composition (time resolution 10 seconds)	Provider: SwRI Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Launch Vehicle	Deliver approximately 4,000kg payload consisting of four observatories to a highly elliptical Earth orbit	Provider: Lead Center: N/A Performing Centers: KSC Cost Share Partners: None	None
Ground Systems	Provide during operations minimum science data payback of four Gbits of data per observatory each day.	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Four Spacecraft	Deliver high-rate data from instruments to ground station with a high accuracy for two years	Provider: GSFC Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Science Operations	Provide science data to the community and archive	Provider: University of Colorado, Laboratory for Atmospheric and Space Physics Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: None	None
Four Instrument Suites	Provide measurements of electric fields, plasma waves, energetic particles, and hot plasma composition	Provider: SwRI Lead Center: GSFC Performing Centers: GSFC Cost Share Partners: Austria, France, Japan	None

Project Risks

Risk Statement	Mitigation
If: Manifesting problems prevent a March 2015 launch of MMS , Then: Increased costs could exceed the baseline development cost estimate.	Hold present development schedule, maintain dialog with Launch Services to push for priority into the desired time slot.

Acquisition Strategy

The MMS spacecraft is being designed, developed, and tested in-house at GSFC using a combination of GSFC civil servants and local contractors. The acquisition of subcontracted spacecraft sub-assemblies, components, and parts is through procurement contracts issued by the MMS procurement office.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Launch Vehicle	United Launch Alliance (ULA)	C, FL
Instrument Suite	SwRI	an Antonio, TX

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
All	SRB	N/A	Operations Readiness Review (ORR)	TBD	Mar 2014
All	SRB	Aug 2012	System Integration Review (SIR)	Successful Review	N/A

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	21.4	--	**25.8**	29.2	28.7	37.8	25.2
STP Program Management and Future Missions	1.4	--	**5.2**	8.6	7.9	17.1	4.6
Solar Terrestrial Relations Observatory (STEREO)	9.0	--	**9.5**	9.5	9.6	9.6	9.6
Hinode (Solar B)	8.2	--	**8.3**	8.3	8.5	8.5	8.5
TIMED	3.0	--	**2.7**	2.7	2.7	2.6	2.5
Change from FY 2012	--	--	**4.4**				
Percentage change from FY 2012	--	--	**20.6 %**				

The Sun, solar system, and universe consist primarily of plasma, a gas composed of ions, electrons, and neutral particles that conducts electricity and behaves distinctly different from a normal gas, liquid, or solid. Plasma strongly interacts with magnetic fields, resulting in many spectacular phenomena in space, including the auroras over Earth's polar regions.

Solar Terrestrial Probe (STP) missions provide the scientific basis for space weather prediction by increasing understanding of the fundamental plasma processes inherent in all the relevant astrophysical systems. STP missions study processes such as the magnetic reconnection, particle acceleration, ion-neutral interactions, and the creation and variability of magnetic dynamos.

STP missions are strategically defined and prioritized by the National Academies decadal surveys for heliophysics. Science investigations (i.e., instruments) on STP missions are competitively selected.

The STP Other Missions and Data Analysis budget includes operating STP missions, program management, and limited funding for future missions to be launched in the next decade. For more information, go to the STP program at: http://stp.gsfc.nasa.gov/.

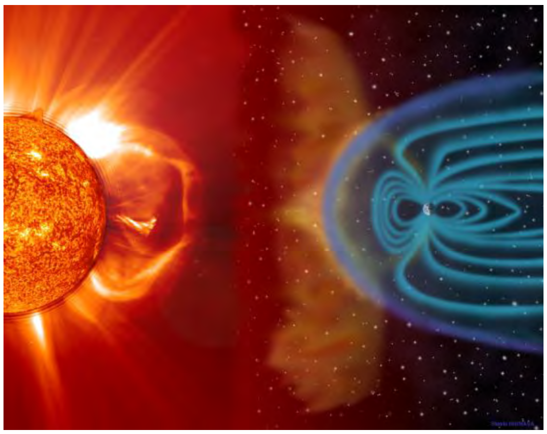
Mission Planning and Other Projects

PROGRAM MANAGEMENT AND FUTURE MISSIONS

Program Management and Future Missions provide the resources required to manage the planning, formulation, and implementation of all STP missions. The program office ensures successful achievement of STP program cost and schedule goals, while managing cross-project dependencies, risks, issues, and requirements as projects progress through formal key decision points. Additionally, Future Missions

Formulation	Development	Operations

supports the STP program strategic planning for addressing the recommendations of the heliophysics decadal survey and the pre-formulation activities for STP missions not yet approved as projects.



Coronal mass ejections were once thought to be initiated by solar flares. Although most are accompanied by flares, it is now understood that flares and mass ejections are related phenomena, but one does not cause the other. This has important implications for understanding and predicting the effects of solar activity on Earth and in space. If a coronal mass ejection collides with Earth, it can excite a geomagnetic storm. Large geomagnetic storms have, among other things, caused electrical power outages and damaged communications satellites. Therefore, to understand and predict space weather and the effect of solar activity on Earth, a detailed understanding of the processes underlying flares, mass ejections, and geomagnetic storms is required.

Operating Missions

SOLAR TERRESTRIAL RELATIONS OBSERVATORY (STEREO)

STEREO enables studies of the origin of the Sun's coronal mass ejections and their consequences for Earth. The mission consists of two spacecraft, one leading and the other lagging Earth in its orbit. STEREO's instrumentation targets the fundamental process of energetic particle acceleration in the low solar corona and in interplanetary space. The mission is able to image the structure and evolution of solar storms as they leave the Sun and move through space toward Earth. The mission also provides the foundation for understanding space weather and developing predictive models. The models in turn will help identify and mitigate the risks associated with space weather events. Additionally, it will improve our space weather situational awareness not only for Earth and in low earth orbit, but throughout the solar system.

Recent Achievements

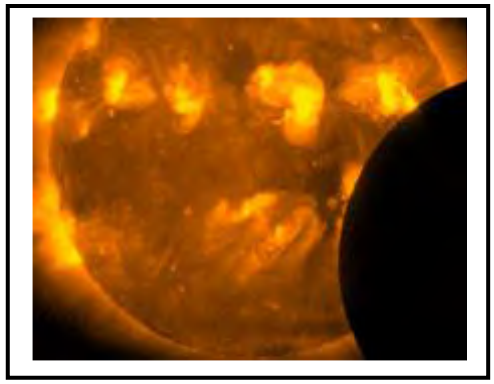
On July 23, 2012, a massive cloud of solar material erupted off the Sun's right side, zooming out into space, passing one of the STEREO spacecraft along the way. Using the STEREO data, scientists clocked this giant cloud, known as a coronal mass ejection as traveling between 1,800 and 2,200 miles per second as it left the Sun. Measuring a coronal mass ejection at this speed, traveling in a direction safely away from Earth, represents an unusual opportunity for researchers studying the Sun's effects. The event pushed a burst of fast protons out from the Sun. The number of charged particles near STEREO jumped 100,000 times within an hour of the coronal mass ejection's start. When such bursts of solar particles interact with Earth's magnetic field they are referred to as a solar radiation storm, and they can block high frequency radio communications as used, for example, by airline pilots. Like the coronal mass ejection, this solar energetic particle event is also the most intense ever measured by STEREO. While the ejection was not directed toward Earth, the solar energetic particle did, at a much lower intensity than at STEREO,

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

affect Earth, offering scientists a chance to study how such events can widen so dramatically as they travel through space.

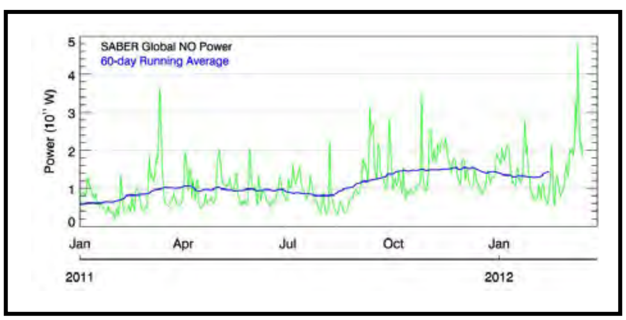
HINODE



Hinode is a Japanese Institute of Space and Astronautical Science mission operating as a follow-on to the highly successful Japan, U.S., U.K. Yohkoh (Solar-A) collaboration. The mission consists of a coordinated set of optical, Extreme UltraViolet and x-ray instruments that are studying the basic heating mechanisms and dynamics of the active solar corona. By investigating the fundamental processes that connect the Sun's magnetic field and the solar corona, Hinode is discovering how the Sun generates magnetic disturbances and the high-energy particle storms that propagate from the Sun to Earth.

Recent Achievements

Spectacular images from the Hinode spacecraft show the solar eclipse, which darkened the sky in parts of the Western United States and Southeast Asia on May 20, 2012. Hinode images of the eclipse enable scientists to develop an improved model of the telescope performance. This can be used to obtain significantly enhanced observations in high resolution of faint features of the solar corona. This will allow scientists to study the extended solar corona and the structure of the high temperature solar atmosphere.



THERMOSPHERE, IONOSPHERE, MESOSPHERE ENERGETICS AND DYNAMICS (TIMED)

The TIMED mission characterizes and studies the physics, dynamics, energetics, thermal structure, and composition of the least well-understood region of Earth's atmosphere, the mesosphere-lower thermosphere-ionosphere system. This region of interest, located between altitudes of approximately 60 to180 kilometers above the surface of Earth, is the interface between Earth's lower atmosphere below and the magnetosphere above, and can be influenced by forcing from either of these regions. The mesosphere-lower thermosphere-ionosphere system can undergo rapid changes in character due to both natural and human-induced (anthropogenic) effects.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

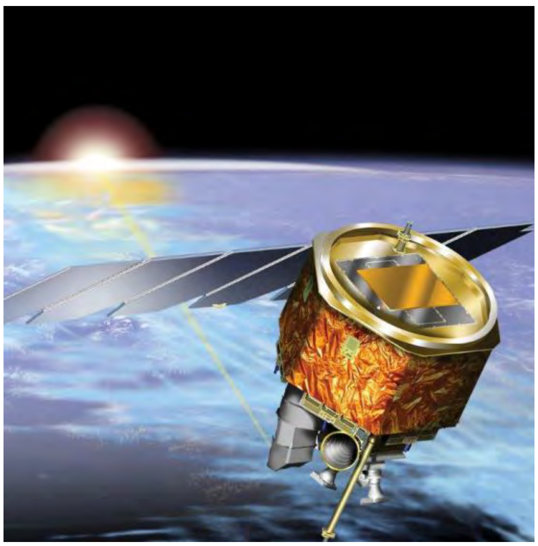
On March 8, 2012, TIMED observed the effects of gigawatts dumped into Earth's upper atmosphere from the first major solar storm of the year. A coronal mass ejection propelled in our direction by an X5-class solar flare hit Earth's magnetosphere and triggered major geomagnetic storms. X-class flares are the most powerful kind of flares. Energetic particles rained down on the upper atmosphere, depositing their energy, producing spectacular auroras around the poles and significant upper atmospheric heating all around the globe. The image to the left reflects what TIMED observed.

TIMED monitors infrared emissions from Earth's upper atmosphere, in particular from carbon dioxide (CO_2) and nitric oxide (NO), two substances that are the most efficient coolants in thermosphere and that play a key role in the energy balance of air hundreds of km above our planet's surface. For a three-day period, the thermosphere absorbed 26 billion kilowatt hours of energy. TIMED observed how infrared radiation from CO_2 and NO re-radiated 95 percent of that total back into space. During the heating impulse, the thermosphere puffed up like a marshmallow held over a campfire, temporarily increasing the drag on low-orbiting satellites as well as orbital debris.

HELIOPHYSICS EXPLORER PROGRAM

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	65.8	--	**95.2**	123.7	87.9	88.2	88.2
Other Missions and Data Analysis	65.8	--	**95.2**	123.7	87.9	88.2	88.2
Change from FY 2012	--	--	**29.4**				
Percentage change from FY 2012	--	--	**44.7 %**				



NASA's Aeronomy of Ice in the Mesosphere (AIM) satellite is a SMEX-class mission that remotely senses night-shining clouds in the mesosphere. These noctilucent clouds are made of ice crystals that form over the summer poles at an altitude too high and a temperature too cold for water-vapor clouds. Recent results from the mission have provided evidence of change in the behavior of these noctilucent clouds, with the data showing dramatically lower ice content. This is leading scientists to speculate about changes in weather conditions and pole-to-pole atmospheric circulation, and whether these changes are driven by the solar cycle.

The Heliophysics Explorers Program provides frequent flight opportunities for world-class scientific investigations on focused and timely science topics. Explorers uses a suite of smaller, fully competed missions that address these topics to complement the science of strategic missions of the Living With a Star and Solar Terrestrial Probes (STP) programs. Highly competitive selection ensures that the most current and best strategic science will be accomplished.

Full missions include Medium Explorers (MIDEX), Explorers (EX), and Small Explorers (SMEX). Missions of Opportunity (MO) are typically instruments flown as part of a non-NASA space mission.

EX missions were introduced within the 2011 Announcement of Opportunity. In response to the currently available expendable launch vehicles, EX missions were conceived. In September 2011 NASA selected three heliophysics EXs and three MOs for initial study. In Spring 2013, NASA will select one or two missions for implementation.

The Explorers program selected IRIS in 2009. IRIS is a small explorer mission, currently in the development phase and scheduled for launch in FY 2013.

Other Missions and Data Analysis supports numerous operating Heliophysics Explorer missions, as well as program management functions and funding for future mission selections.

For more information on Explorer missions, go to: http://explorers.gsfc.nasa.gov/missions.html.

HELIOPHYSICS EXPLORER PROGRAM

EXPLANATION OF MAJOR CHANGES

There are no programmatic changes. The Explorer program now carries the budget for the Advanced Composition Explorer and Ramaty High Energy Solar Spectroscopic Imager (RHESSI) missions. This transfer from Heliophysics Research to Explorer increases the consistency of our budget structure, without affecting the projects in any way.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	65.8	--	**95.2**	123.7	87.9	88.2	88.2
Heliophysics Explorer Future Missions	3.8	--	**65.7**	99.8	67.6	64.5	67.5
Heliophysics Explorer Program Management	4.7	--	**3.7**	6.4	4.1	7.4	4.4
Interface Region Imaging Spectogr (IRIS)	39.1	--	**8.4**	1.0	0.0	0.0	0.0
Interstellar Boundary Explorer (IBEX)	1.6	--	**3.7**	3.4	3.4	3.4	3.4
TWINS	1.0	--	**0.6**	0.6	0.6	0.6	0.6
CINDI	1.0	--	**0.9**	0.2	0.0	0.0	0.0
Aeronomy of Ice in Mesophere (SMEX-9)	3.0	--	**3.0**	3.0	3.0	3.0	3.0
Time History of Events and Macroscale In	6.0	--	**4.2**	4.2	4.2	4.2	4.2
ACE	3.7	--	**3.0**	3.0	3.0	3.0	3.0
RHESSI	1.9	--	**2.0**	2.0	2.1	2.1	2.1
Change from FY 2012	--	--	**29.4**				
Percentage change from FY 2012	--	--	**44.7 %**				

Explorer missions offer the ability to meet the full range of heliophysics science identified as being vital and urgent by the National Academies' decadal surveys. These missions are designed to be lower cost and have a short development cycle; they provide smaller, focused science investigations to supplement the larger strategic mission lines.

The Heliophysics Explorers Other Missions and Data Analysis budget includes operating Explorer missions, program management, and funding for the mission currently in the competitive principal investigator-led mission procurement cycle.

For more information, go to the Explorer program at: http://explorer.gsfc.nasa.gov/.

Mission Planning and Other Projects

EXPLORER FUTURE MISSIONS

Explorer Future Missions provides the resources required to manage the planning, formulation, and implementation of all Explorer missions. The program office ensures successful achievement of Explorer program cost and schedule goals, while managing cross-project dependencies, risks, issues, and requirements as projects progress through formal key decision points. Additionally, Future Missions supports the Explorer procurement activities, including the pre-formulation activities for missions not yet

Formulation	Development	Operations

approved as projects.

The Explorer program has selected six science proposals for evaluation as potential future science missions. Following detailed mission concept studies, one of the full mission concepts and/or one-or-more of the mission of opportunity concepts would be selected in April 2013 to proceed toward flight with launches potentially in 2016 and/or 2018.

EXPLORER PROGRAM MANAGEMENT

Explorer Program Management encompasses the program office resources required to manage the formulation and implementation of all Explorer projects. The program office is responsible for providing support and guidance to projects in resolving technical and programmatic issues and risks, for monitoring and reporting technical and programmatic progress of the projects and for achieving Explorer cost, schedule and technical goals and requirements.

INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

The Interface Region Imaging Spectrograph explorer is a SMEX mission selected in June 2009 and is expected to launch in June 2013. IRIS will enable scientists to understand how the solar atmosphere is energized. IRIS will provide significant new information to increase our understanding of energy transport into the corona and solar wind and provide an archetype for all stellar atmospheres. The unique instrument capabilities, coupled with state of the art 3-D modeling, will fill a large gap in knowledge of this dynamic region of the solar atmosphere. The mission will extend the scientific output of existing heliophysics spacecraft that follow the effects of energy release processes from the Sun to Earth. IRIS will provide key insights into all these processes, and thereby advance our understanding of the solar drivers of space weather from the corona to the far heliosphere, by combining high-resolution imaging and spectroscopy for the entire chromosphere and adjacent regions. IRIS will resolve in space, time, and wavelength the dynamic geometry from the chromosphere to the low-temperature corona to shed much-needed light on the physics of this magnetic interface region.

IRIS is a three-axis stabilized, sun-pointed mission that studies the chromosphere in the far ultraviolet and near ultraviolet with 0.33 arcsecond spatial resolution, 0.4 kilometers per second velocity resolution, and a field of view of 171 arcsecond. This two-year mission fills a critical observational data gap by providing simultaneous, co-spatial and comprehensive coverage from photosphere (about 4,500 kelvin) up to corona (less than or equal to 10 meters kelvin). IRIS consists of a 20-centimeter aperture telescope assembly that feeds an imaging spectrograph and a separate imaging camera system with wavelengths in the far ultraviolet and near ultraviolet. A spacecraft bus based upon heritage designs supports the science mission and provides pointing, power, and data communications for the mission.

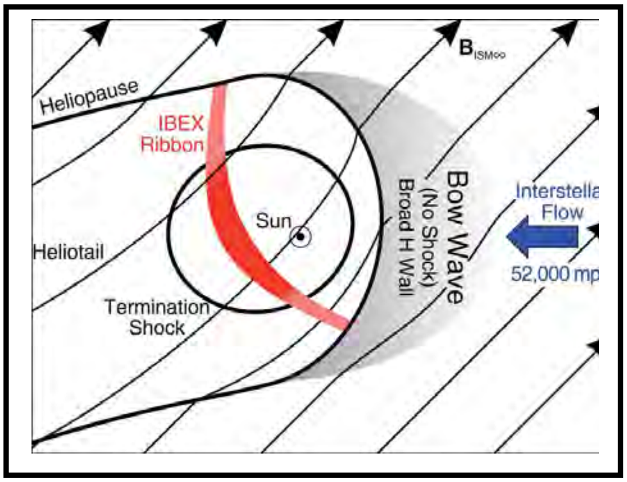
During FY 2013, IRIS will complete Observatory Integration and Test and is expected to complete Pre-Ship Review in March and Flight Readiness Review in June of 2013. The current launch readiness date is scheduled in June 2013. After launch, IRIS will enter a 30-day commissioning period and begin science operations.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

IRIS completed the design and development phase and entered into the integration and test phase in June 2012.



Operating Missions

INTERSTELLAR BOUNDARY EXPLORER (IBEX)

The Interstellar Boundary Explorer is the first mission designed to detect the edge of the solar system. As the solar wind from the Sun flows out beyond Pluto, it collides with the material between the stars, forming a shock front. These interactions create energetic neutral atoms, particles with no charge that move very quickly. This region emits no light that can be collected by conventional telescopes, so IBEX measures the particles that happen to be traveling inward from the boundary instead. IBEX contains two detectors designed to collect and measure energetic neutral atoms, providing data about the mass, location, direction of origin, and energy of these particles. From this data, maps of the boundary are created. The mission's focused science objective is to discover the nature of the interactions between the solar wind and the interstellar medium at the edge of the solar system. This region is important because it shields a large percentage of harmful galactic cosmic rays from Earth and inner solar system.

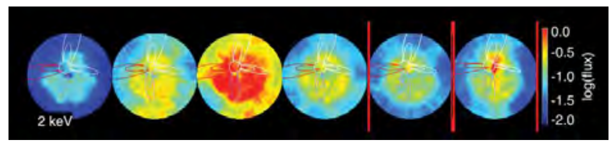
Recent Achievements

IBEX provided unprecedented measurements of the interstellar flow speed and direction, revealing that the bow shock, widely accepted by researchers to precede the heliosphere, does not exist. A sonic boom made by a jet breaking the sound barrier is an earthly example of a bow shock. The revised speeds indicate that the heliosphere, the bubble surrounding the sun and solar system with solar wind, moves at about 52,000 miles per hour, roughly 7,000 miles per hour slower than previously thought, slow enough to create more of a bow "wave" than a shock. It is too early to say what this new data means for Earth's heliosphere, but there are likely implications for how galactic cosmic rays propagate around and enter the solar system, which is relevant for human space travel. The figure shows a schematic of the elongated heliosphere with its three boundaries, the Termination Shock, the Heliopause, and the Bow Wave. These observations also show that oxygen is roughly half as abundant in the local interstellar medium as in the solar system, which suggests that either a large amount of oxygen atoms are embedded in interstellar dust grains or our solar system was borne outside the local interstellar cloud.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

TWO WIDE-ANGLE IMAGING NEUTRAL ATOM SPECTROMETERS (TWINS)



TWINS provides stereo imaging of Earth's magnetosphere, the region surrounding the planet controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. TWINS gives a three-dimensional global visualization of this region, which has led to a greatly enhanced understanding of the connections between different regions of the magnetosphere and their relation to solar variability. TWINS is a NASA-sponsored mission of opportunity that has been operational since 2008 and approved for extended operations until September 2014.

Recent Achievements

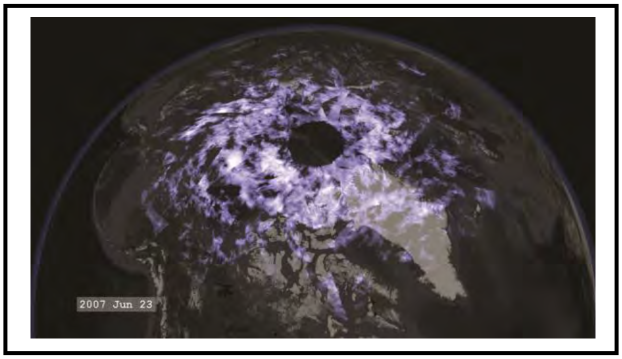
For the first time, instrumentation aboard TWINS and IBEX observed the impact from inside and outside Earth's magnetosphere, respectively. The energetic neutral atom cameras aboard each spacecraft enabled global imaging of the magnetosphere as it compressed in response to sharply faster solar wind that resulted from a powerful solar storm. The IBEX images show an immediate compression of the magnetosphere as it was impacted by charged particles from the solar wind. Minutes later, one of the TWINS spacecraft, carrying identical energetic neutral atom sensors that provide stereoscopic imaging, observed changes in the inner magnetosphere. About 15 minutes after impact, the trapped particles in the Van Allen belts propagated down the field lines toward the poles and into Earth's atmosphere, where they produced additional energetic neutral atoms. The brief time delay in losing particles to the atmosphere suggests that internal magnetospheric processes take some time after compression from the initial impact. The image above reflects TWINS observations.

THE COUPLED ION-NEUTRAL DYNAMICS INVESTIGATIONS (CINDI)

CINDI is a mission to understand the dynamics of Earth's ionosphere. This mission studies the behavior of equatorial ionospheric irregularities which can cause significant service interrupts for communications and navigation systems. CINDI data incorporated into state-of-the-art physics models is leading to advances in specification and prediction of space weather. CINDI is in extended phase until September 2014. The mission consists of two instruments on the Communication/Navigation Outage Forecast System satellite, a project of the US Air Force.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

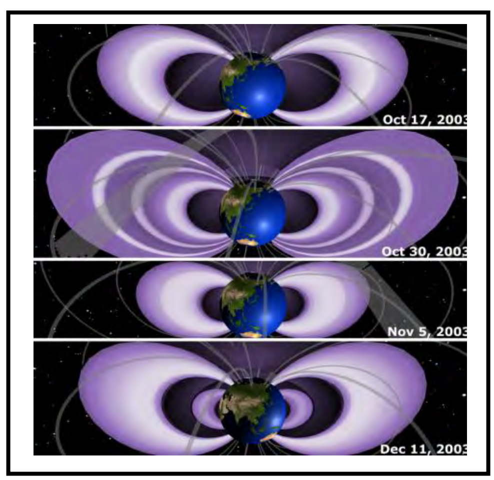


AERONOMY OF ICE IN THE MESOSPHERE (AIM)

The Aeronomy of Ice in the Mesophere is a mission to determine why polar mesospheric clouds form and why they vary. Polar mesospheric clouds, Earth's highest-altitude clouds, form each summer in the coldest part of the atmosphere about 50 miles above Polar Regions. These clouds are of particular interest, as the number of clouds in the middle atmosphere, or mesosphere, over Earth's poles has been increasing over recent years, and they are thought to be related to climate change. The spacecraft launched on April 25, 2007, completed its prime mission in FY 2009, and is currently in extended phase until September 2014.

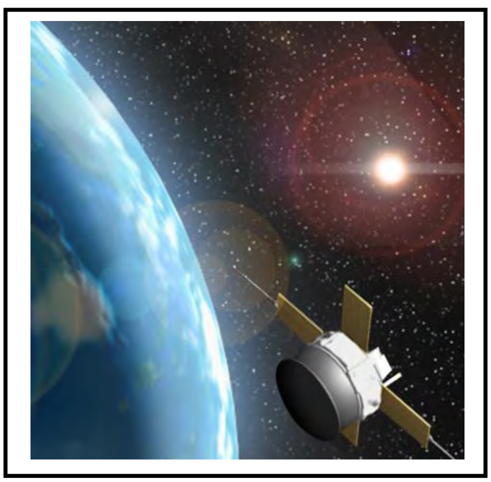
Recent Achievements

NASA's AIM and TIMED spacecraft tracked the very last shuttle launch plume and found that the water vapor in the mesosphere and lower thermosphere spread much faster than expected. On July 8, 2011, the Space Shuttle Atlantis launched for the final time. At approximately 70 miles above the east coast of the United States, it released 350 tons of water vapor exhaust. As the plume of vapor spread and floated on air currents high in Earth's atmosphere, it crossed through the observation paths of seven separate sets of observations including data from AIM and TIMED. The AIM and TIMED teams found and that within 21 hours, much of the water vapor collected near the arctic where it formed polar mesopheric clouds. Such information will help improve global circulation models of air movement in the upper atmosphere, and also help with ongoing studies of polar mesopheric clouds. Significantly, AIM observations showed a clear difference between typical polar mesopheric clouds and this shuttle-made one. Normally smaller particles exist at the top, with larger ones at the bottom. The shuttle plume polar mesopheric cloud showed a reversed configuration, with larger particles at the top, and smaller at the bottom, which offers a way to separate out such clouds in the historical record. The image above reflects observed mesopheric clouds.



TIME HISTORY OF EVENTS AND MACROSCALE INTERACTIONS DURING SUBSTORMS (THEMIS) AND ACCELERATIONS, RECONNECTION, TURBULENCE, AND ELECTRODYNAMICS OF THE MOON'S INTERACTION WITH THE SUN (ARTEMIS)

THEMIS is a Medium Class Explorers mission that launched on February 17, 2007, and is currently operating in extended phase until September 2014. Starting as a five-spacecraft mission, the three inner probes of THEMIS now focus on collecting data related to the onset and evolution of magnetospheric substorms, while the two outer probes (now referred to as ARTEMIS) have been repositioned into lunar orbits). Magnetospheric substorms are the explosive release of stored energy within the near Earth space environment leading to important space weather effects. The two ARTEMIS probes orbit the Moon's surface at approximately one hundred miles altitude and provide new information about the Moon's internal structure and its atmosphere. ARTEMIS provides two-point observations essential to characterizing the Moon's plasma environment and hazardous lunar radiation. THEMIS and ARTEMIS, among others in the heliophysics portfolio, are examples of missions offering important dynamics knowledge useful for future human spaceflight. Radiation belts surrounding Earth were discovered over 50 years ago, but many mysteries surrounding these still exist today. Newly completed analysis of data taken by NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) constellation have shed light on the swelling and shrinking of the belts in response to incoming solar energy. One question is to determine if, when the belts shrink, do particles escape up and out into interplanetary space or down toward Earth. Now, a new study using multiple spacecraft simultaneously has tracked the particles and determined the escape direction for at least one event: up. This is crucial for protecting our many satellites that fly through the region. The image above reflects the swelling and shrinking of the belts.



ADVANCED COMPOSITION EXPLORER (ACE)

The Advanced Composition Explorer observes particles of solar, interplanetary, interstellar, and galactic origins, spanning the energy range from solar wind ions to galactic cosmic ray nuclei. ACE measures and enables comparisons of the composition of the solar corona, the solar wind, other interplanetary particle populations, the local interstellar medium, and galactic matter. Changing conditions over the solar cycle are presenting new opportunities, including forecast space weather

Recent Achievements

Solar wind comes in two distinct types, known simply as fast and slow wind, though they differ in other ways, such as composition. Their different compositions suggest that they originate from distinctly different places in the solar corona. The fast wind comes from coronal holes, regions of the solar atmosphere from which the magnetic field connects directly to interplanetary space. However the source of the slow solar wind remains contentious. Studies provided insights into the source of the slow wind using a combination of observations, theory, and computer modeling. This research found that slow wind comes from a region where the geometry of the magnetic field creates a froth of narrow corridors, dynamically opening and closing over time. This dynamic process creates a wide zone of relatively slow solar wind that is highly variable, mixing gases from closed coronal magnetic-field regions with different gases from coronal holes where the field is open to the heliosphere. The broad width and dynamic mixing match observations that were not explained by previous models. This work helps us to understand and ultimately predict the complex structure the solar

Formulation	Development	Operations

wind exhibits even during quiescent times.

RAMATY HIGH ENERGY SOLAR SPECTROSCOPIC IMAGER (RHESSI)

The Ramaty High Energy Solar Spectroscopic Imager satellite focuses on the highest energy x-rays and gamma-rays produced by the Sun, helping to observe solar flares of all shapes and sizes.

Recent Achievements

The satellite is pointed toward the Sun, and constantly in rotation, which provides a serendipitous bit of side research. By monitoring the limb of the Sun on its four second rotation cycle, RHESSI’s Solar Aspect System (SAS) has produced ten-years' worth of precise measurements of the Sun's diameter. This has already provided scientists with one of the most accurate measurements of the oblateness of the Sun, which is the difference between the diameter from pole to pole and the equatorial diameter. With the new data obtained during the Venus Transit on June 5 through 6, 2012, the RHESSI team hopes to improve the knowledge of the exact shape of the Sun and provide a more accurate measure of the diameter than has previously been obtained. The precise diameter is of fundamental interest because there may be a relationship between the Sun's diameter and the amount of radiation it emits and therefore an effect on Earth and its climate.

AERONAUTICS

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	569.4	572.9	**565.7**	565.7	565.7	565.7	565.7
Aviation Safety	80.1	--	**80.0**	80.3	81.5	82.4	82.5
Airspace Systems	92.7	--	**91.5**	91.5	91.9	92.4	92.4
Fundamental Aeronautics	186.3	--	**168.0**	166.9	163.4	160.1	159.7
Aeronautics Test	79.4	--	**77.0**	77.5	78.6	79.6	79.8
Integrated Systems Research	104.2	--	**126.5**	126.8	127.4	128.2	128.4
Aeronautics Strategy and Management	27.2	--	**22.7**	22.7	22.8	22.9	22.9

AERONAUTICS

AERONAUTICS

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	569.4	572.9	**565.7**	565.7	565.7	565.7	565.7
Aviation Safety	80.1	--	**80.0**	80.3	81.5	82.4	82.5
Airspace Systems	92.7	--	**91.5**	91.5	91.9	92.4	92.4
Fundamental Aeronautics	186.3	--	**168.0**	166.9	163.4	160.1	159.7
Aeronautics Test	79.4	--	**77.0**	77.5	78.6	79.6	79.8
Integrated Systems Research	104.2	--	**126.5**	126.8	127.4	128.2	128.4
Aeronautics Strategy and Management	27.2	--	**22.7**	22.7	22.8	22.9	22.9
Subtotal	569.9	573.4	**565.7**	565.7	565.7	565.7	565.7
Rescission of prior-year unob. balances**	-0.5	-0.5	**--**	--	--	--	--
Change from FY 2012	--	--	**-3.7**				
Percentage change from FY 2012	--	--	**-0.6 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Aeronautics Strategy and Management pursuant to P.L. 112-55, Division B, sec. 528(f).*

As part of a collaborative effort with the FAA Technical Center, NASA flew the Ikhana MQ-9, a large unmanned aircraft, equipped with Automatic Dependent Surveillance-Broadcast (ADS-B) in FY2012. This demonstration was a critical step in the developing a new innovative way to safely immerse a flying unmanned aircraft in the national airspace system through virtual techniques.

Air transportation is vital to the Nation’s economy. On a typical day during peak hours there are more than 5,000 planes carrying passengers and cargo throughout the United States.

According to a 2011 report from the FAA, “The Economic Impact of Civil Aviation on the U.S. Economy”, civil aviation flies more than 800 billion passenger miles, generates 10 million jobs, and contributes $1 trillion in US economic activity per year. It provides $436 billion in direct economic activity from the transport of cargo and passengers and consistently generates America’s largest manufacturing trade surplus.

This is why NASA’s investment in aeronautics research is critically important to advance the Nation's global leadership in aviation, to grow the economy and increase jobs, and to continue to provide safe and efficient air travel to the flying public. From NASA’s decades-long contributions to aviation, successful transfers of

AERONAUTICS

NASA technologies have formed the DNA of modern aircraft. NASA's Aeronautics Research Mission Directorate (ARMD) continues to work to solve the challenges in the Nation's air transportation system: air traffic congestion, safety, and environmental impacts. This year NASA is pursuing a new project to accelerate the development and certification of composite materials for use in aviation.

ARMD develops revolutionary technologies that will bring breakthroughs for cleaner, safer, and more efficient aircraft and for the Nation's transition to the Next Generation Air Transportation System, or NextGen. NextGen is a multi-agency effort, led by the Department of Transportation's Federal Aviation Administration (FAA), to transform America's air traffic management system from an aging ground-based system to a satellite-based system. Combined with many other advanced levels of automated support technologies that NASA is developing, NextGen will shorten routes to enable time and fuel savings, reduce traffic delays, increase capacity, and permit controllers to monitor and manage aircraft more safely.

ARMD brings innovation to aeronautics through the seedling fund; expands knowledge, and develops concepts, tools, and methods in the fundamental research programs; and assesses and matures the integrated benefits of the most promising technologies in the Integrated Systems Research Program. ARMD conducts this cutting-edge research through partnerships with academia, industry, and other government agencies. The partnerships foster a collaborative research environment across which multiple communities can exchange ideas and knowledge. These collaborations help ensure the future competitiveness of the Nation's aviation industry and strong future workforce.

ARMD also engages with the aeronautics community to solicit community input through a variety of methods such as independent reviews by external subject matter experts, the NASA Advisory Council's Aeronautics Committee, studies, and community roundtable meetings. The Aeronautics Research and Technology Roundtable (ARTR) is a particularly effective avenue to engage and collaborate with the aeronautics community. ARMD initiated the ARTR, which includes participation by senior-most representatives from government, industry, and universities, two years ago. Through the ARTR, the aviation community is defining and exploring critical issues related to the Nation's aeronautics research agenda that are of shared interest and exploring options for innovative public-private partnerships that could support rapid high confidence knowledge transfer. ARMD also charters studies in partnership with the National Academies to have in-depth analyses on important research subjects available for NASA and the community. The recently published National Research Council's study, "Recapturing NASA's Aeronautics Flight Research Capabilities," confirms the central role of flight research in discovering complex aeronautical phenomena and advancing the maturity of key technologies. NASA will utilize the specific insights of the study in advancing its ongoing and future flight research activities.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The Advanced Composites Project was added to the Integrated Systems Research Program in FY 2014 to focus on reducing the timeline for development and certification of innovative composite materials and structures. This project will boost American industry and help maintain a U.S. global leadership in the field of composite materials which is a major element of all new aircraft development.

AERONAUTICS

ACHIEVEMENTS IN FY 2012

NASA developed and tested a new decision-support system called “Dynamic Weather Re-Route” that automatically finds alternative routes that help airlines save time and fuel for en-route aircraft. The biggest cause of airline flight delays is hazardous weather. Flight routes are based on predicted weather and established prior to aircraft departure. Because weather patterns and severity change over time, flight routes often become congested and inefficient which results in delays, wasted fuel, and sometimes hazardous conditions for aircraft and travelers. Flight dispatchers currently lack automation tools to generate new routes that could save time and fuel once the aircraft are airborne. NASA Researchers are now engaged with U.S. airlines to conduct field trials of this tool through 2013, which will demonstrate its payoffs under real-world air traffic management scenarios.

NASA successfully conducted multiple integrated Air Traffic Management Technology Demonstration #1 (ATD-1) simulations with active FAA controllers and airline pilots. These new technologies better manage scheduling and spacing of aircraft in congested terminal airspace to allow more precise spacing, greater arrival efficiencies, and operational cost savings. These simulations used Dallas/Ft. Worth and Los Angeles airport data sets providing additional information about ATD-1 efficiency and its benefits for aviation operations. Results from these studies are being used to refine the plan for additional ATD-1 experiments in 2013 involving U.S air carriers and the FAA with field demonstrations in planning for 2016-17.

NASA completed analyses and detailed reports of ground-based tests that characterized the gaseous and particulate emissions of hydro-treated renewable jet (HRJ) fuel as a potential alternative, carbon-neutral aviation fuel. These tests measured emissions immediately downstream of a large transport aircraft jet engine operating on the ground. The results showed that HRJ fuel and their blends had substantially reduced particulate emissions, minor effects on gaseous emissions, and no measureable adverse effect on engine performance.

NASA advanced the state of the art and reduced the technical barriers of safe and routine UAS integration in the NAS. As part of a collaborative effort with the FAA Technical Center, NASA achieved the first flight of an unmanned aircraft equipped with Automatic Dependent Surveillance-Broadcast (ADS-B). ADS-B is a satellite-based aircraft tracking technology that provides detailed and accurate position, velocity, and altitude information to air traffic controllers and other ADS-B equipped aircraft. This demonstration was a critical step in the development of a Live Virtual Constructive – Distributive Environment (LVC-DE), an innovative way to safely immerse a flying unmanned aircraft in the NAS through virtual techniques. The LVC-DE will provide the backbone for eventual flight tests to validate the concepts and procedures developed by the project – these flight tests are scheduled for FY2015 and FY2016.

WORK IN PROGRESS IN FY 2013

NASA will expand its work on characterization of emissions from alternative fuels with in-flight tests to measure gaseous and particulate emissions from aircraft engines burning HRJ fuel. This data will be obtained while the aircraft is in flight at high, cruise-relevant altitudes and will help establish HRJ fuel as a potentially carbon-neutral aviation fuel. These tests are a follow on to research from 2012 that characterized the gaseous and particulate emissions of HRJ fuel as a potential alternative, carbon-neutral aviation fuel. The results showed that HRJ fuel and their blends had substantially reduced particulate emissions, minor effects on gaseous emissions, and no measureable adverse effect on engine performance.

NASA will make progress on UAS integration through initial evaluations and risk reduction activities of the project's operationally relevant environment. The relevant environment provides the infrastructure to enable the human-in- the-loop simulations and flight tests required to demonstrate integrated Separation Assurance, Human Systems Integration, and Communication efforts. In addition, NASA will conduct simulations that assess the performance of aircraft separation assurance methods as well as develop communication models for all classes of UAS. These validated communication models are required to provide confidence in simulation results. Finally, NASA will work to provide recommendations for risk-related data collection to support development of UAS regulations.

NASA will continue to address the development of an integrated national strategy for capability management with the DoD through the NPAT. In FY 2013, ATP will work with DoD to sponsor the NPAT Aeronautics Test Facility Users Meeting, a conference where NASA, DoD, and industry users of major National wind tunnels can discuss capabilities and provide feedback on future requirements and needed improvements.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA's Integrated Systems Research Program's Environmentally Responsible Aviation Project focuses on technologies that can simultaneously reduce aircraft fuel burn, noise, and emissions. Advanced "Ultra High Bypass Turbofan" is a technology that has the potential to dramatically reduce fuel burn and noise at the same time. The Ultra High Bypass engine is a much more fuel efficient version of the aircraft engine commonly used by airliners today. NASA will continue its investigation of Ultra High Bypass technologies by conducting a wind tunnel test of a Geared Turbo Fan model with advanced noise treatments installed. NASA will use this test to determine the effectiveness of those treatments and their impact on the performance of the engine. Data from the test will contribute to a comprehensive performance database for Modern Ultra High Bypass Propulsor Technologies that will be used by NASA and industry to update systems studies.

NASA will also augment the FY 2012 ground-based tests on HRJ with in-flight tests to measure gaseous and particulate emissions from aircraft engines burning HRJ fuel. This data will be obtained while the aircraft is in flight at high, cruise-relevant altitudes and will help establish HRJ fuel as a potentially carbon-neutral aviation fuel. In the fixed wing research area, NASA will continue a flight test campaign in which gas and soot emissions from the use of hydro-treated renewable jet fuel will be measured.

NASA will validate the ATD-1 Operational Concept through Human-in-the-Loop (HITL) simulation at the FAA Technical Center to enable entry of ATD-1 technology into the field for demonstration. This activity builds, installs and approves the operational procedures, ground and air automation tools, and avionics systems associated with the field demonstration at the FAA's William J. Hughes Technical Center (WJHTC). The NASA ATD-1 team working at the WJHTC with FAA personnel will conduct HITL simulations to assess the readiness of technologies to progress to the field for demonstration. A series of interactive simulations is anticipated using various simulation scenarios tested by current air traffic personnel and commercial flight crews.

NASA will evaluate concepts for separation assurance, sense and avoid, and ground control stations with communication system performance estimates through an Integrated HITL simulation in FY 2014 to provide data for further technology development. In addition, the Project will continue to mature and evaluate the Live Virtual Constructive – Distributed Environment that will be used to provide demonstrations of UAS integrated into the NAS.

Programs

AVIATION SAFETY PROGRAM (AVSP)

The Aviation Safety Program provides knowledge, concepts, and methods to the aviation community to manage increasing complexity in the design and operation of vehicles and the air transportation system. This includes advanced approaches to enable improved and cost effective verification and validation of flight critical systems. The program provides knowledge, concepts, and methods to avoid, detect, mitigate, and recover from hazardous flight conditions and maintain vehicle airworthiness and health. The program will investigate sources of risk and provide technology needed to help ensure safe flight in and around atmospheric hazards.

AIRSPACE SYSTEMS PROGRAM (ASP)

The Airspace Systems Program develops and explores fundamental concepts, algorithms, and technologies to increase throughput of the National Airspace System and achieve high resource efficiency. The program transitions key technologies from the laboratory to the field by integrating surface, terminal, transitional airspace, and en route capabilities. The FAA and U.S. carriers can then utilize the technologies to enable operational enhancements envisioned by NextGen.

FUNDAMENTAL AERONAUTICS PROGRAM (FA)

The Fundamental Aeronautics Program conducts fundamental research to improve aircraft performance and minimize environmental impacts from subsonic air vehicles and explores advanced capabilities and configurations for low boom supersonic aircraft.

AERONAUTICS TEST PROGRAM (ATP)

The Aeronautics Test Program ensures the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities and flight operations assets to meet Agency and national aeronautics testing needs. The ATP is responsible for the management and upkeep of NASA’s major active wind tunnels, as well as the Western Aeronautical Test Range and flight test support aircraft at the Dryden Flight Research Center.

AERONAUTICS

INTEGRATED SYSTEMS RESEARCH PROGRAM (ISRP)

The Integrated Systems Research Program conducts research on promising concepts and technologies at an integrated system level. The program explores, assesses, and demonstrates the benefits of these potential technologies in a relevant environment. The program research includes environmentally responsible aviation, unmanned system integration into the national airspace, and a new project focused on reducing the timeline for certification of advanced composite materials.

AERONAUTICS STRATEGY AND MANAGEMENT (ASM)

The Aeronautics Strategy and Management program explores novel concepts and new processes in aeronautics, funds institutional expenses for the mission directorate, and supports NASA involvement with the NextGen Joint Planning and Development Office (JPDO).

AVIATION SAFETY

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	80.1	--	**80.0**	80.3	81.5	82.4	82.5
Change from FY 2012	--	--	**-0.1**				
Percentage change from FY 2012	--	--	**-0.1 %**				

NASA is working with partners to develop an advanced aerodynamic model that will greatly enhance the capabilities of aircraft simulators used to train airline pilots. The new model will allow simulators to accurately represent a broader range of potentially hazardous flight conditions.

The current US air transportation system is widely recognized to be among the safest in the world. Over the past 10 years, the commercial accident rate has continued to drop, a credit to industry and government working together to solve problems and proactively identify new risks. However, the FAA Aerospace Forecast projects steady growth in the next 20 years, and while NextGen will meet this demand by enabling efficient passage through the increasingly crowded skies, it will come with increased reliance on automation and operating complexity. Therefore, the aviation community must continue to be vigilant for the United States to meet the public expectations for safety in this complex, dynamic domain. To meet the challenge, the Aviation Safety Program develops cutting-edge technologies to improve the intrinsic safety of current and future aircraft that will operate in NextGen. The program's contributions range from providing fundamental research and technologies on known or emerging safety concerns, to working with partners in addressing new safety challenges for NextGen. The program has three primary objectives:

- Continue to improve aviation system-wide safety;
- Advance the state-of-the-art of aircraft systems and flight crew operations; and
- Address the inherent presence of atmospheric risks to aviation.

The Aviation Safety Program has developed research plans with milestones and metrics in technology areas corresponding to these objectives. All areas emphasize innovative methods and use a systems analysis approach for identifying key issues and maintaining a research portfolio that addresses national aviation safety needs.

For more information, go to: http://www.aeronautics.nasa.gov/programs_avsafe.htm.

EXPLANATION OF MAJOR CHANGES

None.

AVIATION SAFETY

ACHIEVEMENTS IN FY 2012

NASA developed and tested a static-code analyzer that can automatically review large-scale software systems for errors without needing to run the software. This capability is part of an ongoing NASA research effort to reduce the time and cost associated with assuring the safety of complex, flight-critical systems. NASA's tool reduced the analysis time from the three to four hours typical of a currently available commercial product down to several minutes. The NASA tool also achieved a false positive rate of five percent or less.

NASA advanced its data mining algorithms that look for anomalous events occurring across thousands of flights that can represent precursors to aviation safety incidents. In a validation test, the latest algorithm successfully predicted the occurrence of known safety events with at least 10 percent more lead time than prior methods. Earlier recognition can be a good indicator of an algorithm's ability to reliably identify a wide range of potential safety concerns. NASA conducted these tests on real flight datasets of at least 10 terabytes. In addition to detecting the known anomalies earlier, the algorithm also identified one previously unknown anomaly that was validated by a domain expert to be a legitimate safety concern. NASA provided the capabilities to the FAA and multiple airlines.

NASA completed a concept of operations for an integrated vehicle health assurance system. In this concept, NASA provides its research approach for monitoring the health of aircraft systems during in-flight and post-flight analyses and then using that knowledge to confidently predict system malfunctions before they occur. The concept integrates ground-based inspection and repair information with in-flight measurement data for airframe, propulsion, and avionics subsystems. This approach can eventually contribute to airline maintenance practices that rely more on the actual system health of an individual aircraft and less on fleet-wide reliability averages.

NASA completed a first generation engine icing simulation code that predicts the adverse effects on engine performance due to high ice water content icing. Under these conditions, ice crystals from strong, high altitude thunderstorms can adhere to engine compressor blades, leading to power reduction or loss. NASA calibrated the simulation code with ground-test data from the National Research Council of Canada.

WORK IN PROGRESS IN FY 2013

NASA will develop multidisciplinary technologies in support of an onboard capability to assess the instantaneous health state of an aircraft. This system, known as a "vehicle-level reasoner," will analyze real-time operational data from an aircraft's subsystems. It will then use data mining to isolate root-causes of adverse events, predict possible failures that could occur on future flights, and propose mitigation strategies as appropriate. The reasoner can support both on-board decision-making by pilots and early maintenance interventions for predicted failures. NASA plans to demonstrate the system's monitoring, problem investigation, and decision support capabilities.

NASA will conduct its first ground-based test of an engine operating in high ice water content icing conditions. During the test, NASA will use a real engine known to be susceptible to degraded performance under these conditions. Being able to replicate these flight conditions represents a significant enhancement to the Propulsion Systems Laboratory at Glenn Research Center in Cleveland, OH that has been under development for the past five years. The test will attempt to duplicate an actual high altitude-icing event that occurred in a similar engine. Over time, the high ice water content icing conditions simulated in Propulsion Systems Laboratory will be validated by more extensive atmospheric data that do not currently exist. NASA expects that engine manufacturers will eventually be able to conduct tests in the laboratory that will support new FAA certification requirements for engines operating under these icing conditions.

NASA will conduct its second in a series of ground tests involving a transport aircraft engine operating under extreme environmental conditions. The Vehicle Integrated Propulsion Research (VIPR) tests are part of a partnership between NASA, the US Air Force, Pratt & Whitney, and other government and industry participants. The VIPR series will evaluate the ability of new systems to diagnose correctly a range of engine faults using advanced sensors capable of operating under high temperature, pressure, and vibration conditions. The second test will capture more data to validate experimental algorithms that form the foundation of the diagnostic capabilities. Future VIPR tests are expected to evaluate the sensors and diagnostic systems in an engine subjected to sufficient contaminants to cause complete shutdown. The VIPR series will provide essential data and technology validation for capabilities that can be used as part of an engine health management system.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will conduct a ground-based demonstration of a wireless sensor which provides lightning protection and can also detect and diagnose damage in composite structures. This new technology will allow airframe designers to meet lightning strike protection requirements while also detecting and diagnosing damage scenarios such as delamination, punctures, and rips. In addition, the technology is anticipated to weigh less than common practice conductive mesh technologies currently used on composite aircraft.

NASA will conduct an integrated, high-fidelity simulator demonstration of an aerodynamic model that supports flight crew training requirements for assuring safe aircraft control. This model will accurately represent the flight characteristics of a commercial aircraft under aerodynamic stall conditions, a capability that does not exist in current-day simulators. As part of a government-industry review of world-wide aviation accidents, the aviation community is looking carefully into enhanced training requirements for stall recognition and recovery. Improper pilot response under these conditions can contribute to a loss-of-control accident. Over the past decade, in-flight loss of control is the most common cause of fatal aviation accidents worldwide. Augmenting a flight simulator with NASA’s aerodynamic model will allow pilots to recognize the conditions that can lead to a stall, and then respond correctly if a stall does occur. NASA’s will validate the model with subscale aircraft flight tests, as well as other available flight test and accident data. NASA is partnering with the Navy, The Boeing Company, FAA, National Transportation Safety Board, and the Commercial Aviation Safety Team on this activity.

AVIATION SAFETY

Program Elements

SYSTEM-WIDE SAFETY AND ASSURANCE TECHNOLOGIES

The goal of system-wide safety and assurance technologies research is to provide knowledge, concepts, and methods to proactively manage increasing complexity in the design and operation of vehicles in the air transportation system. To meet this goal, NASA is addressing the following challenges:

- Safely incorporate technological advances in avionics, software, automation, and concepts of operation by developing verification and validation tools for manufacturers and certifiers to use to assure flight critical systems are safe in a rigorous and cost- and time-effective manner;
- Understand and predict system-wide safety concerns of the airspace system and vehicles by developing technologies that can use vehicle and system data to identify accurately precursors to potential incidents or accidents;
- Improve operator effectiveness within aviation systems by incorporating design elements that enhance human contributions to aviation safety; and
- Predict the life of complex systems by developing technologies that can reason under uncertainty about root causes, predict faults and remaining useful life across multiple systems, and aid decision making across multiple systems.

VEHICLE SYSTEMS SAFETY TECHNOLOGIES

The goal of vehicle systems safety technologies research is to identify risks and provide knowledge needed to avoid, detect, mitigate, and recover from hazardous flight conditions, and to maintain vehicle airworthiness and health. To meet this goal, NASA is addressing the following challenges:

- Demonstrate new capabilities that enable pilots to better understand and respond safely to complex situations;
- Develop and demonstrate new integrated health management and failure prevention technologies to ensure the integrity of vehicle systems between major inspection intervals and maintain vehicle state awareness during flight; and
- Develop and evaluate integrated guidance, control, and system technologies that enable safe and effective crew and system aircraft control under hazardous conditions.

ATMOSPHERIC ENVIRONMENT SAFETY TECHNOLOGIES

The goal of atmospheric environment safety technologies research is to investigate sources of risk and provide technology needed to help ensure safe flight in and around atmospheric hazards. To meet this goal, NASA is addressing the following challenges:

- Address the atmospheric hazard of in-flight icing, of both engine and airframe, in cooperation with the icing community to characterize the various icing environments, develop remote sensors to detect conditions, understand and model the effects of ice accretion, and support the development of methods to mitigate the conditions; and

- Sense and mitigate risks associated with other atmospheric hazards that pose serious threats to aviation.

Program Schedule

Date	Significant Event
Q1 FY14	Demonstration of a wireless sensor that provides lightning protection and damage detection in composite aircraft
Q3 FY14	Demonstrated use of an advanced software technique to verify the safety of a complex aircraft or ground automation software system
Q3 FY14	Development of proficiency elements for manual handling skills in the automated flight deck
Q3 FY14	Development and demonstration of a formal model that assesses safety by analyzing roles and responsibilities between humans and automated systems
Q4 FY14	Integrated, high-fidelity simulator demonstration of an aerodynamic model that supports flight crew training requirements for assuring safe aircraft control
Q3 FY15	Evaluation of methods to scale engine icing conditions from sea level to higher altitudes

Program Management & Commitments

The ARMD Associate Administrator has oversight responsibility for the program. The program director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD and NASA programs.

Program Element	Provider
System Wide Safety and Assurance Technologies	Provider: ARC, DFRC, GRC, LaRC Lead Center: ARC Performing Centers: ARC, DFRC, GRC, LaRC Cost Share Partners: The Boeing Company, Commercial Aviation Safety Team (CAST), DoD, easyJet, FAA, Honeywell, , JPDO, ONERA, Southwest Airlines
Vehicle Systems Safety Technologies	Provider: ARC, DFRC, GRC, LARC Lead Center: LaRC Performing Centers: ARC, DFRC, GRC, LARC Cost Share Partners: A&P Technology, Alcoa Technical Center, American Airlines, ANSYS, The Boeing Company, CAST, Cessna Aircraft Co., DoD, DLR, FAA, General Electric Aircraft Engines, Goodrich, Honeywell, JPDO, Makel Engineering, Moog, National Aerospace Laboratory of the Netherlands, ONERA, Pratt and Whitney, United Technologies Corp., University of South Carolina, Wichita State University
Atmospheric Environmental Safety Technologies	Provider: DFRC, GRC, LARC Lead Center: GRC Performing Centers: DFRC, GRC, LARC Cost Share Partners: The Boeing Company, CAST, DoD, Environment Canada, FAA, Honeywell, INTA (Instituto Nacional de Técnica Aerospacial), JPDO, National Research Council Canada, ONERA

Acquisition Strategy

The program spans research and technology from foundational research to integrated system capabilities. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. NASA encourages teaming among large companies, small businesses, and universities for all procurement actions.

MAJOR CONTRACTS/AWARDS

NASA's aeronautics programs award multiple smaller contracts that are generally less than $5 million. They are widely distributed across academia and industry.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Expert Review	Nov 2012	The 12-month review is a formal independent peer review. Experts from other government agencies report on their assessment of technical and programmatic risk and program strengths and weaknesses.	The projects are reviewed for relevance, quality and performance and receive recommendations from reviewers.	Dec 2013

AIRSPACE SYSTEMS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	92.7	--	**91.5**	91.5	91.9	92.4	92.4
Change from FY 2012	--	--	**-1.2**				
Percentage change from FY 2012	--	--	**-1.3 %**				

An artist's rendering of future integrated air and ground-based technologies developed by the Airspace Systems Program (ASP) to meet the vision for the nation's aviation infrastructure and operations. ASP technologies aim to increase the efficiency of the national airspace by introducing advanced air transportation operations across new communication channels.

The Airspace Systems Program creates technologies that will help transition to the Next Generation Air Transportation System (NextGen). NextGen is a multi-agency effort to overall our National Airspace System to make air travel more convenient and dependable, while ensuring flights are as safe, secure and hassle-free as possible. NextGen integrates new and existing technologies, policies and procedures to reduce delays, save fuel and lower aircraft exhaust emissions. The Airspace Systems Program, with the Federal Aviation Administration (FAA) and its other industry and academic partners, conceives and develops NextGen technologies that will provide advanced levels of automated support to air navigation service providers and aircraft operators for reduced travel times and travel-related delays both on the ground and in the sky. These advanced technologies provide shortened routes for time and fuel savings, with associated improvements in noise and emissions, and permit controllers to monitor and manage aircraft for greater safety in all weather conditions. As the predicted volume of air traffic climbs, this transformation aims to reduce gridlock, both in the sky and at airports.

The associated economic impacts of these delays and inefficiencies are predicted to cost the Nation tens of billions of dollars annually. Delayed flights cost an already struggling airline industry nearly $20 billion in additional operating costs. Passengers affected by delayed flights lost time valued at more than $10 billion. Other industries that rely on the airline industry suffered a loss as much as $10 billion as a result of delays. Jet fuel consumed as a result of delay cost more than $1.6 billion in 2007 leading to over 7 million-metric tons of carbon dioxide emissions. This represents over $40 billion in adverse economic impact due to aviation delays in the United States. The Airspace Systems Program works to reduce these costs. (Source: Report by the Joint Economic Committee Majority Staff, "Your Flight Has Been Delayed Again: Flight Delays Cost Passengers, Airlines, and the U.S. Economy Billions," Chairman, Sen. Charles E. Schumer, Vice Chair, Rep. Carolyn B. Maloney, May 2008.)

AIRSPACE SYSTEMS

This research seeks to maximize flexibility and effectiveness in the use of airports and airspace while accommodating projected growth in air traffic, and aims to enable the seamless operation and utilization of the full potential capabilities of new aircraft types such as advanced rotorcraft, unmanned aerial systems, high-speed aircraft, and hybrid wing body aircraft.

For more information, go to http://www.aeronautics.nasa.gov/programs_asp.htm.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

NASA transferred the results of its research to define and validate the Efficient Descent Advisor (EDA) concept to the FAA in FY 2012 for further evaluation and potential operational use. The concept helps air traffic controllers allow airliners of all sizes to more efficiently descend from cruising altitude to arrive at an airport using less engine power while maintaining a safe distance from other aircraft. As a result, airlines save money on fuel and aircraft release fewer emissions into the atmosphere and the workload of air traffic controllers is reduced (since automation is added to the process.) In fact, NASA simulations showed potential annual savings of $300 million in fuel.

NASA also successfully simulated airport operations using an integrated set of software that better manages scheduling and spacing of aircraft in congested terminal airspace. The technologies, which include Automatic Dependent Surveillance-Broadcast, produced more precise aircraft spacing allowing for increased arrival rates and operational cost savings. NASA conducted the simulation with active FAA controllers, airline pilots, and data sets from the Dallas/Fort Worth and Los Angeles airports. In addition, NASA successfully simulated safe interval management procedures to a single airport with dependent parallel runways utilizing NextGen flight-deck technologies. Benefits analysis indicates that these technologies have the potential to save several percent of total operational fuel costs due to more efficient arrivals. Although dependent on the level of aircraft equipage, annual system-wide savings are estimated at between $200 million to $300 million. Results from these simulations are being used to refine the plans for a future technology demonstration.

In addition, NASA developed weather translation models that provided an estimate of the weather's impact (e.g., high surface winds, low visibility, etc.) on an airport's capacity for 1 to 8 hours in the future over a 15-minute interval. These models incorporated forecasts from three state-of-the-art, airport-centric weather forecasts from the National Weather Service. On average, two of the models were able to predict the weather-impacted airport arrival rate (AAR) at 2 representative airports over a 1 to 8 hour look-ahead time horizon within 10 to 15 percent of the actual weather impacted AAR. The third model was able to estimate the weather-impacted AAR over a one hour look-ahead time horizon within five percent of the actual weather impacted AAR at three representative airports. This improvement in use of weather predictions will provide substantial increase in airport arrival throughput.

AIRSPACE SYSTEMS

WORK IN PROGRESS IN FY 2013

NASA will conduct human-in-the-loop simulations of advanced trajectory-based algorithms that reduce aircraft delays during taxi. Delays on the airport surface have been recognized as one of the major factors limiting the ability of airports to accommodate high levels of surface traffic throughput. These algorithms will include a more advanced surface movement planning horizon, of up to one hour, leading to reduced surface congestion. Benefits studies for several complex U.S. airports show a taxi delay reduction of between three to five minutes resulting in annualized fuel savings of $2.5 million to $7.5 million at each airport using these algorithms. Technology transition to FAA may occur as early as 2015.

NASA is collaborating with FAA to explore the use of NASA's Precision Departure Release Capability (PDRC) that couples advanced airspace flow management and airport surface traffic tools. PDRC allows precision scheduling of departing aircraft to allow for smooth integration into available slots in the high-altitude overhead streams. Missed departure slots in the overhead stream translate to departure delays and lost system capacity. The technology automates what is today an inefficient manual process for negotiating a take-off time between the control tower and en route control center. As compared to today's process, take-off time conformance is expected to double in improvement, representing an estimated $20 million in annual system-wide savings. NASA is working with FAA to support their plans to incorporate PDRC in a demonstration that begins in early 2013.

Seventy percent of air traffic delays are caused by bad weather. Until now, airline dispatchers and FAA traffic managers did not have a way to continuously reevaluate the pre-departure weather avoidance routes for each flight. NASA's Dynamic Weather Rerouting (DWR) tool enables dynamic, 'real-time' adjustments to flight paths to avoid bad weather with minimum delay while also saving fuel. The tool integrates trajectory-based automation convective weather modeling that predicts the growth and movement of storms, and algorithms to automatically compute minimum-delay routes around bad weather. The tool shows the potential to provide significant operational savings to airlines. Researchers are now engaged with U.S. airlines to conduct field trials of the tool through 2013, which will demonstrate its payoffs under real-world air traffic management scenarios. Laboratory simulations and field tests of DWR conducted have shown potential average savings of 10 minutes or, in operating cost, an estimated $1,700 per flight impacted by severe weather.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA has initiated plans to demonstrate ground-based controller managed spacing of arriving flights combined with flight deck interval management technologies. These plans would enable fuel and time-savings along with increased capacity for early adopters of Automatic Dependent Surveillance-Broadcast equipage. In order to demonstrate user benefits of these concepts, NASA is jointly working with FAA to partner with airlines, aircraft manufacturers, avionics manufacturers, ground-based automation system integrators, and airports to test these technologies under practical conditions of arriving flights at a dense terminal of a busy commercial airport. Results from integrated technology simulations in 2013 are being used to refine the plan for the Air Traffic Management Technology Demonstration #1 (ATD-1) system evaluation with FAA in 2014 and field demonstrations planned for 2015 to 2017. This complex and integrated set of ground-based and flight deck technologies will enable expanded terminal area capacity and reduced flight time and fuel consumption for arriving aircraft. Annual system-wide benefits are estimated at several hundred million dollars.

AIRSPACE SYSTEMS

NASA will conduct a simulation of a surface decision support system called the Spot and Runway Departure Advisor that reduces stop-and-go activity on taxiways. This technology targets improved efficiency of airport surface operations from both air traffic control and airline operations points of view: Long departure queues and excessive fuel burn and emissions, that result in high operating cost for airlines and adverse impacts on the environment, would be reduced. The simulation will be conducted at NASA's Future Flight Central facility at NASA's Ames Research Center, Moffett Field, CA using Charlotte International Airport operations data and will examine how the operations could be improved by better scheduling at various key points on the airport surface. The users of this technology include FAA tower controllers and airline ramp controllers.

NASA will assess initial results of an innovative national airspace system modeling architecture that will use real-life, one-way feed of aircraft traffic and weather data and allow testing of advanced, gate-to-gate concepts in an integrated fashion to accelerate application of NextGen technologies. The architecture for this new capability will enable shadow-mode assessment of realistic technologies for NextGen. It will allow integrated impact assessment of multiple concepts and technologies, study interactions across different concepts, test competing alternatives, and uncover any potential unknowns related to national airspace system performance. This complex modeling and simulation capability will enable rapid evaluation of new airspace management concepts that cannot be evaluated in today's national airspace.

Program Elements

NEXTGEN CONCEPTS AND TECHNOLOGY DEVELOPMENT

By developing gate-to-gate concepts and technologies, this project helps to realize the NextGen air traffic management goals of enabling significant national airspace increases in capacity and efficiency while striving to lower the total cost of air transportation. The project studies the key future roles and responsibilities between humans and automation, whether they exist in ground-based air traffic control systems or on the flight deck of an aircraft. Included in project investigations are methods to optimize flight routes, as well as arrivals and departures, and to better coordinate surface and runway operations. Also under study are ways to mitigate the adverse effects of weather to insure the most advantageous use of the airspace system and reduce travel delays, and accommodate an expected growth in overall air travel. Successful investigations in these areas will require close, highly coordinated interaction with the NextGen System Analysis, Integration, and Evaluation Project.

NEXTGEN SYSTEMS ANALYSIS, INTEGRATION, AND EVALUATION

The initial focus of this project is to ensure that NASA's air traffic management concepts, technologies, and procedures are matured and tested in laboratory simulations to determine their NextGen viability. A subset will be further demonstrated and evaluated by field tests in relevant flight environment that integrate both air and ground capabilities. Ultimately, coordination with other Government organizations and industry stakeholders will ensure the appropriate NASA technologies are transitioned to system users and the FAA for their implementation consideration to realize NextGen benefits. Successful maturation and application of advanced NextGen technologies requires:

AIRSPACE SYSTEMS

- Incorporating fast-time modeling and simulation and feedback results to validate research concepts and assess their collective technological impact;
- Determining the feasibility of integrated concepts and technologies using human-performance models and human-in-the-loop simulations; and
- Conducting collaborative field trials to evaluate the impact of integrated concepts and technologies for total operational cost savings important to users of the national airspace.

Program Schedule

Date	Significant Event
Q2 FY14	Air Traffic Management Technology Demonstration #1, Operating Concepts Validation and system assessment
Q4 FY14	Spot and Runway Departure Advisor evaluation for Charlotte International Airport
Q4 FY14	Dynamic Weather Re-Route testing
Q4 FY14	Initial instantiation of shadow-mode NextGen simulator
Q1 FY15	Air Traffic Management Technology Demonstration #1, Simulation at the FAA William J. Hughes Technical Center
Q4 FY15	Spot and Runway Departure Advisor operational field evaluation with an airline and airport partner
Q4 FY16	Initial evaluation of one future scenario in the shadow-mode NextGen simulator

Program Management & Commitments

The ARMD Associate Administrator has oversight responsibility for the program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD and NASA programs.

Program Element	Provider
NextGen Concepts and Technology Development	Provider: ARC, LaRC Lead Center: ARC Performing Centers: ARC, LaRC Cost Share Partners: FAA, JPDO, Boeing, General Electric, American Airlines, United Airlines, Rockwell Collins
NextGen Systems Analysis, Integration, and Evaluation	Provider: ARC, LARC Lead Center: ARC Performing Center: ARC, LARC Cost Share Partners: FAA, JPDO, Honeywell, General Electric, Boeing

AIRSPACE SYSTEMS

Acquisition Strategy

Airspace Systems Program spans research and technology from foundational research to integrated system capabilities. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

MAJOR CONTRACTS/AWARDS

NASA's aeronautics programs award multiple smaller contracts that are generally less than $5 million. They are widely distributed across academia and industry.

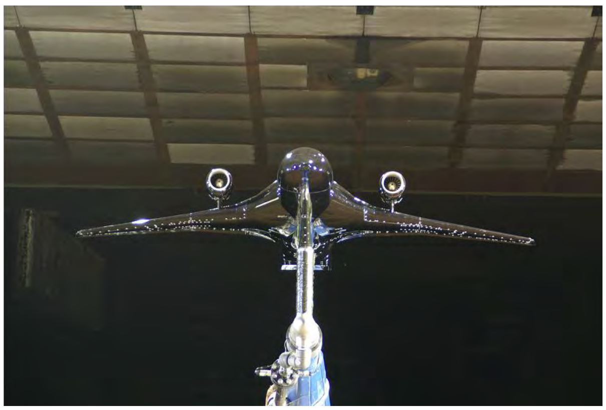
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Expert Review	Nov 2012	The 12-month review is a formal independent peer review. Experts from other Government agencies report on their assessment of technical and programmatic risk and/or program weaknesses.	The projects are reviewed for relevance, quality and performance and receive recommendations from reviewers.	Nov 2013

FUNDAMENTAL AERONAUTICS

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	Actual FY 2013	FY 2014	Notional FY 2015	Notional FY 2016	Notional FY 2017	Notional FY 2018
FY 2014 President's Budget Request	186.3	--	**168.0**	166.9	163.4	160.1	159.7
Change from FY 2012	--	--	**-18.3**				
Percentage change from FY 2012	--	--	**-9.8 %**				



As part of NASA's Fundamental Aeronautics Program, researchers from California Polytechnic State University, San Luis Obispo, California, tested a 1/11th scale hybrid wing body aircraft concept known as AMELIA (Advanced Model for Extreme Lift and Improved Aeroacoustics), in the National Full Scale Aerodynamic Complex at Ames Research Center. For the first time, three aircraft design features that usually cause conflicts with each other were tested together: short take-off and landing, cruise efficiency, and reduced aircraft noise. As many as 30 students, from summer interns to graduate students writing their masters' theses, participated in this research. AMELIA's test results will be released to the aeronautical community in 2013.

The Fundamental Aeronautics (FA) program develops knowledge, technologies, tools, and innovative concepts to enable new aircraft that will fly faster, cleaner, and quieter, and use fuel far more efficiently. These aircraft will be needed as the Nation transitions to NextGen.

NASA research is inherent in every major modern U.S. aircraft, and the type of research performed by the FA program will prime the technology pipeline, enabling continued US leadership, competitiveness, and jobs in the future. Some of the key benefits of this work include:

- Dramatically reduced aircraft noise and emissions;
- Dramatically improved fuel efficiency; and
- Increased mobility and air travel flexibility.

Research performed by the FA program impacts a wide variety of air vehicles from helicopters and commercial airliners to high-speed vehicles that can travel faster than the speed of sound. NASA's work is focused on civil applications, however, there is significant coordination with the Department of Defense to help maximize the effectiveness and impact of NASA research.

While NASA is focused on future vehicles, many of the tools and technologies that are developed have an immediate impact to industry. Ultimately, FA program research enables a future in which a variety of advanced air vehicles improve the flexibility, efficiency, and environmental impacts of the air transportation system.

For more information, go to: http://www.aeronautics.nasa.gov/fap.

FUNDAMENTAL AERONAUTICS

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Several highlights follow from the many successful accomplishments of the Fundamental Aeronautics program.

NASA completed analyses of ground-based tests that characterized the gaseous and particulate emissions of hydro-treated renewable jet fuel, an alternative aviation fuel. The results showed that hydro-treated renewable jet fuels and their blends had substantially reduced particulate emissions, minor effects on gaseous emissions, and no measureable adverse effect on engine performance. Understanding the effects of alternative fuels is important to industry and government agencies such as the Federal Aviation Administration and the Environmental Protection Agency to help ensure that aircraft can safely and efficiently use alternative fuels. Increased use of alternative jet fuels has the potential to reduce overall carbon emissions associated with aviation. In addition, these fuels can also decrease US dependence on foreign petroleum.

To realize significant improvements in efficiency and reductions in the environmental impact of aviation, it may be necessary to develop new aircraft designs that have little resemblance to today's tube-and-wing aircraft. Advanced computational tools are also needed to help develop, create, and test new concepts and designs. To help realize these new concepts and accompanying tools, NASA completed wind tunnel testing of a new concept that was very different from a tube-and-wing and demonstrated its reduced noise potential and improved short take-off and landing performance. Results from this test will be used to improve computational tools for a number of advanced aircraft configurations.

In addition to improving the performance (e.g., efficiency and environmental impact) of vehicles, the FA program also made advances in making air travel even more flexible and convenient. For example, modern helicopters perform a number of unique missions including life saving operations and transportation to relatively isolated locations. Making helicopters quieter and more efficient will increase their ability to carry additional passengers and cargo for current and future missions. To support these improved capabilities, NASA made significant advances in rotary wing propulsion systems that included new types of engine compressors and new transmissions.

People are always looking to spend less time traveling and more time at their destination. One way to help achieve this desire is faster air transportation. However, the noise associated with sonic booms has always been a limiting factor - although this may change thanks to NASA research. The FA program successfully completed wind tunnel tests that validated computational tools developed for designing and shaping supersonic aircraft to produce quieter sonic booms. NASA conducted the first tests in a new facility for simulating sonic boom noise as heard indoors as part of the Agency's efforts to understand how far sonic boom noise must be reduced to allow unrestricted overland flight.

New computational design tools under development can greatly decrease the time needed for designing air vehicles and allow industry to explore new configurations. NASA completed the first generation of the Integrated Design and Engineering Analysis software tool, which enables the rapid and automated conceptual design of a hypersonic air-breathing vehicle. This new fully-automated software tool reduces the time necessary to conduct a vehicle design and analysis from 3 months (with current methods) to less than 24 hours.

NASA studied hypersonic planetary physics by obtaining unique Martian atmospheric pressures, heat shield temperatures and heat shield recession data (loss of mass due to the ablation of the heat shield) from the instrumentation installed on the Mars Science Laboratory carrying the Curiosity Rover. This highly unique data is being analyzed by researchers at NASA and universities to inform all future Mars landing missions to enable reduced vehicle mass or a larger, more capable scientific payload.

WORK IN PROGRESS IN FY 2013

NASA will expand its work on characterization of emissions from alternative fuels with in-flight tests to measure gaseous and particulate emissions from aircraft engines burning alternative fuel. Researchers previously conducted tests on the ground but this will provide the first opportunity to collect key data in flight at high, cruise-relevant altitudes and will help establish hydro-treated renewable jet fuel as a potentially carbon-neutral aviation fuel.

NASA will continue to explore new propulsion capabilities including a better understanding of the viability of widely variable speed transmissions using a unique test facility at Glenn Research Center in Cleveland. The ability to significantly change rotor speed can lead to rotorcraft that are both faster and more efficient. Even though several countries are trying to accomplish this, it is a technology that has not yet been developed for manned rotorcraft. In addition, NASA will also test new drag reduction technologies that will save a considerable amount of fuel. Prior testing indicated savings of up to 25 percent, and testing in 2013 will continue to further explore this technology.

NASA will deliver high fidelity tools for prediction of sonic boom and drag that are suitable for low sonic boom supersonic aircraft design. These tools are needed to determine the shape of aircraft that will produce low boom signatures. To verify that these tools are accurate, wind tunnel experiments will be completed to compare experimental data to predictions. In addition to improving the capability to design low-boom aircraft, NASA will continue to perform experiments to improve understanding of how this low-boom signature will be heard on the ground. This is an important step to ultimately changing regulations so that over-land supersonic flight is permitted.

NASA will continue to press forward the development and improvement of computational tools that are critical for new vehicle design. These tools include computational fluid dynamics and aircraft drag prediction methods using the latest high-performance computers and advanced modeling of airflow, combustion, and noise generation physics. This will lead to improved aircraft, engine, and combustor modeling, which will ultimately allow industry to have more confidence in the ability to accurately predict the performance of new and unusual designs. This capability helps ensure that US industry maintains a competitive edge by exploring more advanced ideas than others and reducing the time it takes to develop new designs.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

To help demonstrate the benefits of new aircraft configurations and to understand the key challenges associated with these new concepts, NASA will conduct several investigations. To improve the efficiency of wings, NASA will conduct high-fidelity experimental and computational studies of a truss-braced wing configuration; one in which very long, slender, and efficient wings are supported by an additional brace. These concepts have been considered by industry, but so far, no in-depth study of their strengths and challenges have been conducted. Research on these kinds of configurations may lead to reductions of fuel burn in transport aircraft. NASA will also test a coupled engine inlet and fan that is capable of high performance and operability while being part of an embedded engine system (engines buried within the aircraft body). This unusual approach is not found in today's commercial aircraft, and it could lead to new designs with significant improvements in performance.

NASA will assess the capability of new rotor control technologies by investigating three different concepts. Because it is rotating and creating a number of wakes, the rotor environment is one of the most difficult to understand compared to other air vehicles. New rotor control technologies have the potential to enable a significant leap ahead in modern rotor designs. To advance propulsion technologies, NASA will partner with the US Army to design a new type of engine turbine that uses variable speed in a fuel-efficient manner. Both the active rotor research and the variable-speed turbine research are targeted to increase speed, enhance fuel efficiency, and reduce noise for both conventional and advanced rotorcraft configurations.

The next critical steps in overcoming the barrier to overland supersonic flight are flight validation of advanced aircraft design tools and technologies combined with community overflight studies. The combination of these efforts would provide data to support the development of a noise-based standard to replace the current prohibition of civil overland supersonic flight. NASA's high-speed effort will focus on ensuring the readiness of low-boom aircraft design tools for application in a flight demonstration project and on the validation of study methodologies, survey tools, and test protocols required for community overflight studies as described above.

NASA research will advance the capabilities and use of ceramic matrix composites to push the envelope on this material's ability to withstand high temperatures, while being strong and lightweight, which allows for the design of propulsion systems that are more efficient and effective. Work with government and industrial partners will demonstrate the feasibility of incorporating these ceramic matrix composites into future aircraft engines and accelerate the introduction of their performance benefits into the fleet.

Program Elements

FIXED WING

NASA fixed wing research explores and develops tools, technologies, and concepts to enable revolutionary advances in energy efficiency and environmental compatibility of future generations of transport aircraft. This research is necessary for the sustained growth of commercial aviation that is vital to the US economy. The scientific knowledge gained from this research, in the form of experiments, data, calculations, and analyses, is critical for conceiving and designing more efficient, quieter, and greener aircraft. Fixed wing research is focused on the future, with an eye towards the "N+3" generation; targeting vehicles that are three generations beyond the current state-of-the-art (generation N) and requiring mature technology solutions between 2025 and 2030.

FUNDAMENTAL AERONAUTICS

ROTARY WING

Rotary wing research develops and validates tools, technologies, and concepts to overcome key barriers for rotorcraft vehicles. The research efforts advance technologies that increase rotorcraft speed, range, and payload, and decrease noise, vibration, fuel burn, and emissions. This research will enable improved computer-based prediction methods, technologies, and concepts for future high-speed, efficient rotorcraft able to operate as commercial vehicles in the national airspace system while enhancing their ability to do the missions that only rotorcraft can do. In FY 2014, NASA will explore options for the future of its rotary wing research. The goal is to ensure the critical research areas are continued while completing and phasing out lower priority areas. NASA will coordinate with its partners in industry and other government agencies to ensure that their research needs are fully considered throughout the process.

HIGH-SPEED

High-speed vehicle research includes tools, technologies, and knowledge that will help eliminate today's technical barriers preventing practical, commercial supersonic flight. These barriers include: sonic boom; supersonic aircraft fuel efficiency; airport community noise; high altitude emissions; prediction of vehicle control, operation, and performance; and the ability to design future vehicles in an integrated, multidisciplinary manner. The high-speed research also includes expansion of foundational knowledge necessary for controlled, air-breathing hypersonic flight capability.

AERONAUTICAL SCIENCES

Aeronautical Sciences will advance computer-based tools and models as well as scientific knowledge that will lead to significant improvements in the ability to understand and predict flight performance for a wide variety of air vehicles. Examples of this research include the development of new computational tools that are used to predict the airflow around vehicles ultimately leading to greater abilities to predict vehicle performance in flight. Another important area of research, applicable across a number of air vehicle types, is improving the understanding and development of new types of strong and lightweight materials that are important for aviation.

Program Schedule

Date	Significant Event
Q2 FY14	Test and analysis completed for advanced rotor concepts
Q4 FY14	Truss-braced wing evaluation via high fidelity test and analysis
Q4 FY14	2700° Fahrenheit ceramic matrix composite fabricated
Q1 FY15	Fuselage drag reduction assessment
Q4 FY15	Characterize cruise-altitude gaseous and particulate emissions from alternative fuels via flight test and analysis
Q4 FY15	Tools and technologies enabling the design of supersonic aircraft that achieve low sonic boom validated as ready for demonstration
Q4 FY15	Demonstrate improved computational fluids prediction capabilities

FUNDAMENTAL AERONAUTICS

Program Management & Commitments

Program Element	Provider
Fixed Wing Project	Provider: ARC, DFRC, GRC, LaRC Lead Center: GRC Performing Centers: ARC, DFRC, GRC, LaRC Cost Share Partners: US Air Force, Boeing, Pratt & Whitney, Northrop Grumman, General Electric Aviation, United Technologies Corporation, Rolls Royce/LibertyWorks, Honeywell, FAA, ONERA, DLR, JAXA, Lockheed Martin, Cessna, US Navy, US small businesses and universities.
Rotary Wing Project	Provider: ARC, GRC, LaRC Lead Center: LaRC Performing Center: ARC, GRC, LaRC Cost Share Partners: Boeing, United Technologies Research Center, US Army, Vertical Lift Consortium (VLC), Bell Helicopter Textron, Sikorsky Aircraft, Rolls Royce/LibertyWorks, GE, Pratt and Whitney, FAA, ONERA, DLR, NLR, US Navy, US small businesses and universities.
High Speed Project	Provider: ARC, DFRC, GRC, LaRC Lead Center: LaRC Performing Center: ARC, DFRC, GRC, LaRC Cost Share Partners: Boeing, Pratt & Whitney, General Electric Aviation, Rolls Royce/Liberty Works, Gulfstream Aerospace, United Technologies Corporation, US Air Force, FAA, JAXA, Lockheed Martin, Aerion Corporation, US Navy, US small businesses and universities.
Aeronautical Sciences Project	Provider: ARC, DFRC, GRC, LaRC Lead Center: GRC Performing Center: ARC, DFRC, GRC, LaRC Cost Share Partners: Boeing, Pratt & Whitney, General Electric Aviation, Rolls Royce/LibertyWorks, Gulfstream Aerospace, United Technologies Corporation, US Air Force, FAA, JAXA, Lockheed Martin, Aerion Corporation, US Navy, US small businesses and universities.

Acquisition Strategy

The Fundamental Aeronautics program spans research and technology from fundamental research to integrated system-level capabilities. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

MAJOR CONTRACTS/AWARDS

NASA’s aeronautics programs award multiple smaller contracts which are generally less than $5 million. They are widely distributed across academia and industry.

FUNDAMENTAL AERONAUTICS

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Expert Review	Nov 2012	The 12-month review is a formal independent peer review of the program. Experts from outside the Fundamental Aeronautics Program or from other government agencies will report on their assessment of technical and programmatic risk and program weaknesses. NASA receives recommendations in a timely fashion and develops a response no later than six months after the review.	The projects are reviewed for relevance, quality and performance and receive recommendation s from reviewers.	Dec 2013

AERONAUTICS TEST

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	79.4	--	**77.0**	77.5	78.6	79.6	79.8
Change from FY 2012	--	--	**-2.4**				
Percentage change from FY 2012	--	--	**-3.0 %**				

The Hybrid Wing Body (HWB) acoustics test in the LaRC 14x22' Subsonic Tunnel for NASA's Integrated Systems Research Program. Shown are the new phased microphone array, new acoustic treatment, traverse mechanism, and the HWB model pitched forward. The new acoustic capability is designed to evaluate the potential of the HWB to achieve noise reduction objectives and also to develop and validate noise prediction methods.

US leadership in aerospace depends on ready access to technologically advanced, efficient, and affordable aeronautics test capabilities. These capabilities include major wind tunnels, propulsion test facilities, and flight test assets including the Western Aeronautical Test Range. The Federal Government owns the majority of these critical test capabilities in the United States, primarily through NASA and DoD. However, changes in the aerospace community, primarily the decrease in demand for wind tunnel testing over the last two decades, requires an overarching strategy for the management of these National assets. The Aeronautics Test Program's mission is to retain and invest in NASA aeronautics test capabilities considered strategically important to the Agency and the Nation, and establish a strong, high-level partnership to expand cooperation and cost-sharing between NASA and DoD, facilitating the establishment of an integrated national strategy for the management of their respective facilities. This national view is becoming more important, specifically in addressing the challenges NASA and the Nation are facing, in terms of managing and evolving this large, critical set of capabilities in a changing and increasingly demanding environment. The National Partnership for Aeronautical Testing is the high-level NASA and DoD council working to expand cooperation and the establishment of an integrated national strategy for capability management.

Aeronautics Test Program facilities and assets are dispersed across the United States. The facilities and assets are located at the Ames Research and Dryden Flight Research Centers in California, Glenn Research Center in Ohio, and Langley Research Center in Virginia. These facilities and assets are able to perform tests covering the flight envelope from subsonic through hypersonic speeds and include unique capabilities ranging from simulating icing environments to modeling extreme dynamic situations. The program offers NASA, other Government agencies, the U.S. aerospace industry, and academic institutions unmatched research and experimental opportunities that reflect four generations of accumulated aerospace skill and experience. These capabilities encompass every aspect of aerospace ground and flight-testing and associated engineering.

For more information, go to http://www.aeronautics.nasa.gov/atp.

AERONAUTICS TEST

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

NASA successfully executed more than 10,000 hours of ground testing and approximately 800 hours of flight test support for NASA and the Nation, achieving high overall customer satisfaction ratings and meeting facility availability and performance goals. Ground test examples include operations in the Glenn Research Center's 9 by 15-foot Low Speed Wind Tunnel for low speed aerodynamic, aeromechanical and aeroacoustic testing of a series of second generation, counter-rotating (open rotor) blade sets to determine the efficiency and noise characteristics for advanced ultra-high bypass engine applications. Flight test examples include the Waveform and Sonic Boom Perception and Response (WSPR) project at Dryden Flight Research Center, which involved gathering "first ever" qualitative data from supersonic flights of sonic boom impact and acceptability from a select group of more than 100 volunteer Edwards Air Force Base residents.

NASA continued to address critical shortfalls identified in the 2012 National Aeronautics Research, Development, Test, and Evaluation Infrastructure Plan through efforts directed to engine icing research at the Propulsion Simulation Laboratory at Glenn Research Center and acoustic measurement at the 14 by 22-foot Tunnel at Langley Research Center. Investments in test technology included advanced facility electronic systems required to meet modern research testing requirements and targeted investments in wind tunnel force measurement systems.

NASA completed a project to modify an existing G-III subsonic research aircraft testbed at DFRC, which will result in new experimental flight test capability to assess emerging flight technologies. One of the first intended uses of the aircraft is to enable NASA to explore and mature alternative unconventional aircraft designs with the potential to meet simultaneous research goals for community noise, fuel burn, and nitrogen oxides emissions.

NASA continued to address declining stakeholder advocacy and limited facility utilization through assessments of National infrastructure requirements and the identification of suitable capability alternatives across the government and U.S. industry. Assessments focused primarily on test capability and capacity, operational cost, facility condition, required upgrades, and projected demand. In 2012, NASA decided to close the Unitary Plan Wind Tunnel and the 20-Inch Mach 6 CF4 Tunnel located at the Langley Research Center and to redirect funds that were used for these facilities to invest in the sustainment of NASA facilities required for current and future research.

WORK IN PROGRESS IN FY 2013

The program will provide an operational engine icing research capability at the Propulsion Simulation Laboratory. This new engine icing test capability will enable research of the high-altitude engine icing problem encountered by commercial aircraft and will help ensure that testing capabilities are available to support the research, development, test, and engineering milestones of NASA and National programs.

The program will perform a condition assessment of the ground support facilities, systems, and equipment within the Flight Test Project portfolio. This assessment will provide knowledge of the ground-based assets that provide support to critical flight-testing and will inform strategic investment decisions to ensure that testing capabilities continue to be available to support the research, development, test, and engineering milestones of NASA and DoD programs.

The Aeronautics Test Program is aggressively addressing issues with data accuracy, data validation, and facility productivity at the National Transonic Facility. Through focused efforts, data acquisition and facility measurement and control systems are being scrutinized and improved so that high quality and repeatable research and testing data can be provided quickly and without interruption. This will ensure that high Reynolds Number testing capabilities are available and productive to NASA and national programs.

The program will continue to address the development of an integrated national strategy for capability management with the DoD through the National Partnership for Aeronautical Testing. In FY 2013, ATP will work with DoD to sponsor the partnership Aeronautics Test Facility Users Meeting, a conference where NASA, DoD, and industry users of major National wind tunnels can discuss capabilities and experiences and provide feedback on future requirements and needed improvements.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Aeronautics Test Program will continue to address opportunities and challenges with respect to operating and sustaining NASA's strategically important but aging test capabilities. In particular, the program will continue improving its approach to long-range forecasting of aeronautics test demand, identifying and acting on investment opportunities and determining the best approach to staying in step with emerging national research test requirements. In FY 2014, ATP will continue its emphasis on modernizing electronic systems for ground and flight testing to provide higher levels of performance (accuracy, repeatability, stability, and data acquisition and processing throughput). ATP will continue working with NASA Centers to develop and implement novel and cost effective ground and flight test operations models thereby providing the best possible match between test capability supply and demand. ATP will also continue to study opportunities to divest and consolidate testing infrastructure and assets across the national portfolio, implement the most equitable and cost effective test capability pricing strategies, and identify and invest in needed capability improvements and technology development to address emerging NASA and national aeronautics test requirements.

Program Elements

FLIGHT TEST

The Flight Test project is located at Dryden Flight Research Center and consists of an integrated set of capabilities that support aircraft operations and maintenance. Included in these elements are the Western Aeronautical Test Range, and the support and test bed aircraft required for research flight and mission support projects. The project capabilities also include the Simulation and Flight Loads Laboratories, a suite of ground-based laboratories that support research flight and mission operations. ATP provides up to 50 percent of the fixed costs for these assets to ensure facility and staff availability.

AERONAUTICS TEST

GROUND TEST

The Ground Test Project includes subsonic, transonic, supersonic, and hypersonic wind tunnels and propulsion test facilities at Ames Research, Glenn, and Langley Research Centers. These facilities cover the flight envelope from subsonic through hypersonic speeds and include unique capabilities ranging from simulating icing environments to modeling extreme dynamic situations. As with the flight test capabilities, ATP provides up to 50 percent of the fixed costs for these assets to ensure facility and staff availability.

Program Schedule

Date	Significant Event
Q2 FY14	Update and publish the Program Strategic Plan
Q4 FY14	Upgrade data acquisition and control systems for the Glenn Research Center 10 by 10 foot Supersonic Wind Tunnel
Q4 FY14	Improvements to data measurement techniques and flow quality at the Langley Research Center National Transonic Facility
Q4 FY14	Develop and implement an updated Memorandum of Understanding with DOD for the National Partnership for Aeronautics Testing to improve the Council's communication and focus on an integrated strategy for managing national aeronautics test infrastructure

Program Management & Commitments

The ARMD Associate Administrator has oversight responsibility for ATP. The ATP Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD and NASA programs.

Program Element	Provider
Flight Test	Provider: DFRC, LaRC Lead Center: DFRC Performing Centers: DFRC, LaRC Cost Share Partners: DoD
Ground Test	Provider: ARC, GRC, LaRC Lead Center: GRC Performing Centers: ARC, GRC, LaRC Cost Share Partners: DoD

AERONAUTICS TEST

Acquisition Strategy

Acquisitions supporting ATP activities are performed at each of the test sites consistent with the Federal Acquisition Regulation (FAR) and the NASA FAR Supplement. Each Center is responsible for coordinating major acquisitions supporting ATP activities through the ATP Office as required by the ATP Director.

MAJOR CONTRACTS/AWARDS

NASA's aeronautics programs award multiple smaller contracts that are generally less than $5 million. They are widely distributed across academia and industry.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Relevance	Expert Panel	Dec 12, 2012	Periodic reviews are carried out by the US users of ATP facilities. The last major community outreach meeting was held in December 2012 with NASA, DoD, and US. aerospace industry users at ARC.	N/A	May 2014
Annual Project Review	Independent Review Panel	Nov 2012	The primary purpose of the annual project review is to provide an independent assessment by subject matter experts of the project's relevance, technical quality, and performance.	The projects are reviewed for relevance, quality and performance and receive recommendations from reviewers.	Nov 2013

INTEGRATED SYSTEMS RESEARCH

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	104.2	--	**126.5**	126.8	127.4	128.2	128.4
Change from FY 2012	--	--	**22.3**				
Percentage change from FY 2012	--	--	**21.4 %**				

NASA research on future aircraft engine designs, such as the "Open Rotor", aims to reduce the environmental impact of aviation.

One of the greatest challenges that NASA faces in transitioning advanced technologies into future aeronautics systems is closing the gap caused by the difference between the maturity level of technologies developed through fundamental research and the maturity required for technologies to be infused into future air vehicles and operational systems. The Integrated Systems Research Program's goal is to demonstrate integrated concepts and technologies to a maturity level sufficient to reduce risk of implementation for stakeholders in the aviation community. The research in this program is coordinated with ongoing, long-term fundamental research within the other three aeronautics research programs, as well as efforts of other government agencies. This helps to ensure the most promising research is transitioned between the fundamental research programs and ISRP. The program conducts integrated system-level research on those promising concepts and technologies to explore, assess, and demonstrate the benefits in an operationally relevant environment. The program matures and integrates technologies for accelerated transition to practical application. The Advanced Composites Project has been added to the ISRP portfolio in FY2014 to focus on reducing the timeline for development and certification of innovative composite materials and structures, which will help American industry retain their global competitive advantage in aircraft manufacturing.

NASA will make significant technology advancements contributing to national aviation challenges through the ISRP portfolio. The portfolio consists of three projects, the Environmentally Responsible Aviation (ERA) Project, the Unmanned Aircraft Systems Integration in the National Airspace System (UAS/NAS) Project and the Advanced Composites Project.

One of the national challenges that ISRP is focused on is the impact of aviation on the environment. In 2008, US major commercial carriers and Department of Defense burned 19.6 billion and 4.6 billion gallons, respectively. This fuel consumption released 250 million tons of carbon dioxide into the atmosphere. Additionally, aircraft noise, particularly in the vicinity of airports, continues to be regarded as the most significant hindrance to the National Airspace System capacity growth. The ERA Project goal is to reduce the impact of aviation on the environment through the development of vehicle concepts and technologies that can simultaneously reduce aircraft fuel burn, noise and emissions. Using aircraft system-level assessments in addition to ground and flight tests, the project is evaluating promising vehicle configurations and airframe and propulsion system related technologies to assess the combined potential to simultaneously meet challenging fuel burn, emission and noise reduction goals.

Another national challenge that the program is addressing is the routine access of unmanned aircraft systems into the National Airspace System for civil use. NASA has partnered with the FAA to determine how UAS research, expertise, and assets can be leveraged between the two agencies and duplication of effort can be minimized. The FAA is providing Subject Matter Experts to support NASA's UAS Integration in the NAS Project to review research objectives and assumptions. The FAA and NASA have shared UAS research project plans and analysis results. FAA and NASA established an umbrella Interagency Agreement for UAS Research which will allow the FAA to centralize and focus its collaboration with NASA while leveraging expertise across all NASA research centers.

Historically, UAS have supported military and security operations overseas, with training occurring primarily in the United States. In addition, UAS are utilized in US border and port surveillance by the Department of Homeland Security, scientific research and environmental monitoring by NASA and National Oceanic and Atmospheric Administration, public safety by law enforcement agencies, research by state universities, and various other uses by Government agencies. Interest is growing in civil uses, including commercial photography, aerial mapping, crop monitoring, advertising, communications and broadcasting. To address the increasing civil market and the desire by civilian operators to fly UAS, the FAA is developing new policies, procedures, and approval processes. The need for developing and implementing new standards, procedures and guidance to govern civil unmanned airspace systems operations in the National Airspace System in a timely manner has grown more important than ever. NASA's Unmanned Airspace Systems Integration in the National Airspace Project will contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine civil UAS access to the National Airspace System. Advancing the state of the art is being accomplished through system-level integration of key concepts, technologies and/or procedures, and demonstrations of integrated capabilities in an operationally relevant environment. Close integration and continued validation with key stakeholders is a guiding tenet of the project. Those stakeholders include FAA, DoD, other Government agencies, and industry)

The Advanced Composites Project will address the national challenge developing and maturing of tools and methods to reduce the development and certification timeline for new materials and structures. There is significant competitive pressure in the international community to accelerate the use of composites in aerospace vehicles because of the weight and lifecycle cost savings they provide. The lack of accepted analysis and test protocols and poor understanding of damage tolerance, production process variability, and long-term durability of composites can pose significant developmental risks. Assuring product safety therefore results in unacceptably high development costs and certification times. To mitigate these risks, developers must rely on time-consuming and costly testing procedures resulting in high development cost and certification times. Additionally, accelerating the development, verification, and regulatory acceptance of new composite materials, structural design methods, test, inspection, and manufacturing processes will enhance the competitiveness of US industry. The goal of Advanced Composites Project is to reduce the time for development, verification, and regulatory acceptance of new composite materials and design methods. NASA will meet this objective through the development and use of high fidelity and rigorous computational methods, new test protocols, and new inspection techniques.

For more information, go to http://www.aeronautics.nasa.gov/programs_isrp.htm.

INTEGRATED SYSTEMS RESEARCH

EXPLANATION OF MAJOR CHANGES

NASA added the Advanced Composites project to the Integrated Systems Research Program in FY 2014 to focus on reducing the timeline for development and certification of innovative composite materials and structures which will help American industry retain their global competitive advantage in aircraft manufacturing.

ACHIEVEMENTS IN FY 2012

Based on data obtained during extensive ground test campaigns, NASA completed an assessment of two types of highly fuel efficient jet engine concepts by comparing their performance in reducing the rate of fuel consumption and noise. One of the systems, referred to as "Open Rotor", does not encase the engine fan blades in an engine housing as is typical in traditional jet engine designs. The second system, referred to as an "Ultra High Bypass Turbofan" is a much more fuel efficient version of the aircraft engine commonly used by airliners today. Research has validated that both engine concepts have the potential to dramatically reduce fuel burn. The Open Rotor shows greater potential for fuel burn reduction with a 36 percent reduction versus a 27 percent reduction for the Ultra High Bypass Turbofan. However, the noise reduction is greater for the Ultra High Bypass Turbofan with a reduction of 24 decibels versus the 13 decibel reduction for the Open Rotor. These results provide data to the aviation industry and regulatory community to make informed decisions on future aircraft propulsion systems, with a continual emphasis on reducing their impact on the environment.

While closing out the technology development efforts of the first phase, the Environmentally Responsible Aviation project defined the Phase 2 technology portfolio. Through a series of reviews and assessments based on the potential benefit of the technologies to meet project goals, as well as the associated costs and risks, NASA selected eight, large-scale integrated technology demonstrations to advance Environmentally Responsible Aviation research through FY 2015. The integrated technology demonstrations build on work performed during the first phase of the project and will focus on five areas: aircraft drag reduction through innovative flow control concepts; weight reduction from advanced composite materials; fuel and noise reduction from advanced Ultra High Bypass engines; emissions reductions from advanced engine combustors; and fuel consumption and community noise reduction through innovative airframe and engine integration designs.

As part of a collaborative effort with the FAA Technical Center, NASA conducted a flight test of a large (Ikhana MQ-9) unmanned aircraft equipped with Automatic Dependent Surveillance-Broadcast a satellite-based aircraft tracking technology that provides detailed and accurate position, velocity, and altitude information to air traffic controllers and other Automatic Dependent Surveillance-Broadcast equipped aircraft. This demonstration was a critical step in the development of a Live Virtual Constructive – Distributive Environment, an innovative way to safely immerse a flying unmanned aircraft in the national airspace system through virtual techniques. The Live Virtual Constructive – Distributive Environment will provide the backbone for eventual flight tests to validate the concepts and procedures developed by the project – these flight tests are scheduled for FY 2015 and FY 2016.

WORK IN PROGRESS IN FY 2013

FY 2013 is the start of Phase 2 for the Environmentally Responsible Aviation project. During FY 2013 NASA will complete community noise assessments for advanced tube and wing, and hybrid wing body aircraft configurations and engines. NASA will seek to demonstrate synergistic acoustic integration between advanced engines and airframe concepts that will enable the goal of 42 decibel cumulative noise reduction below Stage 4 in the 2020 timeframe. In addition, NASA will complete ground-based testing of a second generation Geared Turbofan propulsion technology (an Ultra High Bypass engine concept) in partnership with Pratt & Whitney. This assessment is expected to quantify increases in propulsive system efficiency and noise reduction available from this propulsion system technology.

NASA will also continue to make progress on unmanned aircraft systems integration through initial evaluations and risk reduction activities of the project's operationally relevant environment. The relevant environment provides the infrastructure to enable the human-in-the-loop simulations and flight tests required to demonstrate integrated separation assurance, human systems integration, and communication efforts. In addition, NASA will conduct simulations that assess the performance of aircraft separation assurance methods as well as develop communication models for all classes of unmanned aircraft systems. These validated communication models are required to provide confidence in simulation results. Finally, NASA will work to provide recommendations to the FAA for risk-related data collection to support development of unmanned aircraft systems regulations.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA plans to complete flight tests of a wing design equipped with adaptive compliant trailing edge technology. Integration of compliant structures in next generation aircraft will reduce weight and drag contributing to a reduction of fuel burn. The flight test will demonstrate and establish airworthiness for a compliant structure used as large primary control surface in a relevant flight environment and accelerate the infusion of this technology. In addition, NASA will continue to advance Ultra High Bypass technology through low speed ground tests of the geared turbofan performed in FY 2014. NASA will also complete low-speed performance and operability testing of an Ultra High Bypass engine integrated with a semi-span hybrid wing body model. This test, planned for FY 2014, will provide a low speed assessment of the interference effects between the propulsion system and airframe that could impact engine operation, aerodynamic characteristics, and drag (fuel burn).

The Unmanned Aircraft Systems Integration in the National Airspace System project will evaluate concepts for separation assurance, sense and avoid, and ground control stations with communication system performance estimates through an integrated human-in-the-loop simulation in FY 2014 to provide data for further technology development. In addition, the project will continue to mature and evaluate the Live Virtual Constructive Distributed Environment that will be used to provide demonstrations of unmanned aircraft systems integrated in the National Airspace System. The demonstrations will utilize unique flight and simulation assets from geographically dispersed facilities by integrating NASA Centers, FAA facilities and other institutions through the Live Virtual Constructive Distributed Environment.

FY 2014 will be the first year of execution for the Advanced Composites project. During FY 2014, the project will pursue partnerships with industry, academia and other government agencies to expedite validation of advanced production, test, and analysis methods. A collaborative FAA and NASA research effort will be established to ensure the Advanced Concepts project will addresses FAA needs. The project will also initiate small-scale material and structures tests to acquire data to validate new analysis methods and determine new test protocols that will be shared with our partners in industry, academia, FAA and other government agencies.

INTEGRATED SYSTEMS RESEARCH

Program Elements

ENVIRONMENTALLY RESPONSIBLE AVIATION

NASA is addressing vehicle-related environmental concerns through system-level research and experiments of promising vehicle concepts and technologies that simultaneously reduce fuel burn, noise, and emissions. Research and development efforts are focused on understanding how advanced environmental technologies can best work in an integrated vehicle and aviation operations system. Through system-level analysis, promising advanced vehicle and propulsion concepts and technologies can be down-selected based on their potential benefit towards the stated national goals. Among the technologies to be explored are the following:

- Advanced aircraft architectures that enable simultaneous reduction of noise, fuel burn, and environmentally harmful emissions;
- Advanced propulsion systems for low noise and reduced fuel burn;
- Lightweight, low drag wing and fuselage concepts for reduced fuel burn and noise;
- Fuel flexible, low nitrogen oxide combustor designs; and
- Optimized propulsion and airframe integration concepts for reduced fuel burn and noise.

UNMANNED AIRCRAFT SYSTEMS INTEGRATION IN THE NATIONAL AIRSPACE SYSTEM

NASA also focuses on technologies to enable routine civil operations for unmanned aircraft systems of all sizes and capabilities in the national airspace system. Current federal aviation regulations are built upon the condition of a pilot being in the aircraft; therefore many of those regulations are not directly applicable to unmanned aircraft systems. To date, the primary user of unmanned aircraft systems has been the military. As the unmanned aircraft systems user base expands, the technologies and procedures to enable seamless operation and integration of unmanned aircraft systems in the national airspace system need to be developed, validated, and employed by FAA through rule-making and policy development.

Specifically, NASA is addressing technology development in several areas to reduce the technical barriers related to the safety and operational challenges. The technical barriers include:

- Robust separation assurance algorithms;
- Command and control, and air traffic control communication systems;
- Consistent standards to assess UAS ground control stations; and
- Airworthiness requirements for the full range of UAS size and performance.

NASA will validate data and technology through a series of high fidelity human-in-the-loop simulations (i.e., where a human is part of the simulation and influences the outcome) and flight tests conducted in a relevant environment. Integrated test and evaluation will be conducted focusing on three technical challenges: separation assurance, performance standards and certification, and developing a relevant test environment. The project deliverables will help key decision makers in government and industry make informed decisions, leading towards routine unmanned aircraft systems access.

INTEGRATED SYSTEMS RESEARCH

ADVANCED COMPOSITES PROJECT

NASA is addressing new test protocols and methods to reduce the development and certification timeline for new materials and structures. It is inevitable that composite structures will see increased application due to the pressure to develop more efficient, sustainable vehicles. The present approach for the development and certification of composites is largely based on testing. It is relatively slow, and fairly expensive, but does provide results that have been rigorously validated. NASA will focus on the development and use of high fidelity and rigorous computational methods, new test protocols, and new inspection techniques to shorten the timeline to bring innovative composite materials and structures to market. NASA will engage key players from government (e.g., FAA, Department of Defense), industry, and academia to mature and verify the methodology, to ensure effective transition to industry, and to assure it can be proven safe for use by certification authorities such as the FAA. To achieve the goal of reducing the current 10 to 20 year timeline for development and certification down to three to five years, NASA will:

- Develop validated test and analysis methods to enable faster certification of new composite materials, design methods, and production processes;
- Develop new analysis, test, and inspection protocols that will increase safety assurance by validating the durability and damage tolerance of composites; and
- Reduce the variability in production processes to allow for reduced design margins, leading to further weight reduction.

Program Schedule

Date	Significant Event
Q2 2014	Geared turbofan engine test
Q4 2014	Adaptive compliant trailing edge flight test
Q4 2014	Simulation of UAS operations with technologies for separation assurance
Q4 2014	Active flow control enhanced vertical tail flight test on Boeing 757
Q1 2015	Flap edge and landing gear noise reduction flight test on Gulfstream G550
Q2 2015	New concepts and technologies for UAS flight test
Q4 2015	Pultruded Rod Stitched Efficient Unitized Structure multi-bay pressure box demonstration

INTEGRATED SYSTEMS RESEARCH

Program Management & Commitments

Program Element	Provider
Environmentally Responsible Aviation	Provider: ARC, DFRC, GRC, LaRC Lead Center: LaRC Performing Centers: ARC, DFRC, GRC, LaRC Cost Share Partners: Boeing, General Electric, Pratt & Whitney, Air Force Research Laboratory, FAA, Gulfstream, Goodrich, Rolls Royce Liberty Works
Unmanned Aircraft Systems Integration in the National Airspace System	Provider: ARC, DFRC, GRC, LaRC Lead Center: DFRC Performing Centers: ARC, DFRC, GRC, LaRC Cost Share Partners: Cost Share Partners: Rockwell Collins, FAA

Acquisition Strategy

NASA's Integrated Systems Research Program develops and further matures promising technologies to the integrated system level. This necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

MAJOR CONTRACTS/AWARDS

NASA's aeronautics programs award multiple smaller contracts which are generally less than $5 million. They are widely distributed across academia and industry.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	Review Panel	Nov 2012	The 12-month review is a formal independent peer review. Experts from other government agencies report on their assessment of technical and programmatic risk and program weaknesses.	The projects are reviewed for relevance, quality and performance and receive recommendations from reviewers.	Nov 2013

AERONAUTICS STRATEGY AND MANAGEMENT

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	26.7	--	**22.7**	22.7	22.8	22.9	22.9
Subtotal	27.2	--	**22.7**	22.7	22.8	22.9	22.9
Rescission of prior-year unob. balances*	-0.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-4.0**				
Percentage change from FY 2012	--	--	**-15.0 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

Through NASA's Aeronautics Seedling Fund, researchers studied aerogel substrates for patch antennas. The number of antennas on a commercial aircraft could be reduced by two thirds with use of aerogel antennas. R&D Magazine recently recognized this research as a 2012 R&D 100 Winner.

The Aeronautics Strategy and Management (ASM) program provides research and programmatic support that benefits each of the other five programs. The program efficiently manages directorate functions including: Innovative Concepts for Aviation, Outreach, and Cross Program Operations.

Innovative Concepts for Aviation invests in new ideas to meet aeronautics challenges through an internal Seedling Fund and externally through the Leading Edge Aeronautics Research for NASA fund. The Seedling Fund annually provides NASA civil servants the opportunity to perform research, analysis, and develop proof-of-concepts for ideas that have the potential to meet national aeronautics needs. This fund supports early-stage efforts not currently supported by ARMD programs and projects, with the goal of infusing promising concepts into the ARMD research portfolio or into NASA's Small Business Innovation Research program for further development. The Leading Edge Aeronautics Research for NASA fund is complementary to the Seedling Fund and has similar goals, but it invests in innovative ideas from outside NASA. Developing new ideas is critical part of NASA Aeronautics' three-pronged approach of investing in new ideas, fundamental research, and integrated systems research.

EXPLANATION OF MAJOR CHANGES

The ARMD funding for Education has been transitioned out of ASM as part of the Administration's STEM consolidation initiative to centralize STEM education activities across the Federal government.

AERONAUTICS STRATEGY AND MANAGEMENT

ACHIEVEMENTS IN FY 2012

Research began on twenty new ideas that were selected through NASA's Aeronautics Seedling Fund. After the first year of research, NASA selected the most promising twelve projects for further research. The study of electromagnetic properties of aerogels for use in antennas is one example of research funded by this fund. A commercial aircraft can have as many as 100 antennas. Aerogel antennas could enable wider bandwidth, reduce the number of antennas on an aircraft by two-thirds, and reduce the mass of antennas to only 20 percent of today's standard. Another example is the study of the use of computer-controlled laser ablation to condition titanium surfaces of aircraft components prior to adhesive bonding. Current surface treatments utilize harsh chemical etching or grit blasting that involve high facility maintenance costs and have quality control issues.

NASA established a Leading Edge Aeronautics Research fund to provide non-NASA researchers an opportunity to conduct research into early-stage innovative ideas that meet aeronautics challenges. The fund announcement received over 180 innovative ideas from academia and industry. NASA selected the best 16 proposals and research efforts began in FY 2013. One example is research into the feasibility of using helicopter rotor blades to pressurize air centrifugally for a pneumatic rotor blade de-icing system. Helicopter rotors are more susceptible to icing than the rest of the fuselage. This concept may enable significantly safer and more efficient rotorcraft flight in icing conditions. Another example is the investigation of a preliminary hybrid wave-rotor electric aero-propulsion design. The design will optimally combine a wave rotor combustion turbine engine with an electrical drive. For subsonic regional jets, the design could enable 90 percent fuel cuts from current levels.

NASA selected 25 students, from eighteen different universities across the country to receive the Aeronautics Scholarship for 2012. The recipients are both graduate and undergraduate students. They are studying a wide-variety of subjects within aeronautics. The aeronautics scholarships are competed and awarded annually.

During a two-day event called "Ideas in Flight," in July 2012, interns from NASA's Aeronautics Scholarship Program and Aeronautics Academies briefed NASA leadership on their experiences working with researchers over the summer at Ames Research Center, Dryden Flight Research Center, Glenn Research Center, and Langley Research Center. Presentation topics included aerodynamic research to lower drag, strategies for how to integrate unmanned aircraft systems into the national airspace, advancements in aeroacoustics research, options for using speech recognition tools in an air traffic control setting, toolbox development for analysis of subscale aircraft, characteristics of synthetic jet fuels, intelligent aircraft engines for next generation air transportation, and more. The technologies had a common goal: To help the United States retain a leadership role in aviation by transforming the air transportation system, maintaining safety, and reducing aircraft noise, emissions and fuel use. This annual activity gives scholarship recipients an opportunity to present before a professional audience, which is something that real-life scientists do on a regular basis.

WORK IN PROGRESS IN FY 2013

In FY 2013, Innovative Concepts for Aviation will select new recipients for research awards, and will conduct a "virtual technical seminar. This seminar will provide a forum for the researchers to present and discuss the results of their research with participants located across the country by using remote collaborative meeting technologies. The presentations will be available live over the Internet and accessible to the public later via the NASA Web sites. The seminar will become a regularly scheduled activity, eventually occurring twice each year.

NASA will select recipients for the annual aeronautics scholarships, and will invite the students to participate in the 2013 “Ideas in Flight” activities.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will continue funding new research ideas through both the Aeronautics Seedling Fund and the Leading Edge Aeronautics Research fund. These fund both initial and follow-on phases of promising research for NASA employees and selected external proposals. The most promising ideas are evaluated for incorporation into the existing programs.

Program Elements

INNOVATIVE CONCEPTS FOR AVIATION

Innovative Concepts for Aviation explores novel concepts and processes with the potential to create new capabilities in aeronautics research. The program’s goal is to mature the new concepts and incorporate them into the existing research programs or launch new avenues of aeronautics research. To meet this goal, NASA will target both internal and external aeronautics communities.

Program Schedule

Date	Significant Event
Q1 FY13	Leading Edge Aeronautics Research for NASA, Round 1 Awards
Q2 FY13	Aeronautics Seedling Fund, Round 3 Awards
Q3 FY13	Selection of Aeronautics Scholarship Recipients
Q4 FY13	Aeronautics Seedling Fund, Round 2 Further Study Awards
Q4 FY13	“Ideas in Flight” event with Aeronautics Scholars and Academy interns at NASA Headquarters
Q1 FY14	Aeronautics Seedling Fund, Round 4 Awards
Q1 FY14	Leading Edge Aeronautics Research for NASA, Round 1 Further Study Awards
Q2 FY14	Aeronautics Seedling Fund, Round 3 Further Study Awards
Q2 FY14	Leading Edge Aeronautics Research for NASA, Round 2 Awards

Program Management & Commitments

The ARMD Associate Administrator has oversight responsibility for the program.

AERONAUTICS STRATEGY AND MANAGEMENT

Acquisition Strategy

The research conducted through Innovative Concepts for Aviation activities will use a wide array of acquisition tools relevant to the research objectives including external solicitations through full and open competitions.

MAJOR CONTRACTS/AWARDS

The Aeronautics Strategy Management program awards smaller contracts, which are generally less than $1 million.

INDEPENDENT REVIEWS

Because this is a support program, NASA has not scheduled any independent reviews at this time. However, NASA has established an annual internal review for Innovative Concepts for Aviation.

SPACE TECHNOLOGY

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	573.7	577.2	**742.6**	742.6	742.6	742.6	742.6
Partnership Development & Strategic Integration	29.5	--	**34.1**	34.3	34.4	34.5	34.6
SBIR and STTR	171.6	--	**186.4**	192.0	200.4	211.6	211.6
Crosscutting Space Technology Development	183.9	--	**277.6**	256.2	213.2	241.0	244.3
Exploration Technology Development	190.0	--	**244.5**	260.1	294.6	255.5	252.0

SPACE TECHNOLOGY

SPACE TECHNOLOGY

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	573.7	577.2	**742.6**	742.6	742.6	742.6	742.6
Partnership Development & Strategic Integration	29.5	--	**34.1**	34.3	34.4	34.5	34.6
SBIR and STTR	171.6	--	**186.4**	192.0	200.4	211.6	211.6
Crosscutting Space Technology Development	183.9	--	**277.6**	256.2	213.2	241.0	244.3
Exploration Technology Development	190.0	--	**244.5**	260.1	294.6	255.5	252.0
Subtotal	575.0	578.5	**742.6**	742.6	742.6	742.6	742.6
Rescission of prior-year unob. balances**	-1.3	-1.3	**--**	--	--	--	--
Change from FY 2012	--	--	**168.9**				
Percentage change from FY 2012	--	--	**29.4 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Crosscutting Space Technology Development pursuant to P.L. 112-55, Division B, sec. 528(f).*

Using advanced composite manufacturing techniques, Space Technology fabricated a 2.4 meter diameter lightweight composite cryogenic propellant tank. The Boeing led team developed the largest out-of-autoclave composite tank fabricated to date. Using out-of-autoclave composite tanks for cryogenic propellants could significantly reduce the mass and fabrication costs of next generation space launch systems.

Space Technology enables a new class of missions by drawing on talent from the NASA workforce, academia, small businesses, and the broader space enterprise to deliver innovative solutions that dramatically improve technological capabilities for NASA and the Nation.

The rapid development and infusion of new technologies and capabilities is a critical component to advancing the Nation's future in space. This fuels an emerging aerospace economy and collaborates on the space technology needs of other government agencies and the overall aerospace enterprise. NASA supports these objectives and contributes to the demands of larger national technology goals by investing in Space Technology.

Using a broad investment strategy, NASA's Space Technology investments address the identified range of technology areas found in NASA's Space Technology Roadmaps as prioritized by the National Academies. The Space Technology portfolio supports a combination of early stage conceptual studies, discovering entirely new technologies (technology readiness level (TRL) 1-3); rapid competitive development and ground-based testing (TRL 3-5) to determine feasibility; and flight demonstrations in a relevant environment to complete the final step to mission infusion (TRL 5-7).

The Space Technology account supports the Office of the Chief Technologist (OCT) which coordinates the Agency's overall technology portfolio to identify development needs, ensure synergy, and reduce duplication. By coordinating these efforts, along with other technology programs within NASA, the office facilitates integration of available and new technology into operational systems that support specific human-exploration missions, science missions, and aeronautics. The Chief Technologist also engages the larger aerospace community including other Government agencies, and, where there are mutual interests, develops partnerships to efficiently develop breakthrough capabilities. The office leads and enhances technology transfer and commercial partnerships opportunities through a wide range of users to ensure that the full value of these development efforts is realized.

Under the direction of the Space Technology Mission Directorate, NASA funds the development of pioneering technologies that will increase the Nation's capability to perform space science, operate in space, and enable deep space exploration. Significant progress in technology areas such as in-space power systems, solar electric propulsion, radiation protection, next generation life-support, human robotic systems, cryogenic fluid handling, and entry, descent and landing capabilities, are essential for future science and human exploration missions. Developing these solutions will stimulate the growth of the Nation's innovation economy by enabling new technology sectors in areas such as nanotechnology, robotics, advanced manufacturing and synthetic biology.

Different strategies taken by Space Technology programs serve to develop the Nation's current and future technology workforce while gaining critical technology capabilities needed for future missions. By using varying funding mechanisms, including contracts, grants, fellowships, prize authority, and funded Space Act Agreements, NASA leverages and diversifies technology suppliers to include ideas from NASA Centers, other government agencies, industry, academia, small businesses, and individual entrepreneurs to meet National technology needs. To ensure continuous availability of transformative and crosscutting technology, NASA will continue a steady cadence of new solicitations. Openly competitive opportunities ensure the best ideas and talents from all sectors of the aerospace enterprise are brought to bear to solve future needs while maximizing the value of the Nation's investments. This technological diversity results in a sustainable pipeline of revolutionary concepts, and regularly engages NASA's workforce in cutting edge technology. Development and demonstration activities are openly shared to ensure consideration and dissemination by a wide range of potential users.

Reaching NASA's future exploration objectives will require a strong commitment to advanced technology and innovation. American technological leadership is vital to our national security, our economic prosperity and our global standing. The United States continues to exemplify economic leadership, in part, due to the technological investments made in earlier years, through the work of the engineers, scientists, and elected officials who had the wisdom and foresight to make the investments required for our country to emerge as a global technological leader. That commitment accelerated the economy with the creation of new industries, products and services that yielded lasting benefits. NASA innovation serves as an inspiration for young people to pursue science, technology, engineering, and mathematics (STEM) education and career paths. A technology-driven NASA will continue to fuel our Nation's economic engine for decades to come.

For more on Space Technology, go to: http://www.nasa.gov/spacetech.

SPACE TECHNOLOGY

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The budget accelerates the development of a high-powered Solar Electric Propulsion (SEP) system. SEP systems have broad applicability to science and human exploration missions, and several of the components (i.e. high-power solar arrays) are of potential benefit to the commercial satellite sector and other government agencies. NASA has identified a near-term infusion opportunity for this technology as propulsion for the robotic segment of a proposed asteroid retrieval mission. Space Technology will also increase its focus on technologies that enhance capabilities in asteroid detection, characterization, mitigation, proximity operations, and resource utilization. Additional changes arise due to the phasing profiles of on-going, high priority development efforts and support of the Congressionally mandated increases in the Small Business Innovation Research and Small Business Technology Transfer Programs.

ACHIEVEMENTS IN FY 2012

- Space Technology successfully demonstrated the feasibility of inflatable heat shields through the launch of the Inflatable Reentry Vehicle Experiment-3 (IRVE-3) from the Wallops Flight Facility in Virginia. Such heat shields offer the opportunity to significantly increase the landed mass and landing accuracy capabilities for future missions to other planets, such as Mars, and to provide significantly greater capability for return payloads to Earth.
- The Mars Curiosity rover mission was successful with the Mars Science Laboratory Entry, Descent and Landing Instrument (MEDLI) on board. MEDLI streamed real-time atmospheric and heating data from sensors imbedded within the vehicle's heatshield. Data from MEDLI will help engineers design safer, more efficient entry systems for future missions. MEDLI was joined on the trip to Mars by technologies from six Small Business Innovation Research companies (described further in the SBIR/STTR account), each with their own role to enhance Curiosity's primary mission.
- Space Technology involved Universities and academic institutions in its development objectives through more than 350 fellowships, direct competitive awards and partnerships with NASA Centers and commercial contractors for its technology developments and demonstrations.

WORK IN PROGRESS IN FY 2013

- Laser Communications Relay Demonstration (LCRD) project, designed to deliver data rates that enable new classes of science and human exploration missions, is beginning ground validation activities of advanced laser communication systems. This mission targets dramatic increases in the communication capabilities of NASA's current Tracking and Data Relay Satellite System (TDRSS).
- Low Density Supersonic Decelerator (LDSD) project, designed to enable precise landing of higher-mass payloads to the surface of planets, is conducting three critical full-scale tests of advanced ring-sail parachutes and supersonic inflatable aerodynamic decelerators (SIADs) to validate their performance prior to supersonic-speed flight demonstrations.
- The Composite Cryogenic Propellant Tank project, which successfully fabricated a 2.4-meter cryogenic propellant tank in FY 2012, is scaling up and fabricating a 5.5-meter diameter tank that will yield lower mass rocket propellant tanks to meet future Space Launch System needs.

- The PhoneSat mission is launching as a rideshare on the inaugural flight of the Orbital Sciences Corporation's Antares vehicle currently scheduled for early 2013. These three CubeSats equipped with smartphones will be used to demonstrate command and control capability of operational satellites using affordable, off the shelf components and built within a rapid development cycle.
- Game Changing Development is completing several high priority project elements which NASA initiated in FY 2012. Significant completions and deliverables include the fabrication, testing, and delivery of advanced components needed for next generation EVA suits (high energy density batteries, rapid cycle amine air processors (carbon dioxide removal system), and variable oxygen regulators), non-flow through fuel cells needed for long duration spaceflight; and key components for the potential Advanced Exploration Systems (AES) RESOLVE mission (Neutron Spectrometer and Lunar Advanced Volatiles Analyzer).

KEY ACHIEVEMENTS PLANNED FOR FY 2014

- Space Technology's high priority projects, funded within Crosscutting Space Technology Development and Exploration Technology Development, will conduct three Critical Design Reviews and six ground or flight demonstrations, making significant progress toward spaceflight demonstrations targeted for FY 2015.
- Small Spacecraft Technologies will conduct a flight demonstration of the Edison Demonstration of Smallsat Networks (ESDN) spacecraft cluster of eight CubeSats.
- Approximately 25 Space Technology Research Fellows will graduate from American universities with advanced degrees, prepared to contribute to the economy by solving the nation's difficult technological challenges.
- Along with the 5.5-meter composite cryogenic propellant tank mentioned above, Game Changing Development is delivering key improvements to component technologies including an alternate water processer that reduces resupply requirements and recovers 85 percent more wastewater for use, and development of regenerative fuel cells that can convert water to energy, building on the FY 2013 non-flow through fuel cell work.
- Space Technology will continue a steady cadence of new solicitations to ensure the availability of advanced technologies, prioritizing technology gaps identified by the National Academies in the review of the Space Technology Roadmaps.
- Game Changing Development will test and deliver two competing approaches for large scale, deployable solar array systems, two power processing units, and advanced thrusters. These key developments enable the Solar Electric Propulsion system developed for the robotic segment of the asteroid retrieval mission.

Programs

PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

This program supports the Office of the Chief Technologist which provides the strategy, leadership, and coordination that guide NASA’s technology and innovation activities. OCT documents and analyzes NASA’s technology investments and tracks progress, aligning them with the Agency’s plan. OCT leads technology transfer and technology commercialization activities, extending the benefits of NASA’s technology investments to have a direct and measurable impact on daily life. The office employs principles that encourage partnerships, technology use, and commercialization; ensuring NASA technologies energize the commercial space sector, and provide the greatest benefit to the Nation.

SMALL BUSINESS INNOVATION RESEARCH (SBIR) AND SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)

SBIR and STTR continue to support early-stage research and mid-TRL development performed by small businesses through competitively awarded contracts. These programs produce innovations for both Government and commercial applications. SBIR and STTR provide the high-technology small business sector with opportunities to develop technology for NASA, and commercialize those technologies to provide goods and services that address other national needs based on the products of NASA innovation.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

Crosscutting Space Technology Development activities enable NASA to develop transformative, broadly applicable technologies and capabilities that are necessary for NASA's future science and exploration missions and support the space needs of other U.S. Government agencies and the commercial space enterprise. To achieve these goals, NASA's CSTD activities span early-stage conceptual studies through flight demonstrations, employing a variety of funding mechanisms, including grants, broad agency announcements, announcement of opportunities, and prize opportunities. Investment areas within this account include: Space Technology Research Grants, NASA Innovative Advanced Concepts, Center Innovation Fund, Centennial Challenges, Game Changing Development, Technology Demonstration Missions, Small Spacecraft Technology and Flight Opportunities.

EXPLORATION TECHNOLOGY DEVELOPMENT

Exploration Technology Development advances technologies required for humans to explore beyond low Earth orbit. The program leverages the existing technical strength of the NASA Centers and addresses known needs in support of future human exploration activities. Example projects include Composite Cryogenic Propellant Tanks, Solar Electric Propulsion, Green Propellant Infusion Mission, Cryogenic Propellant Storage and Transfer, Human-Robotic Systems, and Human Exploration Telerobotics. ETD technologies are higher risk investments that support architecture and systems development efforts within the Exploration account by maturing breakthrough technology prior to systems integration.

PARTNERSHIP DEVELOPMENT & STRATEGIC INTEGRATION

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	29.5	--	**34.1**	34.3	34.4	34.5	34.6
Change from FY 2012	--	--	**4.6**				
Percentage change from FY 2012	--	--	**15.6 %**				

This robot assistant, dubbed "a Mars rover in a hospital" by one of its developers, incorporates systems based on NASA–funded work at the Massachusetts Institute of Technology. The robot can now be found roaming the halls of hospitals, helping with everything from registering patients to logging vital signs.

The Office of the Chief Technologist (OCT) serves as the NASA Administrator's principal advisor on matters concerning Agency-wide technology policy and programs. OCT's Partnership Development and Strategic Integration efforts provide the strategy and leadership that guide all of NASA's technology and innovation activities. OCT helps NASA achieve a dual mandate. The first is to foster technology transfer, including infusion of technologies into NASA missions, and the second is to facilitate commercialization of technologies emerging from NASA research and development. OCT coordinates NASA internal and NASA external technology strategic planning and technology transfer. This office also documents, tracks, and analyzes NASA's technology investments and technological innovations, ensuring they are consistent with the NASA technology needs and strategy.

EXPLANATION OF MAJOR CHANGES

Increased funding supports implementation of the technology transfer plan developed in response to the President's Memorandum on Technology Transfer and Commercialization of Federal Research.

ACHIEVEMENTS IN FY 2012

NASA contractors and civil servants reported over 1,600 new innovations. Of this number, the majority are owned by small businesses with whom NASA has partnered. NASA filed 139 patents for government-owned inventions with commercial potential. The Agency also executed 25 licenses for patents in its intellectual property portfolio and nearly 700 software usage agreements. NASA also communicated the impact of Agency technology development by highlighting more than 40 innovations in its annual Spinoff report. In addition, NASA developed 12 significant partnerships with both the public and private sectors in FY 2012. The National Academies delivered the final report reviewing NASA's space technology roadmaps in February 2012. The National Academies recommendations were incorporated into the inaugural NASA Strategic Space Technology Investment Plan (SSTIP), a comprehensive strategic plan that prioritizes space technologies essential to the pursuit of NASA's mission and achievement of national goals.

WORK IN PROGRESS IN FY 2013

NASA is implementing a number of activities to improve technology transfer including: revision of Agency technology transfer policies to reflect best practices and federal regulations and conducting training to convey the importance of invention disclosure and technology transfer activities. In addition, NASA is exploring new technology transfer pilot efforts including an online licensing capability that will enable the public to access, license, and use NASA-developed technologies more readily. NASA is also finalizing a new Agency-level policy that will increase use of Cooperative Research and Development Agreements. NASA is expanding the use and capability of TechPort (a tool the agency uses to track and analyze its technology portfolio) to include broader access, enabling NASA to efficiently disseminate key information about its current technology investments for the public benefit. NASA is analyzing the value of and piloting new approaches to using innovative partnerships, prizes, and challenges to facilitate and accelerate innovation both within and outside the agency. Additionally, NASA is working with entrepreneurial space businesses to identify economic drivers of private and commercial space industry.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will facilitate the transfer of Agency technology and engage in partnerships with other government Agencies, industry, and international entities to generate U.S. commercial activity and other public benefits. NASA will establish new cost-sharing partnerships and other forms of collaboration, and will participate in regional economic innovation clusters focused on the synergy between NASA technology and regional industry.

NASA will implement revised technology transfer policies, conduct training for Agency personnel and will continue to explore innovative methods both for reaching new industry audiences and making the technologies available.

The finalized NASA Strategic Space Technology Investment Plan will be used to prioritize NASA's investments in space technologies across the Agency. NASA will begin its biennial update of the Strategic Space Technology Investment Plan and will initiate an update of the Space Technology Roadmaps, expanding their scope to include information technologies and aeronautics.

NASA will implement an initiative to enhance documentation of NASA-developed technology use by mission directorates and Centers. NASA will also work closely with other government agencies to crosswalk NASA investments to their technology efforts, gaining new synergies and enabling new opportunities for technology use.

PARTNERSHIP DEVELOPMENT & STRATEGIC INTEGRATION

Program Elements

PARTNERSHIP DEVELOPMENT

Partnership Development provides leadership for the Agency's technology transfer and commercialization activities, and increases the exchange of ideas and technologies with external organizations. Through Partnership Development, NASA is responding to the legislative requirements and Administration priorities promoting technology transfer. Partnership Development offices at each NASA Center pursue applications for the NASA-developed technologies and use partnerships, licenses, and agreements to transfer the technologies from the laboratory to the marketplace. NASA's technologies provide advanced capabilities, new tools, equipment, and solutions for industry. This spurs economic growth, creates new markets, and helps U.S. industry be competitive and maintain global technological leadership.

Partnership Development has four primary functions:

- Enabling Technology Transfer: Provides Agency-level management and oversight of NASA-developed and owned intellectual property, and manages transfer of these technologies to external entities. Activities include the capture of new inventions, management of intellectual property documents, creation and marketing of licenses, development of technology transfer-focused partnerships, and tracking and reporting a number of technology related products, including patents, licenses, and software use agreements.
- Facilitating Partnerships: Provides Agency-level coordination, negotiation, and development of partnership agreements that expand and strengthen NASA's transfer, commercialization, and use of externally developed technologies. Activities include development of non-traditional partnerships to systematic engagements with regional, state, and local partners.
- Utilizing Prizes and Challenges: Provides Agency-level leadership and coordination of NASA's organizations that conduct prizes and challenges to spur innovation and increase the number and type of individuals participating in innovation activities. NASA uses prizes and competitions to provide technology breakthroughs that lower mission costs, and strengthen expertise to develop solutions for tomorrow.
- Emerging Space: Provides analytical support to Agency decision makers concerning the rapid growth of national and international entrepreneurial space communities, their technology needs, and opportunities for NASA to develop or transfer technologies that will facilitate their growth. Activities include monitoring commercial activities, evaluating historical trends, investigating current technology needs, coordinating collaboration discussions, and fostering activities that benefit these new markets and the fullest use of space for commercial purposes.

STRATEGIC INTEGRATION

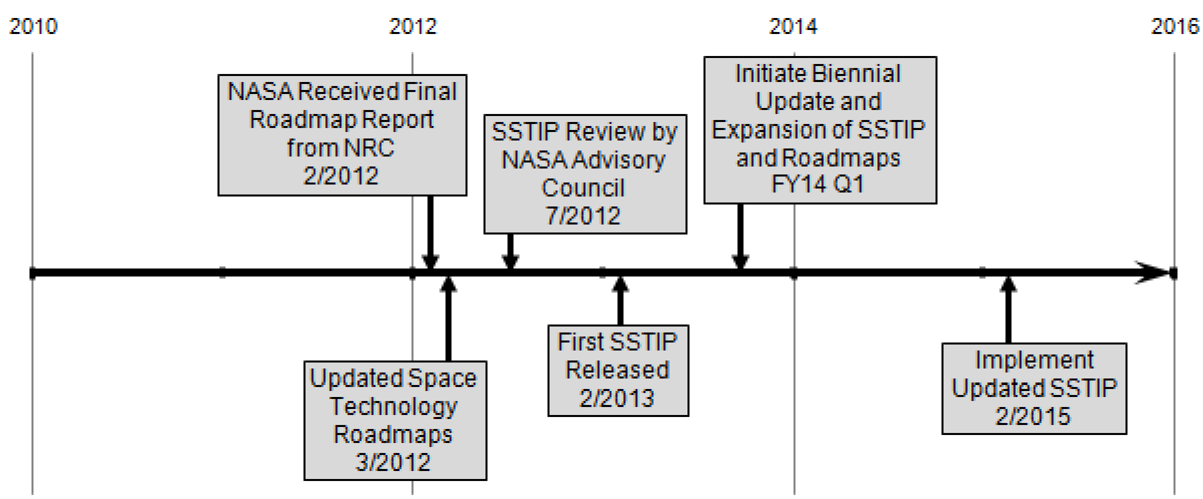
Strategic Integration develops policy, requirements, and strategy for NASA's technology development activities in support of the Chief Technologist by coordinating with NASA mission directorates, other government agencies, and external organizations. These efforts help to identify priorities, needs, technology development opportunities, and activities that assist NASA in achieving its goals and enable NASA to benefit from cross-agency technological advancements.

PARTNERSHIP DEVELOPMENT & STRATEGIC INTEGRATION

Strategic Integration performs an Agency-level technology coordination role to assist NASA in meeting mission requirements while filling technology gaps, anticipating future needs, and avoiding duplication of effort, through mechanisms such as the Space Technology Roadmaps. To facilitate technology coordination, Strategic Integration manages the execution of the NASA Technology Executive Council, a decision body, and the Center Technology Council, a recommendation council. Both councils are designed to ensure full-Agency participation in technology planning and decision-making activities. The NASA Technology Executive Council works to align the Agency's technology investments with the current priorities, minimize duplication, and ensure that needed capabilities are developed. The Center Technology Council provides advice to the Office of the Chief Technologist and the NASA Technology Executive Council on major issues that relate to technologies of importance to NASA, with a focus on agency-wide NASA technology policies and programs.

Additionally, to facilitate strategic planning of Agency technology development, NASA developed the Technology Portfolio System (TechPort). This web-based tool captures, tracks, and supports analysis of NASA's technology investment portfolio in an efficient and coordinated manner. NASA uses the system to document and track technology investments, comparing the portfolio against the strategic plan and utilizing the NASA Technology Executive Council to make appropriate adjustments. Strategic Integration identifies opportunities to use NASA-developed technology in future NASA missions and supports documentation and communication of the societal impact of NASA technology investments.

Program Schedule



PARTNERSHIP DEVELOPMENT & STRATEGIC INTEGRATION

Program Management & Commitments

Program Element	Provider
Partnership Development	Provider: N/A Lead Center: NASA Headquarters Performing Centers: Each NASA Center has a technology transfer lead. NASA Ames runs Emerging Space Office Cost Share Partners: N/A
Strategic Integration	Provider: N/A Lead Center: NASA Headquarters Performing Center: Chief Technologists at each Center. TechPort operation representatives at each Center. Cost Share Partners: N/A

Acquisition Strategy

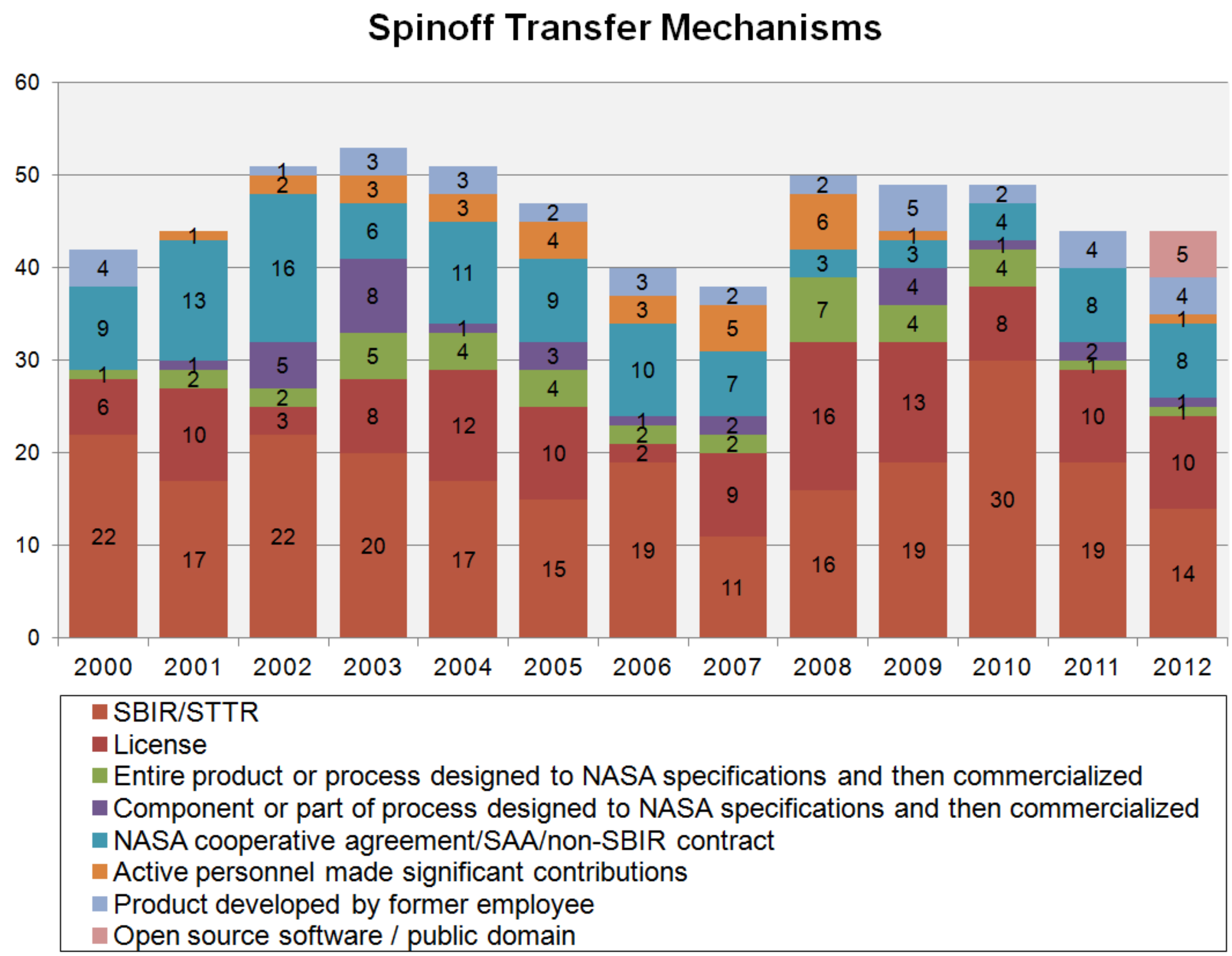
This organization does not participate in a substantial amount of procurement activity.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Other	National Academies	Feb 2012	Final report reviewing NASA's draft Space Technology Roadmaps.	Report identified key technologies that furthered development of space capabilities for the nation's aerospace industry. NASA finalized the roadmaps and implemented the Strategic Space Technology Implementation Plan development in response to these recommendations.	Q1 FY14

HISTORICAL PERFORMANCE

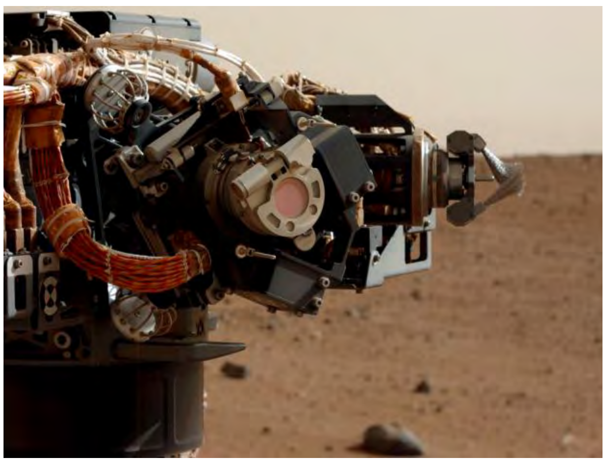
Technology transfer efforts at NASA result in spinoff technologies that create new industries, provide jobs, and address national needs through technology advancements that impact life on Earth. Below, the graphic shows the variety of mechanisms used by a subset of NASA technologies to go from the Agency to outside entities to be commercialized.



SBIR AND STTR

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	171.6	--	**186.4**	192.0	200.4	211.6	211.6
Change from FY 2012	--	--	**14.8**				
Percentage change from FY 2012	--	--	**8.6 %**				



Supporting the Mars Curiosity Rover's mission, Honeybee Robotics (an SBIR company with just over 35 employees) developed the dust removal tool which is used to determine the characteristics of various rock formations and their suitability for drilling and further analysis. This small company also designed the sample manipulation system, which plays an integral role in delivering Marian surface samples to the analytical instruments within the Sample Analysis at Mars (SAM) instrument package.

NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs fulfill a statutory requirement to support early-stage research and development. The programs provide the small business sector with an opportunity to compete for funding to develop technology for NASA and to commercialize that technology to spur economic growth. Research and technologies funded by competitively-awarded SBIR and STTR contracts have made important contributions to numerous NASA programs and projects. The Agency is actively working to increase the number of NASA-funded SBIR and STTR technologies used in NASA's missions and projects. Some high-profile programs benefiting directly from SBIR technologies include the Next Generation Air Transportation System; smart sensors that assess launch vehicle structural health, three-dimensional flash-Lidar technologies to assist with collision avoidance and navigation for space applications, and end-of-arm tooling on Mars surface rovers and landers.

NASA issues annual program solicitations for the SBIR and STTR programs that set forth a substantial number of topic areas. Both the list and description of topics are sufficiently comprehensive to provide a wide range of opportunities for small business concerns to participate in NASA's research and development programs.

Phase I awards give small businesses the opportunity to establish the scientific, technical and commercial merit, and feasibility of the proposed innovation in fulfillment of NASA needs. Phase II awards focus on the development, demonstration, and delivery of the proposed innovation. The most promising Phase I projects are awarded Phase II contracts through a competitive selection based on scientific and technical merit, expected value to NASA, and commercial potential. Phase II Enhancement (II-E) is an incentive for cost share to extend the research and development efforts of the current Phase II contract. Phase III is the commercialization of innovative technologies, products and services resulting from a Phase II contract. This includes further development of technologies for transition into NASA programs, other

Government agencies, or the private sector. Phase III contracts are funded from sources other than the SBIR and STTR programs and may be awarded without further competition.

EXPLANATION OF MAJOR CHANGES

The SBIR and STTR program reauthorization annually increases the required rate of investment for each program relative to extramural Agency Research and Development beginning in FY 2012 and continuing through FY 2017. In accordance with the law, NASA will increase the SBIR investment by 0.1 percent to 2.8 percent, and increase the STTR investment by 0.05 percent, to 0.40 percent of Agency Research and Development.

ACHIEVEMENTS IN FY 2012

SBIR and STTR awarded 298 Phase I SBIR and STTR contracts and 102 Phase II SBIR and STTR contracts in FY 2012. In addition, NASA funded small businesses saw success with technology infusion, bringing significant contributions to the Mars Science Laboratory:

- GrammaTech, Inc. of Ithaca, New York developed software for eliminating defects in mission-critical and embedded software applications directing rover operations
- Starsys Research, Inc. of Louisville, Colorado developed planetary gearboxes for the articulated robotic arm and the descent braking mechanism for controlling rate of descent to planetary surface
- Creare, Inc. of Hanover, New York developed a space-qualified vacuum pump for the Sample Analysis at Mars (SAM) instrument package
- Yardney Technical Products, Inc. of Pawcatuk, Connecticut developed lithium ion batteries that enable the power system to meet peak power demands or rover activities
- Honeybee Robotics, Inc of New York, New York created a dust removal tool used to remove the dust layer from rock surfaces and to clean the rover's observation tray and designed the sample manipulation system for the Sample Analysis at Mars instrument package
- inXitu,Inc. Of Mountain View, CA had features of their automated sample handling system implemented in the Chemistry and Mineralogy experiment instrument

Similarly, three SBIR/STTR contractors established partnerships with the Space Launch System (SLS) program to support critical modeling and simulation requirements for SLS development:

- Streamline Numerics, Inc. of Gainesville, Florida for the development of an effective fluid-flow design tool that can be used in the design process by engineers for modeling full 3-D geometries with unsteady flow analysis. Specific areas of interest include combusting flows in injectors and cavitating flows in turbomachinery components with real-fluids.
- AI Signal Research of Huntsville, Alabama for high frequency data diagnostics tools to modify and validate PC-Signal software as well as expand analysis and environment prediction capabilities for current and future propulsion components.
- Tetra Research Corporation of West Princeton, Illinois for the development of advanced flow analysis tools for solid rocket motor simulation for accurate simulation of motor pressure and thrust as a function of time.

SBIR AND STTR

WORK IN PROGRESS IN FY 2013

Space Technology selected 39 small business proposals for SBIR Phase II contract awards. The selected projects have a total value of approximately $27 million. NASA awarded the contracts to small high technology firms in 17 states. Technologies awarded seek to address aviation safety and aircraft efficiency, provide new optics technology for detecting extra-solar planets, and potentially mitigate the harmful effects of space radiation. In addition to meeting NASA's needs, the proposals also provide innovative research in areas that have other commercial applications. Further, NASA has 35 Phase II-E projects currently under negotiation with 29 companies. These projects will leverage approximately $4.5 million of SBIR funds with approximately $7.6 million in non-SBIR funds to further advance technologies of interest to NASA and non-NASA users.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The SBIR and STTR program will continue addressing NASA's core competencies through a solicitation that is aligned with Space Technology roadmaps and the National Aeronautics Research and Development Plan. The STTR budget will support awards associated with the solicitation released in fall of 2013.

Program Elements

SBIR

The SBIR program was established by statute in 1982 and reauthorized in 2011 to increase research and development opportunities for small business concerns. The program stimulates U.S. technological innovation, employs small businesses to meet Federal research and development needs, increases private sector commercialization of innovations derived from Federal research and development, and encourages and facilitates participation by socially disadvantaged businesses.

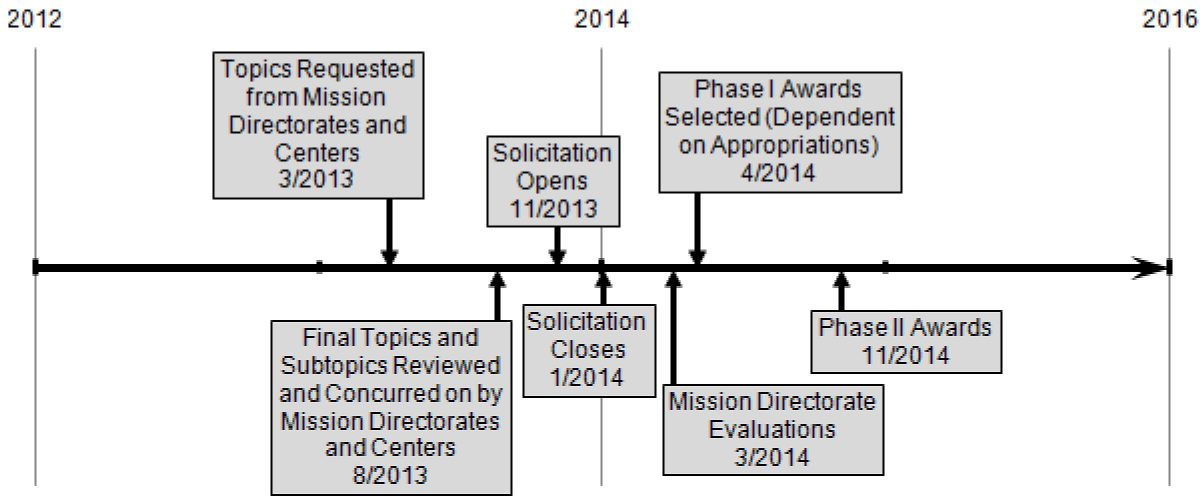
In FY 2014, the SBIR program is supported at a level of 2.8 percent of NASA's extramural research and development budget. In FY 2014, the maximum value for an SBIR Phase I contract will be $200,000 for a period of performance of six months. For Phase II, the maximum total value of an SBIR award is $1,500,000 over a 24-month period of performance. The number and size of awards are based on the quality of proposals received.

STTR

The STTR program, established by statute in 1992, and reauthorized in 2011 to award contracts to small business concerns for cooperative research and development with a non-profit research institution, like a university. NASA's STTR program facilitates transfer of technology developed by a research institution through the entrepreneurship of a small business, resulting in technology to meet NASA's core competency needs in support of its mission programs. Modeled after the SBIR program, STTR is funded separately with funding set at 0.40 percent of the NASA extramural research and development budget. In FY 2014, the maximum value for an STTR Phase I contract is $125,000 for a period of performance of twelve months. For Phase II, the maximum total value of an STTR award is $750,000 over a 24-month period of performance. The number and size of awards are based on the quality of proposals received.

Program Schedule

SBIR and STTR Program Year 2013 solicitation and award schedule is below.



Program Management & Commitments

Program Element	Provider
SBIR and STTR	Provider: Various Small Businesses and their research partners Lead Center: NASA HQ; Level 2: ARC Performing Centers: All Centers play a project management and implementing role. Cost Share Partners: SBIR Phase II Enhancement (2-E) matches cost share funding with SBIR and STTR up to $250,000 of non-SBIR and non-STTR investment(s) from a NASA project, NASA contractor, or third party commercial investor to extend an existing Phase II project to perform additional research.

SBIR AND STTR

Acquisition Strategy

SBIR and STTR program management, in conjunction with NASA Center Chief Technologists and a mission directorate steering council, work collaboratively during the SBIR and STTR acquisition process (from topic development and proposal review and ranking) in support of final selection. Mission directorate and NASA Center personnel interact with SBIR and STTR award winners to maximize alignment and infusion of the SBIR and STTR products into NASA's future missions and systems. Topics and subtopics are written to address NASA's core competencies and are aligned with Space Technology roadmaps.

MAJOR CONTRACTS/AWARDS

In addition to the 298 Phase I SBIR and STTR contracts and 102 Phase II SBIR and STTR contracts mentioned above, the NASA SBIR/STTR Program awarded 18 Phase II-E contracts in FY 2012. The Phase II Enhancement (II-E) matches cost share funding with SBIR and STTR funds up to $250,000 of non-SBIR and non-STTR investment(s) from a NASA project, NASA contractor, or third-party commercial investor to extend an existing Phase II project to perform additional research. Phase II-E contracts in FY 2012 were worth a total of $2.1 million from the SBIR/STTR Program, along with $2.4 million in non-SBIR matching contributions. These were amongst a total of 78 Phase III awards tracked by the SBIR/STTR Program in FY 2012, bringing a total of $17.1 million in non-SBIR funding to NASA SBIR/STTR contractors to further develop or commercialize their technologies.

Element	Vendor	Location (of work performance)
SBIR Phase II E awards	Vista Photonics, Inc. (2 awards)	Santa Fe, NM
	Remote Sensing Solutions, Inc.	Barnstable, MA
	The DNA Medicine Institute	Cambridge, MA
	Michigan Engineering Servicing, LLC	Ann Arbor, MI
	Plasma Processes, LLC	Santa Fe, NM
	Whittinghill Aerospace, LLC	Boulder, CO
	SPEC, Inc	Cary,IN
	Horizon Performance	Camarillo, CA
	Honeybee Robotics, Ltd.	New York, NY
	Busek Company, Inc.	Natick, MA
	Parabon Computation, Inc.	Herndon, VA
	NxGen Electronics, Inc.	San Diego, CA
	Am Biotechnologies, LLC	Reston, VA
	Fibertek, Inc.	Houston, TX
	CFD Research Corporation (2 awards)	Huntsville, AL
	Austin Satellite Design	Austin, TX

SBIR AND STTR

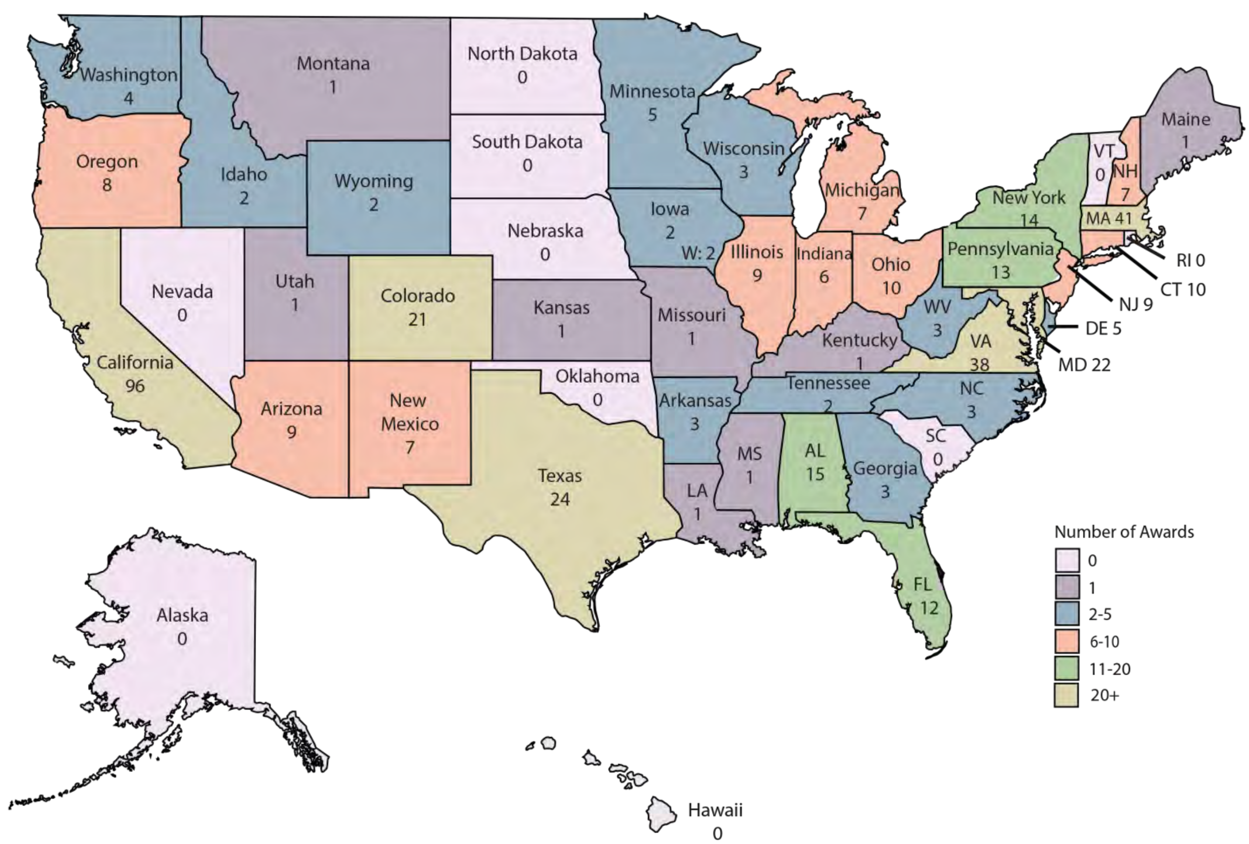
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Performance	National Academies	Ongoing	Assessment of the SBIR program.	TBD	FY 2014
Performance	GAO	Nov 2012	The GAO has been tasked to assess all SBIR/STTR programs for their performance in combating Waste, Fraud, and Abuse.	GAO found no concerns to address.	Ongoing

HISTORICAL PERFORMANCE

FY 2012 selections represented by geographic location.

SBIR & STTR 2012 Awards (2011 Ph I, 2010 Ph II, 2008 Ph II Es)



CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	182.7	--	**277.6**	256.2	213.2	241.0	244.3
Subtotal	183.9	--	**277.6**	256.2	213.2	241.0	244.3
Rescission of prior-year unob. balances*	-1.3	--	**--**	--	--	--	--
Change from FY 2012	--	--	**94.9**				
Percentage change from FY 2012	--	--	**51.9 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

As the rocket-powered sled accelerated down the four-mile-long track at speeds of several hundred miles an hour, the Supersonic Inflatable aerodynamic decelerator experienced loads 25 percent greater than it will face during an actual atmospheric entry at Mars. The inflatable decelerator, a balloon-like ring inflated around the perimeter of an entry vehicle, is intended to increase its diameter and surface area to aid in aerodynamically slowing the vehicle as it plunges through the atmosphere.

NASA invests in crosscutting technologies with the objective of leveraging the development of key technologies that enable or significantly advance the space missions for multiple customers. In addition, NASA is developing a pipeline of technology investments to ensure the emergence of new ideas and the infusion of advanced capabilities into actual missions.

Maturing technologies from idea and concept inception all the way through demonstration in a relevant environment is a significant challenge, and comes with inherent technical and programmatic risk. The program effectively and efficiently manages technology development with focus on relevance and takes advantage of expected challenges in the maturation process. By supporting projects at all technology readiness levels, Crosscutting Space Technology Development creates a technology cascade, resulting in mature, ready-to-infuse technologies that increase the nation's in-space capabilities. In the process of creating these new technologies, NASA supports training and inspires the next generation of inventors, scientists, and engineers.

Crosscutting Space Technology Development (CSTD) funds these crosscutting efforts within eight of Space Technology's nine investment areas, conducting Early Stage Innovation (includes Space Technology Research Grants, NASA Innovative Advanced Concepts, Center Innovation Fund and Centennial Challenges) Game Changing Development, Technology Demonstration Missions, Small Spacecraft Technology, and Flight Opportunities.

This program also supports NASA's role in the National Nanotechnology Initiative, the Advanced Manufacturing Partnership, and the Materials Genome Initiative. These efforts enable NASA to develop and advance technological capabilities in support of Agency mission directorates, enable collaborations with other Government agencies, and support private industry through an expansion of the Nation's technology-base.

EXPLANATION OF MAJOR CHANGES

Space Technology has combined Edison and Franklin programs into the Small Spacecraft Technology program. Increased funding supports early stage concepts and technologies useful for asteroid detection, characterization, proximity operations, mitigation, and resource utilization.

Program Elements

EARLY STAGE INNOVATION

NASA sponsors advanced aerospace system concept studies and foundational technology development efforts on a wide range of topics such as asteroid detection, characterization, proximity operations, mitigation, and resource utilization, as well as autonomous robotics, and radiation mitigation. As an entry point of NASA's pipeline of revolutionary concepts and early stage technologies, Space Technology supports early-stage development under the following investment areas:

Space Technology Research Grants accelerates the development of high risk/high payoff, low TRL technologies to support the future space science and exploration needs of NASA, other government agencies and the commercial space sector through two competitively awarded components: NASA Space Technology Research Fellowships and Space Technology Research Opportunities. The first component awards fellowships for graduate student research (Master's and Doctoral degree) on space technologies with significant potential to impact future national aerospace needs. Selected students perform research on their respective campuses and spend time at NASA Centers and/or not-for-profit research and development laboratories. The second component funds groundbreaking research in space technology via grants to university-based research teams. Both components target early-stage research and development within technology topic areas that are a high priority to the Agency and where the Nation's academic institutions can play a critical leading role.

NASA Innovative Advanced Concepts (NIAC) solicits early studies of visionary concepts in support of NASA's future missions and broader aerospace enterprise needs. NIAC executes annual solicitations seeking exciting, unexplored, technically credible new approaches that could one day change the possible in space and aeronautics. NIAC efforts improve the Nation's leadership in key research areas, enable far-term capabilities, and spawn disruptive innovations that make aeronautics, science, and space exploration more effective, affordable, and sustainable. The NIAC core program supports research through two phases of study. Phase I awards are typically nine-month efforts (up to $100,000) to explore the overall viability and advance the technology readiness level of visionary concepts. A follow-on Phase II develops the most promising Phase I concepts for up to two years (about $500,000) and explores infusion paths within NASA and beyond. Candidate studies may be selected from multiple sources: educational institutions, commercial and not-for-profit organizations, research laboratories, federal agencies, and NASA Centers (including the Jet Propulsion Laboratory).

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

Center Innovation Fund stimulates aerospace creativity and innovation at the NASA Centers. The activities fall within the scope of NASA's space technology roadmaps, or enhance capabilities that contribute to NASA strategic goals and/or significant national needs. NASA distributes the funds among the Centers to support emerging technologies and creative initiatives that leverage Center talent and capabilities. NASA scientists and engineers lead individual tasks and activities, but partnerships with academia, private industry, individual innovators as well as other NASA Centers and government labs are encouraged. The individual Centers have full discretion on the use of these funds. Each Center Chief Technologist coordinates a competitive process at his or her Center for the selection of activities. Centers report on progress periodically and the program office at NASA Headquarters evaluates the Center efforts on an annual basis.

Centennial Challenges uses partnerships to host prize competitions aimed at finding solutions to technical challenges that support NASA's missions in aeronautics and space. NASA provides the prize purse, and partners with private non-profit entities to manage the competitions at no cost to NASA. The program has been successful at engaging non-traditional participants such as independent inventors, non-government funded entities, and educational institutions, thus expanding the pool of innovators available to achieve the Nation's challenging technology goals. Active challenges include the Sample Return Robot challenge, hosted by Worcester Polytechnic Institute. The Night Rover Challenge, hosted by Cleantech Open, seeks to advance energy storage technologies such as lithium-ion batteries, and demonstrates their ability to meet performance goals while enduring the extreme temperatures and vacuum conditions seen in space. In addition, Centennial Challenges is partnering with the Aeronautics Research Mission Directorate to conduct the Unmanned Aircraft Systems (UAS), Airspace Operations Challenge (AOC). The AOC seeks to demonstrate how to overcome the key technological barriers related to sense and avoid for safe separation and autonomous interactions within a congested airspace. This request sets aside $5 million to announce new Centennial Challenges starting in FY 2014, including the creation of a seed fund to encourage prize competitions across the agency, and to pilot varying types of prize competitions.

Achievements in FY 2012

- **Space Technology Research Grants** funded research at 57 universities in 29 states and 1 U.S. territory including: selection of 48 new Space Technology Research Fellowships and continuation of 74 students from 2011 selections. Among the 2012 students selected, Charles Amos from the University of Texas at Austin is conducting research in high-performance energy storage. Space Technology Research Grants also selected 10 early career faculty researchers to receive grants for research in high-priority technology areas including: (1) communications and navigation, (2) human health, life support and habitation systems, (3) human exploration destination systems, and (4) materials, structures, mechanical systems, and manufacturing. In addition, awards were made for 10 university-led proposals for study of innovative, early-stage space technologies designed to improve space radiation monitoring and protection, spacecraft and system thermal management, and optical space science observation systems.
- **NIAC** completed 29 Phase I studies from 2011 with five patents pending. Through its FY 2012 solicitation, NIAC selected 18 new Phase I, and 10 new Phase II studies, continuing the most promising 2011 efforts. NIAC projects have generated over 200 national and international media articles. Selections for Phase II included research into asteroid threat mitigation, cave-hopping robots to explore planetary skylights, and innovative manufacturing approaches such as printable spacecraft and contour crafting (robotic construction using in-situ resources).

- The **Center Innovation Fund** saw approximately 170 activities funded at NASA Centers, and several technologies found infusion paths to other NASA missions including: woven thermal protection systems (Orion Multi Purpose Crew Vehicle), altitude compensating nozzle (Aeronautics), Miniature Exercise Device (Exploration), and electrically-controlled extinguishable solid propellant (Small Business Innovative Research).

Work in Progress in FY 2013

- **Space Technology Research Grants** will announce selections of additional research fellowships for the Fall 2013 class, and issue a solicitation for new university-based grants in late 2013; announce 2013 Phase I **NIAC** awards, and select promising Phase I concepts for Phase II NIAC studies; and support additional **Center Innovation Fund** activities.
- **Centennial Challenges** will initiate at least two new challenges in late FY 2013 depending on outcome of early FY 2013 activities, which include the second Sample Return Robot Challenge and the initial Unmanned Aircraft Systems (UAS) Airspace Operations Challenge.

Key Achievements Planned for FY 2014

- **Space Technology Research Grants** will continue supporting the technology development pipeline through new space technology graduate fellows and university research grants through continued support of previous years' awards and the competitive selection of new efforts in both components and continue to gain breakthrough ideas from the Nation's top talent. Approximately 25 Space Technology research fellows will graduate from American universities with advanced degrees, prepared to contribute to the economy by solving the Nation's difficult technological challenges.
- NASA will initiate new Phase I **NIAC** awards and further develop the most promising concepts for Phase II NIAC studies. **Center Innovation Fund** efforts will continue with the completion of previous year awards and the selection of new awards.
- Initiate at least two new **Centennial Challenges**, including one relevant to near Earth asteroid detection, characterization and mitigation efforts.

GAME-CHANGING DEVELOPMENT (CROSSCUTTING)

Within Game Changing Development, NASA focuses on maturing transformational technologies across the critical gap between early stage innovation and flight demonstration of a new technology. NASA will measure the success of the Game Changing Development investments as a whole, rather than expecting each project to produce breakthrough or revolutionary results. NASA expects that, over time, the dramatic advances in transformative space technology, such as crosscutting efforts funded here, will enable entirely new NASA missions, and lead to solutions for a wide variety of society's technological challenges. Within this area, NASA funds fixed duration investments identified as high priorities by NASA Mission Directorates. A subset of these projects is described below:

- **Advanced Manufacturing Technologies** supports innovation in low-cost manufacturing processes and products to include metallic joining, and various manufacturing techniques, such as additive, composites and digital manufacturing. This project looks for opportunities to improve the manufacturing technologies, processes, and products prevalent in the aerospace industry.

Initial investments have supported additive manufacturing for rocket engines and in-space manufacturing. Future investments will focus on advancing composite manufacturing processes, identifying ideal material mixtures, and developing in situ resource construction techniques. This project supports NASA's interface with the President's Advanced Manufacturing Partnership, including the Agency's role in the National Network for Manufacturing Innovation. This initiative brings together government agencies to collaborate toward modernization of manufacturing, and supports direct investments in small businesses and training for the high-skilled manufacturing workforce.

- **Nanotechnology** advances nanotechnology research and applications for space technology focused primarily on reducing vehicle mass and improving reliability through the development of carbon nanotube based, ultra-high strength structural reinforcements, and nanotechnology derived sensors. This project supports NASA's participation and interface with the National Nanotechnology Initiative.
- **Space Synthetic Biology** leverages the efficiency of life in using its surrounding resources and turning those resources into habitats, materials and forms that perform a wide range of functions efficiently. This project element researches a range of genomics and synthetic biology approaches for the design of organisms that can utilize materials found in space to support future human and robotic exploration activities.
- **Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS)** is a joint effort with the U.S. Army and NASA to develop a three-stage expendable launch vehicle capable of lifting 100 kilogram payload to a 750 kilometer circular orbit with a target production cost of approximately $1 million per launch vehicle. The vehicle development strategy employs low cost manufacturing procedures used in the automotive and like industries to create nano-launch vehicles for much less than one-tenth the cost of equivalent traditional launchers. To address the critical impediment of lack of affordable avionics, NASA is also working to develop a prototype suite of inter-connectable common avionics modules that are physically and electrically suitable for packaging into nano-launchers or nano-sats and able to perform all of the navigation, guidance, control and communications functions.

As projects complete their life cycle, additional game changing technologies will be selected through broad Agency announcements as well as funded Space Act agreements open to industry, academia, and the NASA Centers, or brought up from successful efforts with Space Technology Research Grants, Center Innovation Fund, NIAC, and SBIR/STTR.

Achievements in FY 2012

- **Advanced Manufacturing Technologies** partnered with Pratt Whitney Rocketdyne to develop an additively manufactured sub-scale RL-10 injector using selective laser melting which will be tested by Glenn Research Center. If successful, the additively manufactured injector can be produced at a fraction of the cost and save 15 months of manufacturing time.
- **Synthetic Biology** developed the first successful "Bio Brick," a composite material that can be used for construction purposes. The brick uses soil and a biopolymer following development of prototype molding systems and test articles produced, which permits high-volume production of test articles.
- NASA Centers (Marshall, Langley, Ames and Kennedy) formulated an integrated team to begin design analysis for **SWORDS**. Integrated Product Teams across NASA are actively working with

interagency partners, Space Florida and the MidAtlantic Spaceport in Virginia to change the paradigm regarding how rocket vehicles and their components are manufactured and assembled.
- **Nanotechnology** initiated modeling studies to understand behavior of carbon nanotube materials under applied mechanical loads and determined effects of processing and post-processing treatments on tensile properties of nanotube sheets, tapes, and yarns. In addition, NASA developed new multi-axis micro-scale testing capability for carbon nanotube materials.

Work in Progress in FY 2013

- **Advanced Manufacturing Technologies** is testing and demonstrating high-quality, space-worthy aerospace parts using additive manufacturing systems, a process which could reduce cost of acquiring parts with limited availability or demand. NASA participated in a pilot institute with the Department of Defense, Department of Energy, NIST, and the National Science Foundation (Institute for Manufacturing Innovation in Additive Manufacturing) and supported preliminary design efforts for the National Network of Manufacturing Innovation (NNMI). Space Technology is hosting a technical interchange meeting to review NASA's advanced manufacturing portfolio and develop a three to five-year investment strategy.
- The **Barrier Infrared Detector** completed development of an advanced sensor system that can operate in space at higher temperatures, which reduces or eliminates the active cooling requirements associated with current sensor systems. This benefit, combined with the use of cheaper sensor materials, results in a tenfold reduction in system mass, a five times reduction in power requirements and a 40 times cost reduction when compared to the current state of the art infrared sensors for Earth observing missions.
- For **SWORDS**, NASA analysis informed vehicle design and configuration and is leading development of a common avionics system that will significantly reduce cost for the system. Following preliminary design review, the Agency will support structural and engine testing, provide vehicle and system analysis, and conducted high speed wind tunnel testing to finalize vehicle design as it is developed for its 2014 suborbital and orbital launches. The launch system is on track to maintain its aggressive schedule with the primary focus on meeting a low cost objective over performance.

Key Achievements Planned for FY 2014

- **Advanced Manufacturing Technologies** guided by the strategic planning efforts in FY 2013, NASA will focus on advancing composite manufacturing processes, identify and mature ideal material mixtures of interest to the aerospace community and develop in situ resource construction techniques. The Agency will continue identifying additional engine/stage components where additive manufacturing techniques could significantly reduce part cost and build time.
- **Nanotechnology** will demonstrate the use of structural nanocomposites in the payload fairing of a suborbital launch vehicle. The launch will demonstrate reduced structural weight over conventional materials and a reduced vibration environment in the payload bay due to the inherent energy dissipation capacity of nanocomposite materials.
- **Space Synthetic Biology** will produce a prototype bio-electrochemical system for air and/or water processing that provides improved performance over current systems for CO2 management for air revitalization or wastewater treatment for water recovery, or an integration of both.

- NASA will integrate the common avionics system, conduct vehicle performance analysis during hot fire testing, and provide ground processing support for **SWORDS** prior to and during its 2014 suborbital and orbital launches. At a launch vehicle cost of below $1 million, realizing this system will open the vastly expanding market demand for a lost cost and quickly available launch system for nano-satellites.

TECHNOLOGY DEMONSTRATION MISSIONS (CROSSCUTTING)

Through crosscutting Technology Demonstration Missions (TDM), NASA demonstrates technologies already matured through the proof-of-concept, initial validation and ground testing phases in a relevant flight environment, prior to integration in future missions. Focused areas for these demonstration missions address needs that not only support future NASA missions, but also respond to the capability demands of other government agencies and the commercial space sector. To remain affordable, flight demonstrations of mature technologies are supported primarily through hosted payloads, rideshares and secondary payloads. Further, the portfolio of demonstration projects will be managed under strict cost and schedule guidelines, particularly after they transition from formulation to implementation. The current portfolio of crosscutting Technology Demonstration Missions is described below:

- **Low Density Supersonic Decelerators** demonstrates new entry descent and landing (EDL) technologies capable of increasing the landed mass and landing precision over current baseline systems. NASA has been using Viking era parachutes for decades and has reached the upper limit of their utility. Space Technology is developing and testing a variety of decelerators systems to support future Mars missions. The project is designing, developing and testing a ring-sail parachute as well as a pair of supersonic inflatable aerodynamic decelerator systems. The inflatable decelerators are being put through a series of tests utilizing wind tunnels, rocket sleds, and rocket-powered, flight demonstrations at sub-orbital altitudes. In addition, advanced parachute demonstrations will be conducted in the thin air found in the Earth's stratosphere, and is funded, in part, through a partnership with the Planetary Division of the Science Mission Directorate. Once proven, these technologies are expected to infuse into future science missions with potential application to future robotic and human missions to Mars. The larger ring-sail parachute, in particular, is under consideration for infusion on the Mars 2020 mission.
- **Laser Communications Relay Demonstration** will perform an in-space demonstration of a reliable, capable, and cost-effective optical communications technology that will provide data rates up to 100-times higher than today’s radio frequency communication systems. These higher bandwidth capabilities will prove necessary for future human and robotic space missions. The project intends to demonstrate two-way and relay laser communications between two, earth-based ground stations and a satellite in geostationary orbit. The technology is directly applicable for infusion into the next generation of NASA's Tracking and Data Relay Satellite System (TDRSS). The resulting technologies will improve bandwidth for space operations. The flight demonstration will be supported through a hosted payload on a future Loral Space and Communications launch and is funded in partnership with Space Communications and Navigation (SCaN) Division within Human Operations and Exploration Mission Directorate.
- **Deep Space Atomic Clock** validates a miniaturized mercury-ion atomic clock that is 100 times more accurate than today’s non-atomic clocks used for spacecraft navigation systems. This project element will demonstrate ultra-precision timing in space and its benefits for one-way radio-based navigation. It will free precious deep space communications bandwidth to perform greater science data return instead of receiving and transmitting navigation updates. Precision

timing and navigation is critical to the performance of a wide range of future deep space science missions and has the potential to improve the Nation's next generation GPS system. The demonstration is planned for launch via rideshare and is funded in a partnership with SCaN.
- **Sunjammer Solar Sail Demonstration** will deploy and operate a solar sail with an area seven times larger than ever flown in space. It is potentially applicable to a wide range of future space missions, including serving as an advanced space weather warning system to provide more timely and accurate notice of solar flare activity. This technology also will allow for propellantless deep space exploration missions. NOAA is collaborating with NASA and L'Garde Inc. on the demonstration. The National Research Council's Committee on a Decadal Strategy for Solar and Space Physics recently identified the tremendous potential of solar sails in supporting future heliophysics missions. The flight demonstration will be supported by a rideshare.

Achievements in FY 2012

- **Low Density Supersonic Decelerators** conducted sled tests using a newly developed rocket sled platform to perform initial inflation and stability testing of a full-scale inflatable decelerator at equivalent dynamic pressure conditions for an actual planetary entry. These tests are a first step in proving the feasibility of using supersonic inflatable decelerators for future entry, decent and landing systems.
- Both **Solar Sail** and **Deep Space Atomic Clock** progressed through mission design and system requirements reviews, and moved into the concept and technology development phase. Both met these key milestones on schedule to meet FY 2015 launch dates.

Work in Progress in FY 2013

- **Low Density Supersonic Decelerators** passed their preliminary design review and moved into the implementation phase. Last fall, the project conducted two ring-sail parachute development verification test campaigns and conducted subscale parachute testing on eleven designs to down select a final design for the 30 meter, supersonic parachute in spring 2013.
- **Laser Communications Relay Demonstration** continued ground development activities for the optical space terminal and optical ground station designs to support system requirements. The project will proceed to preliminary design review by the third quarter of FY 2013 and remains on track to demonstrate a comprehensive space communications transformation.
- **Deep Space Atomic Clock** will design the ultra-stable oscillator, global positioning system receiver and clock and hold its system preliminary design review in mid-2013 moving from the design phase toward project implementation.
- **Solar Sail** recently completed a series of deployment tests of their 89-foot prototype boom, the structural support for the solar sail once unfurled. This deployment test focused on the spreader system which increases the strength of the solar sail boom and is particularly important for larger solar sails. NASA held its preliminary design review in early FY 2013, moving the project into the implementation phase. Later this year, NASA will hold a critical design review.

Key Achievements Planned for FY 2014

- **Low Density Supersonic Decelerators** will conduct its final sled tests for both the ring-sail parachute and the larger of the two supersonic inflatable aerodynamic decelerator test articles, and conduct the first high-speed, high-altitude flight demonstration to simulate Mars Atmospheric

entry/descent conditions for the world's largest planetary parachute, and the world's first supersonic inflatable decelerators.
- **Deep Space Atomic Clock** will complete its critical design review and fabricate the global positioning system receiver and clock ultra-stable oscillator, and conduct final payload integration and testing prior to the flight readiness review in early FY 2015.
- **Solar Sail** will be entering its final design and fabrication phase progressing toward system integration and flight readiness review in FY 2014 as it prepares for an early FY 2015 launch.

SMALL SPACECRAFT TECHNOLOGY

Small Spacecraft Technology develops and demonstrates technologies to enable new small spacecraft capabilities applicable for NASA's missions in science, exploration and utility by other government agencies, the commercial aerospace enterprise and the academic space sector. Small spacecraft can provide a low-cost platform for rapid in-space testing of new technologies and innovations. Small spacecraft can also perform unique missions that would not be possible with conventional spacecraft, such as simultaneous space weather observations from dozens of small satellites distributed around the globe. All small spacecraft demonstrations are delivered to space through rideshares or as hosted payloads aboard other vehicles going to appropriate destinations. NASA will share the results of the program's development and demonstrations with the national space community to provide opportunities for infusion into ongoing or planned missions.

- **Edison Demonstration of Smallsat Networks** will fly a group of eight small satellites to demonstrate their utility as low-cost platforms for coordinated space science observations and other applications. Each satellite carries an instrument for measuring the space radiation environment and the information from all satellites will be collected through a single ground station.
- **Integrated Solar Array and Reflectarray Antenna for High Bandwidth CubeSat**, a three-unit CubeSat that will demonstrate a radio frequency communication system that dramatically boosts the amount of data that the small satellite can transmit by using the back of its solar array as a reflector for the antenna.
- **Optical Communications and Sensor Demonstration** will demonstrate a laser communication system for sending large amounts of information from a satellite to Earth and also demonstrate low-cost radar and optical sensors for helping a pair of 1.5-unit CubeSats maneuver near each other. The mission is expected to take two years to develop and launch.
- **CubeSat Proximity Operations Demonstration** will use two three-unit CubeSats to demonstrate rendezvous and mechanical docking of small spacecraft in orbit. This project is expected to take three years to develop, launch, and operate.

Achievements in FY 2012

Small Spacecraft Technology competitively selected three projects to advance technologies for small spacecraft in the areas of communications, proximity operations, rendezvous and docking. Technology demonstration flights will take place from 2014 to 2016. In addition, Small Spacecraft Technology completed a preliminary design review of the Edison Demonstration of Smallsat Networks spacecraft cluster and finalized preparations for the launch of the PhoneSat mission.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

Work in Progress in FY 2013

The PhoneSat mission will send three CubeSats into space as a rideshare on the inaugural launch of the Orbital Science Corporation's Antares vehicle currently scheduled for early 2013. The PhoneSat spacecraft are expected to be the lowest-cost spacecraft ever launched by NASA and they employ an off-the-shelf mobile telephone as the on-board computer and control system. This flight will demonstrate the potential utility of such satellites as extremely low-cost platforms for science, exploration and commercial ventures in space.

Key Achievements Planned for FY 2014

The Edison Demonstration of Smallsat Networks spacecraft cluster of eight small satellites is expected to launch in late 2013. NASA is partnering with the Operationally Responsive Space Office for a launch on the Super Strypi launch vehicle. NASA is also providing a unit for dispensing multiple satellites for this launch. The Integrated Solar Array and Reflectarray Antenna is planning for a launch in 2014, and the Integrated Optical Communications and Proximity Sensors for CubeSats missions will be preparing for launch in early 2015.

FLIGHT OPPORTUNITIES

Flight Opportunities matures technologies by providing affordable access to space environments while also facilitating the development of the commercial reusable suborbital transportation industry. The project also procures commercial parabolic flights to test technologies in environments that simulate microgravity and the reduced gravity environments. Flight Opportunities has seven companies on contract to provide integration and flight services aboard commercial reusable sub-orbital vehicles. In addition, the Zero G Corporation is on contract through NASA's Reduced Gravity Office for parabolic flights. These vehicles carry payloads in reduced gravity and near the boundary of space. The program supports flights for unfunded payloads selected though Announcements of Flight Opportunities and funded payloads selected through FY 2012 and FY 2013 NASA Research Announcements. In addition, the program is collaborating with Science Mission Directorate and other NASA programs to make space available for technologies appropriate for the available platforms within the Flight Opportunities program.

Achievements in FY 2012

- Selected 14 advanced payloads for technology development and subsequent suborbital flights; through Announcements of Opportunities, selected 26 advanced space technology payloads for parabolic and suborbital flights.
- Conducted 3 parabolic flight campaigns and 4 reusable suborbital flight campaigns flying 30 technology payloads in relevant flight environments.
- Conducted a series of suborbital, reusable launch vehicle flights through Masten Space Systems to demonstrate the ability of the GENIE system to simulate a planetary descent and landing achieving full closed-loop control on a trajectory 50 meters in altitude and 50 meters downrange.
- Launched on a UP Aerospace Inc. SpaceLoft™ vehicle with the Suborbital Flight Environment Monitor. This compact, self-contained payload monitors and records on-board environmental parameters of interest during flight using commercially available instruments.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

Work in Progress in FY 2013

Flight Opportunities plans to utilize four of eight flight providers to host payloads supported by the Space Technology program on multiple flights. The program conducted one parabolic flight campaign and three suborbital flight campaigns in late 2012 and is scheduled to conduct two parabolic flight campaigns (with approximately 10 payloads) and at least five suborbital campaigns through the remainder of FY 2013. The program will continue solicit and select payloads through an Announcement of Opportunities for both parabolic and reusable suborbital flights. By the end of FY 2013, the program also expects to release its second Broad Area Announcement to solicit and select payload technology developments and flight services. By the end of FY 2013, the program expects to have nearly 100 payloads in its payload pipeline and will have flown 24 flights on four different platforms, to accommodate approximately 85 payload flights. The suborbital, reusable platforms are generating business outside of Space Technology. For example, Masten Space Systems is supporting landing demonstrations for JPL and has advertised flights available. In addition, UP Aerospace has conducted several launches for, for Department of Defense and education customers.

Key Achievements Planned for FY 2014

Flight Opportunities expects two additional providers to be utilized for the first time in FY 2014 and will schedule multiple flight campaigns based on payload demand using all eligible flight providers. With a demand of approximately 150 payload flights expected, Space Technology will support additional flights on suborbital reusable platforms, conducting approximately 30 flights.

Program Schedule

Specific timelines for deliverables and achievement major milestones vary from project to project, and depend on successful demonstration of experimental capabilities.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

Program Management & Commitments

Program Element	Provider
Space Technology Research Grants	Provider: U.S. Universities Lead Center: NASA HQ Program Executive Performing Centers: GRC Cost Share Partners: N/A
NASA Innovative Advanced Concepts	Provider: Various Lead Center: NASA HQ Program Executive Performing Center: Various Cost Share Partners: Cost Sharing is Encouraged
Center Innovation Fund	Provider: NASA Centers Lead Center: NASA HQ Program Executive Performing Center: All Cost Share Partners: Cost Sharing is Encouraged
Centennial Challenges	Provider: Various Lead Center: NASA HQ Program Executive Performing Center: MSFC Cost Share Partners: External partners fund competition events; NASA supplies prize money
Game Changing Development	Provider: Various Lead Center: NASA HQ Program Executive Performing Center: LaRC Cost Share Partners: Various
Technology Demonstration Missions	Provider: Various Lead Center: NASA HQ Program Executive Performing Center: MSFC Cost Share Partners: Other NASA programs; NOAA
Small Spacecraft	Provider: Various Lead Center: NASA HQ program executive Performing Centers: ARC Cost Share Partners: Various
Flight Opportunities	Provider: Various Lead Center: NASA HQ program executive Performing Center: DFRC Cost Share Partners: Various

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT

Acquisition Strategy

Crosscutting Space Technology Development is implemented through a blended acquisition approach, using both open competitive and strategically guided processes. All solicitations are open to the broad aerospace community to ensure engagement with the best sources of new and innovative technology. As such, CSTD efforts are performed by the Nation's highly skilled workforce in industry, academia, across all NASA Centers, and in collaboration with other Government agencies. Awards are made based on technical merit, cost, and impact to the Nation's future space activities. NASA uses acquisition mechanisms such as broad agency announcements, NASA research announcements, Space Act agreements, requests for proposals and prize competitions, with awards guided by priorities cited in the space technology roadmaps and by NASA mission directorates. Future solicitations particularly within Game Changing Development, Flight Opportunities, and Small Spacecraft Technologies will endeavor to use funded Space Act agreements where these approaches are likely to yield more efficient acquisitions.

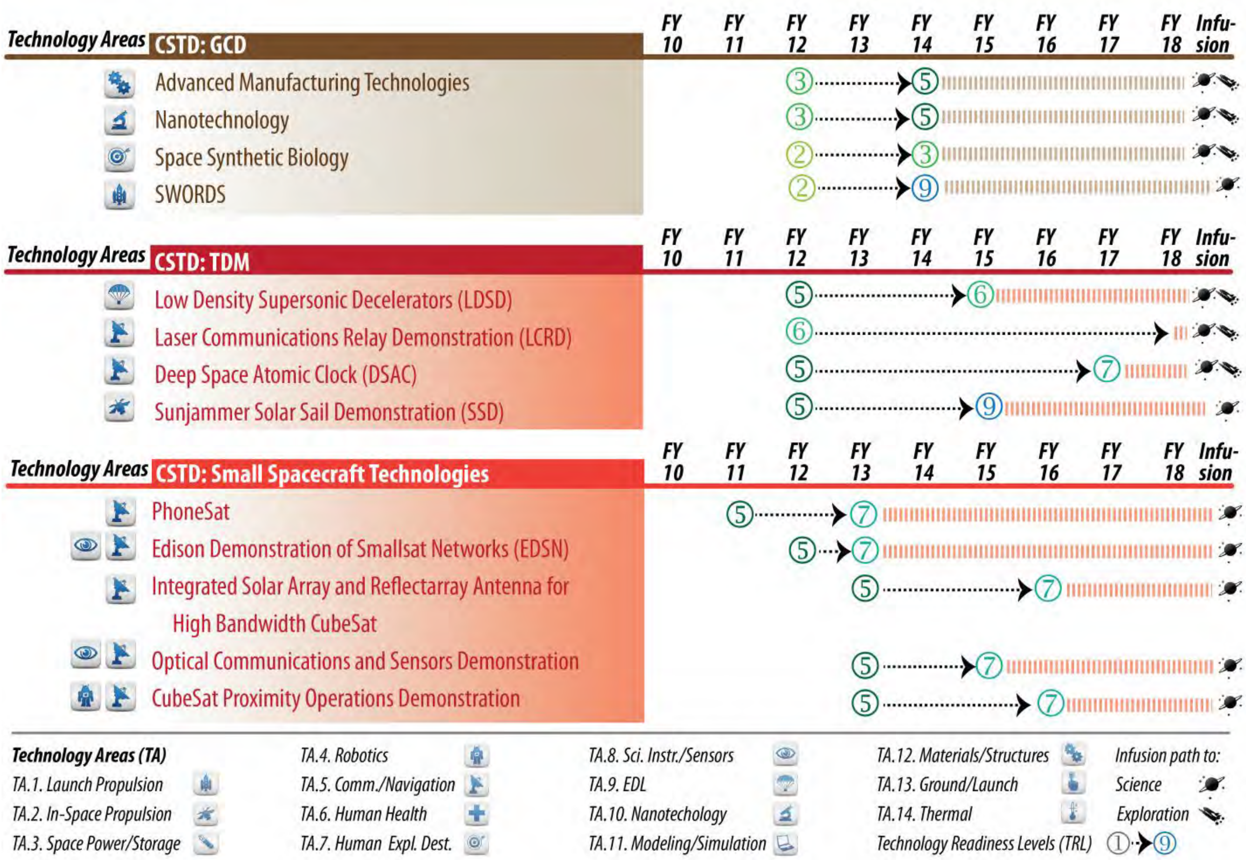
MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Technology Demonstration Missions		
Laser Communications Relay Demonstration	David Israel, Principal Investigator, GSFC	Greenbelt, MD
Deep Space Atomic Clock	Todd Ely, Principal Investigator California Institute of Technology, JPL	Pasadena, CA
Solar Sail	Nathan Barnes, Principal Investigator L'Garde, Inc.	Tustin, CA
Low Density Supersonic Decelerator	Mark Adler, Project Manager, California Institute of Technology, JPL	California Institute of Technology, JPL
Small Spacecraft Technology		
"Integrated Solar Array and Reflectarray Antenna (ISARA) for High Bandwidth CubeSat Laboratory, Pasadena, Calif., partnering with Pumpkin Inc. of San Francisco.	Richard Hodges, JPL Pumpkin Inc.	Pasadena, CA San Francisco, CA
SST: "Integrated Optical Communications and Proximity Sensors for Cubesats," Siegfried Janson, Aerospace Corporation of El Segundo, Calif.	Siegfried Janson, Aerospace Corporation	El Segundo, CA
SST: "Proximity Operations Nano-Satellite Flight Demonstration," Partners on the project include.	Charles MacGillivray, Tyvak Nano-Satellite Systems LLC Applied Defense Solutions Inc 406 Aerospace LLC California Polytechnic State University	Orange, CA Columbia, MD Bozeman, MT San Luis Obispo, CA

Crosscutting Space Technology Development

Historical Performance

This technology investment overview identifies a subset of active Space Technology development efforts, illustrating core technology areas that aligned with the Space Technology roadmaps and anticipated technology maturation through the life cycle of the project leading to its potential mission infusion path. All the projects listed below are on track to mature and deliver technology advancements in the timeframe specified. Specific timelines for deliverables and achievement major milestones vary from project to project, and are widely dependent on successful demonstration of experimental capabilities.



EXPLORATION TECHNOLOGY DEVELOPMENT

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	190.0	--	**244.5**	260.1	294.6	255.5	252.0
Change from FY 2012	--	--	**54.5**				
Percentage change from FY 2012	--	--	**28.7 %**				

ATK's MegaFlexTM solar array is one of two concepts NASA is maturing to support the development of next generation solar arrays capable of generating more than twice the power for the same mass and using only 1/3 the packing volume relative to current systems. NASA is developing these advanced arrays primarily to support advanced Solar Electric Propulsion (an essential capability to provide efficient human exploration beyond cis-lunar space), however the technology is also a critical next step for all future satellites, such as communications satellites, requiring high-power.

The capabilities NASA pursues within Exploration Technology Development (ETD) provide the long-range, enabling technologies required to conduct future human exploration missions beyond low Earth orbit. Space Technology develops and demonstrates these critical technologies to permit affordable and reliable human exploration missions for destinations that include the Moon, Lagrange points, near Earth asteroids, and Mars. Through ETD, Space Technology conducts technology development and testing in laboratories and ground facilities, as well as technology demonstrations in relevant flight environments.

Exploration Technology Development focuses on the highest priority human spaceflight technology gaps as identified in NASA's Space Technology Roadmaps, and is guided by the technology prioritization studies performed by Exploration's human spaceflight architecture studies. Technology development is closely coordinated with the system capability demonstrations pursued within NASA Exploration, particularly within the Advanced Exploration Systems (AES) Program.

Among the priorities identified, the following space technology projects are supported within Game Changing Development's ETD work: Solar Electric Propulsion technologies, Human-Robotics Systems, Next Generation Life Support, In-Situ Resource Utilization, Composite Cryogenic Propellant Tanks, and Entry Systems Technologies. These technologies harness the power of the Sun for in-space propulsion, provide robotic assistance for routine and/or risky in-space operations, move toward closed-loop mission capabilities for long duration missions, improve spacecraft efficiency on launch, and enhance landing capabilities for entry on planets with atmosphere. Game Changing Development (GCD) pursues proof of concept development and testing of these technologies to either provide direct infusion into future exploration missions, or feed systems demonstrations into Technology Demonstration Missions or Advanced Exploration Systems.

EXPLORATION TECHNOLOGY DEVELOPMENT

NASA is also funding the following Technology Demonstration Missions within Exploration Technology Development: Solar Electric Propulsion, Human Exploration Telerobotics, Cryogenic Propellant Storage and Transfer, and Green Propellant Infusion Mission. These technologies test increasingly complicated robotic operations as they are controlled from ground stations to space-based assets, provide dramatically improved in-space cryogenic storage and transfer capabilities, and develop a greener and cheaper alternative for hazardous hydrazine fuel. After successful maturation and demonstration of these critical technologies, Space Technology will infuse them directly into future human exploration architecture and the aerospace community.

EXPLANATION OF MAJOR CHANGES

NASA will accelerate development of a Solar Electric Propulsion demonstration effort within Technology Demonstration Missions. This demonstration is critical to enable infusion of this capability into multiple applications, and will be a key system to enable the robotic segment of NASA's proposed asteroid retrieval mission that would be conducted in cooperation with Human Exploration and Operations and Science mission directorates.

Program Elements

GAME-CHANGING DEVELOPMENT (EXPLORATION)

Within ETD, FY 2013 program activities and FY 2014 plans have been organized into several human exploration-specific Game Changing Development projects.

Solar Electric Propulsion Technologies: For the purpose of future human missions beyond low Earth orbit, and to support the robotic segment of the proposed asteroid retrieval mission, one of the highest priority technology development needs is high power (approximately 300 kilowatts) Solar Electric Propulsion. While NASA has used solar electric propulsion for science missions and the commercial space community has used it for communications satellites, current system components, such as solar arrays, are not scalable to handle power and thrust levels needed deep space human exploration missions. Game Changing Development has several interrelated project elements in place to advance technologies that will feed into a Solar Electric Propulsion (SEP) demonstration to be conducted by Technology Demonstration Missions. Specific supported SEP technologies include:

- Electric Propulsion Thrusters: Leveraging work by the Department of Defense and NASA, these Hall affect electric thrusters will increase individual thruster power from 5 kilowatts to15 kilowatts. With development nearing completion, NASA will conduct ground testing of the thrusters to identify any risk for nozzle erosion, a significant concern in application for continuous long duration operations.
- Solar Array Systems: Following selection of two solar array system development contractors (ATK and Deployable Space Systems), this project makes viable Solar Electric Propulsion systems in excess of 300 kilowatts, while concurrently revolutionizing the power available for commercial geostationary communications satellites and other spacecraft demanding high power. The primary way to rate the efficiency or effectiveness of a solar array is by the amount of power

that it can produce compared to its mass. Another essential parameter for space-based solar arrays is the stowed volume that they require for a given power requirement. In fact, despite a need for solar arrays with ever greater power levels, current arrays have hit an upper limit of approximately 25 kilowatts per satellite because launch vehicle shrouds cannot accommodate greater volumes. The advanced solar arrays under development within this activity are intended to increase the efficiency of solar arrays by a least a fact or two and reduce the equivalent stowed volume threefold relative to existing arrays.

- Power processing units: Transferring and processing power between solar cells and Hall effect thrusters requires the careful design of efficient power management and distribution systems as well as power processing units. Current Game Changing investigations involve two, competing, high voltage (300 Volt) power processing unit design approaches.

Next-Generation Life Support develops next-generation life support systems technologies, including water recovery, thermal control, and spacesuit component technologies. In collaboration with AES, this project is developing portable life-support system technologies to integrate into the next generation Extravehicular Mobility Unit. The project element also develops and demonstrates an alternative water processor that can recover water more efficiently and reduce resupply requirements in comparison to today's current system.

Human-Robotic Systems develops advanced robotics technologies to amplify human productivity and reduce mission risks by improving human-robot interaction, developing robotic assistance, improving robotic planetary rovers and providing in-space servicing, manipulation and mobility systems. Specific technology items include: improved jetpacks and robotically supported spacesuit gloves for extravehicular activities; hardware capabilities for Robonaut 2, a humanoid robot undergoing testing on the International Space Station; and an exoskeleton system, a wearable robot which could be used as an exercise device, a mobility assistant and a joint and muscle health monitor for astronauts. As development activities progress on the ground, International Space Station crews will be provided hardware and software including updates to Robonaut 2, to enable new tasks on the International Space Station. Human Robotics Systems technology also supports the Agency’s role in the National Robotics Initiative. The activities supported under this initiative support the development and use of robots for space exploration, manufacturers and businesses.

Composite Cryogenic Propellant Tanks uses advanced composite materials to develop very large, lightweight propellant tanks using out-of-autoclave manufacturing techniques. Current autoclave processes for composites require use of a complex, high pressure, high temperature vessel that is expensive to operate, particularly when accommodating larger articles such as propellant tanks. Upon successful validation, the composite tanks will be applicable to future NASA human exploration architecture elements including the Space Launch System and its upper stage. In addition, NASA will have contributed to improving upon currently costly aerospace manufacturing processes used for either metallic or composite manufacturing, potentially drastically reducing the cost and time required to manufacture very large aerospace structures.

Entry Systems Technologies designs, analyzes, and tests architectures, component systems, and thermal protection technologies needed for planetary entry missions. Spacecraft experience extreme heating as they use a planet’s atmosphere to slow the spacecraft during entry. Advances in these technologies will enable improved atmospheric entry capability at Venus, Earth, Mars, Titan, and the Giant Planets. Specific innovations and concepts under development and validation include mechanical deployable aeroshells and a new generation of flexible ablative thermal protection materials. The activity also funds advanced analytical capabilities for hypersonic flight including aerothermodynamics and material thermal response analyses. This project successfully demonstrated the Hypersonic Inflatable Aerodynamic Decelerators through deployment from a sounding rocket. This technology could significantly increase the landed mass and landing accuracy capabilities for future missions to other planets such as Mars. Also, within this project, NASA will deliver a remarkable material system breakthrough, woven thermal protection system, to Exploration for the potential use on the Orion crew vehicle and for future use on missions targeting a variety of planetary destinations. Woven Thermal Protection System uses carbon fiber, infused with resin that is then woven in three dimensional layers. By using lightweight, readily available materials and adjusting the weave pattern and density, this cost effective system is fully customizable, providing thermal protection for a wide variety of atmospheric entry conditions.

Advanced In-Space Power develops next generation, high efficiency solar cells, where work focuses on improving reliability and affordability. The activity also develops advanced lithium-ion batteries through the exploration of new anodes, cathodes, and electrolyte chemistries, resulting in batteries capable of more than double the specific energy of the best current batteries. Maturing batteries with high energy density is considered critical for future extravehicular activity suits. Additionally, the project element advances regenerative non-flow through fuel cell technology, resulting in high power fuel cells that do not require consumables and are highly reliable.

In addition to the key technologies mentioned above, Game Changing Development is supporting the maturation of the following technologies:

- **Nuclear Systems** tests power conversion and thermal management technologies for future in-space nuclear power systems.
- **Autonomous Systems** develops and demonstrates integrated autonomous systems capable of simplifying and managing complex ground and in-space operations to reduce workload and the dependence upon ground support staff and flight operations centers impacted by long distance related communication time delays. This includes autonomous cryogenic loading operations for mission operations, and habitation automation software for deep space habitats.
- **Lightweight Materials and Structures** develops advanced space structures and material systems as well as modeling and testing to support these capabilities. Structural systems include inflatables for habitats and other space based applications, as well as deployables, rigidizables and tension frames.
- **In-Situ Resource Utilization** enables sustainable human exploration through use of resources found at future exploration destinations. Concepts explore the production of fuel, oxygen, and water from the soil and atmosphere of celestial bodies. Game Changing activities focus on the development of instrumentation to identify potential resources, including neutron and near infrared spectrometers and a lunar advanced volatile analysis instrument in support of the AES RESOLVE project.
- **Advanced Radiation Protection** assesses and matures transformative technologies to improve the radiation protection capabilities of future deep space exploration vehicles and habitats. This element focuses on radiation modeling and analysis as well as forecast modeling of space weather to complement AES work on radiation protection.

EXPLORATION TECHNOLOGY DEVELOPMENT

Achievements in FY 2012

In addition to the successful Hypersonic Inflatable Aerodynamic Decelerator demonstration and the Composite Cryogenic Propellant Tank mentioned in the overview, Space Technology achieved the following:

- **Game Changing** awarded two industry-led teams, through a competitive research announcement, to develop advanced Solar Array Systems. ATK and Deployable Space Systems are concurrently developing robust solar arrays deployment systems required for high powered **Solar Electric Propulsion**. Developing highly efficient and compactly packaged solar array technology is also a key enabler for future high-power commercial communications satellites.
- **Human Robotic Systems** developed and initiated final ground testing of dexterous legs for use by Robonaut 2. These legs allow the humanoid robot to achieve mobility through use of the Space Station hand rails allowing the robot to better support a variety of routine chores. In addition, NASA worked with the Florida Institute for Human and Machine Cognition (IHMC) of Pensacola, and Oceaneering Space Systems of Houston, Texas to develop a robotic exoskeleton called X1. The 57-pound device is a robot that an astronaut could wear over his or her body either to assist or inhibit movement in leg joints.
- **Advanced In-Space Power** developed new electrolyte chemistries, cathodes and anodes that increase energy density and efficiency in lithium-ion batteries. The outcome of this development will produce batteries that can support longer extravehicular activities, lasting up to eight hours, while improving power stability and increased safety. NASA Glenn Research Center utilized its fuel cell expertise, in partnership with the Cleveland Regional Transit Authority, to provide hydrogen gas sensor technology and instruments for Cleveland's new hydrogen fuel cell powered bus and Ohio's only hydrogen refueling station.

Work in Progress in FY 2013

- **Advanced In-Space Power** Fabricated and tested fuel cells for integration into the Advanced Exploration Systems Scarab Rover. The project will also complete a 3-kilowatt, non-flow through fuel cell, which reduces fuel cell system mass and eliminates the primary cause of system failure by replacing pumps with a passive wicking system.
- **Human-Robotic Systems** is completing functional testing of the next generation “jet pack” prototype for use on future extravehicular activities and Exoskeleton continues to enhance capabilities to further support astronaut fitness and joint monitoring. In addition, robotic legs will be delivered to the International Space Station to provide greater mobility for Robonaut 2.
- **Lightweight Materials and Structures** is finalizing prototype design and testing of a complete multi-layer insulation material system critical for cryogenic fluid storage, with potential for infusion into the Cryogenic Propellant Storage and Transfer Technology Demonstration Mission project.
- **Entry Systems Technologies** performed arcjet tests of Woven Thermal Protection Systems demonstrating their performance for application as Orion compression pads.
- **In Situ Resource Utilization** is conducting final fabrication and testing efforts of neutron spectrometers and volatile analysis instruments in preparation for the delivery of these components to Advanced Exploration Systems and the RESOLVE project.
- **Solar Electric Propulsion** will conduct ground testing of high power Hall thrusters, comparing the results with computational models to verify their ability to endure long-duration use.

EXPLORATION TECHNOLOGY DEVELOPMENT

Key Achievements Planned for FY 2014

- **Solar Electric Propulsion** ATK and Deployable Space Systems will complete the development, analysis and ground testing of candidate systems maturing two options for deployment systems. NASA will select one of these advanced solar array designs for inclusion into its planned high-power solar electric propulsion demonstration.
- Following critical design review and delivery of the 2.4-meter tank to Marshall Space Flight Center in late 2013, a 5.5-meter **Composite Cryogenic Propellant Tank** will be manufactured and pressure tested to ensure it can hold extremely cold cryogenics propellant. If successful, these tanks have the potential to significantly reduce the cost and weight for heavy-lift launch vehicles including the Space Launch System and its future cryogenic propulsive stage.
- **Next Generation Life Support** expects to deliver an alternative water processor for evaluation by the AES Water Recovery Project, and the portable life support system components will be delivered for infusion into the Extra Vehicular Activity project element under AES.

TECHNOLOGY DEMONSTRATION MISSION (EXPLORATION)

NASA will continue development of exploration-specific Technology Demonstration Missions that directly enable future human exploration missions as well as provide mature capabilities for U.S. Government agencies, and the overall space industry. This investment area brings technologies up from the proof-of-concept, initial validation and ground demonstration phases, and demonstrates their capabilities within integrated systems in a relevant flight environment, prior to their infusion in future missions. The current portfolio of exploration-specific Technology Demonstration Missions is described below:

- Space Technology will accelerate development of a **Solar Electric Propulsion** capability. The system will use solar array systems, Hall thrusters and power processing technologies matured and tested under Game Changing Development. NASA will leverage internal and external expertise and industry partners to develop a cost effective Solar Electric Propulsion demonstration system. This SEP system will utilize 30 to 50 kilowatt advanced solar arrays, 5 to 15 kilowatt Hall thrusters and high voltage advanced power processing units. This full-scale flight demonstration may be leveraged to provide propulsion for the asteroid retrieval mission. Once proven, high-powered solar electric propulsion will have wide application in commercial communications satellites as well as other government agencies and is critical for future robotic and human NASA missions outside the Earth-moon system.
- **Human Exploration Telerobotics** demonstrates continued and progressively challenging operations for Robonaut 2 and Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) on the International Space Station, as well as the demonstration of remote robotic operations, where robots on Earth are operated from the International Space Station to simulate similar operations of robots at planetary destinations from crewed vehicles.
- **Cryogenic Propellant Storage and Transfer** demonstrates the capability of in-space long-term storage and transfer of cryogenic propellants (liquid oxygen and hydrogen), essential for transportation on deep-space exploration missions. Cryogenic propellant storage and transfer is considered a very high priority for NASA and was further identified in the National Academies' Space Technology Roadmap as a critical capability. Beyond the Orion capsule and Space Launch System, the development of an in-space cryogenic propulsion stage is considered the next critical element of a deep space human exploration architecture. The cryogenic propulsion stage must be

capable of performing long-term storage as well as propellant transfer in a zero-g environment. The same capabilities are also sought for multiple crosscutting applications, including propellant depots.

- **Green Propellant Infusion Mission** seeks to find an alternate to hydrazine fuel, which has been extensively used since the 1960's for space systems. Although highly reliable, hydrazine is highly corrosive and toxic, complicating transportation, handling and ground and flight operations. Green propellant alternatives are actively sought by spacecraft developers as in-space mono-prop replacements for hydrazine. Higher performing and safer green propellant alternatives are at a tipping point. Once demonstrated within the context of an in-space application, rapid infusion will occur into a variety of spacecraft. NASA selected Ball Aerospace to demonstrate the capabilities of AF-M315E. This innovative, low-toxicity propellant is expected to improve overall vehicle performance. It boasts a higher density than hydrazine, meaning more of it can be stored in containers of the same volume; it delivers a higher specific impulse, or thrust delivered per given quantity of fuel; and it has a lower freezing point, requiring less spacecraft power to maintain its temperature. This fuel also has the potential to improve processing efficiency and decrease operational costs by reducing health and environmental hazards. Ball Aerospace joins NASA, Department of Defense, and Aerojet to develop a spaceflight payload to demonstrate a green propellant subsystem for a small to medium-size spacecraft, resulting in a highly safe and functional green propellant system ready for use by commercial and government customers. NASA is in the process of securing a rideshare opportunity for an FY 2015 technology demonstration.

Achievements in FY 2012

As noted in the overview, MEDLI successfully collected pressure, temperature, and thermal protection system recession data as MSL entered the Martian atmosphere. Initial analysis of the data received is already informing future Mars missions. In addition, under **Human Exploration Telerobotics**, Robonaut 2 demonstrated its capabilities in support of numerous housekeeping tasks on the International Space Station by taking environment readings, conducting simulated repairs and handrail cleaning with the hope to offload these tasks from the crew in the future. Space Technology selected a team led by Ball Aerospace & Technologies Corporation of Boulder, Colorado, for a technology demonstration of a high performance "green" propellant alternative to the highly toxic fuel hydrazine. Finally, **Cryogenic Propellant Storage and Transfer** progressed through mission concept review.

Work in Progress in FY 2013

Within Technology Demonstration Missions, NASA is developing technology demonstrations to:

- Conduct challenging **Human Exploration Telerobotics** demonstrations including, the command and control (both locally and from the ground) of Robonaut 2 to autonomously perform functions aboard the International Space Station, as well as command and control of K10 robot from ISS.
- **Cryogenic Propellant Storage and Transfer** is completing key technology developments ahead of designing the flight demonstration system, including test of the active cooling system with one-third reduction in liquid hydrogen boil off.
- **Green Propellant Infusion Mission** conducted a system requirements review and will complete preliminary design review near the end of the fiscal year. Green propellant thruster development and testing is progressing toward the development of flight-weight thrusters.

EXPLORATION TECHNOLOGY DEVELOPMENT

Key Achievements Planned for FY 2014

- **Green Propellant Infusion Mission** will conduct hardware testing and complete critical design review in preparation for the flight demonstration in 2015.
- **Human Exploration Telerobotics** will complete all currently planned Robonaut 2, SPHERES and remote telerobotic operations testing on ISS.
- TDM will be working closely with Game Changing to accelerate technology development of solar arrays, Hall effects thrusters and power processing units to ready them for inclusion into the **solar electric propulsion system.**

Program Schedule

Both Game Changing Development and Technology Demonstration Missions are composed of sets of uncoupled project elements. Each project element pursues independent timelines to achieve technology milestones, technology deliveries, and/or programmatic decision points. Specific timelines for deliverables and milestones vary from project to project, and are widely dependent on the results of design, development, fabrication, analyses, and testing.

Program Management & Commitments

NASA is implementing an integrated management approach to ETD and CSTD projects to capitalize on technical and management synergies. The two main projects under the ETD program, exploration-specific Game Changing Development and exploration-specific Technology Demonstration Missions, each have a Level 1 Headquarters program executive and Center managed Level 2 project office (shared with CSTD).

Program Element	Provider
Game Changing Development	Provider: HQ program executive Lead Center: LaRC Performing Centers: All Cost Share Partners: Varies
Technology Demonstration Missions	Provider: NASA HQ program executive Lead Center: MSFC Performing Center: All Cost Share Partners: Varies

EXPLORATION TECHNOLOGY DEVELOPMENT

Acquisition Strategy

Additional competitively selected project elements will augment those openly selected or created as guided activities in FY 2013 or earlier. The focused technology areas for additional competitive project elements are determined by the priorities established within the Exploration program architecture studies as well as the NASA technology roadmapping and the Strategic Technology Investment Portfolio Plan. To the extent possible and advantageous to the government, future Game Changing Development procurements will use funded Space Act Agreements in place of Cost Plus Fixed Fee or Fixed Price contracts. Technology Demonstration Missions will use both open competition Broad Area Announcements, and directed activities in critical near term areas. Technology Demonstration Missions proposers are strongly encouraged to partner and cost share with non-NASA entities. Space Technology draws on proposals from industry, academia, NASA Centers, and other government agencies, to assemble a portfolio of high-value complementary or gap areas technology demonstrations.

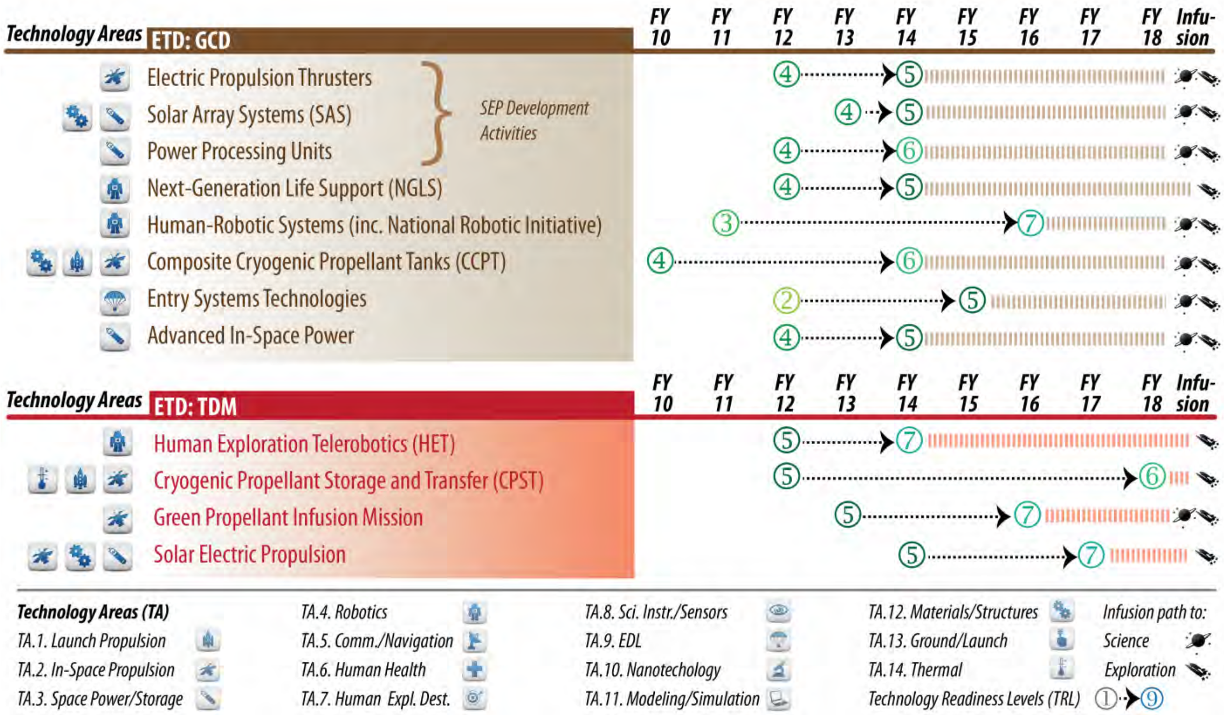
MAJOR CONTRACTS/AWARDS

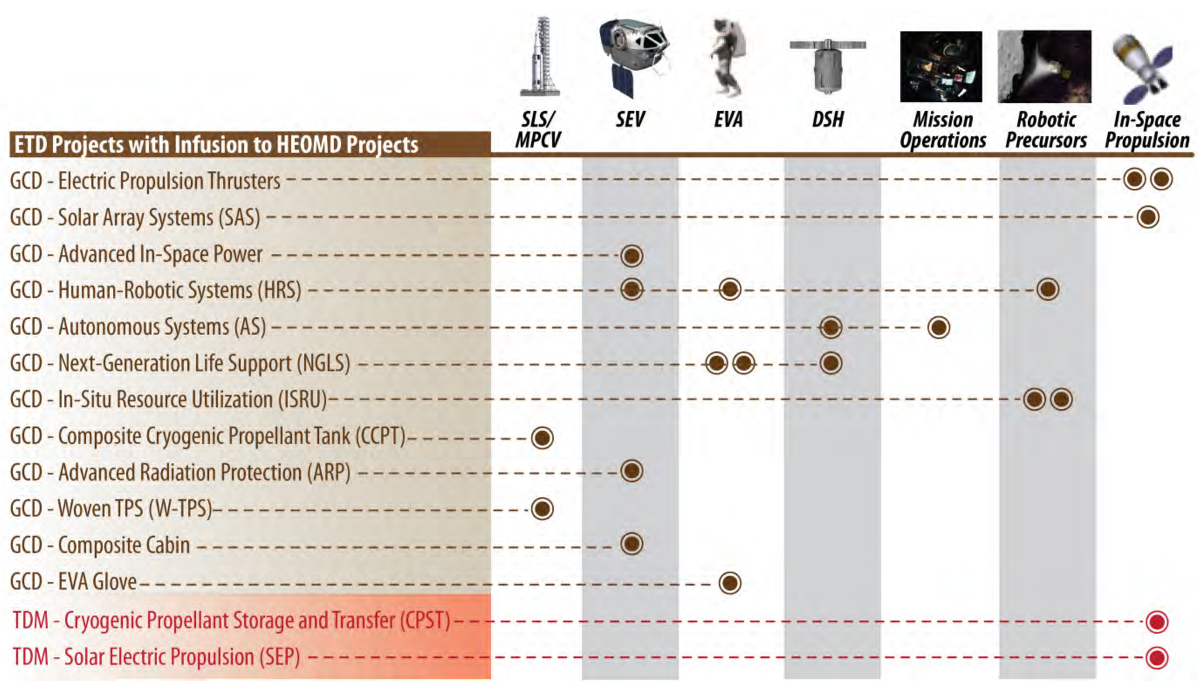
Element	Vendor	Location (of work performance)
GCD-Human Robotics Systems	Rob Ambrose, Principal Investigator, JSC	Houston, TX
GCD-Solar Array Systems	Deployable Space Structures and ATK	Goleta, CA Commerce, CA
TDM-Solar Electric Propulsion	Margaret Nazario, Project Manager, GRC; JPL	Cleveland, OH Pasadena, CA
TDM-Cryogenic Propellant Storage and Transfer	Susan Motil, Project Manager, GRC; MSFC, GSFC, KSC, ARC	Cleveland, OH; Huntsville, AL, Greenbelt, MD; Cape Canaveral, FL, Moffett Field, CA
TDM-Human Exploration Telerobotics	Terry Fong, Project Manager, ARC	Moffett Field, CA
TDM Green Propellant	Ball Aerospace (Prime); Aerojet Corporation; U.S. Air Force Research Laboratory; U.S. Air Force Space and Missile Systems Center	Boulder, CO; Redmond, WA; Edwards, CA; Albuquerque, NM

HISTORICAL PERFORMANCE

The following technology investment overview identifies a subset of active Space Technology development efforts, illustrating their core technology areas (aligned with the Space Technology roadmaps) and anticipated technology maturation through the life cycle of the project as awarded. These efforts were primarily initiated in previous fiscal years by other NASA organizations and transferred to Space Technology. All the projects listed below are on track to mature and deliver technology advancements in the timeframe specified.

EXPLORATION TECHNOLOGY DEVELOPMENT





HUMAN EXPLORATION AND OPERATIONS

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	7877.2	8023.8	**7798.4**	7966.9	7966.9	7966.9	7966.9
Exploration	3707.3	3790.1	**3915.5**	3952.0	3970.7	3799.0	3589.3
Space Operations	4184.0	4247.8	**3882.9**	4014.9	3996.2	4167.9	4377.6

HUMAN EXPLORATION AND OPERATIONS

HUMAN EXPLORATION AND OPERATIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	7877.2	8023.8	**7798.4**	7966.9	7966.9	7966.9	7966.9
Exploration	3707.3	3790.1	**3915.5**	3952.0	3970.7	3799.0	3589.3
Space Operations	4184.0	4247.8	**3882.9**	4014.9	3996.2	4167.9	4377.6
Subtotal	7891.3	8037.9	**7798.4**	7966.9	7966.9	7966.9	7966.9
Rescission of prior-year unob. balances**	-14.1	-14.1	**--**	--	--	--	--
Change from FY 2012	--	--	**-78.8**				
Percentage change from FY 2012	--	--	**-1.0 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Exploration and Space Operations pursuant to P.L. 112-55, Division B, sec. 528(f).*

NASA has entered a new era in human spaceflight, increasing our reliance on the private sector for low Earth orbit operations and reaching beyond low Earth orbit to expand presence into the boundless expanse of space. The Human Exploration and Operations (HEO) budget supports a portfolio of development and operational programs, interwoven to engage private industry, expand international partnerships, and extend the boundaries of scientific and technical knowledge to expand human exploration of space.

Capability Driven Exploration: Enabling Multiple Destinations

In this new era, NASA will implement a multiple destination exploration strategy, using a capability-driven approach. Though the horizon destination is Mars, the President has directed the Agency's next major step to be a mission to an asteroid in 2025. Other potential destinations beyond low Earth orbit, include the Moon and the expanse of space surrounding the Earth and Moon, known as cis-lunar space.

Spaceflight Cornerstone: International Space Station

NASA and its partners from around the globe are using the unique capabilities of the International Space Station (ISS) to build experience and lay the groundwork for future space activities with technology demonstrations, tests, and experiments essential to mission success now and in the future. NASA's ISS research is also critical to advancing capabilities like autonomous rendezvous and docking, advanced communications systems, and human health and behavioral research.

ISS is a unique platform for scientific research, including a major astrophysics experiment designed to uncover the nature of dark matter in the universe, and three Earth science experiments slated to fly beginning in 2014. The internationally developed Alpha Magnetic Spectrometer particle physics detector was launched and attached to ISS in May 2011. ISS provides these instruments a stable space-based platform with independent power, data and thermal control.

In addition, ISS is a means to explore the feasibility of commercial research activities in low Earth orbit. This National Laboratory in space is accessible to a wide range of researchers and entrepreneurs, ready to develop groundbreaking technologies and products. The ISS is funded within the Operations account, while research and development efforts can be found in both the Operations and Exploration budgets.

Affordable American Access to Low Earth Orbit: Commercial Spaceflight

In an effort to reduce reliance on foreign providers and help develop an affordable American capability, NASA is leveraging partnerships with US commercial enterprises to provide cargo and eventually crew transport services to low Earth orbit. Rather than building, owning, and operating the necessary systems, this approach allows NASA to reduce costs, improve affordability and sustainability, and stimulate the US space transportation industry. Commercial systems development is part of the Exploration budget, while the purchase of commercial transportation services for ISS resides in the Operations account.

Exploration Beyond Low Earth Orbit: Space Launch System/Orion Multi-Purpose Crew Vehicle

Exploring deep space requires the capability to transport cargo and crew beyond low earth orbit. NASA is developing a new transportation system that includes a crew capsule, a heavy-lift launch vehicle, and supporting ground facilities and systems. The new launch vehicle, called the Space Launch System, leverages previous NASA systems such as the Space Shuttle main engines and solid rocket boosters, and will evolve from an initial 70-metric ton lift capacity to 130-metric tons, reducing the number of launches needed to conduct the most challenging human exploration missions. The Orion MPCV program is developing the vehicle that will carry a crew of four to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe reentry from deep space return speeds.

Extensive ground operations development is in work to support the new transportation system. Major development and technology efforts are funded within HEO’s Exploration account; test and launch support as well as ground operations services can be found in both the Exploration and Operations accounts. Once the system is operational, communications services will be funded through the Operations budget.

Near-Earth Asteroid: The Next Destination for Human Exploration

The Agency is currently working to align activities across the Human Exploration and Operations, Space Technology, and Science Mission Directorates to affordably pursue the Administration’s goal of a human visit to an asteroid. NASA is studying a robotic mission to capture and bring a small asteroid into a stable orbit in cislunar space. That mission would be followed by a rendezvous with and sampling of the asteroid with a crewed spaceflight mission. NASA will plan and begin design of these activities in 2013 and progress will continue conditional on its feasibility and affordability. HEO will work with SMD to collect the data necessary to identify an appropriate near earth asteroid target. HEO will lead development of a potential asteroid retrieval mission, while leveraging the work of Space Technology on cutting edge in-space propulsion. These steps would make this small captured asteroid accessible as an early destination for crews exploring beyond low Earth orbit with the Orion MPCV and Space Launch System.

EXPLORATION

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	3707.3	3790.1	**3915.5**	3952.0	3970.7	3799.0	3589.3
Exploration Systems Development	3002.0	--	**2730.0**	2789.8	2801.5	2818.3	2819.5
Commercial Spaceflight	406.0	--	**821.4**	821.4	821.4	590.0	371.0
Exploration Research and Development	303.0	--	**364.2**	340.8	347.8	390.7	398.7

Exploration

EXPLORATION

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	3707.3	3790.1	**3915.5**	3952.0	3970.7	3799.0	3589.3
Exploration Systems Development	3002.0	--	**2730.0**	2789.8	2801.5	2818.3	2819.5
Commercial Spaceflight	406.0	--	**821.4**	821.4	821.4	590.0	371.0
Exploration Research and Development	303.0	--	**364.2**	340.8	347.8	390.7	398.7
Subtotal	3711.0	3793.9	**3915.5**	3952.0	3970.7	3799.0	3589.3
Rescission of prior-year unob. balances**	-3.7	-3.7	**--**	--	--	--	--
Change from FY 2012	--	--	**208.2**				
Percentage change from FY 2012	--	--	**5.6 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Exploration Systems Development pursuant to P.L. 112-55, Division B, sec. 528(f).*

As NASA shapes the future of human space exploration, the Agency has developed a unique, multi-destination strategy using a capability-driven approach. Human Exploration and Operations (HEO) programs are developing a core set of evolving capabilities, within the Exploration budget that are intended to ensure that the Nation's space program is robust, affordable, sustainable, and flexible. Rather than creating specialized, destination-specific hardware, this will provide the Agency adequate flexibility to carry out increasingly complex missions to a range of destinations over time.

HEO's Exploration Systems Development programs are developing the first pieces of this capability-driven architecture for human exploration beyond Low Earth Orbit, the Orion Multi-Purpose Crew Vehicle (MPCV) and the Space Launch System (SLS). HEO's Advanced Exploration Systems (AES), in collaboration with Space Technology's solar electric propulsion demonstration project and the Science Mission Directorate's Planetary Science Program, is examining the feasibility of a precursor robotic mission that would approach, characterize, capture, and redirect a small near-Earth asteroid to a stable orbit in cis-lunar space. The SLS and MCV could then bring astronauts to the asteroid, providing a unique opportunity to both test the new deep space human exploration systems and return large asteroid samples to the Earth for study, and achieving the goal of a human visit to an asteroid in a more cost-effective manner.

In an effort to reduce reliance on foreign providers and help develop an affordable American capability, NASA is engaging in partnerships with U.S. the private sector to develop commercial systems to provide crew and cargo transportation services to and from low Earth orbit.

Expanding human presence into deep space requires that NASA expand its technical and scientific knowledge to tackle complex problems and devise creative new solutions to meet demands never before encountered by humans or machines. NASA's study of long-term human exposure to space has revealed unanticipated effects that must be addressed, and complex future missions may well depend on technologies not yet developed. This research is underway in Exploration Research and Development.

EXPLORATION

For more programmatic information, go to: http://www.nasa.gov/directorates/heo/home/index.html.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The Orion MPCV program rephased the vehicle test campaign sequence, shifting the ascent abort test from 2015 to 2018. In addition, NASA entered into an international agreement whereby the European Space Agency will design and develop the Orion MPCV service module for the first Exploration Mission (EM-1), scheduled for 2017.

To support the development of an asteroid mission in the coming years, Advanced Exploration Systems will develop an asteroid capture mechanism, investigate spacecraft control algorithms for capturing and redirecting an asteroid, and demonstrate concepts for astronaut extravehicular activity on the asteroid's surface. Long lead items in support of the overall asteroid retrieval mission may need to be acquired.

ACHIEVEMENTS IN FY 2012

The Space Launch System (SLS) program completed a major system requirements and definition review in July 2012, clearing the way for manufacture and test of key hardware elements. This includes production of a spacecraft docking and berthing mechanism that will fly on Exploration Flight Test-1 (EFT-1) in 2014. In addition, the J-2X engine for the Block 2 upper stage underwent rigorous testing at Stennis Space Center, reaching full power in a fraction of the time achieved by previous high-performance engines.

Early in FY 2012, the Agency added EFT-1 to the Orion MPCV program. This flight test, scheduled for the last quarter of FY 2014, will validate the vehicle's design to support Critical Design Review in 2015. In addition, the vehicle completed a battery of tests, including acoustic and vibration, water impact, and various parachute tests.

In August 2012, following a fully competitive process, the Commercial Crew program signed Space Act Agreements with Blue Origin, Sierra Nevada Corporation, Boeing, and Space Exploration Technologies (SpaceX). The initiative runs through May 2014, supporting commercial design and development efforts. All three providers have completed preliminary milestones providing system and program reviews and are well underway and on schedule for performing the remainder of the CCiCap milestones. Alliant Techsystems, Inc. (ATK), United Launch Alliance (ULA), and Excalibur Almaz Incorporated completed all of their unfunded CCDev2 milestones in FY 2012.

WORK IN PROGRESS IN FY 2013

The final vertical weld on the first production Orion MPCV stage was successfully completed in January 2013. In preparation for core stage testing in 2016, restoration work continues on the B-2 test stand at Stennis Space Center (SSC). Additionally, teams are preparing the Michoud Assembly Facility for production of SLS testing and flight articles.

Orion MPCV teams performed proof pressure testing of the first flight test crew module structure, which demonstrated that the primary structure (with hatches, windows, and wiring) is properly designed to hold an atmosphere for a crew. During the test, three structural ribs had minor cracking at a test pressure level above that ever seen in flight but below the maximum level they should be able to hold. The structure did not lose pressure but the test was stopped. Orion has now repaired this structure for this test flight and will use these test results to make design modifications to future primary structures to remove this issue. Boeing and SpaceX will complete integrated critical design of their Crew Transportation Systems, and perform significant development and risk reduction testing. Sierra Nevada Corporation will advance their system toward critical design, while focusing on safety analysis and subsystem technology maturation and risk reduction.

NASA is currently studying concepts for each segment of an asteroid mission—asteroid detection, characterization, and selection; robotic capture and redirection of an asteroid; and crewed rendezvous and return of samples from the asteroid. NASA plans a Mission Concept Review in the summer of 2013 to assess the technical feasibility and risk management approach to assure the affordability and success of such a mission within NASA’s budget.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In the Exploration Systems Development (ESD) area, SLS will conduct critical design reviews for the booster and core stage elements. The SLS-designed Orion MPCV spacecraft adapter will fly for the first time on uncrewed EFT-1 in 2014. This will be the first test flight of hardware designed and built by the SLS program.

Orion MPCV will complete EFT-1 test flight preparations. The launch window for EFT-1 begins in September of 2014 and extends into the first quarter of FY 2015. Exploration Ground Systems (EGS) will continue modernizing facilities to support the EM-1 launch, and enter the implementation phase of its life cycle, where final designs and initial fabrication take place.

The Commercial Crew program will continue to work towards US-crewed flight to ISS by 2017. SpaceX plans to perform a pad abort test, which will demonstrate the effectiveness of the Dragon spacecraft's launch abort system, and is a key design driver. Sierra Nevada plans to complete risk reduction and technical readiness testing to mature major vehicle systems, such as life support, thermal control, and crew. Boeing will perform a pilot-in-the-loop demonstration to test control hardware and software.

Themes

EXPLORATION SYSTEMS DEVELOPMENT

Programs within the ESD Theme are developing the core capabilities required to implement NASA's multi-destination strategy. The SLS program is developing the heavy lift vehicle that will launch the crew vehicle, other modules, and cargo for deep space missions. The Orion MPCV program is developing the vehicle that will carry the crew to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe reentry from deep space return speeds. The EGS program is working to develop the necessary launch site infrastructure to prepare, assemble, test, launch, and recover the SLS and Orion MPCV flight systems. NASA Headquarters is integrating programs, to streamline decision making processes and enable an affordable long term human exploration program.

EXPLORATION

COMMERCIAL SPACEFLIGHT

In order to reduce reliance on foreign providers and help develop an affordable American capability, NASA is looking to the US private sector to develop and operate safe, reliable, and affordable crew transportation to low Earth orbit.

Via the Commercial Crew program, NASA provides technical and financial assistance to industry partners during the development phase of their crew transportation systems. The program measures progress against fixed-price milestones proposed by the commercial partners and negotiated with NASA. Once these capabilities matured, NASA will purchase services from the private sector to transport crew to the International Space Station. This commercial approach will end U.S. reliance on foreign providers for crew transportation, and stimulate a new space transportation industry. Together with the capabilities to explore deep space provided by SLS and the Orion MPCV, NASA's commercial partnerships will help to assure the Nation's position as the global leader in human space flight.

EXPLORATION RESEARCH AND DEVELOPMENT

Exploration Research and Development (ERD) leads the charge in human space exploration research and development for activities beyond low Earth orbit. ERD consists of two programs, Advanced Exploration Systems (AES) and Human Research Program (HRP), which map directly to the US Space Exploration Policy and the NASA Authorization Act of 2010. AES is working to develop exploration systems to reduce risk, lower lifecycle cost, and validate operational concepts for future human missions to deep space, such as the asteroid rendezvous and capture mission, currently under study. HRP uses research findings to develop procedures that lessen the effects of the space environment on human health and performance while working in the hostile space environment. The program utilizes ground research facilities, the ISS, and analog environments to develop these procedures and further research in areas unique to the Moon, Mars, and future missions.

ORION MULTI-PURPOSE CREW VEHICLE

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	1200.0	--	**1026.8**	1024.9	1027.1	1027.1	1028.3
Crew Vehicle Development	1159.8	--	**993.5**	997.8	1001.8	1001.3	1002.6
MPCV Program Integration and Support	40.2	--	**33.4**	27.1	25.3	25.8	25.8
Change from FY 2012	--	--	**-173.2**				
Percentage change from FY 2012	--	--	**-14.4 %**				

A full-scale model of the Orion Multi-Purpose Crew Vehicle begins a 25,000 foot drop from an Air Force C-17 above the skies over Arizona in February, 2012. This drop test examined how the spacecraft's wake (disturbance of the air flow) affects the performance of the parachute system. This was the latest in a series of parachute drop tests conducted by NASA at the U.S. Army's Proving Grounds in Yuma, Arizona, and the first to utilize an Orion model to create a realistic wake.

For the first time since Apollo, astronauts will once again venture beyond low Earth orbit beginning in 2021, this time aboard the Orion Multi-Purpose Crew Vehicle (MPCV), ensuring US leadership in space for decades to come. The program has incorporated dozens of technology advancements and innovations into the spacecraft's subsystems and components. The vehicle includes crew and service modules, a spacecraft adapter, and a revolutionary launch abort system that will significantly increase crew safety. Its unique life support, propulsion, thermal protection and avionics systems are designed to enable extended duration missions into deep space.

With uncrewed test flights planned for 2014 and 2017, Orion MPCV will be ready for crewed flights in 2021. Orion MPCV's modular design will enable integration of new technical innovations as they become available. An early use of the Orion MPCV and Space Launch System (SLS) may be to rendezvous with a near-Earth asteroid redirected to a stable orbit in the Earth-Moon system, and to extract and return samples from it to Earth.

For further programmatic information, go to: http://www.nasa.gov/orion.

EXPLANATION OF MAJOR CHANGES

For FY 2014, the program rephased the Orion MPCV development test campaign sequence; the ascent abort test (AA-2) previously scheduled for 2015 is now slated to occur in 2018. The AA-2 flight test rephasing provides additional preparatory time to assure range safety readiness. This flight test will evaluate the launch abort system's ability to separate and maneuver the crew module out of the path of the launch vehicle during the initial ascent phase and is key to assuring range safety.

ORION MULTI-PURPOSE CREW VEHICLE

In December 2012, NASA and the European Space Agency (ESA) entered into an agreement for ESA to design and develop the Orion MPCV service module for the first uncrewed exploration mission test flight (EM-1) in 2017. This agreement builds on NASA's existing strong cooperative relationship with ESA on International Space Station (ISS) and other activities.

Projects

ORION MPCV PROGRAM INTEGRATION AND SUPPORT

The Orion MPCV program funds integration and support activity to manage the interfaces that comprise NASA's exploration systems development, including the SLS and EGS. Orion MPCV-specific integration ensures that all necessary cross-program activities occur. This effort is critical to making sure that the system's technical performance meets technical and safety specifications, and supports the programmatic assessment that results in an integrated technical, cost and schedule management. In addition, Orion MPCV integration effort is key to managing interfaces with other HEO activities, including strategic and feasibility studies and small scale research tasks that feed into future human exploration. This ensures coordination and timely integration to avoid potential design and cost issues.

CREW VEHICLE DEVELOPMENT

See the Crew Vehicle Development section.

CREW VEHICLE

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	1159.8	--	**993.5**	997.8	1001.8	1001.3	1002.6
Change from FY 2012	--	--	**-166.3**				
Percentage change from FY 2012	--	--	**-14.3%**				

The Orion Exploration Flight Test 1 (EFT-1) crew module undergoes proof pressure testing in the operations and checkout facility at the Kennedy Space Center in Florida. During the test, technicians incrementally pressurize the spacecraft with breathing air to demonstrate weld strength capability and structural performance at maximum flight operating pressures. When EFT-1 flies in 2014, the uncrewed Orion will return to Earth at a speed of 25,000 miles per hour and endure temperatures up to 4,000 degrees Fahrenheit.

PROJECT PURPOSE

With retirement of the Space Shuttle and growth of commercial transportation to the International Space Station (ISS), NASA is expanding its focus for human spaceflight from low Earth orbit to destinations across the Solar System. The Orion Multi-Purpose Crew Vehicle (MPCV) will carry astronauts on deep space missions for the first time since Apollo.

For further programmatic information, go to: http://www.nasa.gov/orion.

EXPLANATION OF MAJOR CHANGES

For FY 2014, the program rephased the Orion MPCV development test campaign sequence; the ascent abort test scheduled for 2015 will now occur in 2018. The ascent abort flight test rephasing provides additional preparatory time to assure range safety readiness, ahead of the first crewed flight of Orion MPCV in 2021. This flight test will evaluate the launch abort system's ability to separate and maneuver the crew module out of the path of the launch vehicle during the initial ascent phase and is key to assuring range safety.

In December 2012, NASA and the European Space Agency (ESA) entered into an agreement for ESA to design and develop the Orion MPCV service module for the first Exploration Mission (EM-1) in 2017. This agreement builds on NASA's existing strong cooperative relationship with ESA on ISS and other activities.

PROJECT PRELIMINARY PARAMETERS

Orion MPCV will carry a crew of four astronauts beyond Earth orbit for 21 days, or longer if paired with a potential future deep-space habitat. The spacecraft's three components include the crew module, service

CREW VEHICLE

Formulation	Development	Operations

module, and launch abort system, with a separate adapter to connect the crew and launch vehicles. The crew module is a familiar capsule shape on the outside, but inside it contains advanced, state-of-the-art in crew systems. During a mission, Orion MPCV houses the crew, providing a safe environment within which to live and work. Its advanced heat shield protects the crew from the reentry heating of a high-speed return from beyond Earth orbit. The service module is comprised of a crew module adapter and an ESA-developed service module that together provide in-space services to the crew module, including power, propulsion, and other life support systems. On a tower atop the crew module, sits the launch abort system, which, in the event of an emergency during launch or climb to orbit, will activate within milliseconds to propel the crew module to safety. This system also protects the crew module from dangerous atmospheric loads and heating, then is jettisoned once the Orion MPCV is out of the atmosphere and safely on its way to orbit.

ACHIEVEMENTS IN FY 2012

Orion MPCV delivered the first flight test crew module structure to the Kennedy Space Center (KSC) for assembly and integration, in preparation for an Exploration Flight Test-1 (EFT-1) in 2014. During this uncrewed test mission, the module will orbit the Earth twice and then return in a high-energy reentry. EFT-1 will provide NASA with critical vehicle performance data needed to confirm more detailed Orion MPCV spacecraft designs prior to its uncrewed flight with the SLS in 2017.

Early in FY 2012, the Agency added EFT-1 to the program. This decision was made in order to quickly validate the vehicle's innovative, space systems designed to support the Orion MPCV Critical Design Review in 2015. This flight test will validate heat shield performance at approximately 80 percent of lunar return velocity. The heat shield design is one of the key elements of the Orion MPCV design and proper design is needed to develop the lightest and most effective designs. Critical data from this test will be used in support of CDR in 2015. In addition, the vehicle completed a battery of tests, including acoustic and vibration, water impact, and various parachute tests. In conjunction with NASA’s Ground Launch Development and SLS programs, the test mission will also demonstrate spacecraft post-landing recovery procedures, and support launch vehicle adapter development. This adapter will be used on the uncrewed flight in 2017, and first crewed flights beginning in 2021.

In addition, the Orion MPCV program completed significant acoustic and vibration testing in the contractor's Denver facilities, water impact tests at Langley Research Center (LaRC), and parachute tests in various configurations at the Yuma Proving Grounds. The parachute and water impact tests are single system tests of the landing sequence that build towards integrated test of all the landing systems on EFT-1.

These tests are part of the program's risk mitigation efforts, intended to build confidence in the launch and landing systems leading up to EFT-1.

WORK IN PROGRESS IN FY 2013

During FY 2013, the first flight test crew module underwent proof pressure testing. This testing demonstrated that the primary structure, with hatches, windows, and wiring, is properly designed to hold an atmosphere for the crew. During the test, three structural ribs had minor cracking at a test pressure

Formulation	Development	Operations

level above that previously seen in flight, but below the maximum level they should be able to hold. The structure did not lose pressure but the test was stopped. Orion has now repaired the structure for this test flight, and will use the results to make design modifications to future primary structures to eliminate this issue. The program is also engaged in crew and service module manufacturing, impact and parachute testing, and detailed design work for the 2017 Orion MPCV flight article. In addition, detailed EFT-1 mission planning with the Johnson Space Center's (JSC) Mission Operations Directorate will continue throughout the year.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Orion MPCV will finalize EFT-1 flight preparations, with the crew and service modules integrated and flight ready by spring of 2014. By summer, the Delta IV launch vehicle will be ready for flight, and integration of all flight test components, including the launch abort system, will begin. The EFT-1 launch window at Cape Canaveral Air Force Station opens in September 2014 and extends into the first quarter of FY 2015.

ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Key Decision Point A (KDP-A), Formulation Authorization	Feb 2012	Feb 2012
System Requirements Review (SRR)		Mar 2007
System Definition Review (SDR)		Aug 2007
Preliminary Design Review (PDR)		Aug 2009
Resynchronization Review		Jul 2012
Key Decision Point B (KDP-B)	Q1 FY13	Jan 2013
“Delta” Preliminary Design Review	Q4 FY13	Q3 FY14
EFT-1 Launch		4th Quarter FY 2014
Key Decision Point C (KDP-C), Project Confirmation	FY15	Q1 FY15
Critical Design Review (CDR)		Q3 FY15 (under review)
EM-1 Launch		Dec 2017
EM-2 Launch		Aug 2021

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

At Key Decision Point B, the proposed mission and system architecture was deemed credible and responsive to program requirements and constraints, including resources. Additionally, the maturity of the project’s mission and system definition and associated plans was sufficient to begin Phase B. The mission

Formulation	Development	Operations

can likely be achieved within available resources with acceptable risk.

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C in Q1/FY 2015), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Jan 2013	$8,534.1 to $10,288.6	EM-2 Launch, plus one quarter	EM-2 Launch: August 2021

Project Management & Commitments

The Johnson Space Center manages Orion MPCV crew vehicle development, supported by many of the other NASA centers as shown in the table below.

Element	Description	Provider Details	Change from Formulation Agreement
Crew Module	The crew module is the transportation capsule that provides a safe habitat for the crew as well as storage for consumables and research instruments, and serves as the docking port for crew transfers.	Provider: JSC Lead Center: JSC Participating Centers: ARC, GRC, JSC, LaRC Cost Share Partners: N/A	None
Service Module	The service module supports the crew module from launch through separation prior to reentry.	Provider: JSC Lead Center: JSC Participating Centers: ARC, GRC, JSC, LaRC Cost Share Partners: N/A	None
Launch Abort System	The launch abort system is used to propel the crew module to safety in the event of an emergency during launch or climb to orbit.	Provider: JSC Lead Center: LaRC Participating Centers: JSC, LaRC, MSFC Cost Share Partners: N/A	None

CREW VEHICLE

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The mass of the Orion MPCV is not effectively reduced during the design analysis cycles (DACs), Then: Content might be deferred from EM-1 to EM-2 to afford more time for design refinements.	Orion MPCV is executing a mass reduction plan over the next two DACs. Additional mass reduction opportunities will be identified using the results of the EFT-1 flight test.
If: The Orion MPCV test and verification plan is not finalized, Then: There will be uncertainty in the schedule and objective for the EM-1 test flight.	Orion MPCV will continue to refine its test and verification plan in FY 2013 as part of ongoing work to develop the Orion MPCV and SLS flight test plan.
If: The EFT-1 heat shield, which is on the critical path in the EFT-1 manufacturing schedule, experiences delays, Then: Orion MPCV would need to use remaining schedule margin.	To mitigate the schedule, the heat shield design had to be finalized. To finalize the design, additional testing of the avcoat heat shield skin material has been conducted to better characterize the re-entry heating conditions that might cause minor material cracking.

Acquisition Strategy

NASA is using a competitively awarded contract for Orion MPCV design development, test, and evaluation with Lockheed Martin Corporation. This contract was awarded in 2006 and reaffirmed in 2011 as part of reformulating Orion as the Orion MPCV program. An affordability initiative is central to reformulation of the Orion MPCV acquisition strategy. This initiative continuously seeks out and implements innovative development cost savings and schedule acceleration, such as streamlining oversight, furthering incremental building of test vehicles, reducing unneeded deliverables, consolidating test labs, and reusing test articles.

NASA is implementing EFT-1 as an acquisition of flight test data for risk mitigation, through the Lockheed Martin Corporation contract. The primary deliverable is the Orion MPCV flight test data and engineering evaluation of the test results against NASA's formal flight test objectives. As this is a data buy, the flight vehicle itself is not being delivered to NASA. Rather, NASA-unique functions, including mission operations and ground operations, will support the Lockheed-led test activity with oversight provided by NASA personnel in the Orion MPCV program. This innovative teaming arrangement is an extension of the ongoing Orion MPCV program initiative to enable the government and industry team to operate more efficiently within affordability constraints, in addition to reducing technical risks prior to the development effort.

NASA signed an International Agreement with the European Space Agency (ESA) to provide a service module for the Orion MPCV spacecraft's Exploration Mission-1 (EM-1) in 2017. ESA will provide the service module and significant aspects of its design, which will fulfill its cost-sharing responsibility to operate the International Space Station, and compensate NASA for additional ISS supporting services. NASA has the option to collaborate with ESA on a service module for Exploration Mission-2 in 2021.

CREW VEHICLE

Formulation	Development	Operations

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
MPCV Design and Development	Lockheed Martin	Littleton, CO

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
System Requirements Review	SRB	Mar 2007	To evaluate whether program functional and performance requirements are properly formulated and correlated with Agency and Mission Directorate strategic objectives; to assess the credibility of the program's estimated budget and schedule	Program cleared to proceed to next phase.	N/A
System Definition Review	SRB	Aug 2007	To evaluate proposed program requirements and architecture and allocation of requirements to initial projects; to assess the adequacy of project pre-formulation efforts; to determine whether the maturity of the program's definition and associated plans are sufficient to begin implementation.	Program cleared to proceed to next phase.	N/A
Preliminary Design Review	SRB	2009	To evaluate completeness and consistency of the program's preliminary design, including its projects, in meeting all requirements with appropriate margins, acceptable risk and within cost and schedule constraints; and to determine the program's readiness to proceed with the detailed design phase of the program.	Program cleared to proceed to next phase.	N/A

Formulation	Development	Operations

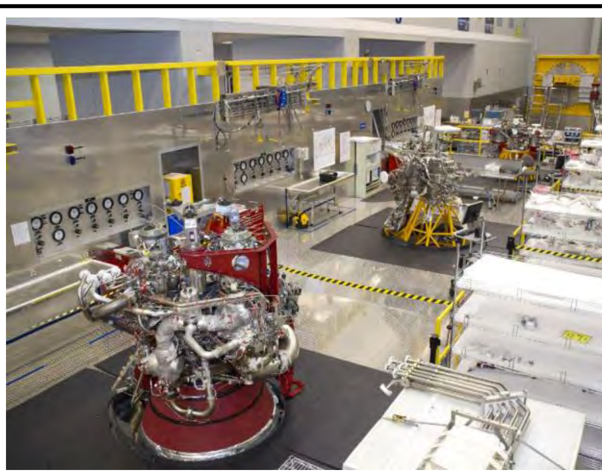
Resynchronization Review	SRB	Jul 2012	To resynchronize the program's preliminary design to the requirements of Exploration system development. NASA procedures allow that a program's management agreement may be changed in response to internal and external events. A significant divergence from must be accompanied by an amendment to the decision memorandum signed at the KDP subsequent to the preliminary design review.	Program cleared to proceed to next phase.	N/A
"Delta" Preliminary Design Review	SRB	Spring 2014 (under review)	To update the program's preliminary design, to ensure completeness and consistency; to determine the program's readiness to proceed with the detailed design phase of the program.	TBD	TBD
Critical Design Review	SRB	Spring 2015 (under review)	To evaluate the integrity of the program integrated design, including its projects and ground systems, to meet mission requirements with appropriate margins and acceptable risk, within cost and schedule constraints; to determine if the integrated design is appropriately mature to continue with the final design and fabrication phase.	TBD	TBD

SPACE LAUNCH SYSTEM

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 14 Request in FY 12 Budget Structure	1872.6	--	**1845.4**	1764.9	1774.4	1791.2	1791.2
Prog. CoF in CECR Account	*71.0*	--	***142.3***	*0.0*	*0.0*	*0.0*	*0.0*
Exploration Ground Systems	*304.5*	--	***318.2***	*408.4*	*414.2*	*436.8*	*445.8*
FY 2014 President's Budget Request	1497.1	--	**1384.9**	1356.5	1360.2	1354.4	1345.4
Launch Vehicle Development	1450.5	--	**1339.8**	1312.9	1312.5	1277.6	1268.7
SLS Program Integration and Support	47.0	--	**45.1**	43.6	47.7	76.7	76.7
Subtotal	1497.5	--	**1384.9**	1356.5	1360.2	1354.4	1345.4
Rescission of prior-year unob. balances*	-0.4	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-112.2**				
Percentage change from FY 2012	--	--	**-7.5 %**				

*Note: * Rescission of prior-year unobligated balances from Launch Vehicle Development pursuant to P.L. 112-55, Division B, sec. 528(f).*



Two J-2X engines and a power pack developed for NASA by Pratt & Whitney Rocketdyne undergo post-test inspections and instrumentation at the Stennis Space Center in Mississippi. The J-2X is a highly efficient rocket engine that will power the upper stage of NASA's Space Launch System. Fueled by liquid oxygen and liquid hydrogen, the engine builds on heritage designs and nearly a half-century of NASA spaceflight experience, along with technological and manufacturing advances to deliver up to 294,000 pounds of thrust. The J-2X is the first new liquid oxygen and liquid hydrogen rocket engine developed in 40 years, and will power exploration to destinations in our solar system.

The NASA Authorization Act of 2010 directed the Agency to develop a heavy-lift rocket that will allow human exploration beyond low Earth orbit for the first time since the last flight of the Saturn V rocket in 1973. The Space Launch System (SLS) will enable crews and their equipment to travel thousands, and eventually millions, of times farther into deep space than is currently possible. This will open the solar system to crewed missions such as exploring mineral-rich asteroids, and eventually the mountains and canyons of Mars. An early test of the SLS and Orion Multi-Purpose Crew Vehicle (MPCV) may be to rendezvous with a near-Earth asteroid redirected to a stable orbit in the Earth-Moon system, and to extract and return samples from it to Earth.

Through its lifetime, SLS capability will evolve using a block upgrade approach, driven by mission requirements. In the near-term, SLS will achieve a 70-metric ton Block 1 capability that will enable early system demonstrations such as test flights near the Moon. The follow-on Block 1A upgrade will use advanced boosters to improve vehicle performance to 105 metric tons, significantly expanding deep space mission capability. The Block 2 upgrade adds an advanced upper stage, enabling performance up to 130 metric tons.

SLS development is an example of the Agency's commitment to fiscal responsibility and budget discipline. With Saturn and the Space Shuttle, NASA has half a century of experience with heavy lift launch vehicles. Leveraging this experience, combined with advances in technology and manufacturing, will allow NASA to build and operate SLS at less cost than previous heavy lift designs. NASA is leveraging a half-century of experience with heavy-lift vehicles like Saturn and the Space Shuttle, along with advances in technology and manufacturing practices, to build and operate SLS at less cost than previous heavy lift designs. NASA is committed to building SLS on schedule and on budget, with a first uncrewed test flight in 2017.

For further programmatic information, go to: http://www.nasa.gov/exploration/systems/sls/index.html.

EXPLANATION OF MAJOR CHANGES

None.

Projects

SLS PROGRAM INTEGRATION AND SUPPORT

The SLS program funds integration and support activity to manage the interfaces between programs that comprise NASA's exploration systems development, including the Orion MPCV and Exploration Ground Systems (EGS). SLS-specific integration ensures that all necessary cross-program activities occur. This effort is critical to making sure that the system's technical performance meets technical and safety specifications, and supports the programmatic assessment that results in an integrated technical, cost and schedule management. In addition, the SLS integration effort is key to managing interfaces with other HEO activities, including strategic studies, feasibility studies, and small scale research tasks that feed into future human exploration. This ensures coordination and timely integration to avoid potential design and cost issues

LAUNCH VEHICLE DEVELOPMENT

See Launch Vehicle Development section.

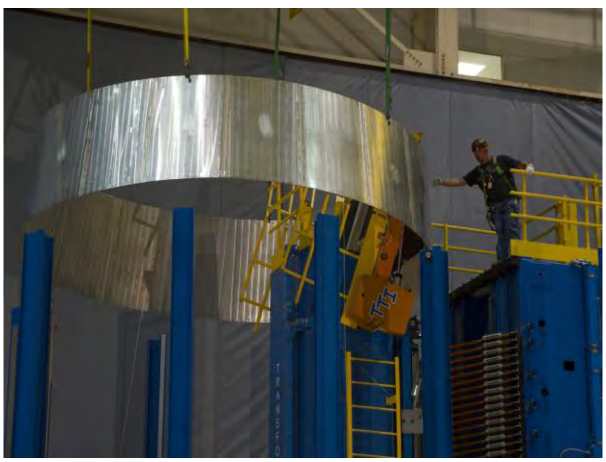
LAUNCH VEHICLES

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	1450.7	--	**1339.8**	1312.9	1312.5	1277.6	1268.7
Subtotal	1451.1	--	**1339.8**	1312.9	1312.5	1277.6	1268.7
Rescission of prior-year unob. balances*	-0.4	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-110.9**				
Percentage change from FY 2012	--	--	**-7.6 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*



Engineers use a state-of-the-art vertical welding tool at the Marshall Space Flight Center in Huntsville, Alabama to movea "pathfinder" version of the adapter design that will connect the Orion Multi-Purpose Crew Vehicle (MPCV) to NASA's new Space Launch System. In 2014, the adapter will be used to mate the Orion MPCV to a Delta IV heavy-lift rocket for Exploration Flight Test-1.The "pathfinder" is an early version of the hardware that is not intended to fly, but to prove the concept and feasibility of manufacturing the design.

PROJECT PURPOSE

With the retirement of the Space Shuttle and growth of commercial transportation to the International Space Station (ISS), NASA is expanding its focus for human spaceflight from low Earth orbit to destinations across the solar system. The Launch Vehicle Development project enables human deep space exploration with development of the Space Launch System (SLS),which will have a lift capability more than two and half times that of any launch vehicle currently in operation. For the first time since the Apollo program nearly fifty years ago, American astronauts will be able to explore space beyond low Earth orbit.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

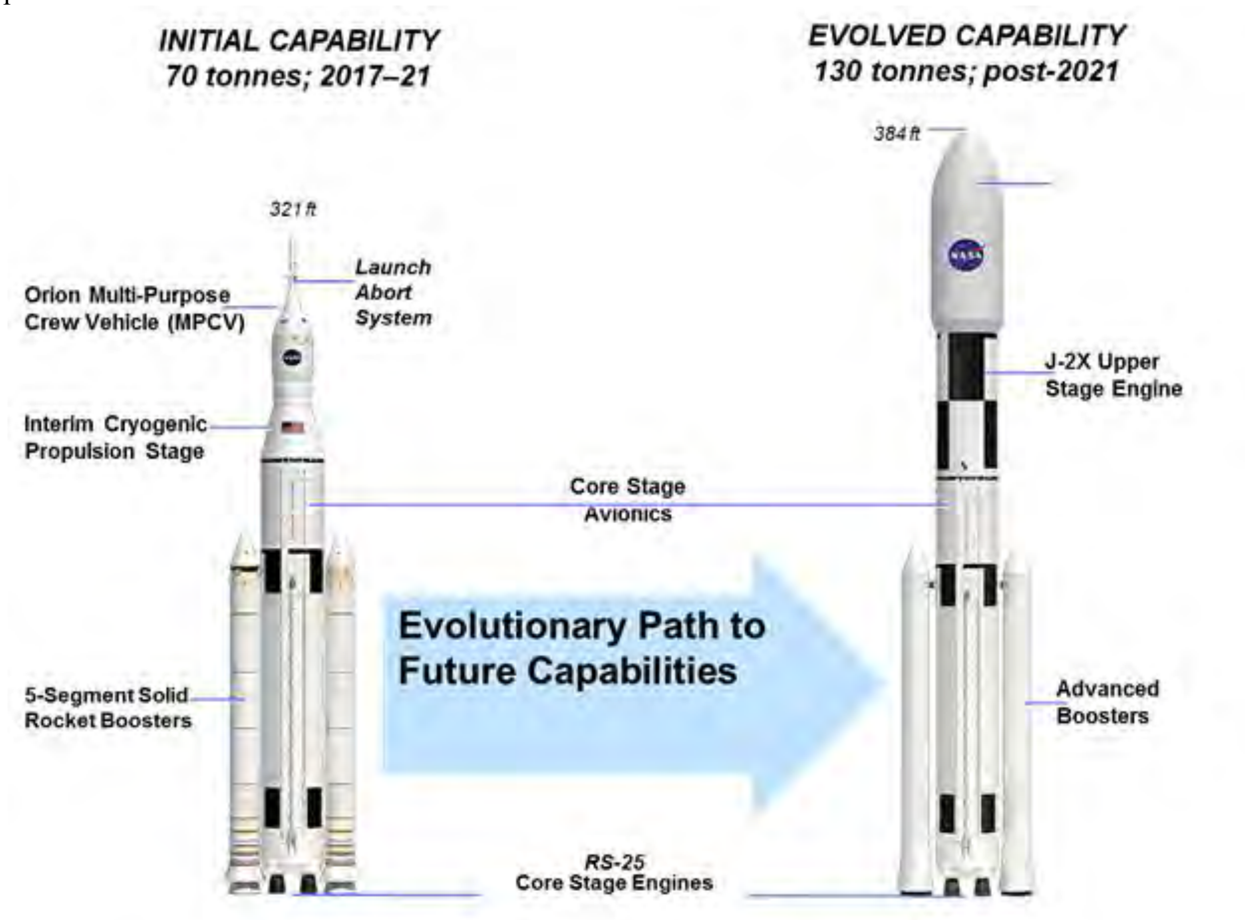
Initially, the SLS launch vehicle will provide a Block 1 capability of 70 metric tons lifted to low Earth orbit. Following successful Block 1 implementation, which will occur between 2017 and 2023, planned upgrades will allow SLS to nearly double its initial capacity, based on evolving mission requirements. These upgrades will increase life capability to approximately 105 metric tons, ultimately leading to a Block 2 capability beyond 2030 that increases lift to 130 metric tons. Launch Vehicle Development will achieve initial cost, schedule, and performance goals by utilizing hardware designed for previous projects,

LAUNCH VEHICLES

Formulation	Development	Operations

including Space Shuttle main engines, five-segment solid rocket boosters from the Constellation program, and the interim cryogenic propulsion stage, based on Delta-IV design.

SLS development leverages a half-century of experience liquid oxygen and liquid hydrogen heavy-lift vehicles, like Saturn and the Space Shuttle, along with advances in technology and manufacturing practices.



As illustrated above, the SLS is designed to be flexible and evolvable. It shares the same basic core stage to allow for different crew and cargo flights as needed, promoting efficiency, time and cost savings. SLS will enable exploration missions beyond low Earth orbit, support travel to asteroids, Mars and other destinations within our solar system.

ACHIEVEMENTS IN FY 2012

The Space Launch System program posted numerous achievements in FY 2012. After its official program start, SLS completed system design review and completed all Agency requirements associated with Key Decision Point B in July 2012. These milestones serve to validate that system performance details are

Formulation	Development	Operations

well defined, and component and system designs are underway. The successful review also initiated the manufacture and testing of key hardware elements, including a large adapter mechanism that will fly with the Orion MPCV test flight EFT-1 in 2014 and future crew vehicle flights on SLS. Meanwhile, the J-2X engine slated for the upper stage of SLS Block 2 continued a rigorous testing campaign at the Stennis Space Center in Mississippi. Combined with progress in refocusing previous program development efforts, wind tunnel testing, design analysis cycles, major tooling installation, and hundreds of other FY 2012 achievements both large and small, SLS launch vehicle development is on track for first launch in 2017.

WORK IN PROGRESS IN FY 2013

The final vertical weld on the first production Orion MPCV stage adapter was successfully completed on January 23, 2013. During FY 2013, major SLS contracts will also be finalized. In preparation for core stage test in the first quarter of 2016, restoration and facility buildup work on the B-2 test stand at Stennis will continue. Additionally, Michoud Assembly Facility is being prepared for production of SLS testing and flight articles. The Michoud Facility began demolition, tool installation, Liquid Hydrogen 2 proof test construction, and roof repairs.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, SLS will conduct critical design reviews for the booster and core stage elements. This review is a major design milestone and the point at which the program assesses hardware elements to determine if the design is mature enough to continue with final flight hardware design and fabrication. The SLS-designed Orion MPCV spacecraft adapter will fly for the first time on Exploration Flight Test 1 (EFT-1) in late FY 2014. This will be the first test flight of hardware designed and built by the SLS program. The adapter will mate the Orion MPCV to the launch vehicle. The same design being used for Orion MPCV's flight on a Delta IV launch vehicle in 2014 will be used for the first Orion MPCV/SLS flight in 2017.

ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization	Nov 2011	Nov 2011
SRR/SDR	Q2 FY12	Q3 FY12
KDP-B	Q4 FY12	Q4 FY12
PDR	Q1 FY14	Q1 FY14
KDP-C	Q1 FY14	Q1 FY14
CDR	Q2 FY15	Q2 FY15
KDP-D	Q1 FY16	Q3 FY17
EM-1 Launch	Dec 2017	Dec 2017
EM-2 Launch	Aug 2021	Aug 2021

Formulation	Development	Operations

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

At Key Decision Point B the proposed mission and system architecture was deemed credible and responsive to program requirements and constraints, including resources. Additionally, the maturity of the project's mission and system definition and associated plans was sufficient to begin Phase B. NASA believes the 2017 test flight can likely be achieved within available resources with acceptable risk.

The cost and schedule ranges and confidence levels generated as part of the SLS KDP-B review were based on the technical and programmatic (cost, schedule, and risk) content required to perform design, development, test, and evaluation activities associated with the SLS Block 1 configuration and capability leading to the first test flight in 2017, plus a quarter for post-flight data analysis.

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review. The table below does not include Exploration Ground Systems costs of $2,492-2,804 million through the same time period

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Jul 2012	7,653-8,587	EM-1 Launch plus one quarter	Mar 2018

Project Management & Commitments

The Marshall Space Flight Center (MSFC) in Huntsville, Alabama is responsible for managing SLS. The Program Manager, based at Marshall, reports to the Deputy Associate Administrator for Exploration Systems Development within the Human Exploration and Operations Mission Directorate at NASA Headquarters. SLS has extensive partnerships with multiple NASA Centers; Kennedy Space Center provides ground operations, Stennis Space Center engine testing, Johnson Space Center Orion MPCV integration, Glenn Research Center (GRC) fairing design, and Langley Research Center and Ames Research Center (ARC) provide analytics and wind tunnel testing. SLS is also partnering with the US Air Force to pursue areas of common interest that may be applicable to future SLS block upgrades.

LAUNCH VEHICLES

Formulation	Development	Operations

Element	Description	Provider Details	Change from Formulation Agreement
Booster	Responsible for development, testing, production, and support for the five-segment solid rocket motor to be used on initial capability flights	Provider: MSFC Lead Center: MSFC Participating Centers: MSFC, SSC Cost Share Partners: N/A	None
Engines	Responsible for development and/or testing, production, and support for both core stage (RS-25) and upper stage (J-2X) liquid engines.	Provider: MSFC Lead Center: MSFC Participating Centers: MSFC, SSC Cost Share Partners: N/A	None
Stages	Responsible for development, testing, production, and support of both the core and upper stages, including liquid engine and avionics integration.	Provider: MSFC Lead Center: MSFC Participating Centers: MSFC, SSC, KSC Cost Share Partners: N/A	None
Spacecraft Payloads and Integration	Responsible for development, testing, production, and support of hardware elements for integrating the Orion MPCV and payloads onto SLS, including the interim cryogenic propulsion stage, Orion MPCV stage adapter, launch vehicle stage adapter, and payload fairings.	Provider: MSFC Lead Center: MSFC Participating Centers: MSFC, SSC, KSC Cost Share Partners: N/A	None

Project Risks

Risk Statement	Mitigation
If: Significant design modifications are required to increase performance, increase structural margins, and/or human-rate the Interim Cryogenic Propulsion Stage (ICPS), Then: ICPS costs could increase and/or the development schedule could slip.	The launch vehicle project will complete Interim Cryogenic Propulsion Stage preliminary design in FY 2013, at which point SLS will identify any modifications that may need to be made to the ICPS, as well as any cost impacts.

LAUNCH VEHICLES

Formulation	Development	Operations

If: SLS variants beyond Block 1 require unanticipated modifications to the Block 1 core stage design, Then: SLS evolution may incur core stage redesign costs to enable SLS commonality beyond the Block 1 variant.	The SLS preliminary design review will include performance, margin, and loads analyses that will envelope both Block 1 and planned upgrades. The preliminary design review follows NASA best practices of utilizing various Ground Rule and Assumption to provide mass and performance margins for factors such as crew safety, booster performance variability, propellant loading uncertainty, engine performance variations, proper orbital disposal of stages, and in-space performance. In addition, prudent design practice requires payload reserves to be carried in the development of systems to allow for mass growth from obsolesce to modern manufacturing to unknown integrated system interaction.

Acquisition Strategy

Procurement for SLS launch vehicle development is structured to meet the Agency's requirement to provide an affordable and evolvable vehicle, within a schedule that supports various mission requirements. Procurements will include use of existing assets to expedite development, as well as further development of technologies and future competitions for advanced systems and key technology areas specific to SLS evolved vehicle needs. NASA is in negotiations with the element vendors to finalize contracts in FY 2013.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Boosters (qualification motors and first two test flights)	ATK Launch Systems	Magna, UT
Core Stage Engine (RS-25)	Pratt & Whitney Rocketdyne, Inc.	Desoto Park, CA
Upper Stage Engine (J-2X)	Pratt & Whitney Rocketdyne, Inc.	Desoto Park, CA
Core and Upper Stages	Boeing Aerospace	Huntsville, AL

INDEPENDENT REVIEWS

Independent reviews will be performed as required by NASA Procedural Requirement (NPR) 7120.5. NASA has established an independent Standing Review Board (SRB) to review the SLS program and launch vehicle project.

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Systems Requirements Review / Systems Definition Review (SRR/SDR)	SRB	Jun 2012	The purpose of the SRR is to evaluate whether the functional and performance requirements defined for the system are responsive to the program's requirements on the project and represent achievable capabilities. The purpose of the SDR is to evaluate the credibility and responsiveness of the proposed mission/system architecture to the program requirements and constraints, including available resources. To determine whether the maturity of the project's mission/system definition and associated plans are sufficient to begin Phase B. The SLS program combined the SRR and SDR into a single key decision point B review, as allowed by NASA NPR 7120.5	The SRB found the SLS program system architecture approach credible and responsive to program requirements and constraints, including resources. The maturity of the project's system definition and associated plans is sufficient to begin Phase B. The 2017 test flight can likely be achieved within available resources with acceptable risk.	N/A
Preliminary Design Review (PDR)	SRB	N/A	The purpose of the PDR is to evaluate the completeness/ consistency of the planning, technical, cost, and schedule baselines developed during formulation. Assess compliance of the preliminary design with applicable requirements and to determine if the project is sufficiently mature to begin Phase C.	TBD	Aug 2013

LAUNCH VEHICLES

Formulation	Development	Operations

Critical Design Review (CDR)	SRB	N/A	The purpose of the CDR is to evaluate the integrity of the project design and its ability to meet mission requirements with appropriate margins and acceptable risk within defined project constraints, including available resources. To determine if the design is appropriately mature to continue with the final design and fabrication phase.	N/A	Mar 2015

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	304.5	--	**318.2**	408.4	414.2	436.8	445.8
Subtotal	304.5	--	**318.2**	408.4	414.2	436.8	445.8
Rescission of prior-year unob. balances*	-0.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**13.7**				
Percentage change from FY 2012	--	--	**4.5 %**				

*Note: * Rescission of $0.050 million prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f). Amount rounds to $0.0 million in table above.*

With the removal of shuttle launch support structures, lightning towers dominate launch complex 39-B at the Kennedy Space Center in Florida. As NASA prepares to expand human space exploration beyond low Earth orbit with the Space Launch System, infrastructure modifications, repairs and upgrades are critical. Once the custom heritage structures and systems are removed, a mobile launcher will provide greater flexibility for users. Additional upgrades include the lightning protection system, fiber optic vs. Apollo-era cabling, and higher efficiency "green" systems.

PROJECT PURPOSE

As NASA enters a new era in human space exploration, space operations at the Kennedy Space Center (KSC) are evolving to support Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) integration and launch. The Exploration Ground Systems (EGS) program is making necessary facility and ground support equipment modifications at KSC to enable assembly, test, launch and recovery of the SLS and Orion MPCV flight elements, as well as modernizing communication and control systems. Upon completion, the KSC launch site will provide a more flexible, affordable, and responsive national launch capability.

For more programmatic information, go to: http://go.nasa.gov/groundsystems.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

The EGS program's primary components are vehicle integration and launch, offline processing, and command, control and communication. The vehicle integration and launch component will complete facility modifications and upgrades to ground support equipment in support of launch vehicle stacking,

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

launch vehicle and spacecraft integration, rollout, and pre-launch and launch operations at the pad. Planned infrastructure upgrades include those affecting the mobile launcher, Launch Complex 39B (LC-39B), the crawler transporter, and the Vehicle Assembly Building (VAB). Offline processing will complete required modifications to the Multi-Payload Processing Facility (MPPF), which will host payload processing, manufacturing, testing, servicing and hazardous operations, and recovery in support of Orion MPCV. Command, control and communications enhancements will secure a future capability for command and control, weather, telemetry and tracking, communications, and customer interface systems.

ACHIEVEMENTS IN FY 2012

Exploration Ground Systems made extensive progress toward transforming the launch infrastructure at KSC to support Exploration Mission-1 (EM-1); NASA's first planned 2017 uncrewed test flight of the integrated SLS and Orion MPCV. The Agency awarded a design contract for the mobile launcher structure and facility support system, to ensure that the launcher is structurally sound and outfitted to support SLS and Orion MPCV requirements both to and on the launch pad. The program finished refurbishing LC-39B systems, including Pad B instrumentation and ground support equipment development. The program also finalized firing room 1 command and control hardware installation, and implemented initial voice, video, and data infrastructure. The first phase of modifications to the MPPF is complete, and facility work to enable Orion MPCV hazardous payload processing is now on contract. This phase of construction consisted of two new 300 ton chillers, a new 40 ton chiller, three chilled water pumps, two new make-up air units, and associated electrical, ducting, insulation and controls.

WORK IN PROGRESS IN FY 2013

With mobile launcher designs complete, NASA will award structural modification and ground support equipment installation design contracts in FY 2013, allowing construction activity to ensure that the launcher is ready for ground support equipment outfitting. Design work is also ongoing for various mobile launcher-to-SLS access points and umbilical sites. High bay 3 demolition in the VAB continues, and by the end of the year, platforms and other remaining systems will be gone. Replacement designs for the VAB pneumatics system, environmental control system, 175-ton crane controls, ground cooling system, and fire suppression system upgrades will near completion in FY 2013.

In the launch equipment test facility where most ground testing is performed, NASA will fabricate and install a second vehicle motion simulator and supporting systems. This will eliminate the testing bottleneck that could delay launch systems validation. The program will also select and begin design work for the LC-39B emergency egress system concept. At Pad B, work is underway to select operations concepts for optimal liquid hydrogen system storage capacity. Communications systems design for the mobile launcher, Pad B, VAB high bays 1 and 3, and MPPF continues to mature, while testing and operations of initial recovery communication capability for Exploration Flight Test-1 (EFT-1) will be completed during FY 2013. In addition, EGS will support phase-in of the KSC -awarded test and operations support contract, enabling all ground processing for SLS and Orion MPCV.

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Modernization and compatibility efforts will continue in FY 2014 to support the EM-1 launch, targeted for late 2017. The program will enter the implementation phase of its life cycle where final designs and initial fabrication take place. Major infrastructure enhancements will continue on the LC-39B flame trench, the flame deflector the ignition overpressure, and sound suppression systems. The ML will undergo ground support equipment and umbilical outfitting on the upper stage, core stage and crew access arm. Orion MPCV in-transit environmental control systems will be installed on the crawler transporter to ensure that it meets transport requirements. In the Vehicle Assembly Building, where vertical stacking of the SLS and Orion MPCV will occur, installation of adjustable platforms will continue to allow maximum vehicle and spacecraft access.

Exploration Ground Systems will also recover the crew module for the EFT-1 mission, while ongoing landing and recovery planning and design are underway in support of EM-1. End-to-end spaceport command and control system applications and displays will be in work, along with transmission, imagery, and voice communication. Integrated verification and validation will commence in order to guarantee mission success and seamless integration and launch site processing during EM-1.

ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization	Nov 2011	Nov 2011
KDP-A	Q2 FY12	Jan 2012
SRR/SDR	N/A	Aug 2012
KDP-B	Q4 FY12	Nov 2012
PDR	N/A	Jan 2014
KDP-C	Q3 FY14	Feb 2014
CDR	N/A	May 2015
KDP-D	TBD	Jun 2017
EM-1 Launch	Dec 2017	Dec 2017
EM-2 Launch	Aug 2021	Aug 2021

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

At Key Decision Point B (KDP B), the proposed mission/system architecture was deemed credible and responsive to program requirements and constraints, including resources. Additionally, the maturity of the project’s mission/system definition and associated plans was sufficient to begin Phase B, and the mission can likely be achieved within available resources with acceptable risk.

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

The cost and schedule ranges and confidence levels generated for EGS KDP B were based on the technical and programmatic (cost, schedule, and risk) content required to support the first Exploration Mission flight (EM-1) in 2017, plus a quarter for post-flight data analysis.

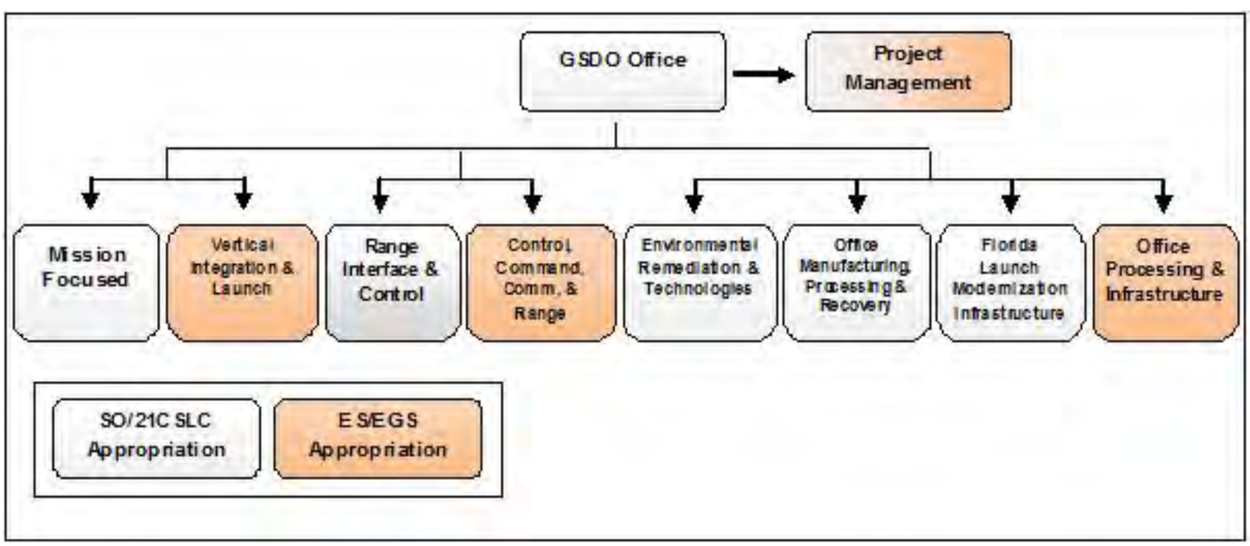
Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Dec 2012	2,492- 2,804	EM-1 launch (Dec 2017)	Dec 2017-Mar 2018

Project Management & Commitments

The Ground Systems Development and Operations program office (GSDO) manages infrastructure development for both Exploration Ground Systems development and 21st Century Space Launch Complex (21CSLC) activities. This single program approach to managing both the 21CSLC content under the Space Operations appropriation, and the EGS content under the Exploration appropriation provides cost-effective synergy between SLS and Orion MPCV requirements, and multi-user customer requirements.

The following diagram shows the distinct break out of 21CSLC and EGS content, as managed under the GSDO Program.



Note: SO = Space Operations account. ES = Exploration account.

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

The following table addresses the various elements within EGS, responsible and participating centers, and any cost share partners.

Element	Description	Provider Details	Change from Formulation Agreement
Vertical Integration and Launch	Performs facility modifications and upgrades to ground support equipment in support of launch vehicle stacking, launch vehicle and spacecraft integration, rollout, and pre-launch and launch operations at the pad	Provider: KSC Lead Center: KSC Participating Center: ARC Cost Share Partners: N/A	N/A
Offline Processing	Enables payload processing activity, manufacturing, testing, servicing and hazardous operations, and recovery in support of Orion MPCV	Provider: KSC Lead Center: KSC Participating Centers: N/A Cost Share Partners: N/A	N/A
Command, Control, and communication	Provides end-to-end command and control, weather, telemetry and tracking, communications, and customer interface systems	Provider: KSC Lead Center: KSC Participating Centers: N/A Cost Share Partners: N/A	N/A
Project Management	Includes project management, safety and mission assurance, logistics, systems engineering, utilities and facility operations and maintenance	Provider: KSC Lead Center: KSC Participating Centers: N/A Cost Share Partners: N/A	N/A

Project Risks

Risk Statement	Mitigation
If: There is a lack of approved emergency egress system requirements from stakeholders, Then: There is a possibility that the baselined ground system concept will not provide an integrated solution that meets the overall egress requirements encompassing initiation of egress through rescue.	GSDO will develop a draft set of requirements for an emergency egress system. The program will begin coordinating those with partnered programs. Once requirements and assumptions are agreed upon by various stakeholders, a Concept of Operations will be defined and a safety analysis will be conducted. This analysis will be shared at the GSDO and ESD Control Boards to seek final approval to proceed to design. A Concept of Operations will then be selected, allowing design, followed by construction, to begin.

EXPLORATION GROUND SYSTEMS

Formulation	Development	Operations

If: There is insufficient time allotted to perform integrated testing activities at Vehicle Assembly Buildingand pad B Then: There is a possibility that the scheduled GSDO Operational Readiness Date (ORD) ready will not be met.	The ML to Pad element integration team will conduct roundtable meetings to develop coordinated approaches to address the issue, and integrate a timeline and task list. Other system activation lessons learned documentation, from sources such as Wallops Island ground systems, will be assessed for application to mitigating this risk. Once a timeline is final, systems integration and test will integrate schedule products to optimize vehicle integration and launch development and systems integration and test schedule activity. This will likely require several iterations.

Acquisition Strategy

To retain flexibility and maximize affordability, GSDO serves as its own prime contractor for Exploration Ground Systems. GSDO executes SLS and Orion MPCV ground infrastructure and processing requirements by leveraging center and programmatic contracts. GSDO also uses pre-qualified indefinite delivery indefinite quantity contractors for more routine work, while exercising full and open competition for larger or more specialized projects such as the mobile launcher structural and facility systems construction contract, and associated ground support equipment fabrication firm-fixed-price contracts. The fixed-price contracting approach is used whenever possible, as it provides maximum incentive for the contractor to control costs, since the contractor is subject to any losses incurred. In addition, it imposes a minimal administrative burden upon the contracting parties.

MAJOR CONTRACTS/AWARDS

Exploration Ground Systems is managed by the GSDO Program Manager, and will encompass projects of varying content and size. Many of these are consistent with the type of architecture and engineering, construction, and programmatic support available within the scope of existing center and program support contracts. Should the project size or scope fall outside that of existing center capabilities, then competitively bid firm-fixed-price contracts will be used. Contracts are provided below.

Element	Vendor	Location (of work performance)
Mobile Launcher Structural and Facility Support Modification Contract	TBD	Kennedy Space Center
Vehicle Assembly Building High Bay Platform Construction	TBD (under NASA's Construction and Environmental Compliance and Restoration appropriation)	Kennedy Space Center

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
All	Standing Review Board	Q1 FY13	Provide an independent assessment of the program's technical plan, cost estimates, schedules, and risks at KDP B	TBD	N/A

COMMERCIAL CREW

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	392.0	--	**821.4**	821.4	821.4	590.0	371.0
Change from FY 2012	--	--	**429.4**				
Percentage change from FY 2012	--	--	**109.5 %**				

Note: The FY 2012 enacted total for Commercial Crew was $406 million. NASA reprogrammed $14 million to Commercial Cargo, and Commercial Crew was paid back using prior year funds with no change in total budget authority.

Crew system engineers and NASA astronauts evaluate the layout of the Dragon crew capsule on the factory floor at the Space Exploration Technologies (SpaceX) facility in Hawthorne, California. The new spacecraft is based on the Dragon cargo vehicle that successfully demonstrated its capability to carry cargo and experiments to and from the International Space Station.

With an eye to the future of human spaceflight, NASA is looking to the US private sector to develop and operate safe, reliable, and affordable crew transportation to low Earth orbit, including the International Space Station (ISS). Partnering with the commercial space industry for access to low Earth orbit and the ISS will reduce our current reliance on foreign providers for this service and help stimulate American industry. As the commercial crew providers focus on low earth orbit, NASA is able to increase focus on developing systems that will expand our deep space exploration capabilities.

Through the Commercial Crew program, NASA is providing technical and financial support to industry partners during the development phase of their crew transportation systems. Progress is measured against milestones that were proposed by the commercial partners and negotiated with NASA before Space Act Agreements were awarded in a fully competitive process. Milestones are fixed-price and based on performance of agreed upon entrance and success criteria. Although they vary in content, milestones are designed as events that mature the partners' progress. Examples include risk reduction testing, design reviews, and partner investment reviews. If the partners fail to complete a milestone, the government owes nothing.

Once these commercial capabilities are matured and certified for use by NASA, the ISS program will purchase services from the private sector to transport NASA crew to and from the ISS. This innovative approach will end the outsourcing of human space transportation currently purchased from foreign providers and enable US private sector capability to access low Earth orbit and ISS. These activities stimulate development of a new space transportation industry available to all potential customers, including the US government. NASA's efforts will strengthen America's space industrial base, providing a catalyst for future business ventures to capitalize on affordable, globally competitive, US space access.

COMMERCIAL CREW

Commercial space transportation is vital to the future of human space exploration and will enable NASA to focus on exploration beyond Earth orbit with the Space Launch System and Orion MPCV.

For more programmatic information, go to: http://commercialcrew.nasa.gov or http://www.nasa.gov/exploration/commercial/crew/index.html.

EXPLANATION OF MAJOR CHANGES

None.

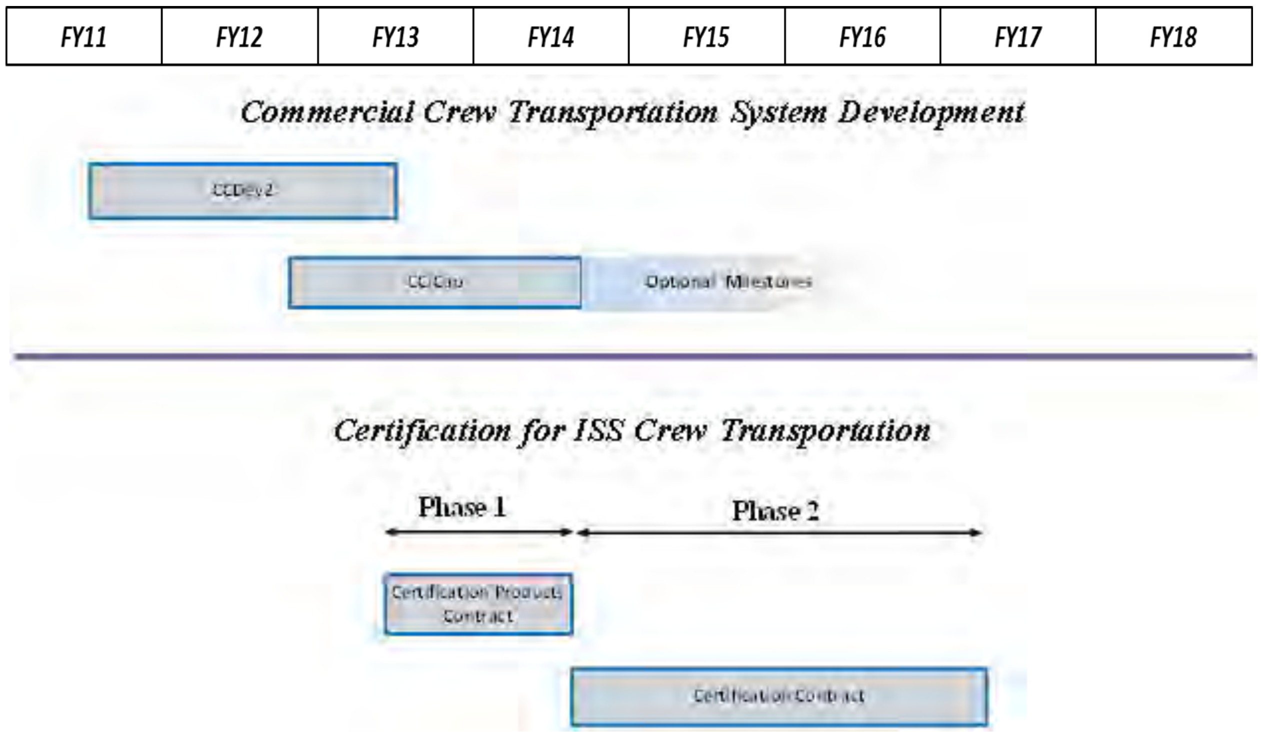
ACHIEVEMENTS IN FY 2012

During FY 2012, NASA's industry partners made significant progress toward developing viable commercial crew transportation systems. NASA began the Commercial Crew Development Round 2 (CCDev2) initiative in FY 2011. This initiative is nearly complete. Space Exploration Technologies (SpaceX) completed all 10 of their milestones by June 2012. By the end of FY 2012, Sierra Nevada Corporation (SNC) completed 12 of 13 milestones, Boeing completed 13 of 14, and Blue Origin completed 8 of 10 milestones. NASA's unfunded partners, Alliant Techsystems, United Launch Alliance and Excalibur Almaz, Inc. all successfully completed their agreements.

On August 3, 2012, NASA signed agreements with three companies for the follow-on initiative, Commercial Crew Integrated Capability (CCiCAP): Boeing for $460 million; SpaceX for $440 million; and Sierra Nevada Corporation for $212.5 million. This initiative is expected to run through May 2014, and will help advance the partners’ commercial design and development efforts, bringing the US closer to its goal of flying American astronauts to and from low Earth orbit and ISS, thereby ending NASA's reliance on foreign governments for this service.

WORK IN PROGRESS IN FY 2013

Progression of Commercial Crew Development Efforts:



NASA's industry partners are currently on track to complete all remaining CCDev2 milestones in early FY 2013. Also, Blue Origin extended its CCDev2 agreement with NASA on an unfunded basis. Under CCiCAP, Boeing and SpaceX will complete integrated critical design of their Crew Transportation System (CTS), as well as perform significant development and risk reduction testing. Sierra Nevada Corporation will advance their CTS toward critical design, while focusing on safety analysis and subsystem technology maturation and risk reduction. NASA is also moving forward with CTS certification activities to mitigate technical risks and cost or schedule impacts. NASA awarded three Federal Acquisition Regulation based fixed-price Certification Products Contracts (CPC). The scope of the contracts is limited to submittal and technical disposition of specific, early lifecycle certification products. The contract period of performance is January 22, 2013 through May 30, 2014, and individual awards are between $9.5 and $10.0 million each. The total value of all CPC awards is under $30 million.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, Commercial Crew industry teams plan to achieve significant milestones as part of their CCiCap agreements. SpaceX will perform a pad abort test, in which an abort is initiated while the capsule is still on the launch pad. This test demonstrates the effectiveness of the Dragon's launch abort system and is a key design driver; it also reduces risk for the later planned in-flight abort test. SNC will complete risk reduction and technical readiness testing to mature Dream Chaser systems, such as environmental control and life support systems, thermal control systems, and crew systems. Elements from these tests will satisfy certification requirements in the SNC certification plan. Boeing will perform a pilot-in-the-loop demonstration, which tests hardware and software associated with controlling the vehicle, and will include human crew operators as a part of the simulated flight activities.

In addition to the base planned milestones, NASA reserves the right to execute previously negotiated optional milestones on a case-by-case basis when it is in the interest of the Government. Successfully meeting FY 2014 milestones will enable the commercial partners to continue to mature their capabilities towards the Commercial Crew program's goal of having US crew transportation capability to low Earth orbit and ISS by 2017.

Also in FY 2014, the first phase of CPC will be accomplished, with the NASA review of the partner designs as compared with NASA safety requirements. Specifically, NASA will review four products from each partner: alternative standards; hazard reports; verification and validation plan; and certification plans. Performance on the second phase of CPC is targeted to begin in mid-2014 and will initiate the final development, testing, and verification necessary to allow crewed demonstration flight to ISS by 2017.

Program Schedule

Refer to above graphic titled “Work in Progress for FY 2013”.

Program Management & Commitments

The Human Exploration and Operations team at NASA Headquarters performs strategic management and oversight of Commercial Spaceflight, and Kennedy Space Center (KSC) has responsibility for Commercial Crew program management, in collaboration with the Johnson Space Center. The Commercial Crew program has partnered with industry, utilizing a combination of Space Act Agreements and Federal Acquisition Regulation-based fixed-price contracts to stimulate efforts to develop and demonstrate crew transportation capabilities.

Program Element	Provider
Commercial Crew Program	Provider: Blue Origin, Boeing, Sierra Nevada Corporation, SpaceX Lead Center: KSC Performing Centers: All Cost Share Partners: Industry Partners (providers above)

Acquisition Strategy

The Commercial Crew program facilitates the development of a US commercial crew space transportation capability with the goal of achieving safe, reliable, and cost effective access to and from low Earth orbit and ISS. In the early lifecycle stages, CCDev activities focused on stimulating industry efforts that successfully matured subsystems and elements of commercial crew spaceflight concepts, enabling technologies and capabilities. For this, NASA utilized Space Act Agreements, which provided maximum flexibility to the provider and maximum affordability to the government. Because of the flexible design of the agreements, NASA was able to efficiently leverage less than expected funds to accomplish significant development work from the partners. Subsequently, NASA continued this effort with CCDev2 to address new concepts to mature the design and development of primary elements, such as launch vehicle or spacecraft.

The current stage of the acquisition lifecycle includes the CCiCap Space Act Agreements, designed to provide a cost-effective approach by which partners can be innovative, creative, and flexible in their design solutions to develop an integrated commercial CTS capability, while still maintaining competition for future stages of the program.

The next stage of the acquisition plan shifts to Federal Acquisition Regulation-based fixed-price contracts for certification and services. In parallel with ongoing CCiCap activities, NASA announced that it will begin competitive acquisition for NASA CTS certification, in two phases. Phase 1 (CPC selection) was awarded in December 2012. The scope of these contracts includes alternative standards, hazard analyses, a certification plan, and a verification and validation plan. CPC activities will not include design, development, test, or evaluation activities. At the conclusion of the contracts, NASA anticipates that more than one commercial provider will have achieved the technical maturity of an integrated design state to enable Phase 2 competition for the CTS certification contract.

NASA will release a separate formal request for proposal for the Phase 2 CTS certification contract. This will include award criteria that require proof of a credible integrated design maturity to achieve successful development, test, evaluation, and final NASA certification as well as a demonstration of at least one crewed ISS mission by 2017. Under NASA's planned strategy, the scope of the CTS certification contract will include development, test, evaluation, and certification activities enabling NASA to approve one or more CTS for performing ISS crew transportation services. During this phase, the Agency will verify whether partners are in compliance with NASA requirements to ensure NASA mission and safety objectives are achievable. NASA believes that having multiple contractors through Phase 2 would provide significant advantages for insuring a safe and affordable CTS through competition. The ultimate number of awards will be driven by technical maturity, funding availability, and mission needs.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
CCiCap	Boeing	Houston, TX
CCiCap	Sierra Nevada Corporation	Sparks, NV
CCiCap	SpaceX	Hawthorne, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Other	NASA Advisory Council	Nov 2012	To provide independent guidance for the NASA Administrator	The Council recommended that NASA revisit its near-term human capital planning to include specific new hires with significant outside business experience to enhance implementation of the Agency's vision of space commercialization. The Council had a finding that there is an increasing acceptance of commercial approaches across NASA.	TBD
Other	Aerospace Safety Advisory Panel	Jan 2013	To provide independent assessments of safety to the NASA Administrator	Recommended that NASA should develop a philosophical approach to the certification process; specifically, when NASA certification is required and when it is not.	TBD
Other	Booz Allen	Oct 2012 - Feb 2013	To provide an independent cost assessment	Findings to be published by early April 2013.	N/A

COMMERCIAL CREW

HISTORICAL PERFORMANCE

Through December 31, 2012

Commercial Orbital Transportation System (COTS) Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through 12/31/12 (in $M)	% No. Completed	% Payments Provided	Status
SpaceX	40	396.0	40	396.0	100%	100%	Completed
Orbital	29	288.0	25	276.5	86%	96%	Active
Rocketplane-Kistler (RpK)	15	206.8	3	32.1	20%	16%	Terminated

CCDev1 Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through 12/31/12 (in $M)	% No. Completed	% Payments Provided	Status
Sierra Nevada Corporation (SNC)	4	20.0	4	20.0	100%	100%	Completed
Boeing	36	18.0	36	18.0	100%	100%	Completed
Blue Origin	7	3.7	7	3.7	100%	100%	Completed
Paragon Space Development Corporation	5	1.4	5	1.4	100%	100%	Completed
United Launch Alliance (ULA)	4	6.7	4	6.7	100%	100%	Completed

CCDev2 Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through 12/31/12 (in $M)	% No. Completed	% Payments Provided	Status
Sierra Nevada (SNC)	13	105.6	12	97.6	92%	92%	Active
Boeing	15	112.9	15	112.9	100%	100%	Completed
SpaceX	10	75.0	10	75.0	100%	100%	Completed
Blue Origin	10	22.0	10	22.0	100%	100%	Completed
United Launch Alliance (ULA)	5	N/A	5	N/A	100%	N/A	Completed
Alliant Techsystems Inc (ATK)	5	N/A	5	N/A	100%	N/A	Completed
Excalibur Almaz Inc (EAI)	5	N/A	5	N/A	100%	N/A	Completed

CCiCap Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through 12/31/12 (in $M)	% Milestones Completed	% Payments Provided	Status
SNC	9	212.5	2	75.0	22%	35%	Active
Boeing	19	460.0	3	126.9	16%	28%	Active
SpaceX	14	440.0	4	145.0	29%	33%	Active

HUMAN RESEARCH PROGRAM

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	157.7	--	**165.1**	164.6	169.5	175.4	180.0
Change from FY 2012	--	--	**7.4**				
Percentage change from FY 2012	--	--	**4.7 %**				

European Space Agency astronaut André Kuipers (ESA), Expedition 30/31 flight engineer, exercises using the advanced resistive exercise device (ARED) aboard the International Space Station. This apparatus has distinct advantages over previous space exercise machines in that it allows for more consistent load bearing and a wider range of movements. The Human Research Program recently published results demonstrating that current crew exercise prescriptions using the ARED combined with appropriate nutrition is an effective countermeasure against bone and muscle loss.

Of all the critical systems involved with sending astronauts into space, the most complex is the human system. While NASA has amassed more than fifty years of crew experience in low Earth orbit, researchers are still unraveling the mysteries of how the space environment affects the human body. The Human Research Program (HRP) is charged with understanding and mitigating the highest risks to astronaut health and performance, including physiological effects from radiation, low gravity, and planetary environments, as well as the unique challenges of providing medical treatment, human factors, and behavioral health support, to explorers in a space environment. To ensure that crews remain healthy and productive during long duration exploration missions beyond low Earth orbit, HRP is working to develop countermeasures and technologies that will allow astronauts to complete their high-risk missions and preserve lifelong health.

Scientists have studied the effects of low gravity on the human body for decades, but some very significant changes have been detected only since the International Space Station (ISS) test bed has enabled crews to experience long-duration weightlessness. Such effects as muscle atrophy, bone loss, and motion sickness are widely known, but what goes on inside the heart or the skull? Researchers have learned that the heart seems to shrink and reduce its ability to fill completely in space, which could compromise exercise or temperature control. In addition, the discovery of increased intracranial pressure that can reshape the optic nerve in male astronauts is resulting in vision changes that may or may not be permanent.

Understanding these effects on astronauts' physiological systems is critical for the mission planners and system developers charged with implementing NASA's vision for human space exploration. As is the case with many space-based medical investigations however, this research may also lead to significant advancements in treating patients on Earth.

HUMAN RESEARCH PROGRAM

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

HRP published flight research results demonstrating for the first time that current exercise prescriptions using the ISS advanced resistive exercise device and appropriate crew nutrition are effective countermeasures against bone and muscle loss. This reflects a major success, as maintaining bone density and muscle mass is critical to enabling long-duration ISS missions and human exploration beyond low Earth orbit.

In addition, the HRP implemented high-fidelity ISS biomedical imaging using the Ultrasound 2, a modified version of a commercially available device that provides high-resolution ultrasound images of target areas in the human body. The unit works in conjunction with a video power converter that provides real-time ultrasound video downlink, enabling ground personnel to obtain the best possible images for use by investigators or medical personnel. This high resolution imaging capability will enhance high priority biomedical research on visual impairment and intracranial pressure.

Launched aboard NASA's Curiosity rover in November 2011, the Radiation Assessment Detector developed by Advanced Explorations Systems, has collected valuable radiation data both during the spacecraft's transit to Mars, and on the planet's surface. In 2012 and beyond, HRP will use this data to better understand the risks of deep space radiation to humans, and update its radiation risk models to support future exploration missions.

WORK IN PROGRESS IN FY 2013

HRP continues to work on the highest health risks associated with human exploration missions, emphasizing involvement of the external national biomedical research community. In FY 2013, the program is enhancing integration of international partners and US and Russian human research activities on the ISS to address these health risks, including a full year US and Russian mission. The program is already working with the ISS program, Crew Health and Safety project, and our other international partners to understand the visual impairment and intracranial pressure and other risks. By working with our Russian partners, HRP will also be able to incorporate data from cosmonauts into current US research on these critical health issues, increasing the amount of available data and enabling the program to more quickly develop mitigation strategies.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Extended future missions in isolated, extreme and confined environments, increase the opportunity for stress-related behavioral conditions to develop. In FY 2014, HRP will complete and test a prototype individualized stress detection system, which will track physiological signals (heart rate and rate variability) and behavioral signals (sleep-wake patterns) to detect chronic stress, high anxiety, and insomnia during space missions. If initial assessment proves successful, analog tests on Earth will follow using people subjected to similar stressful conditions, such as confinement studies, underwater missions, or the extreme environment of Antarctica. The ultimate goal is to use the system on ISS and future space missions to aid in developing methods to help relieve stress.

Another key activity we expect to implement is the new pressure swing adsorption technology. If an astronaut on a long-duration mission has a medical emergency and goes into shock, or contracts an illness such as pneumonia, additional oxygen would be required. Portable concentrators currently available are too large and require too much power for use on a spacecraft. Using computer simulations and component testing, the program's researchers plan to improve pressure swing adsorption efficiency with a capability that is smaller, lighter and uses less power. Once this technology is developed, NASA will create a version for potential use on ISS and/or future spacecraft.

Program Elements

EXPLORATION MEDICAL CAPABILITY

As NASA makes plans to extend human exploration beyond low Earth orbit, identifying and testing next-generation medical care and crew health maintenance technologies is vital. Available health care options evolve based on past experience, anticipated needs, and input from flight surgeons and crew offices. Teams in this area draft requirements for medical equipment and clinical care capabilities, develop remote medical technologies, and assess medical requirements unique to long-duration space missions.

HUMAN HEALTH COUNTERMEASURES

Biomedical expertise is necessary to identify and assess medical, vehicle and spacesuit standards dictated by human physiological needs, and to develop countermeasures that ensure crew health. Researchers define health and medical standards, validate human health prescriptions and exercise system requirements, develop extravehicular activity injury and decompression sickness prevention standards, integrate physiological countermeasures, and establish criteria for NASA fitness for duty, as well as crew selection and performance standards.

BEHAVIORAL HEALTH AND PERFORMANCE

Just as the space environment poses physiological risks to crewmembers, the unique stresses and challenges of space flight can also affect cognitive and mental performance. NASA must assess the impact of space travel on human behavioral health and develop interventions and countermeasures to ensure optimal crew member health and performance. Researchers in this element make extensive use of analogs, which are experimental environments created to simulate certain aspects of space travel. By duplicating space conditions, such as altered day and night cycles, heavy workloads, social isolation, and close living quarters, scientists gain insight into the impact of these circumstances on human behavior and performance and develop countermeasures, equipment, and other interventions to minimize the risks associated with these variables.

HUMAN RESEARCH PROGRAM

SPACE HUMAN FACTORS AND HABITABILITY

Crew performance and well-being can be affected by where they live, what they eat, and even what they wear. Considering external factors is essential when designing a spacecraft, a habitat or even a spacesuit. Human factors experts develop new equipment, procedures, and technologies designed to make the space environment more livable. Food scientists work to create nutritious and palatable meals that can withstand the rigors of spaceflight and still be prepared easily, generating minimal waste. Other areas of study necessary for living and working in space include assessing the impact of and establishing exposure limits for environmental factors, such as chemicals, bacteria, fungi, and lunar dust.

SPACE RADIATION

As NASA expands human presence through the solar system, it is critical that crews are able to safely live and work in a space radiation environment without exceeding exposure limits. Space radiation researchers determine standards for radiation health, habitability, and environments, and define requirements for radiation protection. They also develop tools to assess and predict risks due to space radiation exposure, and strategies to mitigate exposure effects.

ISS MEDICAL PROJECTS

The ISS provides a unique test bed for HRP activities. The medical projects team plans, integrates, and implements approved biomedical flight experiments on the ISS, as well as research studies that use ground analogs to accomplish program objectives. This includes pre and post-flight activities, coordinating flight or analog resources with our international partners, maintaining ISS biomedical research racks and flight hardware, and developing crew training for both flight and analog investigations. This requires operating the telescience support center, which provides real-time operations and data services to all HRP flight experiments. Strong interfaces with external implementing organizations, such as the ISS payloads office, analog coordination offices, and international partners are critical to maintaining a robust research program.

Program Schedule

Date	Significant Event
Nov 2013	Recommendations on Microbiology Requirements
Dec 2013	Technology for Spaceflight Medical Oxygen Concentrators
Jan 2014	Acute Radiation Permissible Exposure Limits Recommendations
Feb 2014	2014 Investigator’s Workshop
Feb 2014	Release 2014 NASA Research Announcement in Space Radiation
Apr 2014	2013 NASA/NSBRI Research Announcement Selections
May 2014	Complete 2014 Mission X: Train Like an Astronaut Fitness Challenge
Jun 2014	Individualized Stress Detection System Prototype
Jun 2014	Nutrition Supplemental Medical Objective Complete

Aug 2014	2014 NASA/NSBRI NASA Research Announcement Release
Sep 2014	Selections 2014 NASA Research Announcement in Space Radiation
Sep 2014	Distributed System for Spaceflight Biomedical Support

Program Management & Commitments

The Human Research program is managed by a program office located at the Johnson Space Center (JSC) with support from Ames Research Center (ARC), Glenn Research Center (GRC), Langley Research Center and Kennedy Space Center.

The HEO Associate Administrator has delegated the authority, responsibility, and accountability of the Human Research Program manager to the Space Life and Physical Sciences Research and Applications Division at NASA Headquarters. Working closely with the Office of the Chief Scientist and the Office of the Chief Health and Medical Officer, this division establishes the overall direction and scope, budget, and resource allocation for the program, which is then implemented by the NASA centers.

Program Element	Provider
Exploration Medical Capability	Provider: JSC Lead Center: JSC Performing Centers: GRC, ARC, and LaRC Cost Share Partners: N/A
Human Health Countermeasures	Provider: JSC Lead Center: JSC Performing Centers: ARC, GRC Cost Share Partners: N/A
Behavioral Health and Performance	Provider: JSC Lead Center: JSC Performing Centers: ARC, GRC Cost Share Partners: N/A
Space Human Factors and Habitability	Provider: JSC Lead Center: JSC Performing Center: ARC Cost Share Partners: N/A
Space Radiation	Provider: JSC Lead Center: JSC Performing Centers: ARC, LaRC Cost Share Partners: Department of Energy

HUMAN RESEARCH PROGRAM

ISS Medical Project	Provider: JSC Lead Center: JSC Performing Centers: ARC, KSC Cost Share Partners: N/A

Acquisition Strategy

NASA awards contracts and grants in HRP to further efforts in mitigating risks to crew health and performance by providing essential biomedical research and technologies for human space exploration, based upon National Academies studies and Agency roadmaps.

Peer review is utilized to assure a high-quality research program. Engagement of leading members of the research community to competitively assess the merits of submitted proposals is essential to assuring the productivity and quality of research. HRP uses NASA Research Announcements to provide scientists selected by peer review the opportunity to develop complete flight experiments and allow universities to participate in flight research by involving their scientists and engineering schools. HRP plans to announce two NASA Research Announcements s in 2014, one of which will be in conjunction with the National Space Biomedical Research Institute (NSBRI). In FY 2014, a NASA Advisory Council Subcommittee on Life and Physical Sciences will also be in place to provide independent guidance and prioritization for Space Life and Physical Sciences Research and Applications Division (SLPSRA) science.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Program Management	NSBRI	JSC

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Peer Review Panel	Feb 2012	Peer review of NASA Research Announcement	Selected grantees	Feb 2013
Quality	Standing Review Board/External Independent Review	Feb 2012	Review of research projects, gaps and tasks	Verifies project prioritization/ reprioritization	Feb 2014
Quality	National Academies	Jun 2012	Review of "NASA Research on Human Health Risks"	Verifies project prioritization/reprioritization	Jun 2013
Quality	National Academies	Jun 2012	Review of Scientific Merit Assessment Processes	Verifies program review process	TBD

HUMAN RESEARCH PROGRAM

Quality	Independent Program Assessment Office	Sep 2012	Review of Program Management Policies and Practices	Verifies adherence to NASA Program Management Policies	Sep 2014
Quality	National Academies	Jul 2011	Decadal survey of life and physical sciences in microgravity	Establish a guide for research in the next decade.	Jul 2021

HISTORICAL PERFORMANCE

The Human Research Program has made significant progress in addressing the biomedical challenges associated with human spaceflight and future space exploration. In FY 2012, the program published a cover article in the Journal of Bone and Mineral Research (2012) documenting or the first time that exercise prescriptions and proper nutrition can mitigate bone loss in crewmembers on the typical long-duration spaceflight missions of 180 days. HRP also recently identified and rapidly developed a research program to address the mission and long-term health risk of microgravity-induced visual impairment and elevated intracranial pressure. Finally, on the leading risk of space radiation health effects, the program has updated its cancer risk and acute radiation exposure models to better protect crew health and safety.

ADVANCED EXPLORATION SYSTEMS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	142.0	--	**199.0**	176.2	178.3	215.3	218.7
Subtotal	145.3	--	**199.0**	176.2	178.3	215.3	218.7
Rescission of prior-year unob. balances*	-3.3	--	**--**	--	--	--	--
Change from FY 2012	--	--	**57.0**				
Percentage change from FY 2012	--	--	**40.1 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

While the spacesuits currently used for extravehicular activity on the International Space Station are fine for floating in space, they are too heavy and do not provide the leg mobility needed for walking on the Moon, an asteroid, or Mars. The next generation Z-2 spacesuit will provide astronauts go-anywhere garb that features more flexible joints, radiation protection for long stays in space, and a unique access hatch on the back. The hatch will allow the suit to dock with a spacecraft or rover, so an astronaut can crawl through without letting dust in or air out.

Advanced Exploration Systems (AES) represents an innovative approach to developing foundational technologies that will become the building blocks for future space missions. Using focused in-house activities to develop and test prototype systems rapidly, AES is pioneering ways to drive a rapid pace of progress, streamline management, and more effectively utilize the NASA workforce as we transition to enabling human spaceflight beyond low-Earth orbit. Teams of NASA engineers and technologists across the country are engaged in small-scale development activities, gaining valuable hands-on experience with hardware and mastering the skills necessary for future space missions. Early integration and testing of technology will reduce risk and improve affordability of future exploration missions.

AES activities focus on crewed systems for deep space, and robotic precursor missions that gather critical knowledge about potential destinations in advance of crewed missions. Major products include systems development for reliable life support, asteroid capture mechanisms, deep space habitats, crew mobility systems, advanced space suits (including concepts for astronaut extravehicular activity with an asteroid), and autonomous space operations. AES will also collaborate with the Science Mission Directorate to explore innovative partnerships to advance Near Earth Object observation and target identification.

As prototype systems are developed, they are tested using NASA ground-based facilities or as flight experiments on the International Space Station. NASA's Space Technology Mission Directorate also contributes to the HEO effort: AES infuses new Space Technology Mission Directorate-developed technologies into exploration missions, as components integrated into prototype systems. AES also works closely with NASA's Science Mission Directorate on a joint robotic precursor activity to develop instruments, support research and analysis efforts, and plan and conduct precursor missions.

EXPLANATION OF MAJOR CHANGES

AES will start studying alternatives for developing an asteroid capture mechanism, investigating spacecraft control algorithms for capturing and redirecting an asteroid, and demonstrating concepts for astronaut extra-vehicular activity (EVA) with an asteroid's surface.

ACHIEVEMENTS IN FY 2012

In FY 2012, AES achieved significant milestones that improved understanding of the risks to future human explorers in space. Annual milestones for each activity measure performance and drive rapid progress through major fabrication, system integration, and test events. Of 56 milestones, AES accomplished 49, for an 88 percent completion rate. Utilizing both flight and simulated test experiments, NASA gained valuable data and technical insight essential to developing technologies critical to space exploration.

Integrated on the Mars Science Laboratory aboard NASA's Curiosity rover, the Radiation Assessment Detector developed by AES successfully obtained the first radiation measurements from the surface of Mars, providing crucial data for future human space exploration. This data will help NASA evaluate the health risks associated with humans traveling to space, and assist in developing technologies that will reduce astronaut exposure to radiation. The detector will continue to take measurements for the duration of the mission.

As part of a joint effort with the Canadian Space Agency, NASA conducted a prototype lunar ice prospecting experiment in Hawaii to determine whether ice in lunar soil can produce propellants and oxygen. The results indicate that this technology can lead to a significant reduction of consumables would need to be launched from Earth to support human missions, which will impact the development of future human exploration architectures. This collaboration will have implications for the manufacture of propellants from embedded ices throughout the inner solar system, including on asteroids and the surface of Mars.

WORK IN PROGRESS IN FY 2013

As NASA works to extend human space exploration beyond low Earth orbit, AES is developing two experiments for the Exploration Flight Test-1 mission, planned for launch in FY 2014. The first includes solid-state radiation detectors that will measure the radiation environment inside the Orion Multi-Purpose Crew Vehicle when it passes through the Earth's radiation belts. The second experiment, in conjunction with the radiation detectors, is an advanced caution and warning system that will monitor the health of critical vehicle systems by using data transmitted to the ground. If successful, these tests will allow NASA to develop compatible sensors and systems for Orion as well as for other vehicles Additional habitat systems research is underway to further study how crew accommodations, life support, power and avionics subsystems will work on future missions. As part of this study, AES is outfitting a mock-up prototype deep space habitat that will integrate the two radiation systems for testing.

AES has contracted with Bigelow Aerospace on a newly planned addition to ISS that will use the orbiting laboratory to test expandable space habitat technology; the module is scheduled to arrive at ISS in 2015 for a two-year technology demonstration.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

AES will begin addressing the technical barriers to successfully deploying an asteroid capture mechanism, which will include development of several potential design concepts, an analysis of alternatives, and downselect to an option for proof-of-concept ground demonstrations, including structural integrity testing. These efforts will be done in collaboration with the Space Technology and Science Mission Directorates in support of a potential integrated mission to redirect and explore an asteroid.

Spacesuit fabrication will begin on an improved suit that will be lightweight, more flexible, and powered by an advanced battery system. In addition, work will continue on a new portable life support system for the next generation suit, which will provide protection from temperature extremes, supply oxygen, and remove carbon dioxide and contaminants from the air.

Due to mass and power constraints, it will not be possible to launch and carry the supplies needed to support crew on long-duration missions beyond low Earth orbit. Extended missions will require new logistics approaches. In FY 2014, ISS crew will test a cascade distillation system to recycle wastewater, and demonstrate extended wear clothing that will reduce the weight of supplies to be launched from Earth. To improve launch vehicle thrust, NASA is also planning to complete tests of high temperature reactor fuel element materials for nuclear thermal propulsion systems. Nuclear propulsion is more efficient, more powerful, and will reduce the trip time for human missions to Mars.

Testing of autonomous mission operations software will also take place on the ISS. When humans explore deep space, astronauts and flight controllers will not be able to relay messages and commands back and forth in a matter of seconds. By the time contact is made with Mission Control, the crew may already need to be working on a solution to a problem, or performing independent operations during a time-critical mission phase. By allowing the crew to develop plans and procedures, this software testing will help reduce the crew's dependence on ground-based mission control.

Program Elements

Five technology elements called "domains" drive the AES activity. Each domain focuses on a specific exploration technology required for future human exploration.

HABITAT SYSTEMS

The focus of the Habitat Systems domain is enabling the crew to live and work safely in deep space. These include developing a deep space habitat, reliable life support systems, logistics reduction, radiation measurements and protection, and experiments to understand how fire spreads in microgravity to improve spacecraft fire safety.

VEHICLE SYSTEMS

Within the Vehicle Systems domain are efforts to develop technologies needed for advanced in-space propulsion stages and small robotic landers. Current initiatives underway include studies of reactor fuel elements and engine concepts for nuclear thermal propulsion systems, modular power systems for multiple exploration vehicles and systems, and a small lander test bed to demonstrate autonomous precision landing.

OPERATIONS

Included in the Operations domain are mission simulations to test systems and operational concepts, developing software for autonomous mission operations, advanced ground systems to automate propellant handling, next generation autonomous networking technology, and common avionics and software for use in multiple systems. These technologies will make mission and ground operations more efficient and cost effective.

ROBOTIC PRECURSOR ACTIVITIES

Robotic Precursor activities focus on developing robotic missions and instruments to provide strategic knowledge about potential destinations for human missions. Current projects include a ground-based radar to image near-Earth asteroids, risk reduction for an asteroid capture mechanism, a detector to measure the radiation environment on the Mars surface, and a lunar ice prospecting experiment.

Program Schedule

Date	Significant Event
Jan 2013	Complete critical design review for the radiation environment monitor scheduled for the first flight test of Orion MPCV in 2014
Mar 2013	Complete initial safety review for the Bigelow inflatable module scheduled to fly on ISS
Jul 2013	Demonstrate autonomous landing and hazard avoidance in flight test of Morpheus lander
Sep 2013	Complete mission concept review for lunar ice prospecting mission scheduled for flight in 2017
Mar 2014	Test cascade distillation system to recycle wastewater
Apr 2014	Demonstrate software for autonomous mission operations on ISS
Jun 2014	Fabricate second generation Z-2 spacesuit
Jul 2014	Test advanced spacesuit battery
Jul 2014	Demonstrate EVA asteroid exploration capabilities in a ground test
Aug 2014	Complete testing and down selection of reactor fuel element materials for nuclear thermal propulsion

Sep 2014	Complete asteroid capture mechanism down-select to an option for proof-of-concept ground demonstrations and complete mission definition

Program Management & Commitments

The Human Exploration Operations Mission Directorate executes AES activities and the mission directorate's associate administrator has delegated the management authority, responsibility, and accountability to the AES Division at NASA Headquarters. The AES Division establishes overall direction and scope, budget, and resource allocation for activities implemented by the NASA centers. Managers at the centers are accountable for executing AES activities; centers having the required competencies are responsible for each activity and other NASA centers provide support. The managers develop plans and work with the supporting NASA centers to allocate budget, workforce, and schedule to various tasks. The managers report directly to the AES Division at NASA Headquarters.

AES and the Planetary Science Division within the Science Mission Directorate jointly fund the Joint Robotic Precursor Activities (JRPA), developing instruments for inclusion on NASA science and international missions. AES has overall management responsibility for this effort, and coordinates with the Science Mission Directorate on JRPA planning and execution.

Program Element	Provider
Crew Mobility Systems	Provider: NASA Centers Lead Center: HQ Performing Centers: JSC, GRC Cost Share Partners: N/A
Habitat Systems	Provider: NASA Centers Lead Center: HQ Performing Centers: MSFC, JPL Cost Share Partners: N/A
Vehicle Systems	Provider: NASA Centers Lead Center: HQ Performing Centers: GRC, JSC, MSFC Cost Share Partners: Department of Energy
Operations	Provider: NASA Centers Lead Center: HQ Performing Centers: ARC, JSC, KSC, MSFC Cost Share Partners: N/A
Robotic Precursor Activities	Provider: NASA Centers Lead Center: HQ Performing Centers: ARC, JPL, KSC Cost Share Partners: Science Mission Directorate, Canadian Space Agency

ADVANCED EXPLORATION SYSTEMS

Acquisition Strategy

AES selected initial activities via a competitive process in which the NASA centers submitted proposals in specific requested areas. Each year, AES terminates activities that do not demonstrate adequate progress, and adds new activities to the portfolio as appropriate. Teams are provided limited procurement funding to purchase materials, equipment, and test facilities. In addition, activities may utilize a small amount of contractor workforce in areas where NASA can cost effectively leverage their skills and knowledge. To limit this, AES strives to enhance these specialized skills within the civil service workforce. In addition, particular activities may issue competitive solicitations or leverage existing contracts for hardware development.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Crew Mobility Systems: Space Suit	ILC Dover	JSC
Habitat Systems: Life Support System Components	Hamilton Sundstrand	MSFC, JSC
Habitat Systems: Inflatable Module	Bigelow Aerospace	JSC
Vehicle Systems: Reactor Fuel Elements	Department of Energy	MSFC

INDEPENDENT REVIEWS

The NASA Independent Program Assessment Office will conduct independent assessments of the AES activities every three years. In 2015, the Assessment Office will assess the relevance, quality and performance of the AES effort. Periodically, representatives from the Office of Chief Engineer, the Office of Safety and Mission Assurance, and the Office of Chief Financial Officer will assess the program performance during Agency-level Baseline Performance Reviews.

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
All	NASA Independent Program Assessment Office	N/A	Assessment of program relevance, quality, and performance	N/A	2015

SPACE OPERATIONS

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	4184.0	4249.1	**3882.9**	4014.9	3996.2	4167.9	4377.6
Space Shuttle	599.3	--	**0.0**	0.0	0.0	0.0	0.0
International Space Station	2789.9	--	**3049.1**	3169.8	3182.4	3389.6	3598.3
Space and Flight Support	805.2	--	**833.8**	845.1	813.8	778.3	779.3

Space Operations

Space Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	4184.0	4249.1	**3882.9**	4014.9	3996.2	4167.9	4377.6
Space Shuttle	599.3	--	**0.0**	0.0	0.0	0.0	0.0
International Space Station	2789.9	--	**3049.1**	3169.8	3182.4	3389.6	3598.3
Space and Flight Support	805.2	--	**833.8**	845.1	813.8	778.3	779.3
Subtotal	4194.4	4259.4	**3882.9**	4014.9	3996.2	4167.9	4377.6
Rescission of prior-year unob. balances**	-10.4	-10.4	**--**	--	--	--	--
Change from FY 2012	--	--	**-301.1**				
Percentage change from FY 2012	--	--	**-7.2 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Space Shuttle and Space and Flight Support pursuant to P.L. 112-55, Division B, sec. 528(f).*

The International Space Station is a microgravity laboratory capable of research in a multitude of physical and biological science disciplines. Inhabited continuously for over a decade and supported by a partnership of 15 nations, the Station currently supports a crew of six astronauts.

As the Nation moves forward into the next chapter of human spaceflight, Space Operations remain critical to the Human Exploration and Operations (HEO) mission.

After the retirement of the Space Shuttle, HEO shifted its operational focus to the full utilization of the International Space Station (ISS) for conducting research. Operations activity also provides safe and reliable access to space; manages rocket propulsion test facilities; maintains secure and dependable communications to ground stations and between platforms across the solar system; and assures the mission readiness of America's astronaut corps.

For further programmatic information, go to: http://www.nasa.gov/directorates/heo/home/index.html.

Explanation of Major Changes for FY 2014

None.

SPACE OPERATIONS

ACHIEVEMENTS IN FY 2012

On May 25, 2012, Space Exploration Technologies (SpaceX) made history when its Dragon spacecraft became the first commercially-owned vehicle to successfully attach to the ISS. Previously, only four government entities (the United States, Russia, Japan, and the European Space Agency) had achieved this challenging technical feat. The milestone heralded a new phase in ISS operations and utilization, as private industry is positioned to assume the role of providing resupply services (i.e., transporting cargo and experiments) to and from this National Laboratory in space.

In addition, the Space Shuttle program continued its program retirement activities, highlighted by the delivery of the orbiters Discovery and Endeavour to the Smithsonian Institution and the California Science Center, respectively. Bolted to the back of the NASA 747 en route to their final homes, each vehicle made a low-altitude, farewell pass over towns and cities across America.

WORK IN PROGRESS IN FY 2013

In early FY 2013, NASA began to replace its aging Tracking and Data Relay Satellites (TDRS), with the deployment of TDRS-K in January. These next generation satellites will assure continuity of reliable space network tracking, data, voice, and video services to NASA, as well as other US government agencies and commercial launch providers. The Space Shuttle program will complete transition and retirement activities to divest its remaining property by the end of FY 2013. This included the delivery of Atlantis to the Kennedy Space Center Visitors Center in November 2012.

In March 2013 Space X successfully launched a Dragon capsule that berthed to the International Space Station, delivering over 1,000 pounds of supplies for the space station crew and for experiments being conducted aboard the orbiting laboratory, and then safely returning completed research experiments to the ground.

NASA continues to maintain and expand ISS utilization as a research platform for scientific, technological, and educational purposes. Other continued operations include delivering mission-critical communication and navigation services, providing support and training for astronauts preparing for ISS, and ensuring technical and safety expertise for future human space systems development.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA plans to launch TDRS-L in February 2014, and carry out on-orbit testing to confirm that the spacecraft is performing as designed. Once testing is complete, the satellite will become an operational element of the space network, relaying data and commands to and from customer science missions and the ISS. The Agency also plans to launch the RapidScat instrument to the ISS, to measure ocean-surface wind speed and direction. This externally mounted instrument will help improve weather forecasts, including hurricane monitoring, and the understanding of how ocean-atmosphere interactions influence the Earth's climate.

NASA will conduct rocket propulsion testing of key Space Launch System components at Stennis Space Center, including the J-2X engine, which will be integrated into the launch vehicle's second stage.

Flight plans for ISS include approximately four Soyuz launches carrying a total of six US on-orbit segment crew members to ISS, and Commercial Resupply Services flights to deliver research and logistics hardware.

Themes

INTERNATIONAL SPACE STATION

The International Space Station is a unique technological achievement, the result of an international effort to conceive, plan, build, operate, and utilize a research platform in space. It is the latest step in the human endeavor to explore and live in space by providing a laboratory and crew in low Earth orbit to conduct research and advance technology development in biology and biotechnology, materials and physical science, and the effects of long-duration spaceflight on the human body.

Among other benefits, these efforts enable future exploration into deep space by allowing researchers to develop and test countermeasures to reduce risk to crew. The results of the research completed on ISS advance many areas of science, enabling down to Earth benefits and giving humankind the experience and increased understanding necessary to journey to other worlds. Many of these advances hold the promise of next-generation technologies in fields such as health and medicine, robotics, manufacturing, and propulsion.

SPACE AND FLIGHT SUPPORT

Space and Flight Support consists of multiple programs providing Agency-level capabilities critical to the success of NASA missions and goals. The Space Communications and Navigation program operates an extensive network of ground-based and orbiting communications nodes, as well as the associated hardware and software needed to collect the data generated by NASA’s crewed vehicles and robotic spacecraft. Assuring access to space is the mission of the Launch Services program, which provides leadership, expertise and cost-effective expendable launch vehicle services for NASA missions. The Rocket Propulsion Test program maintains a wide variety of test facilities that enable NASA, other agencies, and commercial partners to advance their rocket development efforts in a cost-effective manner. The Human Space Flight Operations program ensures that NASA’s astronauts are fully prepared to safely carry out current and future missions.

INTERNATIONAL SPACE STATION PROGRAM

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	2789.9	--	**3049.1**	3169.8	3182.4	3389.6	3598.3
ISS Systems Operations and Maintenance	1378.7	--	**1318.9**	1258.7	1259.2	1330.3	1329.1
ISS Research	225.5	--	**226.4**	229.3	236.4	239.6	249.6
ISS Crew and Cargo Transportation	1185.7	--	**1503.8**	1681.9	1686.7	1819.7	2019.6
Change from FY 2012	--	--	**259.2**				
Percentage change from FY 2012	--	--	**9.3 %**				

The Earth and a portion of the International Space Station's (ISS) solar array panels provide the backdrop as tiny CubeSats are sent into space outside Japan's Kibo laboratory in October, 2012. Using an orbital mechanism attached to the module's robotic arm, this technology demonstration of small satellite deployment from the station could help save costs over launching from Earth.

The culmination of efforts of the United States and its Canadian, European, Japanese, and Russian partners, the International Space Station (ISS) is a highly complex facility that provides an unparalleled capability for human, space-based research. A crew of six aboard the International Space Station, three on the US on-orbit segment, and three on the Russian segment, orbits the Earth about every 90 minutes. The US on-orbit segment is the portion of ISS operated by US and its Canadian, European, and Japanese partners. The Russian on-orbit segment is operated by Russia.

Including its solar arrays, ISS spans the area of a US football field (with end zones) and weighs over 860,000 pounds, not including visiting vehicles. Orbiting Earth 16 times per day at a speed of 17,500 miles per hour, ISS maintains an altitude that ranges from 230 to 286 miles. The complex has more livable room than a conventional five-bedroom house, with two bathrooms, a fitness center, a 360-degree bay window, and state of the art scientific research facilities. In addition to external test beds, ISS houses three major science laboratories (US Destiny, European Columbus, and Japanese Kibo).

As the world's only space-based multinational research and technology testbed, ISS is critical to the future of human space activities. The facility enables scientists to identify and quantify risks to human health and performance and to develop and test countermeasures and technologies to protect astronauts during extended human space exploration. It is also a perfect testbed for evolving critical technologies needed to venture farther into space, such as long-duration life support, navigation systems, advanced lightweight structures, propulsion, and power generation and storage.

ISS offers unique opportunities for research and development, allowing scientists to investigate biological and physical processes in an environment very different from that on Earth. Observing from and

INTERNATIONAL SPACE STATION PROGRAM

experimenting on the ISS provides the chance to learn about Earth, life, and the solar system from a very different frame of reference. NASA and its partners have used the unique "reference point" of ISS to advance science, technology, engineering, and mathematics (STEM) efforts to inspire youth to pursue those fields. The results of the research completed on ISS can be applied to many areas of science, improving life on this planet, and furthering the experience and increased understanding necessary to journey to other worlds.

The ISS international partnership is transforming space exploration from an effort for the advancement of individual nations, to an endeavor that seeks to advance humankind. ISS aims to provide direct research benefits to the public through its operations, research, and technology development activities. The designation of ISS as a National Laboratory enables partners in government, academia, and industry to use the unique environment and advanced facilities aboard ISS to perform investigations. Ultimately, ISS activities may result in health solutions, or lead to technologies that improve our capabilities in space and on Earth. Additionally, ISS supports NASA's effort to develop a low Earth orbit space economy, as the demand for ISS access provides a customer base for commercial crew and cargo system providers.

For additional information on the ISS program, go to: https://www.nasa.gov/mission_pages/station/main/index.html.

For specific information on the many experiments conducted on ISS, go to: https://www.nasa.gov/mission_pages/station/research/experiments_category.html.

EXPLANATION OF MAJOR CHANGES

None.

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	1378.7	--	**1318.9**	1258.7	1259.2	1330.3	1329.1
Change from FY 2012	--	--	**-60.9**	--	--	--	--
Percentage change from FY 2012	--	--	**-4.4%**	--	--	--	--

During this spacewalk in September 2012, Expedition 32 Flight Engineer Sunita Williams installed a camera on the Canadarm2 robotic arm and completed installation of a Main Bus Switching Unit. In so doing, Williams surpassed the women's world record for time spent in extravehicular activity, with a total in excess of 44 hours. This 252nd spacewalk by US astronauts was the 165th in support of International Space Station assembly and maintenance.

The International Space Station (ISS) is a complex research facility and human outpost in low Earth orbit, developed in a collaborative, multinational effort to advance exploration of the solar system, enable unique scientific research, and promote commerce in space.

Safely operating ISS in the severe conditions of space and ensuring that the crew always has a sufficient supply of food, water and oxygen available requires precise planning and logistics. Much like a home, ISS requires routine maintenance and is subject to unexpected mechanical failures. However, the systems on ISS are much more complex than those in an average home. Repairs can be challenging, often requiring the crew to make repairs in space, with support from ground teams on Earth. The astronauts cannot go to the local hardware store to buy materials; as with water and oxygen, support teams on Earth monitor and painstakingly plan replacement parts and "consumables" such as filters, to make sure they are available when needed. The ISS Systems Operations and Maintenance project is responsible for ensuring that ISS is fully operational and available to perform its research mission.

The planning and support needed to allow crew to live and work comfortably requires intensive Earth-based mission operations. Ground teams continually monitor ISS performance, provide necessary vehicle commands, and communicate with crew. Even before the astronauts leave Earth, the Systems Operations and Maintenance project provides crew training to prepare them for their stay aboard ISS.

When developing operations plans to meet ISS program objectives, all aspects of the mission are considered. These include scheduling crew time, coordinating docking and undocking of visiting crew and supply ships, evaluating consumables supply, and managing stowage issues.

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

The Systems Operations and Maintenance project also funds immediate, emergency services and analyses conducted by mission control teams on Earth. In NASA terminology, this is classified as vehicle and program anomaly resolution. Engineers and operators diagnose system failures and develop solutions, while program specialists respond to changing program needs and priorities through replanning efforts. This was the case in October 2012, when NASA had to plan an extravehicular activity to isolate an external thermal control fluid leak, which was in danger of shutting down a portion of the Station's power system. Safety and mission assurance personnel provide evaluations to ensure that safety is never compromised. Without anomaly resolution capability, the ISS cannot function as a safe, human-occupied, Earth-orbiting research facility.

Because ISS is an international partnership, program decisions are not made in isolation, but require coordination with multiple countries to ensure that all technical, schedule, and resources supply considerations are taken into account. The experience that NASA is gaining through integration with its ISS partners is helping the Agency better prepare for future partnerships in human exploration endeavors.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Throughout the year, NASA ground teams continued to monitor overall vehicle health, and oversee general maintenance and performance of all ISS vehicle systems, including command and data handling; communication and tracking; crew health care; environmental control and life support; electrical power; extravehicular activity (EVA); extravehicular robotics; flight crew equipment; guidance navigation and control; propulsion, structures and mechanisms; and thermal control.

In FY 2012, while some systems experienced anomalies, all had acceptable performance with no impact to ISS operations. Overall, system reliability exceeded original predictions. For example, batteries are an essential component of the electrical power system and were originally designed to last over six years. The first two battery sets, installed in December 2000, lasted more than eight and nine years respectively, exceeding the planned design life by over 32 percent. Current batteries on orbit (installed September 2006 and February 2009) are also continuing to outperform their planned life.

Beyond normal operations, the ISS team supported activities during four EVAs: two from the US joint airlock, and two from the Russian segment. As part of satellite servicing activity, the Robotic Refueling Mission demonstrated a gas fitting removal task where robot teleoperators at Johnson Space Center directed Dextre (the Canadian Space Agency's robotic handyman aboard ISS) to retrieve tools and perform the tasks required to cut safety wires and remove representative fittings located on the module aboard ISS. This was a valuable exercise, since many spacecraft use these fittings to fill fluids and gases prior to launch.

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

The ISS program met all of its FY 2012 NASA Performance Goals, including maintaining a six-crew member capability, flying all planned resupply flights, and providing 100 percent of the resources needed to support research.

WORK IN PROGRESS IN FY 2013

The ISS Systems Operations and Maintenance project continues to maintain resources (on-orbit and on the ground) to operate and utilize ISS. NASA expects continued success in providing all necessary resources (including power, data, crew time, logistics, and accommodations) needed to support research, while operating safely with a crew of six astronauts. Four crew rotation and seven cargo resupply missions are planned in FY 2013, including both international partner and US commercial cargo flights. The team has supported one US EVA to date, and will support three additional EVAs from the Russian segment. In addition, the Robotic Refueling Mission will demonstrate additional refueling tasks, including a fluid transfer.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, the Systems Operations and Maintenance program will work with the international partners to maintain a continuous six crew member capability on ISS by coordinating and managing resources, logistics, systems, and operational procedures. The program will continue to manage requirements and changes in ISS resources, including vehicle traffic, cargo logistics, stowage, and crew time. In addition to planning and real-time support for all ISS activities such as EVA and visiting vehicles, the team will provide anomaly resolution and failure investigation activities as needed. Robotic refueling mission operations and data analysis will proceed as NASA continues to engage private industry and other government agencies to determine their interest in these capabilities.

Project Schedule

The table below provides a schedule for potential EVAs. However, ISS conducts near term, real-time assessments of EVA demands along with other program objectives, to efficiently plan all required ISS activities. NASA remains postured to conduct EVAs on short notice in response to specific contingency scenarios. In addition, routine maintenance EVAs are planned when the list of tasks fulfills an EVA and the activity can be accommodated within the program objectives for the increment, while maintaining focus on utilization and research.

Date	Significant Event
Nov 2012	US EVA 20
Apr 2013	Russian EVA 32
Jun 2013	Russian EVA 33
Jul 2013	US EVAs 21 and 22
Aug 2013	Russian EVAs 34 and 35
Oct 2013	Russian EVA 36

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

Dec 2013	Russian EVA 37
Jan 2014	Russian EVAs 38 and 39
Apr 2014	Russian EVAs 40, 41, and 42
Jun 2014	Russian EVAs 43,44, and 45
Aug 2014	Russian EVA 46

Project Management & Commitments

While NASA maintains the integrator role for the entire ISS, each partner has primary authority for managing and operating the hardware and elements they provide. Within NASA, the Johnson Space Center in Houston, Texas leads project management of ISS Systems Operations and Maintenance.

Acquisition Strategy

NASA extended the Boeing US on-orbit segment sustaining engineering contract until September 30, 2015. It is a cost plus award fee contract that provides sustaining engineering support, end-to-end subsystem management, and post production hardware support.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
US on-orbit segment Sustaining Engineering Contract	The Boeing Company	Johnson Space Center

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Program Implementation Review	Standing Review Board	N/A	Assess the program's ability to safely operate and maintain the ISS vehicle and to provide for a continuous human presence on-orbit. In addition, the Program Integration Review will assess ISS utilization activities across agency programs and the National Laboratory.	TBD	May 2013
Other	NASA Aerospace Safety Advisory Panel	Jan 25, 2013	Provides independent assessments of safety to the NASA Administrator.	No formal recommendations or findings.	TBD
Other	NASA Advisory Council	Nov 28-30, 2012	Provides independent guidance for the NASA Administrator.	No formal recommendations or findings.	TBD

HISTORICAL PERFORMANCE

The table below provides the historical health assessment of each ISS system in FY 2012. As the table indicates, all systems were acceptable for the year with the exception of the electrical power system, due to an ammonia leak in a photovoltaic radiator. On November 1, 2012, astronauts conducted a spacewalk to reroute the ammonia flow through a spare radiator so the photovoltaic thermal control system could continue operation.

SUBSYSTEM	Oct 2011	Nov 2011	Dec 2011	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sep 2012
Command and Data Handline (C&DH)	G	G	G	G	G	G	G	G	G	G	G	G
Communications & Tracking (C&T)	G	G	G	G	G	G	G	G	G	G	G	G
Crew Health Systems (CHeCS)	G	G	G	G	G	G	G	G	G	G	G	G
Environments & Life Support (ECLSS)	G	G	G	G	G	G	G	G	G	G	G	G
Electrical Power System (EPS)	G	G	G	G	G	G	G	G	G	G	G	Y
Extra-vehicular Activity (EVA)	G	G	G	G	G	G	G	G	G	G	G	G
Extra-vehicular Robotics (EVR)	G	G	G	G	G	G	G	G	G	G	G	G
Flight Crew Equipment (FCE)	G	G	G	G	G	G	G	G	G	G	G	G
Guidance & Navigation (GN&C)	G	G	G	G	G	G	G	G	G	G	G	G
Propulsion	G	G	G	G	G	G	G	G	G	G	G	G

ISS SYSTEMS OPERATIONS AND MAINTENANCE

Formulation	Development	Operations

Structures & Mechanisms (S&M)	G	G	G	G	G	G	G	G	G	G	G	G
Thermal Systems (TCS)	G	G	G	G	G	G	G	G	G	G	G	G
Payload Facilities	G	G	G	G	G	G	G	G	G	G	G	G

The Electrical Power System is yellow in September 2012 due to an ammonia leak in the photovoltaic radiator on the P6 truss. On November 1, 2012, astronauts conducted a spacewalk to reroute the ammonia flow through a spare radiator so the photovoltaic thermal control system (PVTCS) could continue operation.

Purpose: To provide a sense of the availability and functional status of the on orbit systems

Definitions:

(G) Acceptable performance. Degraded performance of any subsystem may be deemed acceptable, dependent on other mitigating factors such as redundancy, spares availability, or criticality level.
(Y) Degraded system performance with some operations being impacted.
(R) System performance is degraded and there is a significant impact to operations

ISS RESEARCH

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	225.5	--	**226.4**	229.3	236.4	239.6	249.6
Change from FY 2012	--	--	**0.9**				
Percentage change from FY 2012	--	--	**0.4 %**				

Don Pettit, ISS Expedition 30 flight engineer, works with colloidal particles in the microgravity sciences glovebox in March of 2012, studying interactions between particle surfaces and solvents. Results of this experiment will enable scientists to create models and processes to better preserve food and chemicals, evenly distribute ingredients to produce glues, jellies and gelatins, and control light movement in optical devices and materials.

The International Space Station (ISS) is an orbiting platform that provides an unparalleled capability for space-based research as well as a unique venue for developing technologies for future human space exploration. As a research and development facility, ISS enables scientific investigation of physical processes in an environment very different from that of Earth. A range of science laboratories, external testbeds, and observatory sites are available aboard the ISS, enabling astronauts to conduct a wide variety of experiments in the unique environment of low Earth orbit.

ISS supports research across a diverse array of disciplines, including physics, Earth science, space science, biology and biotechnology, human physiology, agricultural science, chemistry and materials science. In addition, ISS is a platform for educational activities that allow the public to connect with NASA and inspire students to excel in science, technology, engineering, and mathematics academic disciplines.

As NASA’s only long-duration flight testbed, ISS is critical to developing plans to extend human space exploration beyond low Earth orbit. Aboard ISS, researchers study the effects of long-duration exposure to the space environment, devising and testing countermeasures that can offset risks to crew.

ISS also serves as a testbed for next generation exploration technologies. The critical power supply for NASA's Mars Science Laboratory aboard the Curiosity rover uses a coating that was first tested on ISS. Material durability data, gathered from tests performed on ISS, have helped spacecraft designers shorten the development time for satellite hardware components.

Research and development conducted aboard ISS also holds the promise of next-generation technologies in health and medicine, robotics, manufacturing, and propulsion.

ISS RESEARCH

Formulation	Development	Operations

In December 2012, NASA contracted Bigelow Aerospace to develop an expandable habitat for ISS. The Bigelow Expandable Activity Module (BEAM) will be used to prove inflatable technology for future human spaceflight and exploration activities. It is planned to launch in May 2015.

As the name implies, the International Space Station is not strictly a NASA endeavor, but a collaborative venture with our international partners, including the Canadian, European, Japanese, and Russian space agencies. Although each partner has distinct national goals for ISS research, all participating agencies share a unified goal to extend the resulting knowledge for future exploration and to benefit humanity. Within NASA, mission directorates prioritize their research investments based on decadal studies from the National Academies and Agency roadmaps.

The ISS Research project funds fundamental research in biological and physical sciences to enable future human exploration and to add to our existing body of knowledge. Also funded is multi-user systems support, which provides strategic, tactical, and operational support to all NASA sponsored and non-NASA sponsored payloads (including those of the five international partners), as well as operation of on-orbit research facilities. ISS research enabling activities are included, as well as support to the Center for the Advancement in Space (CASIS), a non-profit management organization that determines commercial and other non-NASA research priorities for the ISS National Laboratory.

With the conclusion of Expedition 32 in October 2012, more than 1,400 principal investigators from 63 countries around the world have performed approximately 1,500 research investigations utilizing ISS; over 500 research and development results have been published in scientific journals and magazines. ISS will continue to provide research opportunities to scientists, engineers, and technologists through at least 2020.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Scientific accomplishments on ISS continue to increase, as do the quantity of data returned from automated research instruments, and the astronaut crew time dedicated to research.

As NASA looks forward to expanding human exploration of the solar system, work aboard ISS continued efforts to enable long-duration space flight. This year, studies revealed that high-intensity resistive exercise combined with Vitamin D can help preserve bone mass density without the need for pharmaceuticals. While critical to astronaut health, these results may also be relevant to treatments for the estimated 44 million Americans affected by osteoporosis.

Apart from the field of medicine, fluids experiments provided the most refined engineering data yet for design of effective liquid storage devices on spacecraft, critical for future exploration and Earth applications including ground water transportation and heat pipes. In addition, combustion studies

Formulation	Development	Operations

enhanced understanding of "cool flames," which are low-temperature flames ignited by chemical reactions of fuel vapor and air. On Earth, these flames are difficult to observe, but they are responsible for "engine knock" in internal combustion engines. These research results could aid in diesel engine performance and overall combustion safety.

Educational activities aboard ISS have inspired millions of students worldwide, involving them in research, and demonstrating the science and engineering principles behind space exploration. In FY 2012, NASA moved beyond the traditional classroom by incorporating social media and supporting student experiments on ISS. These activities involved over 42 million students and 2.8 million teachers across 44 countries. NASA selected fifteen student experiments, on topics ranging from liver cells to antibacterial resistance from 779 student proposals assembled by 3,500 students in the United States, and are now operating on ISS. Bill Nye "the Science Guy" announced the winners of the YouTube Space Lab student experiment in March 2012. The competition received over 2,000 video proposal submissions from students around the world. The two winning experiments, from the United States and Egypt, were flown aboard ISS and streamed to Earth in September. Such competitions provide students a hands-on opportunity to design experiments and simple demonstrations that can be performed in the classroom and by astronauts aboard ISS.

As manager of ISS National Laboratory utilization, CASIS identified research pathways and announced research solicitations for protein crystal growth, Earth observation, and materials testing. CASIS also announced an agreement with the global pharmaceutical company, Merck Research Laboratories to collaborate on flight experiments with engineered proteins that could ultimately lead to development of new drugs and therapies to treat human immunological diseases.

For a more comprehensive list of research achievements on the ISS, go to: http://www.nasa.gov/mission_pages/station/research/index.html.

WORK IN PROGRESS IN FY 2013

On October 5, 2012, NASA announced a twelve-month study to investigate the effects of long-term stays in space on bone density, muscle mass, strength, vision and human physiology. Although ISS crew visits are currently limited to six months, two astronauts will remain aboard for a full year of research, starting in spring 2015. While critical for future exploration missions, NASA anticipates that this study and other investigations will also have application on Earth. As a growing senior population faces a myriad of age-related health concerns, NASA's research advances knowledge of bone and muscle health, immunology, and innovative diagnostic systems, all of which hold promise for medical treatments on Earth.

The ISS research project continues to develop hardware that supports research such as a large plant chamber planned for deployment in 2015. This facility is key to studying what happens to plants in space, and to determine whether humans can successfully grow food in microgravity during long-duration exploration missions. Plants are not only a source of food, but they provide oxygen, building material, and water recycling. This research will also allow people on Earth to grow more food using less land, and to regenerate lost forest areas more quickly.

ISS RESEARCH

Formulation	Development	Operations

As we move closer to the reality of extended space habitation, there is growing scientific interest in how different gravitational states influence humans. NASA is building hardware to study the effects of gravity on physiology and biology. Since osteoporosis appears to accelerate in space, this same hardware will enable CASIS and commercial partners to focus on potential remedies.

In addition, the ISS multi-user systems support payload integration function will support 300 on-orbit payload investigations and 500 investigators in FY 2013.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, new hardware will be used to perform plant research and investigate gravity effects on physiology and biology. The first phase of a new fruit fly lab will launch in FY 2014, enabling study of micro- and fractional-gravity effects on humans. The fruit fly is a complex organism that has been extensively studied on Earth. At first glance, fruit flies do not seem to be a good analog for humans, but on the molecular level, we share many of the same basic genes and signal transactions. Research on insects is opening up new avenues for development of prevention and therapy against infections, cancer, and inflammatory disease. The new fruit fly lab could also enable greater knowledge of human genetic responses to long-term stays in space.

Externally mounted payloads will be delivered to ISS to study Earth’s atmosphere, cosmic rays, high energy astrophysics, and the origin of the universe. One of these is the Cloud-Aerosol Transport System (CATS), which uses a Lidar remote sensing instrument to provide measurements of atmospheric clouds and aerosols such as pollution, dust, and smoke. The investigation will perform long duration observations of up to three years beginning in 2014, providing continuity in data acquired on previous missions. Observations of Earth’s changing atmosphere enable researchers to understand formative and ongoing processes, and ultimately model and predict future climate changes. The orbit of ISS is particularly suited to measurements of this kind because of the geographic areas it passes over, and because it permits study of day-to-night changes, which other Earth science satellites cannot offer, due to their orbits.

Reusing hardware originally built to test parts of NASA's QuikScat satellite, the Agency will launch the ISS-RapidScat instrument to ISS in 2014 to measure ocean-surface wind speed and direction. As an autonomous externally mounted payload to the Columbus laboratory, the ISS-RapidScat instrument will help improve weather forecasts, including hurricane monitoring, and understanding of how ocean-atmosphere interactions influence Earth's climate. ISS-RapidScat will help fill the data gap created when QuikScat, which was designed to last two years but operated for 10, stopped collecting ocean wind data in late 2009. Current scatterometer orbits pass the same point on Earth at approximately the same time every day. Since the Station's orbit intersects the orbits of each of these satellites about once every hour, ISS-RapidScat can serve as a calibration standard and help scientists stitch together the ocean-surface wind data from multiple sources into a long-term consistent record. A SpaceX Dragon cargo spacecraft will deliver the instrument, and the instrument is expected to operate for two years.

The ISS program will begin work to support hardware development such as a new Cold Atom Laboratory that will take advantage of the microgravity environment to create the coldest matter in the universe, which is just a trillionth of a degree above absolute zero. At these temperatures, individual atoms,

ISS RESEARCH

Formulation	Development	Operations

following the laws of quantum mechanics, approach fractions of a millimeter in effective size and making it possible to visually observe the quantum interactions of clouds of atoms. In 2014, the Cold Atom Laboratory is scheduled to complete the critical design review phase, in preparation for delivery to ISS in 2016. The laboratory could enable significant discoveries in atomic physics, which could have applicability to next generation communications, navigation, timekeeping, and computing.

Project Schedule

An increment is defined as a period of time for ISS operations that spans from one Soyuz undock to the next Soyuz undock. There are four increments per year that consist of cargo ship arrivals and departures, as well as activities performed on board, including the research performed. The table below outlines start dates of the upcoming increments to ISS.

Date	Significant Event
Mar 2013	Increment 35
May 2013	Increment 36
Sep 2013	Increment 37
Nov 2013	Increment 38
Mar 2014	Increment 39
May 2014	Increment 40
Sep 2014	Increment 41

Project Management & Commitments

The Space, Life and Physical Sciences Research and Applications Division (SLPSRAD) at NASA Headquarters manages biological and physical sciences research. The division, working closely with the Office of the Chief Scientist, establishes the overall direction and scope, budget, and resource allocation for the project, which is then implemented by the NASA centers and acts as the liaison with CASIS. Other ISS Research activities such as multi-user systems support and National Laboratory enabling activities are managed by the ISS Program Office.

ISS RESEARCH

Formulation	Development	Operations

Element	Description	Provider Details	Change from Formulation Agreement
Biological and Physical Sciences	This element includes all NASA-sponsored biological and physical research.	Provider: NASA Centers, contractors, and principal investigators Lead Center: HQ Participating Centers: ARC, GRC, JPL, MSFC, JSC Cost Share Partners: N/A	N/A
Multi-user systems support (includes National Laboratory enabling activities)	Multi-user systems support activities support all research on ISS, both NASA sponsored and non-NASA sponsored.	Provider: ISS program and contractors Lead Center: JSC Participating Center: MSFC Cost Share Partners: N/A	N/A

Acquisition Strategy

NASA awards contracts and grants for the conduct of ISS Research. NASA-sponsored biological and physical research is managed by SLPSRAD; NASA selected CASIS to manage non-NASA ISS Research activities. This independent non-profit will further develop national uses of ISS.

Peer review is the means to assure a high-quality research program. Engagement of leading members of the research community to competitively assess the merits of submitted proposals is essential to assuring the productivity and quality of ISS Research. SLPSRAD uses NASA research announcements to provide scientists selected by peer-review the opportunity to develop complete flight experiments and allow universities to participate in flight research by involving their scientists and engineering schools. ISS Research plans to announce two to four biological and physical sciences NASA research announcement opportunities in 2013.

NASA prioritizes research based on National Academies' decadal studies and Agency roadmaps. In FY 2014, a NASA Advisory Council Subcommittee on Life and Physical Sciences will be in place to provide independent guidance and prioritization for NASA-sponsored biological and physical research. Major technology demonstrations require significant cooperative funding, and NASA is developing an approach for cross-Agency prioritization of ISS technology initiatives.

ISS RESEARCH

Formulation	Development	Operations

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Vehicle Sustaining Engineering Contract	The Boeing Company	Houston, TX
Huntsville Operations Support Center	COLSA Corporation	Huntsville, AL
ISS National Laboratory Management Entity	CASIS	Tallahassee, FL

INDEPENDENT REVIEWS

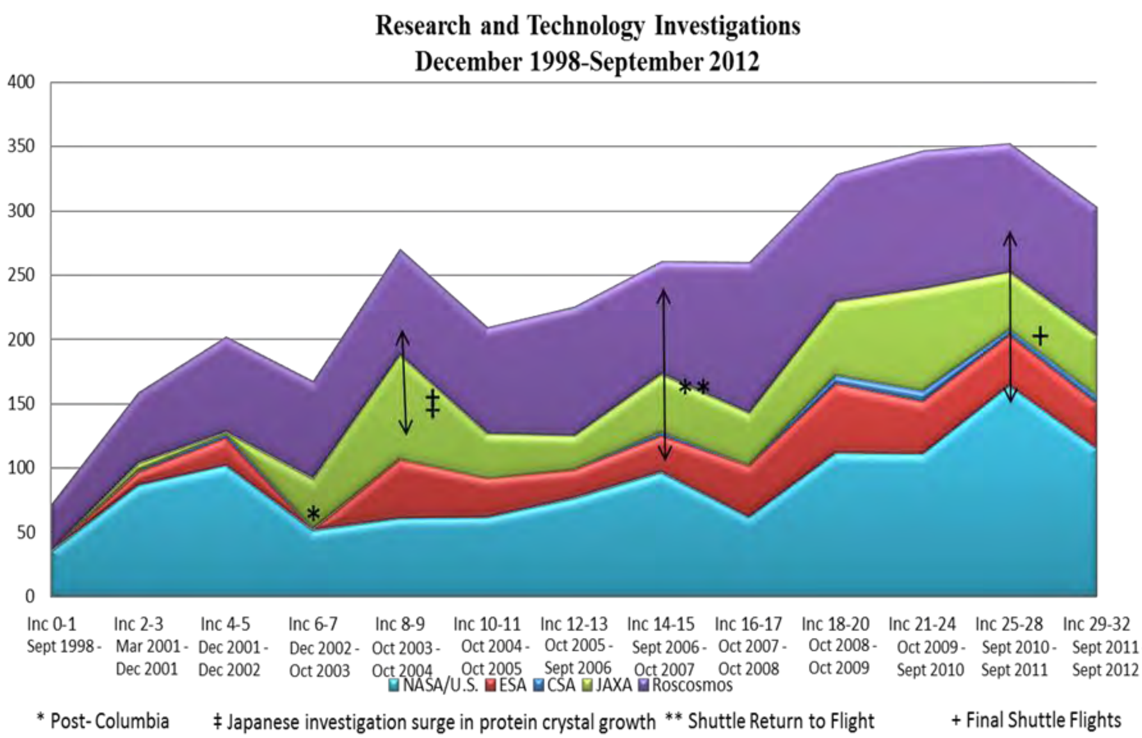
Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Quality	Peer Review Panel	Jul 2012	Peer review of space biology NASA research announcement	Selection of grantees	Nov 2012
Quality	Peer Review Panel	Nov 2011	Peer review of physical sciences NASA research announcement	Selection of grantees	May 2012
Quality	National Academies	Jul 2011	Decadal survey of life and physical sciences in microgravity	Establish a guide for research in the next decade.	Jul 2021
Program Implementatio n Review	Standing Review Board	N/A	Assess the ISS program's ability to safely operate and maintain the ISS e and to provide for a continuous human presence on orbit. In addition, the Program Implementation Review will assess ISS utilization activities across Agency programs and the National Laboratory.	TBD	May 2013
Other	NASA Aerospace Safety Advisory Panel	Jan 2013	Provides independent assessments of safety to the NASA Administrator.	No formal recommendation s or findings.	TBD
Other	NASA Advisory Council	Nov 2012	Provides independent guidance for the NASA Administrator.	No formal recommendation s or findings.	TBD

ISS RESEARCH

Formulation	Development	Operations

HISTORICAL PERFORMANCE

NASA estimates that over 275 research and technology investigations were performed on ISS in FY 2012. The chart below displays historical data by partner agency for research investigations performed on ISS since 1998.



ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	1185.7	--	**1503.8**	1681.8	1686.7	1819.7	2019.6
Change from FY 2012	--	--	**318.1**				
Percentage change from FY 2012	--	--	**26.8 %**				

Japan Aerospace Exploration Agency astronaut Aki Hoshide and NASA astronaut Sunita Williams capture the Space Exploration Technologies Corporation (SpaceX) Dragon commercial cargo spacecraft. Using the Canadarm2 robotic armto berth Dragon to the International Space Station, the crew marked the beginning of NASA's first contracted cargo delivery to the Station.

Maintaining ISS requires an international fleet of vehicles and launch locations to: rotate crew members; replenish propellant; provide science experiments, critical supplies, and maintenance hardware; and dispose of waste. These deliveries sustain a constant supply line crucial to ISS operations and research. The ISS Crew and Cargo Transportation project funds transportation services provided by both international partners and domestic commercial providers.

NASA purchases cargo delivery to ISS under commercial resupply services (CRS) contracts with Orbital Sciences Corporation (Orbital) and Space Exploration Technologies (SpaceX). The FY 2014 budget supports these contracted flights, as well as future flights to provide for cargo transportation, including transportation for National Laboratory research payloads.

The Russian Space Agency, Roscosmos, currently provides ISS crew transportation. NASA plans to purchase crew transportation services from a domestic capability as soon as one becomes available.

The ISS Crew and Cargo Transportation project also funds work supporting visiting vehicles that provide transportation for ISS, such as the system to support crew communications and provide backup capability for the existing cargo transportation providers.

EXPLANATION OF MAJOR CHANGES

None.

ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2012

In FY 2012, CRS contractors passed significant milestones towards achieving commercial cargo transportation services. SpaceX completed one Commercial Orbital Transportation System demonstration flight, and 11 milestones for performance on six commercial resupply flights, including one flown in October 2012. Under the CRS contract, NASA procured capability on the SpaceX demonstration flight, which delivered 1,014 pounds of supplies to ISS, including experiments, food, clothing and technology. On its return trip to Earth, the capsule carried science experiments back to researchers hoping to gain new insights provided by the unique microgravity environment in ISS laboratories. In addition to the experiments, Dragon returned a total of 1,367 pounds of hardware and cargo no longer needed. Orbital completed seven milestones for performance on five future commercial resupply flights.

The Crew and Cargo Transportation project also supported four Russian Soyuz launches in FY 2012, providing crew transportation services to ISS for six US on-orbit segment crew members.

WORK IN PROGRESS IN FY 2013

In FY 2013, the ISS Crew and Cargo Transportation project will continue to provide a stable cargo flight plan, which includes CRS flights to deliver research and logistics hardware to ISS. On October 28, 2012, SpaceX became the first domestic cargo supply and return service provider since the end of the Shuttle program. In March 2013, SpaceX completed their second CRS flight. In total in FY 2013, NASA expects SpaceX to launch two resupply flights, and complete 11 performance milestones on seven resupply flights. NASA expects Orbital to launch one Commercial Orbital Transportation System demonstration flight and one CRS flight, and complete six performance milestones for performance on six resupply flights.

In FY 2013, the ISS Crew and Cargo Transportation project will also continue to provide a stable crew flight plan, which includes approximately four Soyuz launches carrying a total of six US on-orbit segment crew members to ISS.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The ISS Crew and Cargo Transportation project will enable continued research and technology development by providing a stable crew and cargo flight plan. These flight plans include approximately four Soyuz launches carrying a total of six US on-orbit segment crew members to ISS, and commercial resupply flights to deliver research and logistics hardware. NASA expects Orbital to launch two CRS flights, and complete 11 performance milestones on five flights. NASA also expects SpaceX to launch three commercial resupply flights and complete seven performance milestones on five flights.

Project Schedule

Maintaining a regular rate of cargo delivery on a mix of NASA and partner vehicles ensures that nominal operations and maintenance are sustained, while allowing the program to respond to any anomalies that

ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

might occur. The table below shows the scheduled ISS flight plan for FY 2013 and FY 2014. NASA funds SpaceX, Orbital and Soyuz seats related to US on-orbit segment crew requirements. The planned spacing of the Soyuz crew rotation flights assures a continuous six-crew presence on ISS, as well as smooth transitions between crews.

Date	Significant Event
Oct 2012	SpX-1
Oct 2012	Soyuz 32S
Oct 2012	Progress 49P
Dec 2012	Soyuz 33S
Feb 2013	Progress 50P
Mar 2013	SpX-2
Mar 2013	Soyuz 34S
Apr 2013	Progress 51P
May 2013	Soyuz 35S
Jun 2013	Orbital Commercial Orbital Transportation System Demonstration
Jun 2013	ATV-4
Jul 2013	Progress 52P
Aug 2013	HTV-4
Sep 2013	Orb-1
Sep 2013	Soyuz 36S
Oct 2013	Progress 53P
Nov 2013	SpX-3
Nov 2013	Soyuz 37S
Dec 2013	Orb-2 (under review)
Dec 2013	Russian Assembly Flight 3R (Multipurpose Laboratory Module)
Feb 2014	Progress 54P
Mar 2014	Soyuz 38S
Apr 2014	SpX-4
Apr 2014	Orb-3 (under review)
Apr 2014	Progress 55P
Apr 2014	ATV-5
May 2014	Soyuz 39S
Jul 2014	HTV-5
Aug 2014	Progress 56P
Aug 2014	SpX-5

ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

Project Management & Commitments

Johnson Space Center (JSC) is responsible for project management of ISS Crew and Cargo Transportation.

Element	Description	Provider Details	Change from Formulation Agreement
Crew transportation	Roscosmos will provide crew transportation to ISS via the major contract described below until a domestic capability is available.	Provider: Roscosmos Lead Center: JSC Participating Centers: Cost Share Partners: CSA, ESA, and JAXA	N/A
Cargo transportation	Orbital and SpaceX will provide cargo transportation to ISS via the major contracts described below. ESA and JAXA will provide additional cargo transportation as part of the ISS partnership. Roscosmos will also provide nominal cargo transportation via Soyuz purchased for crew transportation.	Provider: Orbital, SpaceX, ESA, JAXA, and Roscosmos Lead Center: JSC Participating Centers: GSFC, KSC Cost Share Partners: CSA, ESA, and JAXA	N/A

Acquisition Strategy

NASA competitively awarded CRS contracts to SpaceX and Orbital on December 23, 2008. These are milestone based fixed-price indefinite delivery, indefinite quantity contracts. Cargo transportation services began in 2012, with the current contracts running through 2016. NASA plans to competitively procure any future cargo transportation services, excluding services obtained via barter with our international partners or nominal cargo transportation provided by Soyuz.

In 2006, NASA modified the Roscosmos contract to include crew transportation, rescue, and related services. The contract is a sole source contract under FAR 6.302-1 (only one responsible source and no other supplies or services will satisfy Agency requirements). NASA has currently contracted with Roscosmos for crew launches through 2015, and crew rescue and return through early 2016. As domestic crew transportation services become available (planned for 2017), NASA will competitively procure those services.

ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Crew transportation	Roscosmos	Moscow, Russia
Cargo transportation	Orbital	Dulles, VA
Cargo transportation	SpaceX	Hawthorne, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Program Implementation Review	Standing Review Board	N/A	The Sustainment and Utilization Program Implementation Review will assess the ISS Program's ability to safely operate and maintain the ISS and to provide for a continuous human presence on-orbit. In addition, the Program Implementation Review will assess ISS utilization activities across Agency programs and the National Laboratory.	TBD	May 2013
Other	NASA Aerospace Safety Advisory Panel	Jan 2013	Provides independent assessments of safety to the NASA Administrator.	No formal recommendations or findings.	TBD
Other	NASA Advisory Council	Nov 2012	Provides independent guidance for the NASA Administrator.	No formal recommendations or findings	TBD

ISS CREW AND CARGO TRANSPORTATION

Formulation	Development	Operations

HISTORICAL PERFORMANCE

Flights to ISS from Inception through March 2013

Vehicle	Provider	Number of Launches	Successful Launches	Unsuccessful Launches
Shuttle	NASA	37	37	0
Soyuz	Roscosmos	34	34	0
Progress	Roscosmos	52	51	1
Proton	Roscosmos	2	2	0
ATV	ESA	3	3	0
HTV	JAXA	3	3	0
Falcon9/Dragon	SpaceX	3	3	0
Antares/Cygnus	Orbital	0	0	0

21ST CENTURY SPACE LAUNCH COMPLEX

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	123.5	--	**39.6**	31.0	36.2	11.8	11.8
Subtotal	130.0	--	**39.6**	31.0	36.2	11.8	11.8
Rescission of prior-year unob. balances*	-6.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-83.9**				
Percentage change from FY 2012	--	--	**-67.9 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

The flight termination system at Cape Canaveral Air Force Station supports all launches from the Cape and the Kennedy Space Center. It is part of the Eastern Range modernization effort funded by NASA's 21st Century Launch Complex, in partnership with the Air Force. Upgrades will include a high rate remote data downlink, S-band radar uplink capability, and encrypted flight termination systems. Upon completion, the Range will provide a sophisticated launch network that enables faster transfer of data, making launch from the Eastern Range more beneficial to commercial and government customers.

With the end of the Space Shuttle program, NASA has set about evolving its workforce and facilities to meet the needs of future exploration of the solar system, as well as new commercial opportunities in low Earth orbit. The Agency created the 21st Century Space Launch Complex (21CSLC) initiative to modernize and transform the Florida launch and range complex at Kennedy Space Center. Upgrades will continue through 2018 as required to meet customer needs, evolving the launch site into a more robust national launch capability for current and future NASA programs, other US government agencies, and commercial industry.
For more information, go to: http://go.nasa.gov/groundsystems.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

In FY 2012, the Agency began extensive infrastructure enhancements aimed at enabling the launch complex to support multiple users. Through 21CSLC, NASA provided new landing facility gates and fences to accommodate customers who require horizontal launch or landing in addition to crawlerway upgrades to support increased launch vehicle weight. NASA recently awarded contracts for re-rock, which entails removal and replacement of old rock to support vehicle rollouts, and transition work on crawlerway legs A and B. As part of range modernization efforts, 21CSLC acquired a 50 megahertz Doppler radar wind profiler and a multiple object tracking radar transmitter.

21ST CENTURY SPACE LAUNCH COMPLEX

WORK IN PROGRESS IN FY 2013

In FY 2013, NASA continues to establish and develop 21CSLC partnerships with government and commercial entities requiring ground processing, launch, recovery, and other KSC services. The Agency selects projects to maximize the number of potential users the launch site can accommodate. Projects planned for FY 2013 include the completion of the design for the Vehicle Assembly Building utility annex's critical system upgrade, a multi-user flame deflector design to protect for different vehicle configurations at Pad 39B, upgrades to interface with Cape Canaveral Air Force Station's new timing system, and functional fault modeling of the cryo testbed lab. Enhancing the landing facility infrastructure will continue in FY 2013, to enable horizontal launch and landing capabilities. A crawler transporter 20-year life extension is underway, as are range autonomous flight safety support system and radio frequency detection, and installation of the gaseous nitrogen meter. Through 21CSLC, NASA will continue to maintain Pad 39A in support of commercial and Department of Defense customers. Additionally, design studies will be completed on the mobile launcher extensible column, multi-use launch mount interface, and medium class launch capability at Launch Complex 39.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

During FY 2014, KSC will perform environmental remediation and technology upgrades to the shoreline and the waste management facility. Mechanical and lighting in commercial facilities at the Eastern Range will be upgraded, and soil and groundwater assessments will be conducted at Pad A. NASA and the US Air Force will continue the combined range interface and control services modernization effort, including installation of a new Doppler radar wind profiler and improvement of the far field antenna range capability. The advanced ground systems and maintenance group will demonstrate and test interfaces with the end-to-end command and control system, while continuing designs to perfect fault isolation and anomaly detection on ground support equipment, facilities, and other flight hardware. These improvements will allow NASA to predict hardware failure and minimize repair cost and resulting launch delays. In addition, the design for the refurbishment of the flame trench at Launch Complex 39-B will also be completed during FY 2014. Such enhancements will help to ensure that the Nation has a robust launch capability.

Program Elements

21CSLC efforts focus on the life cycle of a launch complex as an integrated system to enable more efficient and cost effective ground processing, launch, and recovery operations for a variety of users. The primary product lines for 21CSLC are mission focused modernization, Florida launch modernization infrastructure, environmental remediation and technologies, offline manufacturing, processing and recovery systems, and range interface and control services. These product lines are set up to implement projects identified in support of commercial or Department of Defense initiatives through solicitations submitted to Kennedy Space Center.

Project/Element	Element Content
Offline Manufacturing, Processing and Recovery Systems	Repair and upgrade systems and facilities associated with payload processing, servicing, hazardous operations, and recovery in support of commercial customers
Range Interface and Control Services	Develops capability for communications, range systems, customer interface systems, and advanced ground systems maintenance

Mission Focused Modernization	Provides multi-user facility capabilities to support a variety of vehicles, processed and launched in the horizontal or vertical configuration
Florida Launch Modernization Infrastructure	Modernizes power, utility and facility systems, waste management systems, and safety and security systems throughout the KSC launch infrastructure so that it can maximize the number of potential users
Environmental Remediation and Technologies	Ensures energy conservation, environmental planning and regulatory requirements, natural resource mitigation, and environmental research, including materials replacement and technology development are being addressed

Program Schedule

As a focused set of infrastructure investments, 21CSLC is not required by NASA policy to be managed to the same programmatic milestones as spacecraft projects. However, there are significant revitalization efforts occurring to modernize the Spaceport and attract as many users as possible. Research and development investments in 21CSLC will be completed no later than the end of FY 2018. Some of the major near-term activities are listed below.

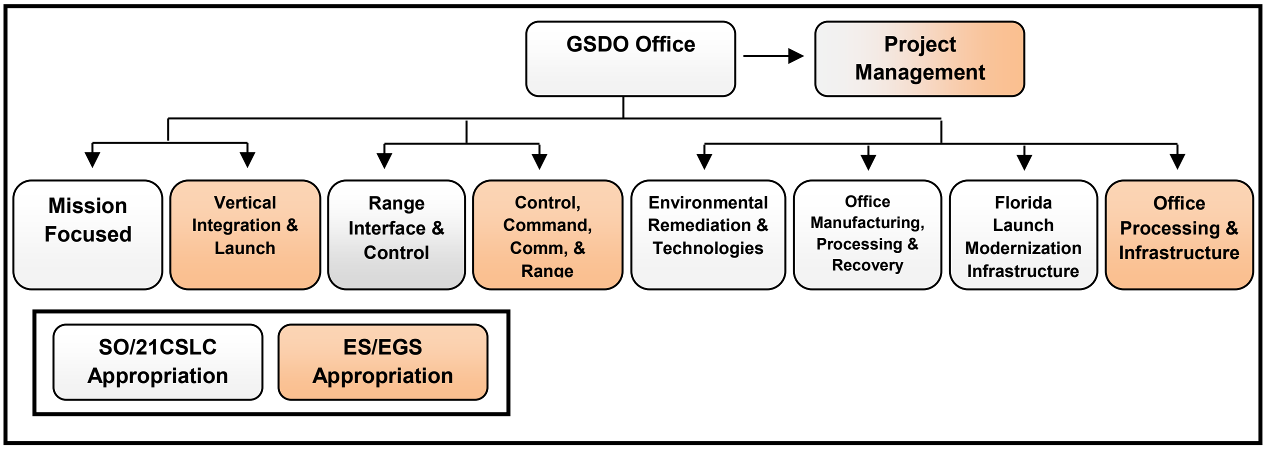
Date	Significant Event
Sep 2013	Shuttle Landing Facility infrastructure extension design complete
Oct 2013	Pad B Flame Trench refurbishment design complete
Mar 2014	Environmental impact mitigation for Shuttle Landing Facility development complete
May 2014	Eastern Range Lightning System upgrade complete
Aug 2014	Advanced Ground System Maintenance Interface to End to End Command and Control System demonstration
Apr 2015	50 megahertz Doppler project complete
Jun 2015	Crawler Transport jacking, equalization and leveling system cylinders complete

Program Management & Commitments

The Ground Systems Development and Operations Program Office (GSDO) manages infrastructure development for both Exploration Ground Systems (EGS) development and 21CSLC activities. This single-program approach to managing both the 21CSLC content under the Space Operations appropriation and the EGS content under the Exploration appropriation provides cost-effective synergy between the Space Launch System and Orion Multi-Purpose Crew Vehicle requirements, and the multi-user customer requirements.

The following diagram shows the distinct break out of the 21CSLC content and the EGS content, as managed under the GSDO program.

21ST CENTURY SPACE LAUNCH COMPLEX



The following table addresses the various elements within 21CSLC, lead and participating centers, and any cost share partners.

Program Element	Provider
Offline Manufacturing, Processing and Recovery Systems	Provider: 21CSLC Lead Center: KSC Performing Centers: N/A Cost Share Partners: N/A
Range Interface and Control Services	Provider: 21CSLC Lead Center: KSC Performing Center: ARC, JPL, GRC Cost Share Partners: US Air Force
Mission Focused Modernization	Provider: 21CSLC Lead Center: KSC Performing Centers: N/A Cost Share Partners: N/A
Florida Launch Modernization Infrastructure	Provider: 21CSLC Lead Center: KSC Performing Centers: N/A Cost Share Partners: N/A
Environmental Remediation and Technologies	Provider: 21CSLC Lead Center: KSC Performing Centers: N/A Cost Share Partners: N/A

21ST CENTURY SPACE LAUNCH COMPLEX

Acquisition Strategy

To retain flexibility and maximize affordability, GSDO serves as its own prime contractor for 21CSLC. The office executes customer ground infrastructure and processing requirements by leveraging center and programmatic contracts. It also uses pre-qualified indefinite delivery indefinite quantity contractors for routine work, while exercising full and open competition for larger or more specialized projects. The firm-fixed-price contracting approach is also used whenever possible because it provides maximum incentive for the contractor to control costs, since the contractor is subject to any losses incurred, and it imposes a minimum administrative burden upon the contracting parties.

MAJOR CONTRACTS/AWARDS

The 21CSLC is managed by the Ground Systems Development and Operations program manager and encompasses projects of varying content and size. Many of these are consistent with the type of architecture and engineering, construction, and programmatic support available within the scope of existing center and program support contracts. Should the project size or scope fall outside the scope of existing center capabilities, then competitively bid contracts will be used. Contracts are provided below.

Element	Vendor	Location (of work performance)
50 megahertz Doppler Radar Wind Profiler	QinetiQ, North America	KSC
Jacking, equalization and leveling cylinder (crawler transporter)	QinetiQ, North America	KSC

INDEPENDENT REVIEWS

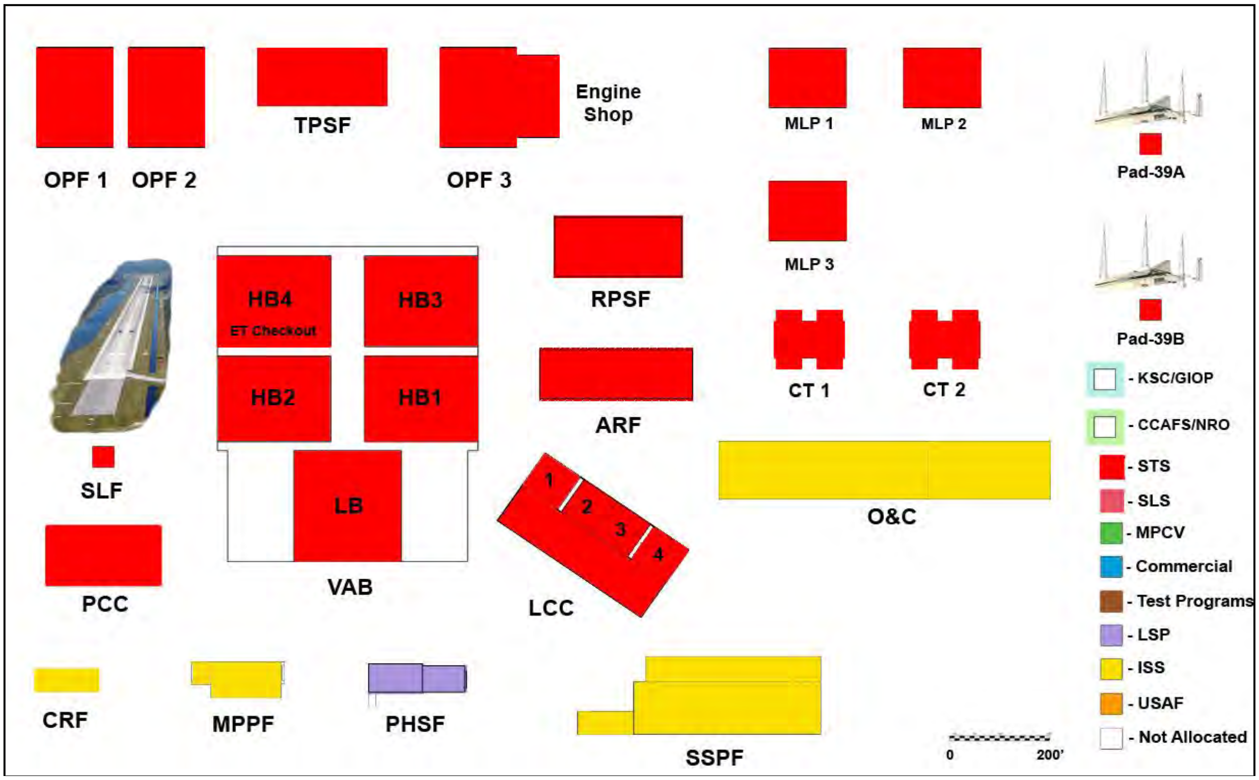
As a focused set of infrastructure investments, 21CSLC is not managed with the same formal independent reviews NASA requires for spacecraft projects.

HISTORICAL PERFORMANCE

Over time, Kennedy Space Center has evolved to meet the changing needs of America's space program. Kennedy Space Center facilities are directly related to its mission of providing payload processing and integration, launch, and landing services for manned and unmanned missions. These facilities are now maturing under the 21st Century Launch Complex initiative to reconfigure from a Shuttle and International Space Station-centric complex to a robust spaceport, capable of supporting a multitude of commercial and government customers. The figures below illustrate this progression.

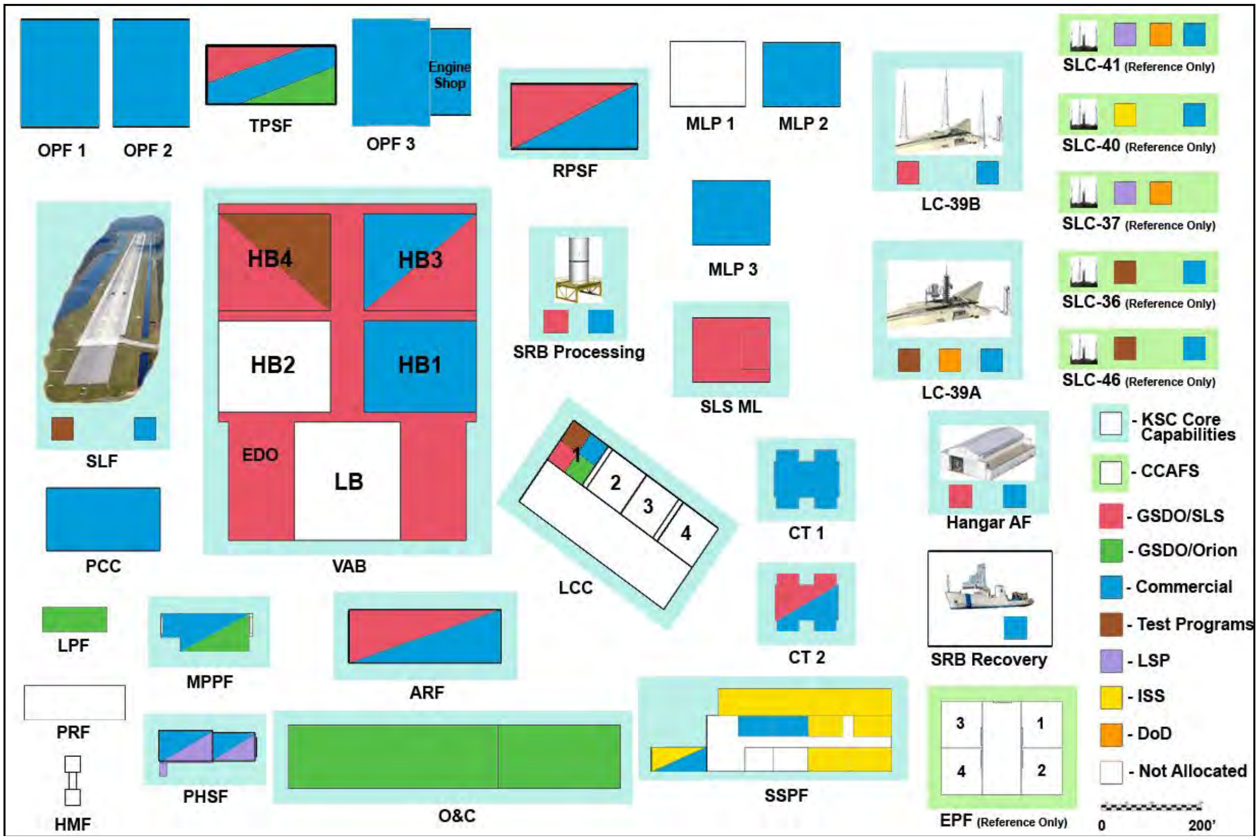
21ST CENTURY SPACE LAUNCH COMPLEX

Historical Shuttle and International Space Station Utilization at KSC



21ST CENTURY SPACE LAUNCH COMPLEX

Current 21st Century Launch Complex and Exploration Ground Systems Utilization at KSC



ARC	Architectures Refinement Cycle	MLP	Mobile Launch Platform
AFF	Assembly & Refurbishment Facility (now BFF)	MPCV	Multi-Purpose Crew Vehicle
BFF	Booster Fabrication Facility	MPPF	Multi-Payload Processing Facility
CCAFS	Cape Canaveral Air Force Station	NRO	National Reconnaissance Office
CRF	Canister Rotation Facility (now LASF)	O&C	Operation & Checkout
CT	Crawler Transporter	OPF	Orbiter Processing Facility
DoD	Department of Defense	PCC	Processing Control Center
EPF	Eastern Processing Facility	PHSF	Payload Hazardous Servicing Facility
ET	External Tank	PFR	Parachute Refurbishment Facility
GIOP	Ground Integration and Operations Program (GSDO precursor)	RPSF	Rotation, Processing, and Surge Facility
GSDO	Ground Systems Development and Operations	SLC	Space launch Complex
HB	High Bay	SLF	Shuttle Landing Facility
HMF	Hypergol Maintenance Facility	SLS	Space Launch System
ISS	International Space Station	SRB	Solid Rocket Booster
KSC	Kennedy Space Center	SSPF	Space Station Processing Facility
LASF	Launch Abort System Facility (formerly CRF)	STS	Space Transportation Program
LB	Low Bay	TPSF	Thermal Protection System Facility
LC	Launch Complex	U/R	Under Review
LSP	Launch Services Program	USAF	United States Air Force
ML	Mobile Launcher	VAB	Vehicle Assembly Building

SPACE COMMUNICATIONS AND NAVIGATION

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	442.9	--	**554.5**	562.7	521.4	506.5	507.5
Space Communications Networks**	355.6	--	**435.9**	412.0	415.5	416.3	416.5
Space Network Ground Systems Sust.	*46.6*		***103.2***	*100.9*	*69.9*	*18.0*	*0.0*
TDRS Replenishment	15.4	--	**41.2**	71.2	28.6	0.0	0.0
Space Communications Support	72.3	--	**77.4**	79.5	77.4	90.2	91.0
Subtotal	443.4	--	**554.5**	562.7	521.4	506.5	507.5
Rescission of prior-year unob. balances*	-0.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**111.6**				
Percentage change from FY 2012	--	--	**25.2 %**				

*Note: * Rescission of prior-year unobligated balances from Space Communications Networks and Space Communications Support pursuant to P.L. 112-55, Division B, sec. 528(f).*

*** The amounts shown for the Space Communications Networks project include funding for Space Network Ground Segment Sustainment, which is described in more detail in a following section.*

Since 1994, the dish antennas of the second Tracking and Data Relay Satellite (TDRS) ground terminal in New Mexico have relayed critical science data and commands between the Earth and missions such as the International Space Station, Hubble, and Terra. Missions in low Earth orbit send signals to the tracking satellites in geosynchronous orbit, and they relay the signals to the ground terminal. Commands from Earth flow from the ground terminal to the TDRS, and then to the mission spacecraft. While the massive dish antennas are themost visible part of the ground terminal, doing the job also requires high-power electronics, digital switchgear, and support systems.

The Space Communications and Navigation (SCaN) program provides mission-critical communications and navigation services that are required by all NASA space missions. SCaN retrieves science and spacecraft health data, uploads commands, and sends data to individual mission control centers. Navigation services accurately determine where a satellite is and where it is going, to enable plans for course changes, interpret science data, and position the spacecraft for the next communications opportunity.

Without SCaN services to move data and commands between spacecraft and Earth, customer missions and space hardware worth tens of billions of dollars would be little more than orbital debris. A communications or navigation failure on the spacecraft or in SCaN network systems could result in complete loss of a mission.

SCaN mission customers range from high altitude balloons at the edge of Earth's atmosphere, through science satellites in low Earth orbit, to the most distant manmade object, Voyager 1,which is at the brink of the solar system, over

SPACE COMMUNICATIONS AND NAVIGATION

11 billion miles from Earth. Other customers include the Hubble Space Telescope in Earth orbit, the Curiosity rover on the surface of Mars, and New Horizons on its way to Pluto. SCaN supports the International Space Station (ISS) as well as its commercial and international servicing vehicles, and will support commercial crew providers and NASA's Orion Multi-Purpose Crew Vehicle (MPCV) when they launch in the future. SCaN also provides services to foreign, international, and non-NASA US missions on a reimbursable basis.

SCaN provides customer missions with the communications and navigation services they need, at the lowest practical cost. Customer mission requirements include the mission's orbit, navigation needs, data rate, and how often communications opportunities occur. SCaN networks and the customer spacecraft must match technical parameters such as radio frequency, data coding, modulation scheme, polarization, and error correction. SCaN supports new spacecraft which are increasingly powerful, complex, and capable of acquiring ever increasing amounts of mission data, but also supports missions launched over 30 years ago that are still returning valuable science data.

SCaN provides communications and navigation services to customer missions through its three space communications networks. The Space Network communicates with missions in Earth orbit, and provides constant communication with ISS; it will also support future commercial crew and Orion MPCV missions. The Near Earth Network communicates with suborbital missions and missions in low Earth, highly elliptical Earth, and some lunar orbits. The Deep Space Network communicates with the most distant missions, such as inter-planetary probes.

The three networks require maintenance, replenishment, modernization, and capacity expansion to ensure service for existing and planned missions. SCaN also purchases ground communications links from the NASA integrated services network to move data between SCaN ground stations, NASA centers, and mission operation and data centers.

The Tracking and Data Relay Satellite (TDRS) Replenishment project is purchasing three third-generation TDRS spacecraft for the Space Network. These spacecraft will ensure adequate Space Network services to customers into the early 2020s.

The Space Network Ground Segment Sustainment project is replacing aging ground hardware and data systems in the Space Network. These ground systems operate the TDRS fleet and route customer mission data between TDRS and the ground.

Space Communications Support provides several functions to efficiently integrate and plan current and future network capabilities to meet customer mission needs while reducing costs. These functions include systems engineering, architecture planning, communications data standards, technology development and testbeds for future capabilities, and radio frequency spectrum management.

For more information, go to: https://www.spacecomm.nasa.gov/spacecomm/.

EXPLANATION OF MAJOR CHANGES

None.

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	355.1	--	**435.9**	412.0	415.5	416.3	416.5
Subtotal	355.6	--	**435.9**	412.0	415.5	416.3	416.5
Rescission of prior-year unob. balances*	-0.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**80.8**				
Percentage change from FY 2012	--	--	**22.8 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

The 70-meter DSS-14 antenna is the largest and most sensitive antenna at the Goldstone Deep Space Communications Complex in California. Operational in 1966 and upgraded in 1998, DSS-14 communicates with deep space missions such as New Horizons, which is on its way to Pluto and Charon. The three Deep Space Network sites- Goldstone; Canberra, Australia; and Madrid, Spain- currently track, receive data from, and transmit commands to over 25 spacecraft, including Voyager 1, which is over 11 billion miles from earth.

The Space Communication and Navigation (SCaN) program manages three space communications networks: the Space Network, the Near Earth Network, and the Deep Space Network. Each network has a different set of customer requirements for spacecraft orbit, signal strength, and real-time coverage. Each also requires maintenance, modernization, and capacity expansion. In addition, SCaN purchases ground-based services through the NASA integrated services network to move data between customers, mission ground sites, and space network ground terminals.

The Space Network provides continuous global coverage to NASA missions in low Earth orbit, and also to launch vehicles. It is the primary US communications link to the International Space Station (ISS), and also provides communications links for ground and balloon research in remote locations such as the South Pole. The Space Network consists of the Tracking and Data Relay Satellite (TDRS) system of communications satellites in geosynchronous orbit, a set of space-to-ground link terminals at White Sands, New Mexico, and the Guam remote ground terminal. Customer missions communicate with the TDRS spacecraft in geosynchronous orbit, and the TDRS relay signals to and from the ground terminals.

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

The Space Network Ground Segment Sustainment effort replaces outdated equipment and standardizes systems at the Space Network ground terminals.

The Near Earth Network services missions in low Earth, geosynchronous, lunar, and highly elliptical Earth orbits, as well as certain suborbital launch locations. The network's ground stations are located at White Sands, New Mexico, the US McMurdo Antarctic Station, and Wallops Flight Facility in Virginia. The network also purchases services from commercial providers in Alaska, Hawaii, Norway, Sweden, Australia, and Chile.

The Deep Space Network services missions from beyond low Earth orbit to the edge of the solar system. The network's ground stations are spaced about 120 degrees apart on the globe in Spain, Australia, and California to maintain continuous communications to distant spacecraft as Earth rotates. NASA owns these stations, and the Deep Space Network Project Office at Jet Propulsion Laboratory manages operations, maintenance, and upgrades.

The Deep Space Network Aperture Enhancement effort is aimed at modernizing and upgrading the Deep Space Network's ground stations to enhance capacity, improve flexibility to support customer missions, and reduce operations and maintenance costs. Much of the network's hardware is over 30 years old and has become difficult and costly to maintain. This is true of antenna structures, exotic electronics such as high-power transmitters, cryogenically-cooled low noise amplifiers, and support elements. Construction efforts, such as new 34-meter antennas, use Construction of Facilities funds appropriated in NASA's Construction and Environmental Compliance and Remediation account.

The SCaN program purchases services from the NASA Integrated Services Network (NISN) to move information between the ground stations of the three space communications networks and NASA Centers and customer mission operations, and data centers. NISN is a centralized commercial service providing point-to-point communication services between ground sites and is managed by NASA's Office of the Chief Information Officer and not by SCaN.

For more information, go to: https://www.spacecomm.nasa.gov/spacecomm/.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

During FY 2012, the Space Network supported 25 customer missions with 176,141 hours of tracking over 147,810 passes. The network also provided primary US communications link with the ISS throughout the year, and supported 13 launches, including NASA's Radiation Belt Storm Probes and two SpaceX Dragon launches to the ISS. Also this year, Space Network operators successfully decommissioned the aging TDRS-4 spacecraft and moved it to a disposal orbit.

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

The Near Earth Network supported 27 missions with 35,011 hours of tracking over 45,124 passes, as well as launch and early orbit operations for the Radiation Belt Storm Probes.

The Deep Space Network supported 36 missions with 95,956 hours of tracking over 18,128 passes. Highlights included entry, descent, landing, and early surface operations of the Curiosity Mars Science Laboratory, launch and lunar orbit insertion for GRAIL, and deep space maneuvers for the Juno mission.

WORK IN PROGRESS IN FY 2013

During the current fiscal year, the Space Network plans to support 25 to 30 missions, with over 175,000 hours of tracking and more than 145,000 passes. The Space Network will accept TDRS-K as an operational asset after it completes on-orbit checkout following successful launch on January 30, 2013, and will continue to support the ISS. In addition, both the Space and Near Earth Networks will support the Interface Region Imaging Spectrograph and Landsat Data Continuity missions.

The Near Earth Network plans to support about 30 missions, with over 35,000 hours of tracking and more than 45,000 tracking passes. Customers will include commercial cargo resupply missions to the ISS. The Near Earth Network will also complete the new antenna at the Alaska Satellite Facility ground station, and perform acceptance testing.

The Deep Space Network plans to support about 35 missions, providing over 100,000 hours of tracking spread over more than 18,000 passes. The network will support launch and lunar orbit insertion of the Lunar Aerosol and Dust Environment Explorer, wake-up and health check of New Horizons, and continue supporting Curiosity on the surface of Mars.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The three space communications networks will provide a level of service similar to those provided in FY 2012 and FY 2013, which included over 208,000 tracking passes totaling more than 310,000 hours. Customer mission highlights in FY 2014 include Juno's Earth flyby, launch of the Mars Atmosphere and Volatile Evolution mission, and the European Space Agency's Rosetta mission when it wakes up from hibernation. The networks will support the Orion Multi-Purpose Crew Vehicle's Exploration Flight Test-1, as well as ISS and its commercial cargo missions.

NASA continues to replenish the networks to maintain mission-critical services for current and future missions. TDRS-L will launch and be accepted as an operational asset after on-orbit checkout. The new DSS-35 antenna at the Canberra, Australia ground station will become operational.

Project Schedule

NASA's space communications networks provide ongoing services to the Agency and customer missions, averaging about six hundred tracking passes a day. This routine, daily service provision is the key function of the three space communications networks. Without these services, customer missions like

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

Voyager, Hubble, ISS, New Horizons, and Opportunity would fail. To continue this routine service provision, NASA is replenishing the space communications networks. Below are some key network replenishment events.

Date	Significant Event
Q3 FY13	TDRS-K accepted into the SN for operational use
May 2014	TDRS-L accepted into the SN for operational use
Q3 FY16	TDRS-M accepted into the SN for operational use
Dec 2014	DSS-35 antenna accepted into the DSN for operational use
Mar 2016	SGSS upgrades accepted into the SN for operational use
Q4 FY13	ASF-3 antenna accepted into the NEN for operational use

Project Management & Commitments

Element	Description	Provider Details	Change from Formulation Agreement
Space Network	Communication and navigation services to customer missions in low earth orbit and launch vehicles	Provider: Space Network Project Office Lead Center: Goddard Space Flight Center (GSFC) Participating Centers: None Cost Share Partners: Non-NASA customers	N/A
Near Earth Network	Communication and navigation services to customer missions in low Earth, highly elliptical, and lunar orbits	Provider: Near Earth Network Project Office Lead Center: GSFC Participating Centers: None Cost Share Partners: Non-NASA customers	N/A
Deep Space Network	Communication and navigation services to customer missions in deep space	Provider: Deep Space Network Project Office Lead Center: JPL Participating Centers: None Cost Share Partners: Non-NASA customers	N/A
NASA Integrated Services Network	SCaN purchases ground communication services from NASA Integrated Services Network	Provider: NISN, through NASA Chief Information Officer Lead Center: NASA HQ Participating Centers: Marshall Space Flight Center and GSFC Cost Share Partners: None	N/A

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

Acquisition Strategy

The major acquisitions for the networks are in place. NASA uses reimbursable, international, and barter agreements; and competitive procurements. NASA's Jet Propulsion Laboratory provides the Deep Space Network.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Deep Space Network	JPL	Pasadena, CA
Space Network Operations	ITT Excelis	McLean, VA
Near Earth Network Operations	ITT Excelis	McLean, VA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Program Integrated Review	Standing Review Board	Sep 2012	Assess the goals, approach, and performance of the SCaN program, including space communications networks.	Passed	None

HISTORICAL PERFORMANCE

Past missions supported by SCaN include:

- Mars rovers Sojourner and Spirit;
- Viking 1 and 2 Mars orbiters and landers;
- Pioneer 10 and 11 Jupiter flybys, Pioneer 11 Saturn flyby, and deep space missions for both spacecraft ;
- Magellan radar mapper of Venus;
- Compton Gamma Ray Observatory and Wide-Field Infrared Survey Explorer (WISE) astronomy missions;
- Ulysses solar observatory;
- Earth observing missions including Ice, Cloud, and land Elevation Satellite (ICESat); and
- Space Shuttle missions starting with STS-08 in 1983.

Ongoing missions still supported by SCaN include:

- Voyager 1 and 2, from their outer planet flybys through the current extended mission as they find and exit the outer limits of the solar system;

SPACE COMMUNICATIONS NETWORKS

Formulation	Development	Operations

- Opportunity Mars rover, Phoenix Mars lander, and Mars Odyssey and Mars Reconnaissance Orbiter;
- Earth science missions such as Aqua, Aura, Terra, and Tropical Rainfall Measuring Mission;
- Hubble Space Telescope, Chandra X-ray observatory, and Spitzer Space Telescope;
- Lunar Reconnaissance Orbiter;
- Landsat series of earth imagers;
- Weather satellites operated by the National Oceanic and Atmospheric Administration; and
- International Space Station, beginning with Shuttle assembly missions and continuing through crewed operations.

To keep supporting its mission customers, SCaN also has to replenish and refurbish the networks that provide the services. The SCaN program installed five modern 34-meter diameter beam waveguide antennas in 1996 and 1997 and a sixth in 2003. The program also launched three second-generation TDRS spacecraft, H, I, and J launched between 2000 and 2002. After these highly visible, critical items, SCaN repaired crumbling concrete and cracking steel in antenna structures, upgraded ground station electrical utility systems, and replaced exotic transmitter and receiver electronics. Without these efforts, the networks would become unusable, customer services would fail, and expensive space missions could be lost.

SPACE NETWORKS GROUND SEGMENT SUSTAINMENT

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	46.7	--	**103.2**	100.9	69.9	18.0	0.0
Subtotal	46.8	--	**103.2**	100.9	69.9	18.0	0.0
Rescission of prior-year unob. balances*	-0.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**56.5**				
Percentage change from FY 2012	--	--	**121.0%**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

Technicians maintain and configure electronics in the ground control equipment room at the second Tracking and Data Relay Satellite ground terminal in White Sands, New Mexico. This equipment is part of the pathway that carries crucial data and commands to and from user missions via the tracking satellites of the space network. NASA will replace aging ground systems, including the equipment pictured, with modern systems that are more reliable and easier to maintain.

PROJECT PURPOSE

NASA's science and human missions such as the Hubble Space Telescope, the International Space Station, and the future Orion Multi-Purpose Crew Vehicle require communications and navigation services to move data to the ground, and commands to the spacecraft. NASA's Space Network provides these services with a fleet of Tracking and Data Relay Satellites (TDRS), and ground stations in New Mexico and Guam. Customer missions send data to the TDRS spacecraft in geosynchronous orbit, and the satellites relay the signals to the ground stations, which include a mix of 10 meter, 18.3 meter, and 19 meter dish antennas; transmitters, receivers, amplifiers; and scheduling and control software to execute more than 145,000 mission passes per year.

The Space Network's ground stations date to the 1980s and are rapidly wearing out. Manufacturers no longer support much of the equipment and software currently in use. To keep some of the outdated equipment running, NASA has had to buy similar used parts on eBay, and modify them to work in the ground stations. Beyond the increased costs for maintenance and repair, the age and wear of the systems increase the risk that ground system failures will disrupt services to customers. If such disruptions occurred, customers could lose critical science data, or even a spacecraft.

To maintain reliable communications services to customer missions, the Space Network Ground Segment Sustainment (SGSS) project is replacing outdated and expensive-to-maintain equipment and systems at the Space Network ground terminals. New equipment and software based on up-to-date technology will be more reliable and cost less to maintain and operate.

SPACE NETWORKS GROUND SEGMENT SUSTAINMENT

Formulation	Development	Operations

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

SGSS will replace nearly all the electronics and software at Space Network ground stations. This includes high-power transmitters and receivers on the ground antennas, low-noise amplifiers, digital signal processors, TDRS fleet management software, tracking pass scheduling software, and numerous other components. Integrating the various exotic and high-power electronics, digital switchgear, and controlling software into a functional, reliable, and low-cost system is a major part of the project. Once the project is complete, any Space Network ground terminal will be able to support any first, second, or third generation TDRS. SGSS consists of development, sustainment, and deployment. The development phase involves meeting new requirements by procuring new hardware and software currently not supported in the Space Network, integrating them into a complete system, and then testing the complete system to ensure it meets the Space Network's requirements. The sustainment phase replaces aging hardware and software with modern components. The deployment phase deploys multiple copies to the Space Network ground stations and space-to-ground-link terminals.

ACHIEVEMENTS IN FY 2012

During FY 2012, NASA completed preliminary designs and element interfaces prior to technical preliminary design review in July. The review confirmed that project requirements and interface definitions between segments are complete and adequately detailed to begin hardware and software design and build.

WORK IN PROGRESS IN FY 2013

NASA will confirm that the SGSS project is ready to proceed to development in FY 2013. Assuming that milestone is achieved, a critical design review will also occur in FY 2013, with the goal of confirming that SGSS is ready to proceed to detailed element design, development, and production. Following that, the contractor will complete the first hardware and software elements, integrate them, and begin system-level testing.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, the SGSS will finish hardware and software component integration at the contractor plant, and begin systems integration. In preparation for placement at ground station sites, the contractor will perform end-to-end testing of hardware and software elements. After successful testing, teams will begin deploying the tested systems to domestic and international Space Network ground station sites.

SPACE NETWORKS GROUND SEGMENT SUSTAINMENT

Formulation	Development	Operations

In 2014, the project will verify data communications and tracking using TDRS space segments. This is an important step towards achieving the new modernized Space Network, which will enable state-of-the-art communications capability with the ISS, Space Launch System, Orion Multi-Purpose Crew Vehicle, and other orbiting spacecraft well into the 21st century.

ESTIMATED PROJECT SCHEDULE

Milestone	Formulation Authorization Document	FY 2014 PB Request
Formulation Authorization (complete)	Nov 2011	
Preliminary Design Review (complete)	Jul 2012	Jul 2012
Key Decision Point-C	Oct 2012	Mar 2013
Deployment of first elements to Space Network ground stations begins	N/A	Oct 2014
System-level integration and test of last elements complete	N/A	Mar 2015
Deployment at all ground stations complete	N/A	Apr 2017
Full Operational Capability, Space Network Ground Segment Sustainment Complete	Dec 2015 - Sep 2017	Sep 2017

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Life cycle cost estimates are preliminary. A baseline cost commitment does not occur until the project receives approval for implementation (KDP-C), which follows a non-advocate review and/or preliminary design review.

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
February 2012	516.5 to 627.5	Full Operational Capability, Space Network Ground Segment Sustainment complete	Dec 2015 to Sep 2017

SPACE NETWORKS GROUND SEGMENT SUSTAINMENT

Formulation	Development	Operations

Project Management & Commitments

Element	Description	Provider Details	Change from Formulation Agreement
Space Network Ground Segment Sustainment	Replace outdated and deteriorating ground systems at Space Network ground terminals	Provider: Space Network Ground Segment Sustainment Project Office Lead Center: GSFC Participating Centers: None Cost Share Partners: Non-NASA US government partners	None

Project Risks

Risk Statement	Mitigation
If: Space Network Ground Segment Sustainment operational delivery is delayed, Then: The Space Network will continue to use existing, high-risk ground systems that are costly to operate. The Deep Space and Near Earth Networks will be unable to use Space Network Ground Segment Sustainment elements to replace elements of their ground systems.	The SCaN program and SGSS project office will carefully manage effort to deliver Space Network products on time, balancing requirements, technical content, budget, and schedule. On-time delivery will allow the Space Network to replace aging and costly ground systems. The Deep Space and Near Earth Networks will be able to replace parts of their ground systems with Space Network Ground Segment Sustainment elements.

Acquisition Strategy

NASA used a full and open competition to select the Space Network Ground Segment Sustainment prime contractor in FY 2011. The contract is cost-plus-incentive-fee. No additional major awards are planned.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Space Network Ground Segment Sustainment	General Dynamics C4 Systems	Scottsdale, AZ

SPACE NETWORKS GROUND SEGMENT SUSTAINMENT

Formulation	Development	Operations

INDEPENDENT REVIEWS

NASA established a Standing Review Board to perform the independent reviews of the Space Network Ground Segment Sustainment project that are required by NPR 7120.5.

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
System Requirements Review	Standing Review Board	Aug 2011	Determine if functional and performance requirements are properly formulated. Determine if estimated budget and schedule are credible.	Passed; recommended changes incorporated into new baseline	None
Key Decision Point-B	Standing Review Board	Feb 2012	Determine if requirements definition and associated plans are sufficient to begin project implementation	Complete	None
Technical Preliminary Design Review	Standing Review Board	Jul 2012	Determine if project is ready to proceed with detailed design of hardware and software elements	Complete	None
Key Decision Point-C	Standing Review Board	Mar 2013	Determine if project is ready to proceed with formal development	Pending	None
Critical Design Review	Standing Review Board	Aug 2013	Determine if project is ready to proceed with production of hardware and software elements		

TDRS REPLENISHMENT

Formulation	Development	Operations

FY 2014 Budget

		Actual			Notional					
Budget Authority (in $ millions)	Prior	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	BTC	Total
FY 2014 President's Budget Request		15.4		**41.2**	71.2	28.6	0.0	0.0	0.0	
2014 MPAR LCC Estimate	405.9	7.2	13.4	**0.0**	0.0	0.0	0.0	0.0	0.0	426.5
Formulation	241.9	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	241.9
Development/Implementation	164.0	7.2	13.4	**0.0**	0.0	0.0	0.0	0.0	0.0	184.6
Operations/Close-out	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
Change from FY 2012		--	--	**25.8**						
Percentage change from FY 2012		--	--	**167.5%**						

Antennas furled and solar panels folded, TDRS-K stands ready to package and ship to Florida for launch in early 2013. Its twin, TDRS-L, is undergoing preflight testing and will launch early in 2014. These spacecraft along with TDRS-M, which is in fabrication, will relay science data and commands to and from NASA customer missions like the ISS, Hubble, and Terra, as well as future missions like Orion Multi-Purpose Crew Vehicle and commercial crew spacecraft.

PROJECT PURPOSE

Successfully launching a satellite into orbit is a critical first step, but any satellite would be worthless without the ability to move data and commands between the spacecraft and Earth. NASA's Space Network provides continuous global tracking, data, voice, and video services to the International Space Station (ISS), space and Earth science missions, launch vehicles, and other government users. These services depend upon a complex system of space to ground terminals and a fleet of communication satellites called the Tracking and Data Relay Satellite (TDRS) system. A failure occurring in any part of the system could lead to the loss of critical mission data, or potentially, an entire mission.

NASA’s current TDRS fleet consists of three first-generation satellites placed into orbit 18 to 24 years ago, and three second-generation satellites that have provided services for a decade or more. The Agency has already retired two first-generation satellites, and the remaining three show signs of upcoming age-related battery and electronics failures. NASA analysis of probable TDRS lifetime indicates that, without new spacecraft, the network will not have sufficient TDRS capacity to service customer missions by 2016.

TDRS REPLENISHMENT

Formulation	Development	Operations

To avoid a system failure or loss of critical capacity, NASA is buying new TDRS spacecraft to replace those that wear out and fail. The TDRS replenishment project is adding three new satellites to the fleet, with the purchase of TDRS-K, L, and M, which will provide sufficient capacity for the network into the 2020s. The project is also working to modify existing Space Network ground facilities to operate these third generation satellites.

For more information, go to: https://www.spacecomm.nasa.gov/spacecomm/programs/tdrss/default.cfm.

EXPLANATION OF MAJOR CHANGES

None.

PROJECT PARAMETERS

The TDRS Replenishment project is purchasing the third-generation satellites TDRS-K, L, and M for the Space Network, as well as making modifications to the existing Space Network ground stations.

ACHIEVEMENTS IN FY 2012

During FY 2012, NASA's TDRS replenishment contractor completed TDRS-K preflight testing and reviews. Engineers and technicians shook, baked, and froze TDRS-K and assessed its performance to make sure it could not only survive the rocket ride to orbit and the harsh environment of space, but would still function perfectly for years to come. After this testing, teams began to package TDRS-K for shipment to Cape Canaveral prior to a FY 2013 launch. In addition, the contractor completed TDRS-L assembly, and began the same preflight testing regimen TDRS-K completed. They also ordered 99 percent of the parts for TDRS-M, to prepare for assembly beginning in FY 2013.

WORK IN PROGRESS IN FY 2013

NASA successfully launched TDRS-K on January 30, 2013. After launch, efforts began to check out the spacecraft on orbit. If TDRS-K performs as expected, NASA will accept the satellite as an operational part of the Space Network. Also this year, the contractor will complete preflight testing on TDRS-L, and begin preparing the spacecraft for launch in February 2014. In addition, they will conduct a production readiness review for TDRS-M, and begin assembling the spacecraft.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA will prepare TDRS-L for launch in February 2014 and, after launch, test the spacecraft's performance on-orbit. Once accepted, TDRS-L will become an operational part of the Space Network, relaying data and commands to and from customer science missions and the ISS. Meanwhile, the contractor will finish TDRS-M assembly, and begin the same preflight testing regime that was performed on TDRS-K and L. Functional testing will verify that the spacecraft works as designed, while vibration and thermal-vacuum testing will confirm that the spacecraft can survive the stresses of launch, and

TDRS REPLENISHMENT

Formulation	Development	Operations

function for years to come in the vacuum and alternating heat and cold of space. The sequential addition of TDRS-K (2013 launch), L (2014 launch), and M (2016 launch) to the Space Network will ensure continued service to customer missions such as ISS, even as the remaining first-generation TDRS spacecraft fail and are retired. Once all three spacecraft are accepted, the Space Network will have adequate capacity until the second-generation TDRS begin retiring in the early 2020s.

SCHEDULE COMMITMENTS/KEY MILESTONES

Milestone	Confirmation Baseline Date	FY 2014 PB Request Date
TDRS-K Launch	Dec 2012	Q2 FY13
TDRS-K Acceptance	N/A	Q3 FY13
TDRS-L Launch	Dec 2013	Feb 2014
TDRS-L Acceptance	N/A	May 2014
TDRS-M Launch Readiness	N/A	Jan 2016

Development Cost and Schedule

The cited development cost is for TDRS-K and L; TDRS-M is considered a production spacecraft with no associated development cost.

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Data	Current Year Milestone Data	Milestone Change (mths)
2010	209.4	75	2013	184.6	-11.8	TDRS-K Launch	Dec 2012	Q2 FY 2013	1 to 3 months
						TDRS-L Launch	Dec 2013	Feb 2014	2 months

Note: The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (joint confidence level); all other CLs (confidence levels) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.

TDRS REPLENISHMENT

Formulation	Development	Operations

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Change from Base Year Estimate ($M)
TOTAL:	209.4	184.6	-24.8
Aircraft/Spacecraft	71.7	71.7	0.0
Payloads	0.0	0.0	0.0
Systems I&T	0.0	0.0	0.0
Launch Vehicle	0.0	0.0	0.0
Ground Systems	53.7	53.7	0.0
Science/Technology	0.0	0.0	0.0
Other Direct Project Costs	84.0	59.2	-24.8

Project Management & Commitments

The TDRS Replenishment Project Office at Goddard Space Flight Center manages the TDRS Replenishment project.

Project Element	Description	Provider	Change from Baseline
TDRS Replenishment	Purchase third-generation TDRS-K, -L, and -M to maintain Space Network communications services to customer missions into the 2020s	Provider: Boeing Space Systems Lead Center: GSFC Performing Centers: N/A Cost Share Partners: Other US government agencies	Development cost reduced. TDRS-M added to purchase.

Project Risks

Risk Statement	Mitigation
If: Existing TDRS spacecraft fail before TDRS-K, L, and M launch, Then: The Space Network may not have adequate capacity to support customer missions.	NASA will manage TDRS-K, L, and M so that launch readiness is as close as possible to planned dates. Actual launch dates will depend not only on TDRS and launch vehicle readiness, but also on the longevity of existing TDRS.

TDRS REPLENISHMENT

Formulation	Development	Operations

Acquisition Strategy

NASA awarded the major contract for TDRS replenishment to Boeing Space Systems in December 2007. The base contract is a fixed-price-plus-incentive-fee contract for TDRS-K and -L, and includes modifications to space network ground systems to support these third-generation spacecraft. In November 2011, NASA exercised a fixed-price-plus-incentive-fee option on the contract to purchase TDRS-M.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
TDRS Replenishment, including TDRS-K, -L, and -M; and modifications to Space Network ground systems to support these spacecraft.	Boeing Space Systems	El Segundo, CA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Critical Design Review	Standing Review Board	Jan 2010	Assess whether the integrated design is mature enough to proceed with final design and fabrication	Passed	None

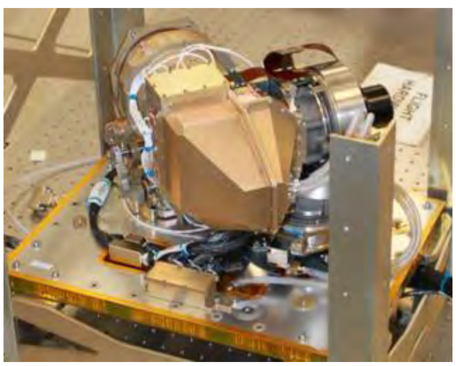
SPACE COMMUNICATIONS SUPPORT

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	71.8	--	**77.4**	79.5	77.4	90.2	91.0
Subtotal	72.3	--	**77.4**	79.5	77.4	90.2	91.0
Rescission of prior-year unob. balances*	-0.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**5.6**				
Percentage change from FY 2012	--	--	**7.8 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*



This flight optical module is part of the Lunar Laser Communications Demonstration that will fly on the Lunar Aerosol and Dust Environment Explorer in 2013, to test optical (laser) communications between Earth and the Moon. Optical communication promises higher data rates with lower power and weight than traditional radio communications. This technology demonstration will be flown in 2013, along with three science instruments on the Lunar Aerosol and Dust Environment Explorer mission. Once proven for space use, new NASA science missions will be able to send back more data and devote limited weight and power to science instruments rather than communications systems.

Much like electricity from a utility company, Space Communications and Navigation (SCaN) services are there when the customer needs them. The SCaN program provides critical communication services to customers such as the International Space Station, the Hubble Space Telescope, and the Mars Curiosity rover. For them, a service outage is far more than an inconvenience.

SCaN has a long history of service reliability, but that success does not come easily; it requires the planning, management, and technology efforts of the Space Communication Support project. Activities that contribute to SCaN's success include architecture planning and systems engineering, standards definition and management, spectrum management, and technology efforts.

Architecture and systems engineering efforts ensure that communication and navigation capabilities are integrated, interoperable, and standardized. At the most basic level, this behind-the-scenes activity ensures that customer missions and SCaN networks work together by defining technical parameters, capacity, and performance. Beyond assuring seamless functionality, planning and standards efforts reduce costs by eliminating duplication across networks, reducing mission-unique requirements, and lowering development costs for customer missions by providing “off-the-shelf” communications solutions and standards.

SCaN is the Agency’s lead for radio frequency spectrum management, and protects NASA's interests in national and international regulatory forums. Spectrum is the set of frequencies, or "channels," that a radio system uses to broadcast or receive signals. Spectrum management ensures that radio frequencies remain available for

SPACE COMMUNICATIONS SUPPORT

Formulation	Development	Operations

communication with NASA missions, as well as radio astronomy and remote sensing applications. As spectrum demand increases around the world for commercial wireless devices and networks such as cell phones, WiFi, broadband, and direct broadcast television, users are moving more and more data. Everyone wants unlimited data and minutes, and no one wants a busy signal because all the frequencies are busy. New or reallocated spectrum assignments to meet this demand must be coordinated nationally and internationally so they do not interfere with other users. If NASA does not defend its radio spectrum assignments in regulatory forums, we could run the risk of terminating missions and losing science data to tweets and video downloads.

Technology efforts led by SCaN have the promise of reducing costs, increasing the amount of data returned from science missions, and reducing science spacecraft weight and power. One technology under study is the use of disruption-tolerant networks, which allow communications to occur even when direct end-to-end links are not available. If your cell phone drops a call and the battery dies, you can still receive a message; the network will either find another way to get the message through, or hold it for later delivery. For SCaN, this capability will improve operational flexibility for customer missions and increase the amount of science data returned, without adding costly ground station capacity.

For more information, go to: https://www.spacecomm.nasa.gov/spacecomm/.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

In July, 2012 NASA's Japanese partners launched the SCaN testbed to the ISS, where it was installed and activated by the crew. The testbed is an advanced, integrated communications system and laboratory facility that allows researchers to develop, test and demonstrate new communications, networking and navigation capabilities in the actual space environment. Over the next several years, NASA will conduct a suite of experiments that will enable development of a new generation of space communications.

Also in FY 2012, NASA led a technical evaluation leading to the US decision to protect GPS frequencies from likely interference from a proposed commercial mobile service using adjacent frequencies. Protecting these frequencies from interference prevents degradation of GPS accuracy and avoids expensive retrofit or replacement of existing receivers and systems. In addition, the Agency successfully protected uses in three radio frequency bands: 22.55 to 23.15 gigahertz for satellite communications uplinks, 37 to 38 gigahertz for research, and 275 to 3,000 gigahertz for passive sensing.

WORK IN PROGRESS IN FY 2013

In FY 2013, the Lunar Laser Communications Demonstration payload launched aboard the Lunar Aerosol and Dust Environment Explorer (LADEE) science spacecraft. The experiment will test optical (laser) communications between the Earth and the Moon. Optical communications transmit data using near-infrared light rather than radio waves. This would allow future missions to transmit at high data rates, and

SPACE COMMUNICATIONS SUPPORT

Formulation	Development	Operations

be free of the encroachment and congestion plaguing radio frequencies. In addition, optical communications systems consume less mass, volume, and power, especially compared with similar radio frequency systems. As the technology evolves, transition to these types of systems will ultimately reduce mission costs and provide opportunities for new science payloads.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

During FY 2014, NASA will utilize the SCaN testbed aboard ISS to perform additional experiments with software-defined radios in an operational environment. In addition, NASA will evaluate the results of the Lunar Laser Communications Demonstration, and incorporate them into planning for an on-orbit optical communications relay demonstration. NASA will continue to develop disruption-tolerant network protocols and standards, and test them on ISS. Development work will also continue on a deep space atomic clock to improve navigation for deep space missions while using fewer resources on mission spacecraft and on the Deep Space Network.

As communications technology and the needs of upcoming NASA missions continue to evolve, domestic and international demand for radio frequency spectrum continues to increase. The Agency's ongoing systems engineering, standards, and spectrum management efforts will continue to respond to new issues. Working with other federal agencies, NASA will free up federal spectrum for domestic commercial use. In addition, preparation will be underway to participate in the 2015 international radio telecommunications regulatory forum to protect Agency radio spectrum uses. Issues include obtaining radio frequency spectrum allocations in the 7 gigahertz range for space communications uses, protecting Deep Space Network ground stations from interference, protecting NASA science uses in the 22 to 26 gigahertz range, and obtaining a spectrum allocation to operate unmanned aerial vehicles. These efforts will protect NASA's communications with its spacecraft and crewed missions, as well as science instruments using radio frequencies, from interference by domestic and international commercial users. If NASA's radio frequency needs are not protected, existing spacecraft and instruments may have to be turned off, and future spacecraft could not operate.

Project Schedule

Date	Significant Event
Q4 FY13	Begin Lunar Laser Communication Demonstration evaluation
Aug 2012	SCaN Testbed installed on ISS
Jan 2013	SCaN Testbed begins testing software-defined radios on ISS.

Project Management & Commitments

Space Communications Support functions are managed by the SCaN Program Office at NASA Headquarters.

SPACE COMMUNICATIONS SUPPORT

Formulation	Development	Operations

Acquisition Strategy

Space Communications Support functions use multiple, small contracted efforts, most of which are support services functions.

MAJOR CONTRACTS/AWARDS

There are no major contracts or awards.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Program Integrated Review	Standing Review Board	Sep 2012	Assess the goals, approach, and performance of the SCaN program, including Space Communications Support functions.	Passed	None

HUMAN SPACE FLIGHT OPERATIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	106.9	--	**111.4**	119.2	120.9	121.9	121.9
Subtotal	107.2	--	**111.4**	119.2	120.9	121.9	121.9
Rescission of prior-year unob. balances*	-0.3	--	**--**	--	--	--	--
Change from FY 2012	--	--	**4.5**				
Percentage change from FY 2012	--	--	**4.2 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

NASA astronaut Sunita Williams, Expedition 32 flight engineer and Expedition 33 commander, attired in a training version of her extravehicular mobility unit spacesuit, awaits the start of a spacewalk training session in the neutral buoyancy laboratory near Johnson Space Center.

At the core of human spaceflight is the crew. The physical presence of human beings actively involved in space exploration broadly expands the benefits and experience for people on Earth. The Human Space Flight Operations (HSFO) program supports the readiness and health of the human system, the crew that has been so integral to the success of the Space Shuttle and International Space Station (ISS) programs.

As NASA is poised to embark on a new phase of human exploration beyond Earth's orbit, the Agency cannot focus only on developing a transportation system capable of reaching destinations throughout the solar system. NASA must also prepare the human system for living and working in a hostile space environment for extended periods of time. As astronauts travel into deep space, what health risks will they face, and how can NASA mitigate them? What kind of training will astronauts require to prepare for being too far from Earth to easily return should a technical anomaly or medical emergency occur? It is not too early to start answering these questions.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

HSFO supported pre-flight training and astronaut medical services for the crews of all flights to ISS, to ensure that the crews were healthy prior to, during, and after each mission. ISS crews completed four successful Expedition launches from Baikonur Cosmodrome in Kazakhstan aboard the Soyuz. Upon completion of their time aboard ISS, NASA's astronauts were back in the United States within 24 hours of Soyuz touchdown.

The program met its goal of improving clinical and research data sharing between ISS partners, with the intent of better understanding the effects of exposure to the space flight environment on humans. In close collaboration with the Human Research Program (HRP), HSFO tailored pre-flight training, medical services, medical operations, and post-flight rehabilitation toward supporting space related clinical and medical research.

Triggered by recent medical evaluations demonstrating vision changes in some crew members, HSFO convened a visual impairment/intra-cranial pressure (VIIP) syndrome panel, consisting of domestic and international experts including NASA's ISS and HRP to address this syndrome. The panel addressed how to evaluate the possible relationship between changes in pressure inside the skull due to shifting body fluids during spaceflight and vision changes. Early in FY 2012, the panel issued recommendations for assessing how the two are related, and how to mitigate vision changes.

WORK IN PROGRESS IN FY 2013

HSFO has planned astronaut training for four crew rotations annually to ISS, and completion of four expedition missions. The program is implementing new targeted solutions and monitoring strategies as recommended by the VIIP Panel Report to screen long-duration crew members, support real time medical operations aboard the ISS, and monitor and rehabilitate returning crews. Personnel are also developing modified medical standards for a 12-month mission scheduled for 2015. NASA has already adopted specific mission criteria to address radiation exposure limits and the VIIP syndrome.

NASA plans to select a 2013 astronaut class, and training will begin in June 2013. Assuming a year and a half of astronaut candidate training, they will be eligible for flight assignment in early 2015. HSFO personnel will screen 2013 candidates to ensure that they meet NASA medical and behavioral health standards. They will also play a critical role in standardizing the pre-flight medical screening, real time medical operations, and post-flight monitoring and rehabilitation requirements of US orbital segment partners (i.e., the Canadian, European and Japanese space agencies), as well as those of the Russian Space Agency.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

HSFO will work closely with NASA’s Office of the Chief Health and Medical Officer (OCHMO) and international counterparts to develop medical standards and criteria for long duration missions including prolonged radiation exposure. To accomplish this goal, HSFO will standardize medical and exposure data into a single integrated system for all international astronauts. This evolved information system will provide private and secure access for all international partners, which is needed to support crew clinical care and vital data management for the human research communities.

Currently, HSFO and the OCHMO are discussing a possible 2014 study on the risk and implications of long-term exposure to space radiation with the Institute of Medicine Committee on Aerospace Medicine and Medicine of Extreme Environments. The National Council on Radiation Protection and Measurements will use this report as they reassess and advise NASA on its radiation standards. Experts will review new methods of monitoring and mitigating long-term bone and muscle loss for effectiveness as they are applied to longer missions.

HSFO is planning to reduce the size of the T-38 fleet, given projected astronauts training requirements.

Program Elements

SPACE FLIGHT CREW OPERATIONS (SFCO)

SFCO provides trained astronauts for all NASA human space flight efforts. Project responsibilities include directing and managing flight crew activities, selecting and training astronaut candidates, determining flight crew training and flight crew simulation requirements, recommending flight crew assignments, and operating program support aircraft -- most notably a fleet of T-38 aircraft for high performance astronaut flight training.

CREW HEALTH AND SAFETY (CHS)

CHS enables healthy and productive crew during all phases of space flight missions, implements a comprehensive astronaut health care program, and works to prevent and mitigate negative long-term health consequences of space flight. The project works with the Human Research Program to transition research products that assure crew health and safety to operations, and medically assesses astronaut candidates as part of the selection process. As research continues on ISS through 2020, CHS actively seeks new ways of doing business, including collaborative opportunities with other Federal agencies and academia.

Program Schedule

Date	Significant Event
Q1- Apr 2014	Astronaut training for long duration flight
Q1- Apr 2014	VIIP Analysis and Evaluation
Q4 - CY14	Complete all T-38 cockpit longeron replacement
Q1- Apr 2014	Institute of Medicine Study
Q2- Apr 2014	Collaborate with the National Council of Radiation Protection and Measurement
Q1- Apr 2015	Medical analysis of long duration flight

Program Management & Commitments

The SFCO program manager reports to the Johnson Space Center (JSC) Director. The CHS program manager reports to the director of the Space Life Science Directorate at JSC, who reports to the JSC

Director. The program is a delegated responsibility from the Human Exploration Operations Mission Directorate.

Program Element	Provider
SFCO will provide trained astronauts for all US human space flight endeavors and bring experienced astronauts expertise to help resolve operations or development issues.	Provider: SFCO Lead Center: JSC Performing Center: JSC Cost Share Partners: None
CHS will assess and maintain the health of astronauts prior to, during, and post flight.	Provider: CHS Lead Center: JSC Performing Center: JSC Cost Share Partners: None

Acquisition Strategy

No major acquisitions are identified. The section below identifies the current contract(s) that support SFCO and CHS.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
Aircraft Maintenance and Modification Program	DynCorp International LLC of Ft. Worth, TX,	Fort Worth, TX
Bioastronautics Contract	Wyle Integrated Science and Engineering Group	Houston, TX

HUMAN SPACE FLIGHT OPERATIONS

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Independent Assessment	National Academies	Sep 2011	Evaluate plans relative to the role and size of SFCO activities following the Space Shuttle retirement and completion of the assembly of the ISS including the astronaut corps' fleet of training aircraft.	The NRC conclusions largely reinforced NASA decision making and approach to crew training.	N/A
Performance	Institute of Medicine	Jul 2012	At the request of NASA, an IOM committee reviewed NASA HRP's Scientific Merit Assessment Processes for directed research.	The IOM committee found that the scientific merit assessment process used by the HRP for directed research is scientifically rigorous and is similar to the processes and merit criteria used by many other Federal agencies and organizations.	N/A

LAUNCH SERVICES

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	81.0	--	**80.5**	84.9	87.6	90.0	90.0
Change from FY 2012	--	--	**-0.5**				
Percentage change from FY 2012	--	--	**-0.6 %**				

With NASA's Mars Science Laboratory spacecraft sealed inside its payload fairing, the United Launch Alliance Atlas V rocket rides smoke and flames as it rises from the launch pad at Space Launch Complex-41 on Cape Canaveral Air Force Station in Florida. The laboratory's components include the car-sized Curiosity rover, which carries ten science instruments designed to search for signs of life.

Without the Launch Services Program (LSP), NASA's robotic science spacecraft would never make it into space, and robotic probes such as the Mars Curiosity Rover, would never reach other planets. For the last 14 years, the Agency has relied on the program to provide space access for scientific and communication satellites, via commercially available domestic launch services. LSP serves the NASA community by contracting launch services to fully address mission needs, and ensure that pricing is consistent and fair. In addition, the program certifies the readiness of new launch vehicles to fly NASA's spacecraft, and conducts engineering analyses and other technical tasks that maximize launch success for every NASA robotic payload.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

LSP successfully launched four major science payloads from four different science disciplines: the National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP), the Mars Science Laboratory (MSL), the Nuclear Spectroscopic Telescope Array (NuSTAR), and the Radiation Belt Storm Probes (RBSP).

LAUNCH SERVICES

Date	Mission	Launch Vehicle Configuration	Launch Site
Oct 2011	NPP	Delta 1	Vandenberg Air Force Base
Nov 2011	MSL	Atlas V	Cape Canaveral Air Force Station
Jun 2012	NuSTAR	Pegasus XL	Kwajalein Atoll
Aug 2012	RBSP	Atlas V	Cape Canaveral Air Force Station

The program was also successful in acquiring launch services for six science missions: the Geostationary Operational Environmental Satellites (GOES-R and S), the Joint Polar Satellite System (JPSS-1), and the Jason-3 spacecraft for the National Oceanic and Atmospheric Administration's (NOAA), as well as NASA's Orbiting Carbon Observatory (OCO-2), and Soil Moisture Active-Passive (SMAP) missions.

Mission	Launch Vehicle Configuration	Launch Provider	Planned Launch
GOES-R and -S	Atlas V	United Launch Services (ULS), LLC of Centennial, CO	Oct 2015 and Feb 2017
OCO-2	Delta II	ULS	Jul 2014
SMAP	Delta II	ULS	Oct 2014
JPSS-1	Delta II	ULS	Nov 2016
Jason-3	Falcon 9	Space Exploration Technologies (SpaceX) of Hawthorne, CA	Dec 2014

In an effort to continually attract new launch providers and products, the NASA Launch Services (NLS) II contract awarded in September 2010 has a unique feature that offers an annual open window for new launch vehicle configurations to be added. In 2012, LSP added a new configuration of the Falcon 9 launch vehicle from SpaceX and a new launch vehicle, the Antares, from Orbital Sciences Corporation (OSC).

WORK IN PROGRESS IN FY 2013

Many of LSP's ongoing activities focus on providing launch expertise and active launch mission management for approximately 35 to 40 robotic missions in various stages of development. Three of these missions are planned for launch in FY 2013. The Tracking and Data Relay Satellite (TDRS-K) and Landsat Data Continuity Mission (LDCM) both successfully launched aboard Atlas V rockets. The Interface Region Imaging Spectrograph (IRIS) is set to launch aboard a Pegasus XL in April. Launch Services activities include engineering, integration, and design and analysis support. Falcon 9 launch vehicle certification, in advance of the Jason-3 mission, will also require a significant LSP effort. In addition to the full launch service management the program provides for most missions, LSP also offers advisory support, expertise, and knowledge to NASA programs and projects utilizing launch services not managed by LSP. The program is currently providing these advisory services to several missions, including:

- The Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, which is launching on a US Air Force Minotaur V;

- The International Space Station Commercial Resupply Services missions, which is launching on SpaceX's Falcon 9 and OSC's Antares;
- The Orion Multi-Purpose Crew Vehicle Exploration Flight Test-1, which is using the ULS Delta IV Heavy launch vehicle; and
- The Commercial Crew Program that may utilize the Atlas V and/or Falcon 9 launch vehicle.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The Launch Services Program has three NASA launches planned: the Mars Atmosphere and Volatile Evolution (MAVEN) and TDRS-L, which are launching aboard Atlas V rockets, and OCO-2, which is launching aboard a Delta II launch vehicle.

The program will also provide launch system advisory support to NASA's Global Precipitation Measurement Core mission, an international NASA collaboration using a foreign launch vehicle, and to Exploration Flight Test-1. In addition, the program will continue to support development and certification of emerging launch providers, and to give launch-related support to approximately 40 NASA scientific spacecraft missions in various phases of development.

Program Schedule

Date	Significant Event
Jan 2013	TDRS-K successfully launched aboard Atlas V Jan 30, 2013
Feb 2013	LDCM successfully launched aboard Atlas V Feb 11, 2013
Jun 2013	IRIS launch aboard Pegasus XL
Aug 2013	LADEE launch aboard Minotaur V*
Nov 2013	MAVEN launch aboard Atlas V
Jan 2014	TDRS-L launch aboard Atlas V
Feb 2014	GPM Core launch aboard H-IIA*
Jul 2014	OCO-2 launch aboard Delta II

**LSP in advisory role only*

Program Management & Commitments

Kennedy Space Center (KSC) is responsible for LSP program management. The Launch Services Program Manager reports to the Director of the Launch Services Office at Headquarters, who provides strategic guidance and oversight.

Program Element	Provider
Expendable Launch Vehicle (ELV) Launch Services	Provider: ULS, OSC, SpaceX, Lockheed Martin Space Systems Lead Center: KSC Performing Center: KSC Cost Share Partners: None

Acquisition Strategy

In 2000, LSP put a unique acquisition strategy in place for procuring ELV launch services from commercial suppliers. To meet the needs of science customers who typically spend three to seven years developing a spacecraft mission, NASA required a contractual approach that covered small, medium, and intermediate-sized missions with an extended lifetime. The original NLS contracts that covered the needed mission sizes were firm-fixed-price, indefinite delivery/indefinite quantity (IDIQ) contracts, containing not-to-exceed prices, with an ordering period that expired in June 2010. NASA Launch Services II contracts are similarly constructed, with an ordering period expiring June 2020. To keep competition fresh and encourage new launch capability development on these 10-year contracts, NASA provides opportunities to US industry on a regular basis to add new commercial launch service providers and/or launch vehicles.

In the year 2000, the US launch market was considerably different than today. As a result, there was a significant price increase in the intermediate launch service class for Atlas V when the NLS II contract was awarded in September 2010.

To help stabilize the Atlas V industrial base, NASA signed an agreement with the US Air Force and National Reconnaissance Office, coordinating launch requirements to establish a more predictable production rate for Atlas V launch vehicles. Due to special terms in our NLS II contracts, any price reduction the US Air Force and National Reconnaissance Office may realize for Atlas V will also be available to NASA.

In an effort to encourage competition, the Launch Service Program continues to offer mission success related advice to new entrant launch vehicle providers. In addition, the US Air Force, National Reconnaissance Office, and NASA have agreed to simplify the certification process and therefore encourage competition by minimizing the burden on new entrant providers. This agreement has established a single certification framework based on NASA’s launch-risk mitigation policy. In addition to the single framework, the organizations also agreed to share data, findings, and lessons learned from certification activities. A Government ELV Executive Board was established between the three signatories to implement both the acquisition and certification components of these agreements.

LSP has also made efforts to provide a more complete launch service that includes payload processing at the launch site by procuring commercial payload processing facilities and services at the east and west coast launch sites, Cape Canaveral Air Force Station in Florida, and Vandenberg Air Force Base in California. The program has negotiated firm-fixed-price IDIQ contracts for commercial payload processing, with an ordering period expiring in December 2013.

Civil service and contractor personnel make up the LSP workforce, while the ELV Integrated Support (ELVIS 2) contract provides contractor support. ELVIS 2 provides LSP with program management support; vehicle engineering and analysis; launch site support engineering; communications and telemetry; technical integration services; Launch Services programmatic safety, reliability and quality support; support at Vandenberg Air Force Base in California; information technology support; and special studies.

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location (of work performance)
NLS-I-L*	ULS, LLC	Centennial, CO
NLS-II-A	Lockheed Martin Space Systems	Denver, CO
NLS-II-U	ULS, LLC	Centennial, CO
NLS-II-S	SpaceX	Hawthorne, CA
NLS-II-O	OSC	Dulles, VA
Payload Processing Facility	Astrotech Corporation	Titusville, FL
Payload Processing Facility	Astrotech Corporation	Vandenberg Air Force Base, CA
Integrated Processing Facility	Spaceport Systems International	Vandenberg Air Force Base, CA
ELVIS 2	a.iSolutions, Inc.	Lanham, MD

**ULS is the only remaining NLS Contractor with active awarded missions*

INDEPENDENT REVIEWS

No independent reviews currently planned.

HISTORICAL PERFORMANCE

LSP Managed ELV Missions from Inception through FY 2012

Launch Vehicle Configuration	Provider	Number of Launches	Successful Launches	Unsuccessful Launches
Athena	Lockheed Martin/Alliant Techsystems	1	1	0
Atlas IIA	Lockheed Martin	5	5	0
Atlas IIAS	Lockheed Martin	1	1	0
Atlas V	Lockheed Martin ULS	2 5	2 5	0 0
Delta II	Boeing Launch Services ULS	26 13	26 13	0 0
Pegasus Hybrid	OSC	1	1	0
Pegasus XL	OSC	12	12	0
Taurus XL	OSC	2	0	2
Titan II	Lockheed Martin	3	3	0

ROCKET PROPULSION TEST

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	43.6	--	**47.8**	47.3	47.7	48.0	48.0
Change from FY 2012	--	--	**4.2**				
Percentage change from FY 2012	--	--	**9.6 %**				

On July 13, 2012 NASA engineers conducted the fifteenth in a series of J-2X engine tests at the Stennis Space Center's A-2 test stand. The upper stage engine is a key component of the Space Launch System, a new heavy-lift launch vehicle capable of carrying the Orion Multi-Purpose Crew Vehicle with its crew, cargo, equipment and science experiments to destinations in deep space. This was the first flight-duration test of the engine's nozzle extension, a bell shaped device to increase engine performance.

Developing rocket propulsion systems is an important aspect of working in space, but it is also a dangerous and costly undertaking. Whether the payload will ultimately be a robotic science experiment or a human-crewed mission, it is crucial that the propulsion system be safe, reliable, and accurate. Thus, a rigorous engine test program is a critical component of any rocket propulsion development activity. NASA's Rocket Propulsion Test (RPT) program maintains and manages a wide range of facilities capable of ground testing rocket engines and components under controlled conditions.

With test facilities located throughout the country, RPT is able to maintain a world-class test infrastructure that provides a single entry point for users. The program retains a skilled workforce that is adaptable to increasingly complex rocket engine development and testing needs. RPT evaluates customer test requirements and desired outcomes, while striving to minimize test time and cost. By consolidating and streamlining NASA's rocket test facilities in this way, the program can efficiently manage usage and eliminate the need for duplicate facilities.

As NASA's principal implementing authority for rocket propulsion testing, the program reviews, approves, and provides direction on test assignments, capital improvements, and test facility modernization and refurbishment. The program integrates multi-site test activities, identifies and protects core capabilities, and develops advanced testing technologies.

RPT also represents NASA as a member of the National Rocket Propulsion Test Alliance, which is an inter-agency alliance between NASA and DoD, established to facilitate efficient and effective use of the federal government's rocket propulsion test capabilities. The RPT Program Manager serves as the co-chair of this alliance, which also coordinates government investment aimed at satisfying the Nation's rocket propulsion developmental and operational testing needs, and is a member of the NRPTA Senior Steering Group.

ROCKET PROPULSION TEST

For additional programmatic information, go to: http://rockettest.nasa.gov/.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Possibly the most notable test activity was that of the J-2X engine. The first human-rated liquid oxygen and liquid hydrogen rocket engine to be developed in 40 years, the J-2X upper stage engine is vital to achieving full launch capability of the heavy-lift Space Launch System (SLS). This capability is critical to NASA's deep space exploration program development. RPT performed additional testing in support of Agency development projects, including a liquid methane, liquid oxygen engine that could one day carry cargo to the Moon.

The Orbital Sciences Corporation and Aerojet conducted several test firings of the AJ-26 engine to clear the engines for use on the Antares first stage. These firings represented the final engine testing prior to shipping to Wallops Flight Facility, and integrating on test and flight launch vehicles. The engines will enable Commercial Orbital Transportation Services test and demonstration flights, as well as upcoming ISS resupply missions.

NASA Advanced Exploration Systems developed a small lander testbed called Morpheus to demonstrate autonomous precision landing and liquid oxygen-methane propulsion, technologies key to landing on the Moon or Mars. These landing systems will improve safety by detecting hazards such as rocks and craters in the landing zone, and automatically maneuvering the lander to avoid them. Liquid oxygen- methane propulsion systems may be used on Mars missions, since crew could produce propellants for the return to Earth from the Martian atmosphere.

In support of Space Shuttle transition and retirement, RPT conducted final preparations for decontamination, cleanup, and removal of hypergolic propellant at Johnson Space Center's White Sands Test Facility (WSTF) prior to shipping the vehicles to final display destinations in Dulles, Virginia and Los Angeles, California. Removing the hypergolic propellants was necessary because the propellant is highly corrosive and poses a health hazard.

By the end of FY 2012, the program had safely performed over 118 tests, clocked over 300,000 seconds of test time, and neared 10,000 seconds of hot fire at various levels of thrust capacity.

WORK IN PROGRESS IN FY 2013

In FY 2013, the Rocket Propulsion Test program continues to lead the Agency's rocket testing activities by providing world-class test facilities and highly skilled workforce needed to support not only NASA emerging engine technologies, but also non-NASA customers, both national and international. RPT utilizes all types and levels of engine capacity to ensure that both Federal and commercial rocket testing move forward. The program ensures that test-related facilities are maintained and modernized to meet the appropriate state of operational readiness. Specific customers planning to use RPT test facilities include

ROCKET PROPULSION TEST

NASA J-2X, NASA Morpheus, NASA SLS, Blue Origin, the Missile Defense Agency, Orbital Sciences Corporation, and other NASA, external reimbursable and international customers.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

RPT will test several components of the SLS using facilities located at Stennis Space Center. One of these components is the J-2X engine, which will be integrated into the second stage of the SLS launch vehicle. The program will continue to prepare for overall SLS integration testing.

Other engine testing includes the RS-68 engine and the Orbital AJ-26 engine at Stennis Space Center and the Missile Defense Agency test article at Johnson Space Center's White Sands Test Facility.

Program Schedule

The following are customer funded testing schedules:

Date	Significant Event
FY 2012, 2013, end in 2014	J-2X testing
Ongoing	RS-68 testing
FY 2012, 2013, end in 2014	AJ-26 testing (Orbital)
FY 2012, through 2017	SLS testing
FY 2013, FY 2014	Missile Defense Agency test article

Program Management & Commitments

RPT is committed to provide highly reliable test facilities and workforce at a competitive cost to both NASA and non-NASA customers.

Program Element	Provider
RPT is NASA's principal implementing authority for rocket propulsion testing. The program integrates multi-site test activities, identifies and protects core capabilities, and develops advanced testing technologies.	Provider: RPT Lead Center: N/A Performing Centers: SSC, JSC/WSTF, GRC Plum Brook Station, Marshall Space Flight Center, Kennedy Space Center Cost Share Partners: Various other NASA programs, DoD, and commercial partners

Acquisition Strategy

No major acquisitions are identified for FY 2014.

MAJOR CONTRACTS/AWARDS

No major contracts or awards are planned for FY 2014.

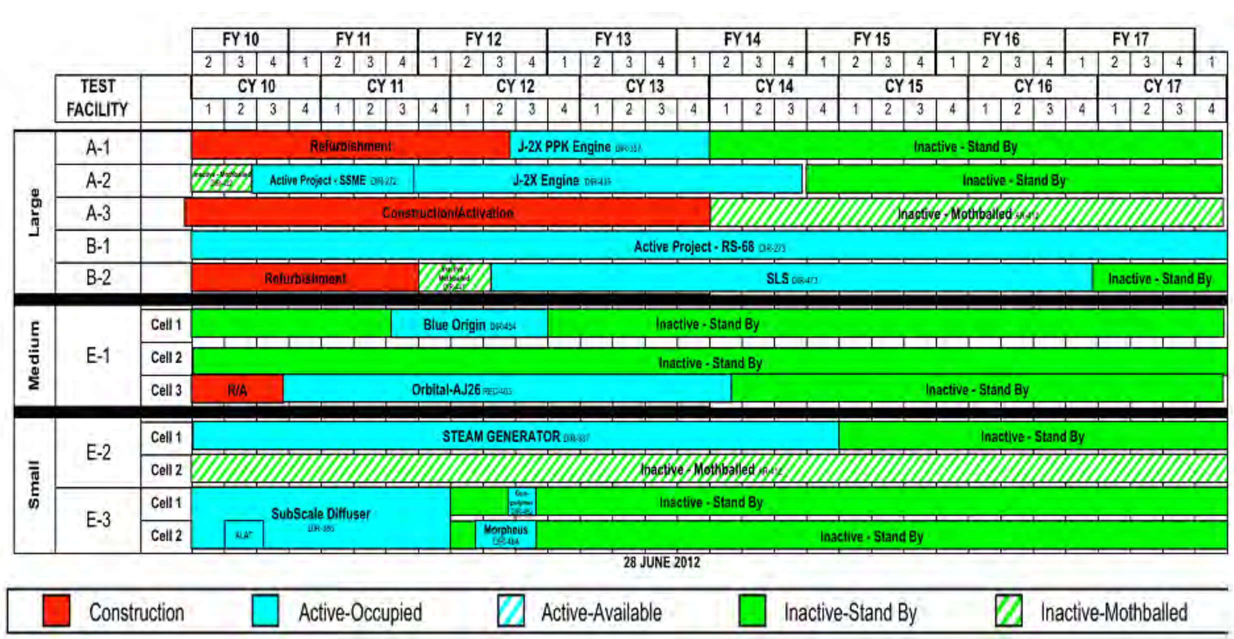
INDEPENDENT REVIEWS

No reviews planned.

HISTORICAL PERFORMANCE

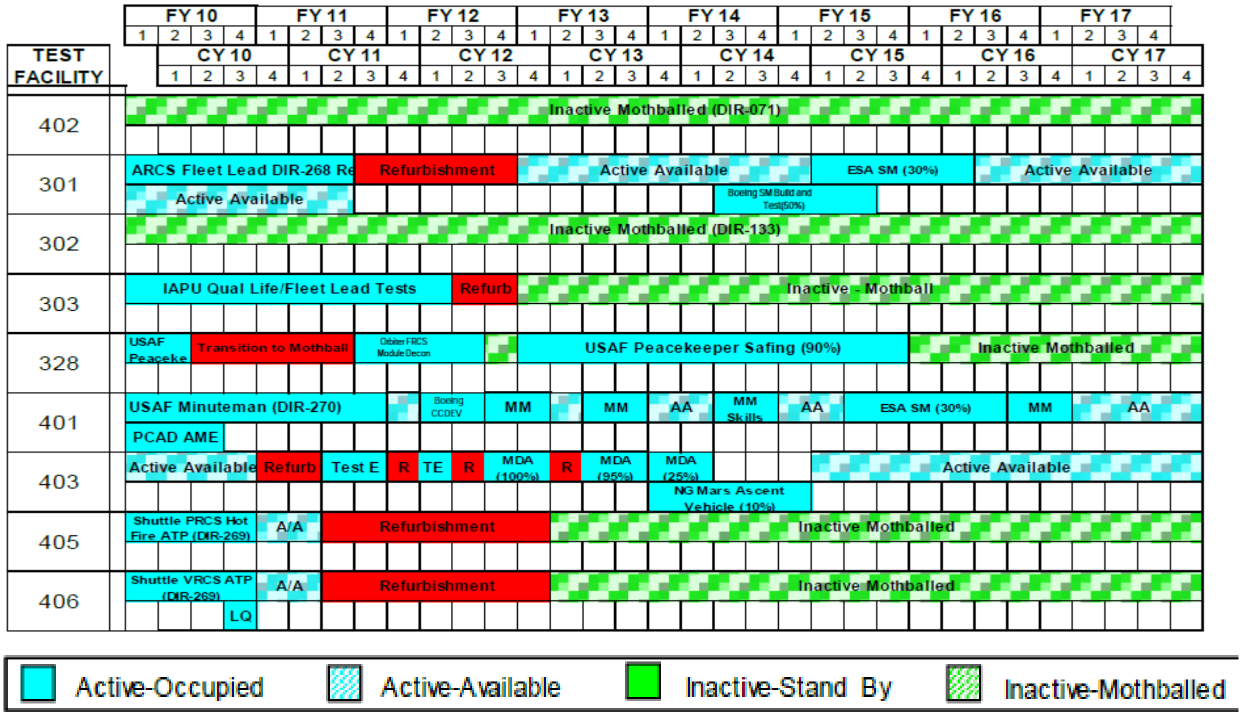
The charts below show past, current, and planned test campaigns at the various rocket propulsion test facilities. The first campaign was at Stennis Space Center in Mississippi, and the second one was at White Sands Test Facility in New Mexico. The test facilities are listed at the left side of the table; “Small”, “Medium”, and “Large” at the far left of the Stennis Space Center chart refers to the thrust class of engines that the facility can test. The top of each chart shows time by quarter of fiscal year and calendar year, and the key to the status of each facility is at the bottom of each chart.

Stennis Space Center Test Stand Utilization FY 2010-FY 2017



ROCKET PROPULSION TEST

White Sands Test Facility Test Stand Utilization FY 2010-FY 2017



EDUCATION

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	136.1	136.9	**94.2**	94.2	94.2	94.2	94.2
Aerospace Research and Career Development (ARCD)	58.4	--	**33.0**	33.0	33.0	33.0	33.0
STEM Education and Accountability (SEA)	80.0	--	**61.2**	61.2	61.2	61.2	61.2

EDUCATION

EDUCATION

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	136.1	136.9	**94.2**	94.2	94.2	94.2	94.2
Aerospace Research and Career Development (ARCD)	58.4	--	**33.0**	33.0	33.0	33.0	33.0
STEM Education and Accountability (SEA)	80.0	--	**61.2**	61.2	61.2	61.2	61.2
Subtotal	138.4	139.2	**94.2**	94.2	94.2	94.2	94.2
Rescission of prior-year unob. balances**	-2.3	-2.3	**--**	--	--	--	--
Change from FY 2012	--	--	**-41.9**				
Percentage change from FY 2012	--	--	**-30.8 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Aerospace Research and Career Development pursuant to P.L. 112-55, Division B, sec. 528(f).*

A group of educators showing their enthusiasm at a hands-on STEM Research Workshop, posed in front of a 34-meter antenna in the Deep Space Network at Goldstone, in California's Mojave Desert. NASA's investment in educators teaching grades 4-12 provides immediate benefit to their classrooms, transferring the excitement of learning, as well as infusing new materials and strategies to inspire their students.

In support of the Administration's FY 2014 Science, Technology, Engineering, and Mathematics (STEM) Education plan, the Agency's education efforts will be fundamentally restructured into a consolidated education program funded through the Office of Education. The Office of Education will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution to achieve the Administration's STEM goals under its wider consolidation strategy. This approach will utilize NASA's expertise and resources to shape the Nation's STEM education portfolio. The FY 2014 request for Education is $94.2 million, and an additional $15 million to support fellowships contained in the Space Technology Mission Directorate Account.

NASA Education's vision is to advance high quality STEM education using NASA's unique capabilities. NASA's education programs will continue to be deliberate in developing and executing strategic partnerships with intergovernmental, academic, industrial, entrepreneurial, and international communities to ensure NASA's education mission and vision are properly addressed. NASA Education activities will define specific benefits and outcomes from each partnership, develop a method to systematically manage partnerships, and leverage each organization's resources appropriately.

In addition to the National Space Grant College and Fellowship Program (Space Grant), Experimental Program to Stimulate Competitive Research (EPSCoR) and Minority University Research and Education Project (MUREP), NASA will consolidate the education functions, assets and efforts of the mission directorates, offices and Centers, for example GLOBE, into a single coordinated STEM Education and Accountability Project. The assets are critical and unique components that NASA can make available to the National Science Foundation, Smithsonian Institution, and Department of Education as they facilitate federal STEM education activities.

NASA will continue to improve STEM education through an internal competitive process that invests in NASA's most effective education programs, and will remain in alignment with the America COMPETES Reauthorization Act of 2010. NASA's education investments will also be aligned with the federal strategic plans of the Administration's Committee on STEM (CoSTEM). NASA's investments will include support for minority serving institutions and community colleges, which generally serve a high proportion of minority students, preparing them for study at a four-year institution.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The Agency's STEM education efforts will be fundamentally restructured into a consolidated education program within NASA Office of Education, and will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution in leading and executing the Administration's STEM education efforts. The Agency aims to increase both the use of NASA resources and the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities.

The Office of Education will utilize an evidence-based competitive process focusing on NASA's most effective internal STEM education activities and assets. In addition to funding the best NASA STEM education assets, these funds will be used to ensure that on-going activities such as the Aeronautics Scholars and Fellows, Graduate Student Researcher Project Fellows, and educators funded through the Endeavor Science Teacher Certificate Program are not abruptly ended. NASA will also allocate funds to allow the Agency to support a data management system for performance measurement, analysis, evaluation, and reporting of NASA's activities.

NASA will allow offices such as the International Space Station Program Office to make available on orbit assets, open access to launch facilities for consolidated programs to develop STEM engagement efforts.

The resources will support NASA's ability to make its people, facilities, and flight platforms available for educational purposes. Identified are core costs necessary for NASA to support involvement with the STEM consolidation efforts.

NASA's expertise, passion and assets play a unique role in the Nation's STEM education portfolio. In addition to Space Grant, EPSCoR, and MUREP, the STEM Education and Accountability Project will identify functions and assets as critical components that NASA can make available to the National Science Foundation, Smithsonian Institution, and Department of Education as they facilitate federal

STEM education activities through the Administration's Committee on STEM process for Agency coordination.

Funding is focused on the most effective and highest priority activities.

ACHIEVEMENTS IN FY 2012

NASA Interdisciplinary National Science Project Incorporating Research and Education Experience (INSPIRE) is a research based student pipeline activity designed for students in ninth to twelfth grade. The centerpiece of the INSPIRE activity is its Online Learning Community. NASA's unique mission provides the content for the community with the intent to generate interest of students in NASA STEM-related education and career opportunities. In FY 2012, NASA selected 2,054 students to participate in an online learning community, compared to 1,923 in 2011, an increase of 131 students (6.8 percent) from 2011. The students represent 49 states, Guam and Puerto Rico.

Based on survey data, 90 percent of the students who participated in INSPIRE report they want to take more STEM courses after participating.

NASA Science, Engineering, Mathematics and Aerospace Academy (SEMAA) is a national education activity designed to increase the participation and retention of historically underserved and underrepresented K-12 youth in the areas of science, technology, engineering, and mathematics (STEM). In FY 2012, the SEMAA project served a total of 70,384 students, parents/adult caregivers, teachers and outreach participants representing an overall 14 percent increase over the number of participants served in FY 2011.

After participation in SEMAA, 88 percent of students surveyed expressed an interest in STEM. All of the teachers (1005) reported using NASA resources in their classroom after participating in NASA professional development, far exceeding the goal of 50 percent.

NASA Undergraduate Student Research (USR) activity offers undergraduate students across the United States immersive research and engineering internship experiences at all ten NASA Field Centers and two NASA Research Facilities. In FY 2012, NASA provided 141 experiences for higher education students. Of that number, 28 interns represented an underserved race or ethnicity and 46 were female. In addition, NASA intern Kody Ensley was named Intern Student of the Year by the American Society of Engineering Educators Cooperative and Experiential Division. He has since joined the NASA workforce as a software engineer at Johnson Space Flight Center.

WORK IN PROGRESS IN FY 2013

NASA continues to align its STEM education activities with the priorities identified in the five-year STEM Strategic Plan issued by CoSTEM. The Agency is consolidating the education activities from NASA's mission directorates, offices, and Centers to ensure educational activities are thoroughly integrated with the proposed programs this account funds.

EDUCATION

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The NASA Office of Education will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution within the framework of the wider consolidated STEM education effort. The Agency aims to increase both the effectiveness and utilization of NASA resources to reach the Administration's STEM education goals.

STEM education resources within NASA will be focused within NASA's Office of Education, which will employ an evidence-based competitive process to reach NASA's most effective internal STEM education activities and assets across the Agency. NASA seeks to make available its unique assets, such as the International Space Station, open to STEM education programs government-wide on a reimbursable basis in order to enhance their effective reach to students and educators. In addition, the Office of Education will expand its evidence-collection activities, and deploy a data management system for performance measurement, analysis, evaluation, and reporting of NASA's activities.

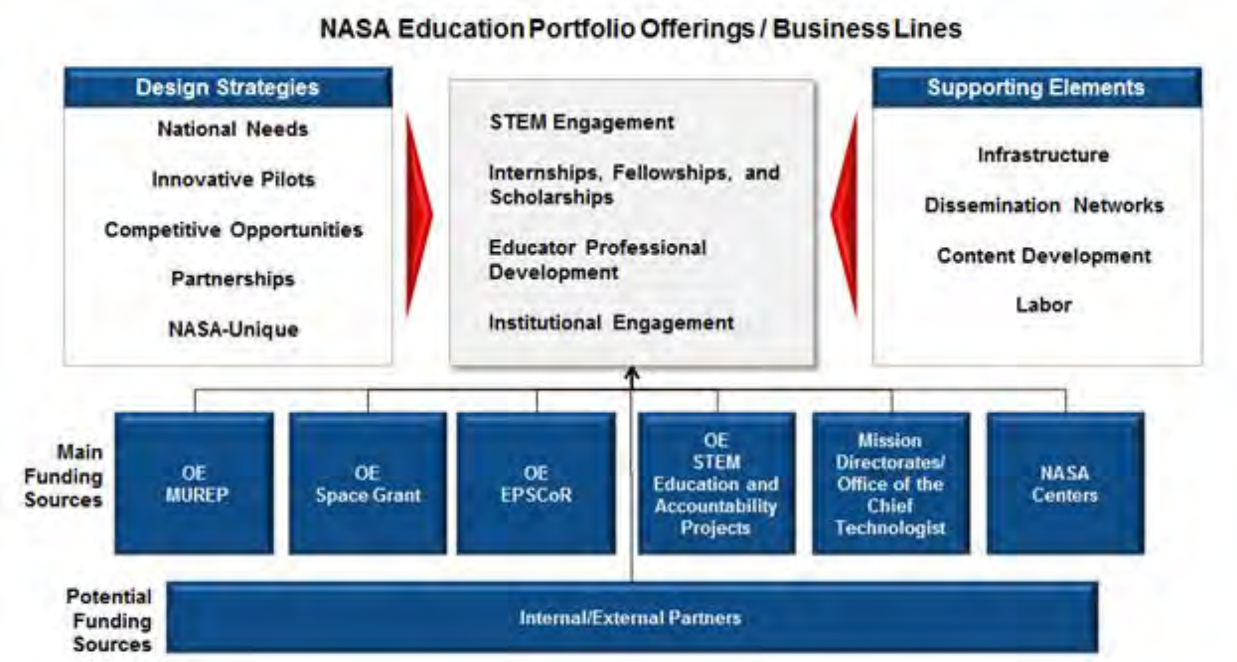
NASA's education portfolio will focus on the following four priorities, which will contribute toward the Administration's goals for STEM education.

- STEM Engagement: Provide opportunities for participatory and experiential learning activities that connect learners to NASA-unique resources;
- NASA Internships, Fellowships, and Scholarships: Utilize NASA facilities and assets to provide work experiences, research opportunities to improve retention in STEM and prepare students for employment in STEM jobs;
- Educator Professional Development: Prepare STEM educators and leaders to deliver quality STEM instruction utilizing unique NASA assets; and
- Institutional Engagement: Improve the capacity of U.S. institutions to deliver effective STEM education.

An overarching operating principle consistent throughout the portfolio is a focus on making opportunities available to a diverse audience of educators and learners, including women, minorities, and persons with disabilities.

The diagram listed below describes a strategically focused portfolio that ensures scalability and flexibility, and enables NASA education to focus its efforts in areas of greatest national need.

Agency's Design Strategies & Funding



Programs

AEROSPACE RESEARCH & CAREER DEVELOPMENT (ARCD)

The Aerospace Research and Career Development (ARCD) program strengthens the research capabilities of the Nation's colleges and universities and provides opportunities; those attract and prepare an increasing numbers of students for NASA-related careers. These institutions conduct research that contributes to NASA's Mission Directorates' research needs and furthers the Nation's scientific and technology innovation agendas. The student programs serve as a major link in the pipeline for addressing NASA's human capital strategies. The programs build, sustain, and effectively deploy the skilled, knowledgeable, diverse, and high-performing workforce needed to meet the current and emerging needs of NASA and the Nation.

The projects in the Aerospace Research and Career Development program are: National Space Grant College and Fellowship Program (Space Grant), and Experimental Program to Stimulate Competitive Research (EPSCoR).

EDUCATION

STEM EDUCATION AND ACCOUNTABILITY (SEA)

The STEM Education and Accountability (SEA) program provides unique NASA assets, including its people, resources and facilities available in support of the Nation's STEM education priorities. The program supports the professional development of interns, fellows and educators, while integrating NASA assets and content into programs designed by the Department of Education, National Science Foundation and the Smithsonian Institution. The program also enhances the research, academic, and technology capabilities of Historically Black Colleges and Universities, Hispanic Serving Institutions, Tribal Colleges and Universities, and other Minority Serving Institutions (MSIs); provides targeted opportunities for underrepresented and underserved learners to participate in research and education opportunities through internships, scholarships, and fellowships; and provides opportunities for minority institutions to improve the quality of their faculty preparation programs and thereby improve the quality and diversity of future STEM leaders.

The projects within the SEA Program are: Minority University Research and Education Project (MUREP), and STEM Education and Accountability Project.

NASA invests in a shared Program Evaluation & Accountability effort across both ARCD and SEA programs. Managed from NASA Headquarters, it ensures alignment, and helps identify and eliminate potential duplication of effort across NASA's education portfolio. NASA also actively participates in the National Science and Technology Council Committee on STEM, serving as the co-chair in the development of the Federal Strategic Plan for STEM Education. These two efforts ensure NASA's investments are non-duplicative of other federal agencies, and are internally coordinated among the Office of Education, mission directorates and centers. These efforts are consistent with both a Government Accountability Office report (GAO-12-342SP) and CoSTEM reports on how to better coordinate STEM efforts across Federal agencies. CoSTEM coordinates Federal programs and activities in support of STEM education, pursuant to the requirements of Section 101 of the America COMPETES Reauthorization Act of 2010.

For more information on CoSTEM reports, go to:
http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/costem.

AEROSPACE RESEARCH AND CAREER DEVELOPMENT (ARCD)

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	56.1	--	**33.0**	33.0	33.0	33.0	33.0
National Space Grant College and Fellowship Project	40.0	--	**24.0**	24.0	24.0	24.0	24.0
Experimental Project To Stimulate Competitive Research (EPSCoR)	18.4	--	**9.0**	9.0	9.0	9.0	9.0
Subtotal	58.4	--	**33.0**	33.0	33.0	33.0	33.0
Rescission of prior-year unob. balances*	-2.3	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-23.1**				
Percentage change from FY 2012	--	--	**-41.2 %**				

*Note: * Rescission of prior-year unobligated balances from NASA Space Grant and EPSCoR pursuant to P.L. 112-55, Division B, sec. 528(f).*

Promoting research that helps to advance its science and technical priorities, NASA partners with a variety of external organizations to engage faculty and research teams. Opportunities such as NASA's Advanced Rocketry Workshops take participants through all aspects of NASA Student Launch Projects.

Aerospace Research and Career Development (ARCD) supports national STEM efforts through the National Space Grant College and Fellowship Program (Space Grant) and the Experimental Program to Stimulate Competitive Research (EPSCoR).

The NASA Authorization Act of 1988 (P.L. 100-147) established Space Grant with a goal of enhancing the Nation's science enterprise by funding education, research, and public service projects through a national network of university-based Space Grant consortia. The NASA Authorization Act, FY 1992 (P.L. 102-588) established EPSCoR to strengthen the research capability of jurisdictions that have not in the past participated equitably in competitive aerospace research activities. The goal of the NASA EPSCoR is to provide seed funding that will enable jurisdictions to develop an academic research enterprise directed toward long-term, self-sustaining, nationally competitive capabilities in aerospace and aerospace-related research. This capability will, in turn, contribute to the jurisdiction's economic viability and expand the Nation's base for aerospace research and development.

These national projects enable NASA to advance more strategically STEM literacy by enhancing science and engineering education and research efforts in higher education, K-12, and informal education. In addition to education, ARCD promotes research and technology development opportunities for faculty and research teams that advance the Agency's scientific and technical priorities.

AEROSPACE RESEARCH AND CAREER DEVELOPMENT (ARCD)

EXPLANATION OF MAJOR CHANGES

See Explanation of Major Changes section of Education Account Overview. Funding is focused on the most effective and highest priority activities.

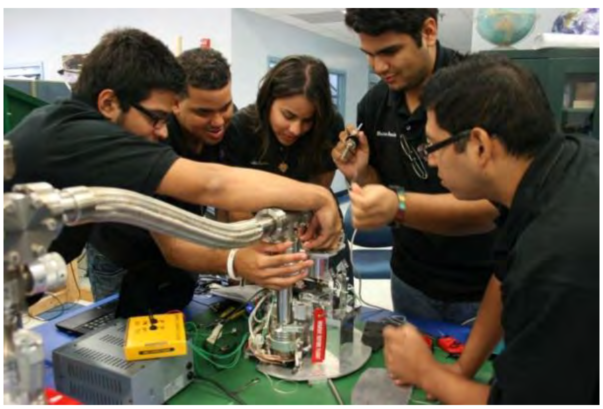
NASA SPACE GRANT

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	38.9	--	**24.0**	24.0	24.0	24.0	24.0
Subtotal	40.0	--	**24.0**	24.0	24.0	24.0	24.0
Rescission of prior-year unob. balances*	-1.2	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-14.9**				
Percentage change from FY 2012	--	--	**-38.3%**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*



The best reinforcement for learning is doing. Through a series of design challenges for experiment payloads and launches, Space Grant provides students with hands-on experiences. Taking the knowledge and skills gained from these experiences back to the classroom helps to foster greater academic success.

The National Space Grant College and Fellowship Program (Space Grant) is a competitive grant opportunity project, enabling the active involvement of the entire country in NASA activities through its national network of 52 consortia in 50 states, the District of Columbia, and the Commonwealth of Puerto Rico. Space Grant supports and enhances science and engineering education and research efforts for educators and learners, by leveraging the resource capabilities and technologies of over 1,000 affiliates from universities, colleges, industry, museums, science centers, and state and local agencies. Training grants with each consortium align their work with the Nation's STEM education priorities and the annual performance goals of the Agency.

Space Grant enables NASA to provide flight opportunities for students to access space to gain research and hands-on engineering experiences on a variety of authentic flight platforms, including high-altitude balloons, sounding rockets, aircraft, and space satellites. Space Grant leverages Agency investments in STEM education through collaborations with other national NASA education activities. Space Grant also supports student participants in internship experiences at NASA Centers.

EXPLANATION OF MAJOR CHANGES

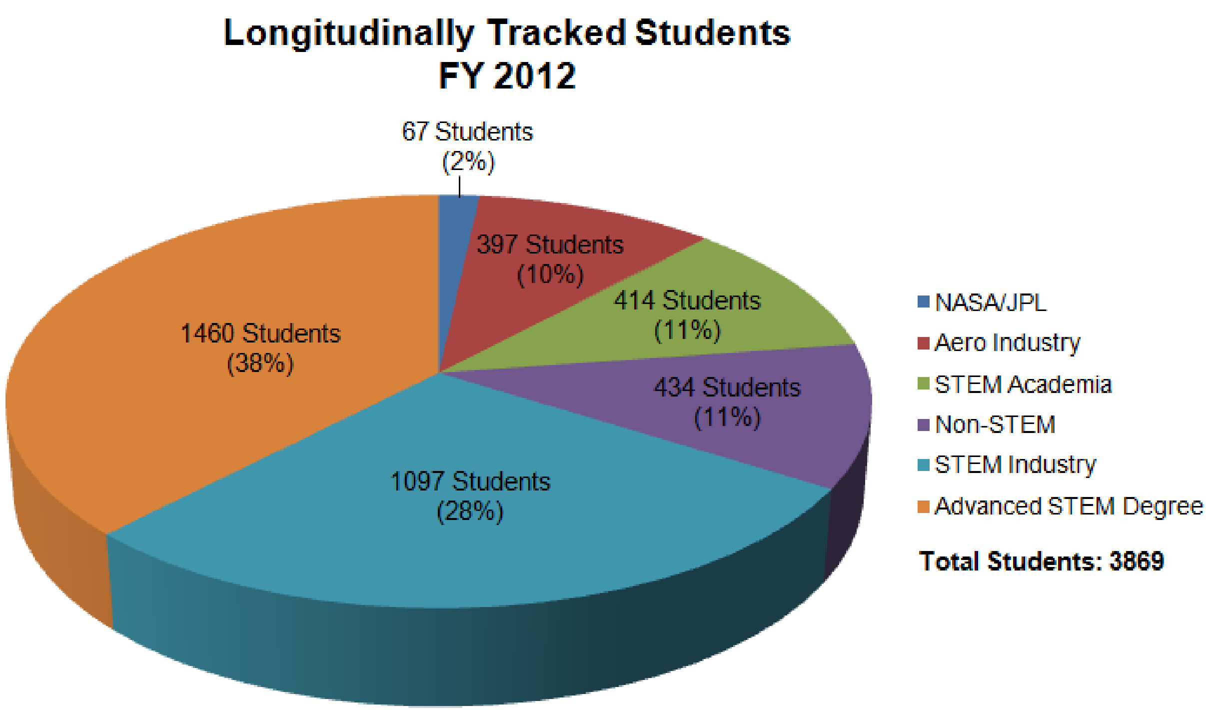
See Explanation of Major Changes section of Education Account Overview. Funding is focused on the most effective and highest priority activities.

NASA SPACE GRANT

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2012

In FY 2012, over 24,000 Space Grant-supported undergraduate and graduate students participated in scholarships, fellowships, internships and authentic hands-on research and engineering challenges. Diversity is a key component within the Space Grant project, achieving a 23 percent participation of underrepresented students, and 34 percent participation of female students in Space Grant activities. Educators are an important target audience of Space Grant. This year over 19,000 educators participated in NASA education activities. Space Grant also targets elementary and secondary students through NASA instructional and enrichment activities, reaching over 164,000 precollege students. The Agency conducts longitudinal tracking of Higher Education students receiving significant investments. The table below shows the status of 3,869 students who were longitudinally tracked in 2012 after taking their "next step" from Space Grant.



The Space Grant consortia supported flight project activities led by teams of students. Those project activities included:

Three payloads as part of the CubeSat Launch Initiative;
The fifth Rock-On Workshop with representation from twelve universities;
The third Rock-Sat-C launch with representation from ten universities;

NASA SPACE GRANT

Formulation	Development	Operations

The second Rock-Sat-X launch with representation from four universities; and
A flight of the High Altitude Student Platform (HASP) with 12 payloads from 14 universities.

WORK IN PROGRESS IN FY 2013

The currently open Space Grant solicitation directly addresses the need to improve retention rates in STEM majors during the first two years of undergraduate STEM education and to increase the number of pre-service K-12 educators qualified to teach in STEM fields. Additionally, the solicitation seeks to insure that participants are representative of the diversity of the United States. The Agency will award the cooperative agreements during the second quarter of FY 2013. The Space Grant team is currently preparing to solicit an organization to conduct an independent external evaluation to be completed in 2014.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In 2014, the program budget will support the base awards for Year 5 of 5 for the 52 consortia which includes the following elements:

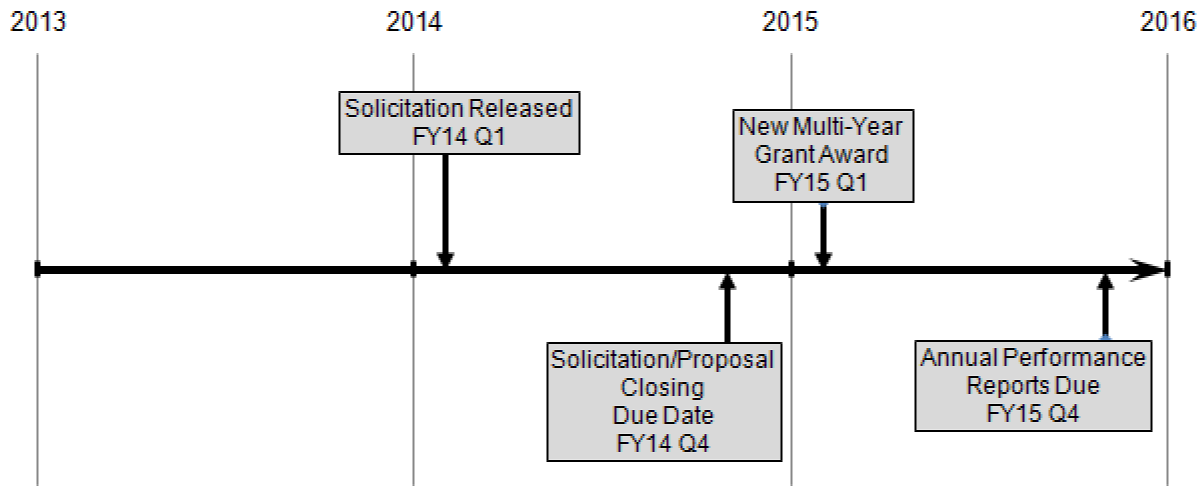
- Provide hands-on experiences for U.S. graduate and undergraduate students to prepare them for the future workforce and/or academic careers;
- Conduct programs and projects that align with the NASA Education priorities, missions and state-specific needs to build upon the education pipeline in pre-college, higher education, and informal education;
- Promote a strong STEM education base from elementary through secondary levels while preparing teachers in these grade levels to become more effective at improving student academic outcomes;
- Continue to build upon and maintain the existing national network of universities with interests and capabilities in aeronautics, space and related fields; and
- Leverage the opportunities emerging from the NASA Education strategy to develop high-impact, nationwide partnerships.

Space Grant will assess the results of the completed independent external evaluation to determine possible changes to the program in conjunction with the NASA Education strategy and direction. The solicitation will reflect this new direction.

NASA SPACE GRANT

Formulation	Development	Operations

Project Schedule



Project Management & Commitments

The Space Grant Project Manager at NASA Headquarters provides management responsibility for day-to-day Space Grant operations. Award selections by the 52 lead institutions are based on peer reviews by external panels that evaluate performance, and internal/external panels that assess performance, merit, and alignment to Agency education, research, and technology goals. Each consortium program or project must demonstrate alignment with NASA education objectives that align with NASA strategic goals. Civil servants at NASA centers actively engage with regional space grant consortia, providing direction, oversight, and integration with center and mission directorate activities.

NASA SPACE GRANT

Formulation	Development	Operations

Acquisition Strategy

NASA solicits Space Grants through full and open competition for proposals accepted from Space Grant consortia in each state, Washington D.C., and the Commonwealth of Puerto Rico. Each consortium program or project must demonstrate alignment with NASA education objectives that align with NASA strategic goals. Awards are based on peer reviews by external panels that evaluate performance, and internal/external panels that assess performance, merit, and alignment to Agency education, research, and technology goals. Awards are typically for five years.

Consortia must submit annual performance data, student profile and award information (for students who meet the longitudinal tracking threshold), project information, and other performance data. The Space Grant Program Office also performs comprehensive program reviews every five years.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Independent/ External	TBD	N/A	An independent review by an external organization to assess the accomplishments and strategy of the Space Grant program		2014

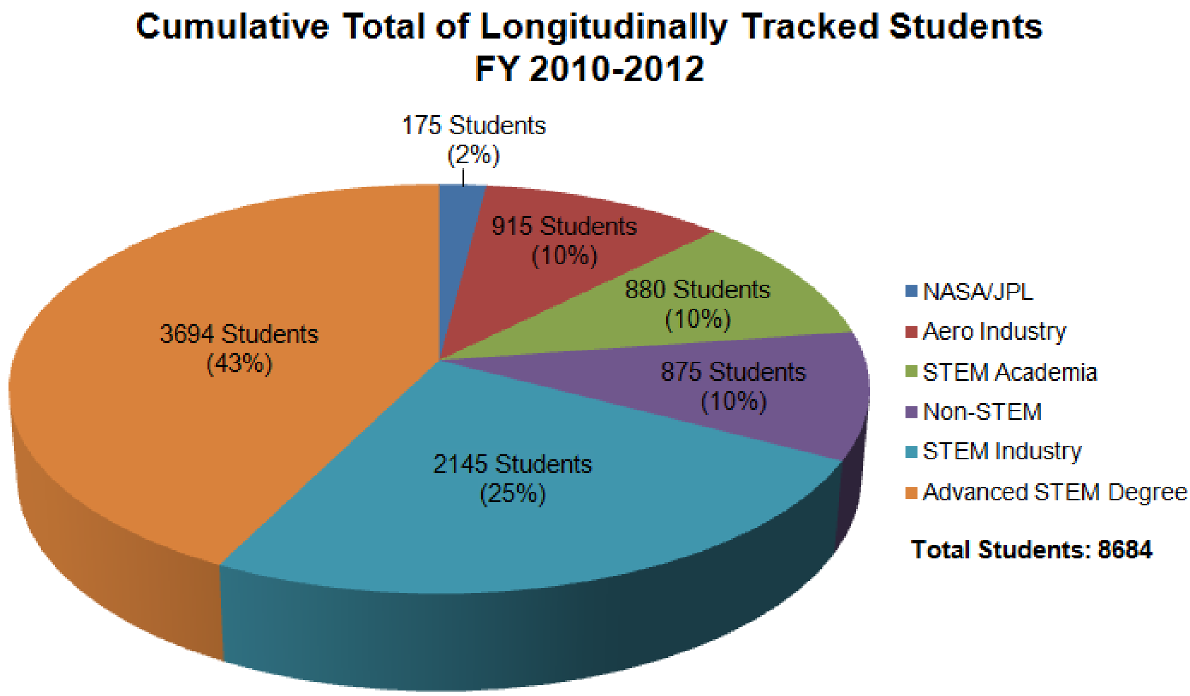
The Space Grant Program evaluation, which concluded in 2009, covered the five-year period 2003-2007 and focused on a merit review of the performance by each consortia in three primary areas: overall performance and results (Program Performance and Results), effectiveness in terms of key elements of grant management practices (Network Participation and Responsiveness), and feedback from the consortium members (Affiliate Opinion Survey). Individual consortium results fell into four categories: Pass, Pass with Weaknesses, Pass with Deficiencies, and Serious Deficiencies. Depending on the category, consortia with results other than "Pass" were required to address the areas cited.

HISTORICAL PERFORMANCE

Between 2010 and 2012, Space Grant reached over 67,000 higher education participants, including 12,626 individuals receiving significant education and research support. Consistent with the definition of all Office of Education higher education student participants, significant awardees receive greater than or equal to $5,000 in monetary support or participate in activities of greater than or equal to 160 hours in duration. Longitudinal tracking of significant student awardees indicates that typically 90 percent of Space Grant award recipients either obtain employment in STEM fields after graduation or matriculate into an advanced STEM degree program. The following graph illustrates student post-graduation employment in STEM career fields over the last three years.

NASA SPACE GRANT

Formulation	Development	Operations



EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR)

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	17.3	--	**9.0**	9.0	9.0	9.0	9.0
Subtotal	18.4	--	**9.0**	9.0	9.0	9.0	9.0
Rescission of prior-year unob. balances*	-1.2	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-8.3**				
Percentage change from FY 2012	--	--	**-48.0%**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

The Native American Research Laboratory (NARL) was established at the University of Montana for native scholar research in the natural and biological sciences. The EPSCoR Research Grant supports undergraduate, graduate, and high school students with significant research experiences in an interdisciplinary environment, as well as exciting inter-governmental and international internships.

The Experimental Program to Stimulate Competitive Research (EPSCoR) is a competitive grant opportunity project that establishes partnerships between government, higher education, and industry and promotes lasting improvements in the R&D capacity of that state or region. By improving research infrastructure, a region will improve its national research and development competitiveness and economy. EPSCoR develops academic research projects to establish long-term, self-sustaining, and nationally competitive activities in states with modest research infrastructure so that they become more competitive in attracting non-EPSCoR funding.

EPSCoR funds states and regions that have not historically participated equitably in Federal competitive aerospace and aerospace-related research activities. EPSCoR supports competitively funded awards in eligible states (as identified by the National Science Foundation) and provides research and technology development opportunities for faculty and research teams. NASA actively seeks to integrate the research conducted by EPSCoR jurisdictions with the scientific and technical priorities pursued by the Agency.

EXPLANATION OF MAJOR CHANGES

See Explanation of Major Changes section of Education Account Overview. Funding is focused on the most effective and highest priority activities.

EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2012

NASA funded Year 1 (of 3) of the multi-year Research Infrastructure Development awards, representing all 29 eligible jurisdictions, with a net value of $3.6 million. These awards will be funded until FY 2014 for a total funding of $10.9 million. NASA also received 57 proposals in response to its annual competitive call for research. NASA funded 17 proposals from 16 states and the U.S. Virgin Islands with a net value of $12.6 million over the 3-year term of the grants. The selected proposals represent research or technology development in NASA's mission directorates. These awards expire at the end of FY 2015. Scientific and technical achievements by the research teams will be identified in the annual and final reports.

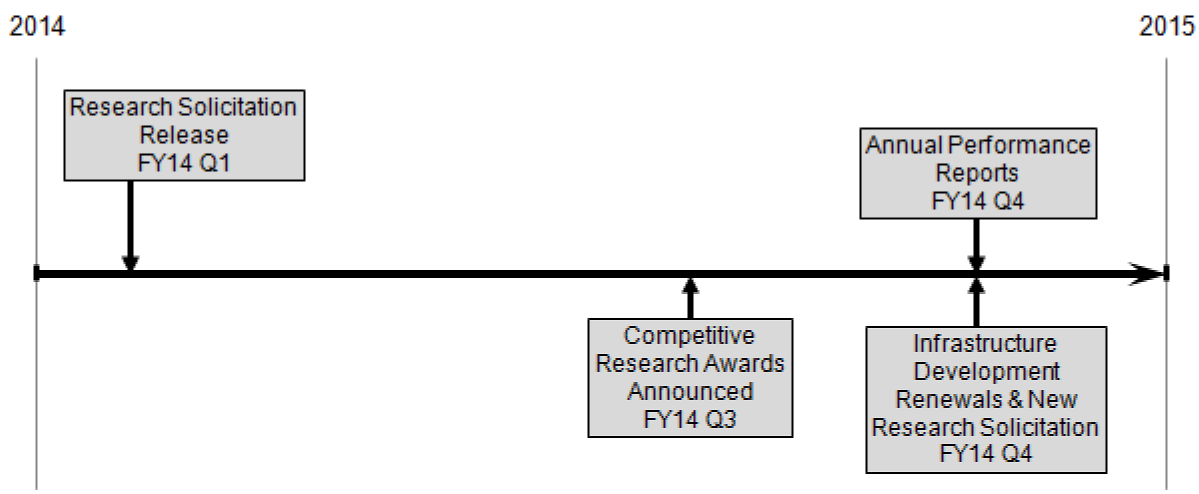
WORK IN PROGRESS IN FY 2013

EPSCoR will make new research awards in January 2013. Each funded proposal is expected to establish research activities that will make significant contributions to NASA's strategic research and technology development priorities and contribute to the overall research infrastructure, science and technology capabilities, higher education, and economic development within the jurisdiction.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, NASA EPSCoR will issue a competitive call for extramural research awards and will support the third and last year of the Research Infrastructure Development awards. The new research solicitation will focus on priority research and the technology development needs of NASA's mission directorates.

Project Schedule



EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR)

Formulation	Development	Operations

Project Management & Commitments

The EPSCoR project manager based at Kennedy Space Center (KSC) provides management responsibility for day-to-day operations. Representatives from each of NASA's mission directorates work closely with EPSCoR project management so that current and future research and engineering needs are reflected in EPSCoR solicitations. The mission directorate representatives serve as the proposal selection committee, further ensuring that the selected work contributes to NASA priorities. Technical monitors at the NASA Centers and Headquarters monitor and assess the progress of each award. They provide scientific guidance and technical advice throughout the year, as required, on the overall progress of the proposed effort, and review all progress reports. Additional involvement may occur, depending upon the nature of the collaboration already established or desired. This includes integrating the EPSCoR research into ongoing activities or research efforts, and increasing the principal investigator and his or her team's awareness of other related or relevant research in NASA.

NASA is a member of the Federal EPSCoR Interagency Coordinating Committee, chaired by the National Science Foundation. The committee works to improve the leveraging of Federal EPSCoR investments.

Acquisition Strategy

NASA solicits and awards EPSCoR through full and open competition among institutions from designated EPSCoR states. Each consortium proposal must demonstrate alignment with the goals of NASA's education programs and the NASA Strategic Plan. Selections are based on peer reviews by external panels that evaluate technical merit and internal and external panels that assess content, merit, feasibility, and alignment to Agency education, research, and technology goals. Awards of up to three years may be made for research and awards of up to five years may be made for infrastructure development, depending on the availability of appropriated funds. Grantees are required to submit performance data annually.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Independent	National Academies	N/A	Cross-agency evaluation of EPSCoR and other Federal EPSCoR-like programs and accomplishments per H.R. 5116 America Competes Reauthorization of 2010	Successful	2013

EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)

Formulation	Development	Operations

HISTORICAL PERFORMANCE

The graph below shows overall statistics of the active research and infrastructure development awards from FY 2009 through FY 2011.

The data elements monitored are consistent with the EPSCoR Interagency Coordinating Committee expectations to measure EPSCoR project performance and the elements of the federal-wide Research Performance Progress Report established by the National Science and Technology Council, Committee on Science, Research Business Models Working Group.

As a consistent set of data are collected over time, EPSCoR anticipates being able to identify significant trends and make program adjustments as necessary.

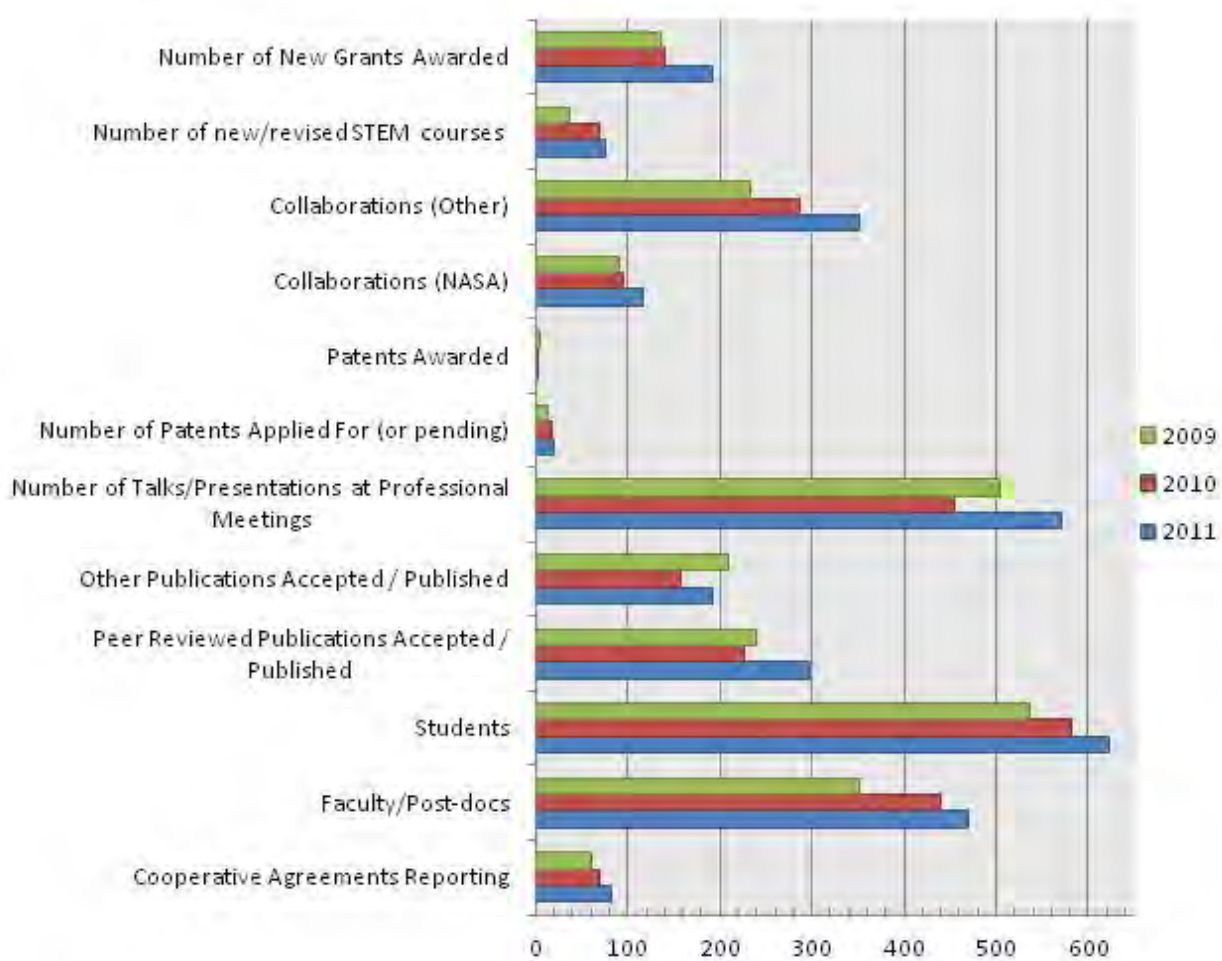


Figure 1: EPSCoR 3-Year Historical Performance Trend Data

STEM EDUCATION AND ACCOUNTABILITY (SEA)

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	80.0	--	**61.2**	61.2	61.2	61.2	61.2
Minority University Research Education Project	30.0	--	**30.0**	30.0	30.0	30.0	30.0
STEM Education and Accountability Projects	50.0	--	**31.2**	31.2	31.2	31.2	31.2
Change from FY 2012	--	--	**-18.8**				
Percentage change from FY 2012	--	--	**-23.5 %**				

The T-shirt says it all! Administrator Bolden is engaged with students as they countdown for their rocket launches during a hands-on Summer of Innovation event in Columbia, South Carolina. Going to special camps and events, participating in activities that challenge and excite, and meeting role models from diverse disciplines helps motivate and encourage students to continue exploring their interests in STEM.

The STEM Education and Accountability program makes unique NASA assets, including people, resources, and facilities available in support of the Nation’s STEM education priorities. The program supports professional development of interns, fellows, and educators, while integrating NASA assets and content into programs designed by the Department of Education, National Science Foundation, and the Smithsonian Institution. It connects NASA’s partners, including higher education institutions, minority-serving institutions, community colleges, NASA visitor centers, museums, and planetariums to the broad scientific discoveries, aeronautics research, and exploration missions of the Agency.

Through the Minority University Research and Education Project, NASA supports the Nation’s Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges through multi-year research grants. Additionally, the project provides internships, scholarships, fellowships, mentoring, and tutoring for underserved and underrepresented learners in K-12, informal, and higher education settings, that includes community colleges, particularly those serving a high proportion of minority and underserved students, including persons with disabilities and women.

EXPLANATION OF MAJOR CHANGES

See Explanation of Major Changes section of Education Account Overview. Funding is focused on the most effective and highest priority activities.

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	30.0	--	**30.0**	30.0	30.0	30.0	30.0
Change from FY 2012	--	--	**0.0**				
Percentage change from FY 2012	--	--	**0%**				

The Harriet G. Jenkins Pre-Doctoral Fellowship Project seeks to increase the number of graduate degrees awarded to women, minorities, and persons with disabilities. Graduate students benefit from research experiences and skills gained through this program, including public presentations of their research findings.

NASA targets recruitment and retention of underrepresented and underserved students, including women and girls, and persons with disabilities. Participation in NASA projects and research stimulates increasing numbers of learners to continue their studies at all education levels and encourages students to earn advanced degrees in STEM fields critical to NASA and the Nation. NASA's Minority University Research and Education Project enhances the research, academic, and technology capabilities of Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), Tribal Colleges and Universities (TCUs), and other Minority Serving Institutions (MSIs); provides targeted opportunities for underrepresented and underserved learners to participate in research and education opportunities through internships, scholarships, and fellowships; and provides opportunities for minority institutions to improve the quality of their faculty preparation programs and thereby improve the quality and diversity of future STEM leaders.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

Curriculum Improvement Partnership Award for the Integration of Research (CIPAIR) assisted two and four-year minority institutions with strengthening their science, technology, engineering and mathematics academic fields and technical programs. In FY 2012, there were 24 CIPAIR grantees, which included 8 HBCUs, 8 HSIs, 4 TCUs, and 4 MSIs. 145 CIPAIR students engaged in NASA-related research where 119 were underrepresented minority students in STEM. Thirty four percent of the total CIPAIR students engaged were females.

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

Motivating Undergraduates in Science and Technology (MUST) awards scholarships and internships to undergraduates pursuing degrees in STEM fields. In FY 2012, a total of 108 students were supported. Twenty seven percent of the students were first generation college attendees. Fifty percent of the MUST Scholars are females and 6.5 percent are disabled students.

NASA Innovations in Climate Education (NICE) is a competitive activity to promote climate and Earth system science literacy. Over 1,400 higher education students participated in 42 new or revised NICE courses offered at four-year institutions and community colleges. In addition, 3,593 elementary and secondary educators and 4,000 elementary and secondary students participated in NASA climate-related educational activities.

University Research Centers (URC) provide a broad-based competitive NASA-related research capability among MSIs that foster new aerospace science and technology concepts. Two hundred sixty-eight students and faculty authored NASA-related research paper. There have also been 4 patent applications with 3 patents granted and 45 students successfully defended their master's thesis or doctoral dissertation.

Achieving Competence in Computing, Engineering, and Space Science (ACCESS) provides summer internships to highly qualified students with disabilities. Since its inception, 265 students have participated in ACCESS internships with 17 students hired at NASA. In FY 2012, ACCESS hosted 15 students with disabilities. Three of the ACCESS interns were women, 11 were undergraduate students and 4 were graduate students.

WORK IN PROGRESS IN FY 2013

MUREP is currently funding internships, fellowships and scholarships for underrepresented and underserved students and support for the development of STEM curricula at minority institutions and community colleges to help prepare underrepresented and underserved students in STEM disciplines and careers. MUREP currently supports 21 HBCUs, 21 HSIs, 4 TCUs, 2 MSIs, and 9 non-profit organizations, which help contribute to MUREP's goals. Some institutions and organizations are recipients of multiple awards. For NASA's full report of accomplishments in MUREP, go to: http://www.nasa.gov/offices/education/performance/index.html.

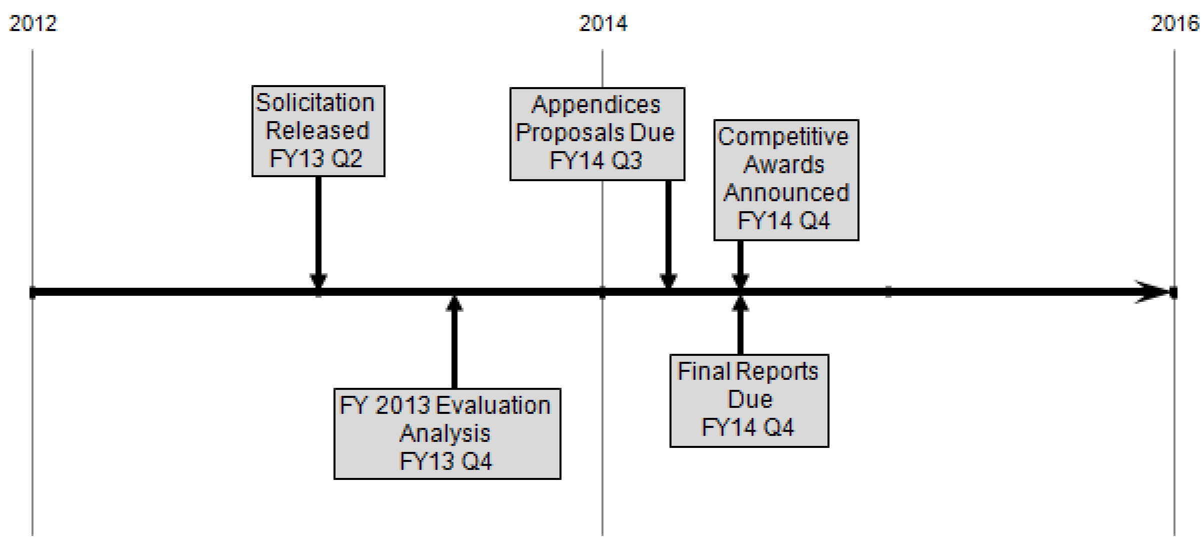
KEY ACHIEVEMENTS PLANNED FOR FY 2014

MUREP will continue to provide competitive funding opportunities to MSIs through an omnibus solicitation called Educational Opportunities in NASA STEM (EONS).

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

Project Schedule



Project Management & Commitments

The MUREP project manager is located at NASA Headquarters and provides management and oversight for overall program operations. NASA Centers manage significant investments in project activity elements. In FY 2013, the current MUREP elements are as follows:

Element	Description	Provider Details	Change from Formulation Agreement
University Research Centers (URCs)	URCs are multi-disciplinary research centers at Minority Serving Institutions (MSI) that are supported to expand the Nation's base for aerospace research and development, and increase the production of underrepresented/underserved students who obtain degrees undergraduate and graduate degrees in NASA-related fields.	Provider: All NASA Centers Lead Center: NASA DFRC Participating Centers: All NASA Centers Cost Share Partners: N/A	

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

Curriculum Improvements Partnership Award for the Integration of Research (CIPAIR)	CIPAIR was designed to strengthen the curricula of MSIs and community colleges in order to attract more students into STEM-based academic programs, retain them, and prepare them for success when they take the next steps in their education or in their careers	Provider: All NASA Centers Lead Center: NASA HQ Participating Centers: All NASA Centers Cost Share Partners: N/A	
Motivating Undergraduates in Science and Technology (MUST)	MUST increases the number of underrepresented/ underserved students in STEM disciplines. Each MUST participant receives three-years of support in the form of a scholarship, internships at a NASA Center, mentoring, and professional development.	Provider: All NASA Centers Lead Center: NASA GRC Participating Centers: All NASA Centers Cost Share Partners: N/A	
Tribal Colleges and Universities Project (TCUP)	TCU activity supports the Nation's Tribal Colleges through grants that provide funding for academic and research infrastructure development and support of STEM students at tribal colleges and universities.	Provider: All NASA Centers Lead Center: NASA GSFC Participating Centers: All NASA Centers Cost Share Partners: N/A	
MUREP Small Projects (MSP)	MSA advances MUREP priorities by identifying gaps or areas where new projects will enhance NASA higher education portfolio and better meet Agency objectives. Achieving Competence in Computing, Engineering, and Space Service is an example of an MSA activity that now fills an identified programming gap (i.e., internships for students with disabilities).	Provider: All NASA Centers Lead Center: NASA KSC Participating Centers: All NASA Centers Cost Share Partners: N/A	
Jenkins Pre-Doctoral Fellowship Project (JPFP)	JPF increases the number of underrepresented/ underserved STEM students at the graduate level. JPF provides three-years of support for each participant with a stipend, tuition off-set, a NASA internship, mentoring, and professional development.	Provider: All NASA Centers Lead Center: NASA ARC Participating Centers: All NASA Centers Cost Share Partners: N/A	

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

NASA Science and Technology Institute for Minority Institutions (NSTI-MI)	NSTI-MSI increases the research capacity of MSIs, increases the number of undergraduate STEM students, and supports Agency research objectives.	Provider: All NASA Centers Lead Center: NASA ARC Participating Centers: All NASA Centers Cost Share Partners: N/A	
NASA Innovations in Climate Education (NICE) (Note: renamed from Innovations in Global Climate Change Education)	NICE provides grants to MSIs to: enhance climate change education; improve the teaching and learning about climate change and Earth system science; increase the number of underrepresented and underserved K-12 teachers of math and science; and increase the number of students prepared for graduate study in climate-related subjects.	Provider: All NASA Centers Lead Center: NASA LaRC Participating Centers: All NASA Centers Cost Share Partners: N/A	

Acquisition Strategy

MUREP solicits new and innovative education products, tools, and services from qualified MSIs and nonprofit organizations. This occurs in response to changes in STEM education trends, identified gaps or opportunities in the education portfolio of investments, a response to demonstrated customer need or demand, or when the Administration or Congress identifies new priorities. NASA awards education cooperative agreements, grants and contracts through full and open competition. Selections are based on peer reviews by external panels that evaluate educational merit and internal/external panels for content, merit, feasibility, and alignment to education goals.

INDEPENDENT REVIEWS

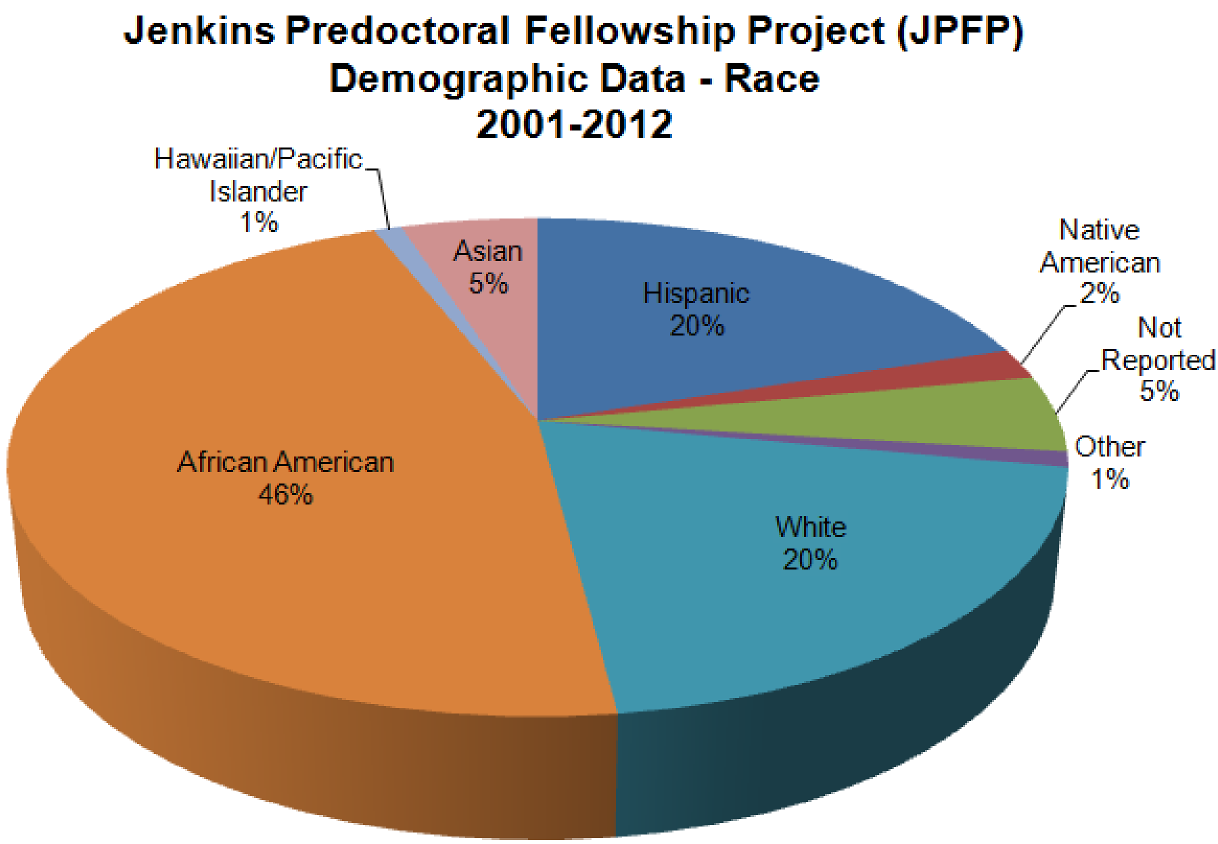
All MUREP activities document performance either through external evaluations or internal reviews conducted by NASA staff. For example, a Technical Review Committee, made up of NASA and industry engineers and scientists, reviews each University Research Centers grantee annually during the five-year performance period. All review reports are used as a part of the renewal package for the individual grantee.

MINORITY UNIVERSITY RESEARCH EDUCATION PROGRAM

Formulation	Development	Operations

HISTORICAL PERFORMANCE

The Harriett G. Jenkins Predoctoral Fellowship (JPF) seeks to increase the number of graduate degrees awarded to underrepresented and underserved persons (women, minorities and persons with disabilities) in the science, technology, engineering and mathematics (STEM) disciplines. The ultimate goal is to increase the U.S. talent pool by developing a more inclusive, multicultural and sustainable STEM workforce. Since its inception JPF has produced 54 M.S. graduates and 121 Ph.D. graduates. There are currently 34 students being supported by the activity as they work to obtain their degree.



Since its inception in 2001, JPF has supported 210 students as they obtained masters and doctoral degrees.

STEM EDUCATION AND ACCOUNTABILITY PROJECTS

Formulation	Development	Operations

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	50.0	--	**31.2**	31.2	31.2	31.2	31.2
Evaluation Performance Monitoring & Acct	25.0	--	**25.0**	24.8	24.5	24.3	24.1
Informal and Formal Education	15.0	--	**5.1**	5.2	5.4	5.6	5.8
Innovation In Education	10.0	--	**1.1**	1.2	1.2	1.3	1.3
Change from FY 2012	--	--	**-18.8**				
Percentage change from FY 2012	--	--	**-37.6 %**				

NASA Deputy Administrator Lori Garver talks with students at a NASA Educational Forum aimed at sharing the excitement of space exploration. Speakers encourage students to think about different careers and how science, technology, engineering and mathematics would help them pursue the career of their dreams.

NASA will consolidate the education functions, assets, and efforts of the Aeronautics Research Mission Directorate, Science Mission Directorate and Human Exploration and Operations Mission Directorate into a single coordinated STEM Education and Accountability Project (SEAP). The project assets are critical and unique components that NASA can make available to the National Science Foundation, Smithsonian Institution, and Department of Education, as they facilitate federal STEM education activities through the Administration's Committee on STEM process for Agency coordination.

SEAP will enhance coordination with other agencies and will focus on those areas of STEM education where the Federal government can have maximum impact. The project will support innovations in performance monitoring, evaluation and formal and informal education. Through grants, cooperative agreements and other mechanisms, NASA will make its people, resources, facilities, and discoveries available to key stakeholders and strategic partners, such as Boys and Girls Clubs, Challenger Centers, NASA visitor centers, science museums, and planetariums.

EXPLANATION OF MAJOR CHANGES

See Explanation of Major Changes section of Education Account Overview. Funding is focused on the most effective and highest priority activities.

SEAP will coordinate three distinct activities:

STEM EDUCATION AND ACCOUNTABILITY PROJECTS

Formulation	Development	Operations

- The Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide hands-on, primary, and secondary school-based science and education program. GLOBE's vision promotes and supports students, teachers, and scientists to collaborate on inquiry-based investigations of the environment and the Earth system working in close partnership with NASA, NOAA, and NSF Earth System Science Projects in study and research about the dynamics of Earth's environment.
- The Agency allocates funds through a coordinated competitive process to ensure the best application of NASA education assets to meet the goals of the Nation's STEM education efforts, including engagement. The most meritorious existing scholarship, fellowships, and grants for graduate students and educators will be supported, as well as many other such experiences previously funded by the Aeronautics Research Mission Directorate, Science Mission Directorate, Human Exploration and Operations Mission Directorate, NASA Centers and the Office of Education.
- NASA will implement a STEM interagency coordination effort, which will serve as the focal point for NASA to ensure that the Agency's assets are put to use effectively in support of the STEM activities that will be directed by the National Science Foundation, the Smithsonian Institution, and the Department of Education. This includes the infrastructure necessary to support the rigorous collection, evaluation, and dissemination of evidence of NASA's contributions towards the achievement of the wider STEM goals.
- Through previous consolidation efforts, NASA had planned to sunset many activities by FY 2014. With a new focus on STEM reorganization across the federal government, NASA is terminating additional activities.

ACHIEVEMENTS IN FY 2012

The goal of SEAP is to engage learners, especially those from underserved and underrepresented populations, in evidence-based learning opportunities designed to increase their involvement and interest in STEM, educate them on the value of STEM in their lives or positively influence the perception of their ability to participate in STEM by connecting them to NASA-unique resources. During FY 2012, the number of elementary and secondary students participating in NASA instructional and enrichment activities was 1,184,786. The percentage of elementary and secondary students expressing interest in STEM careers following their involvement in NASA education programs was 84 percent, a positive indicator that STEM engagement is positively influencing students' interest. In addition, the Summer of Innovation project launched in 2010 in response to the President's Educate to Innovate campaign, engaged 38,949 students in grades four to eight. The majority of the students served by Summer of Innovation were from underserved/underrepresented populations, including:

- 58 percent minority;
- 50 percent female; and
- 79 percent received free/reduced lunch.

Exhibits, planetarium shows, and community-based programming are among 18 new grants NASA selected to receive Agency funding in 2012. The awarded institutions consist of 11 informal education

STEM EDUCATION AND ACCOUNTABILITY PROJECTS

Formulation	Development	Operations

providers and 7 NASA visitor centers that are sharing $10 million resulting from the 63 proposals submitted through NASA Research Announcement, 2011 Competitive Program for Science Museums and Planetariums Plus Opportunities for NASA Visitor Centers and Other Informal Education Institutions.

Nearly 9,000 undergraduate, graduate and high school students applied for NASA-unique formal education opportunities including internships, fellowship, and scholarships through the One Stop Shopping Initiative resulting in 1,173 students selected for support.

WORK IN PROGRESS IN FY 2013

In FY 2013, NASA issued a NASA Research Announcement: Competitive Program for Science Museums, Planetariums, and NASA Visitor Centers Plus Other Opportunities that will operate through FY 2014. This investment in domestic assistance funding enables awardees to share NASA with the public, educators, and learners to provide opportunities to participate in NASA's Mission, foster innovation and contribute to a strong national economy. In FY 2012, NASA began a design review of the Summer of Innovation pilot focused on initial awardees and partners. The future of the project depends on the results of NASA's evidenced-based competitive process.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

SEAP will establish the structure to provide efficient coordination of education efforts throughout NASA, and with external partners. Through the Education Coordinating Council, it will ensure that the most effective NASA assets are made available to support the Nation's STEM education priorities. In collaboration with federal partners, it will review GLOBE and other NASA activities to support the rigorous collection, evaluation, and dissemination of evidence of NASA's contributions towards the achievement of the Nation's wider STEM goals.

Project Schedule

Consistent with the status report on the National Science and Technology Council five-year Federal STEM education Strategic Plan, the STEM Education and Accountability projects will align its portfolio of activities over the next five years.

In year one, NASA will work with the Committee on STEM to finalize criteria for success, develop common evidence standards, evaluation and research toolkits, and identify efficiency and productivity opportunities.

In years two through five, the Agency will establish baselines and increase alignment with the adopted criteria. NASA will align its future evaluation strategy with the status report on the National Science and Technology Council five-year Federal STEM Education Strategic Plan. Successful STEM education practices and strategies identified through STEM education research studies and evaluations will be used to guide NASA investments in STEM education.

STEM EDUCATION AND ACCOUNTABILITY PROJECTS

Formulation	Development	Operations

Project Management & Commitments

The STEM Education and Accountability project managers are located at NASA Headquarters and provide oversight for overall activities and operations. In 2013, NASA will be making new commitments when it selects awardees based on the competitive acquisition strategy described below. Other funds go to NASA Centers, Jet Propulsion Laboratory contractors or other awardees to support competitive commitments made in prior fiscal years.

Acquisition Strategy

SEAP solicits new and innovative education products, tools, and services from qualified organizations. This occurs in response to changes in STEM education trends, identified gaps, or opportunities in the education portfolio of investments, a response to demonstrated customer need or demand, or when the Administration or Congress identifies new priorities. NASA awards education cooperative agreements, grants and contracts through full and open competition. Selections are based on peer reviews by external panels that evaluate educational merit and internal/external panels for content, merit, feasibility, and alignment to education goals. The Education Coordinating Council will make recommendations to the Associate Administrator for Education on any funding allocated to activities implemented directly by NASA.

INDEPENDENT REVIEWS

Independent review is responsive to both a Government Accountability Office report (GAO-12-342SP) and reports from the National Science and Technology Council Committee on STEM. NASA embeds evaluation and accountability requirements within SEA, and will integrate performance monitoring within all three activities and any legacy grant investments from prior fiscal years.

External experts reviewed the Summer of Innovation Pilot as explained in the table below.

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Program design review	External experts	May-Jun 2012	Identify preferred program models; Identify new project requirements based on research evidence	New project requirements identified and implemented in 2013	Nov-Dec 2014
Evaluation design review	External experts	Aug 2012	Identify new evaluation design and develop high-level evaluation plan to assess preferred program model	New evaluation plan developed and implemented by Abt Associates in 2013	Jan 2013 Mar-Apr 2014

CROSS AGENCY SUPPORT

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	2993.9	3012.2	**2850.3**	2850.3	2850.3	2850.3	2850.3
Center Management and Operations	2204.1	--	**2089.7**	2089.7	2089.7	2089.7	2089.7
Agency Management and Operations	789.9	--	**760.6**	760.6	760.6	760.6	760.6

CROSS AGENCY SUPPORT

CROSS AGENCY SUPPORT

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	2993.9	3012.2	**2850.3**	2850.3	2850.3	2850.3	2850.3
Center Management and Operations	2204.1	--	**2089.7**	2089.7	2089.7	2089.7	2089.7
Agency Management and Operations	789.9	--	**760.6**	760.6	760.6	760.6	760.6
Subtotal	2994.0	3012.3	**2850.3**	2850.3	2850.3	2850.3	2850.3
Rescission of prior-year unob. balances**	-0.1	-0.1	**--**	--	--	--	--
Change from FY 2012	--	--	**-143.6**				
Percentage change from FY 2012	--	--	**-4.8 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission of prior-year unobligated balances from Agency Management and Operations pursuant to P.L. 112-55, Division B, sec. 528(f).*

At NASA's Kennedy Space Center in Florida, the space shuttle Atlantis pauses during its 10-mile journey to the Kennedy Visitor Complex. NASA Administrator Charles Bolden, left, and Kennedy Director Bob Cabana hold the just signed document transferring title of Atlantis to the visitor complex. The Atlantis, and millions of other Shuttle Program items, required the expertise of the many disciplines within NASA's institutional support organization, to effectively manage the final disposition of these assets at the Program's conclusion.

Cross Agency Support (CAS) manages the administration of the Agency, operates and maintains NASA Centers and facilities, including Headquarters, and provides oversight to reduce risk to life and mission for all NASA programs.

CAS manages both institutional and program capabilities for the Agency. Institutional capabilities ensure that Agency operations are effective, efficient, and meet statutory, regulatory, and fiduciary responsibilities. Program capabilities ensure that technical skills and assets are ready and available to meet program and project milestones; that missions and research are technically and scientifically sound; and that Agency practices are safe and reliable. Together these capabilities sustain 4,900 buildings and structures on 330,000 acres across the Agency's Centers and facilities.

Missions rely on CAS program and institutional capabilities to accomplish their objectives. Engineering, systems engineering, and safety and mission assurance capabilities support technical activities. Information technology, infrastructure, and security capabilities support the productivity of NASA scientists and engineers. Human capital management, finance, procurement, occupational health and safety, equal employment opportunity and diversity, and small business programs contribute to the strategic and operational planning and management that ensure resources are available when needed.

CROSS AGENCY SUPPORT

International and interagency relations, legislative and intergovernmental affairs, and strategic communications facilitate communications with a broad range of external communities. These program and institutional capabilities and related processes speak to the complexity of the support necessary for successful NASA missions and safe Agency and Center operations.

NASA's CAS account includes two Themes: Center Management and Operations; and Agency Management and Operations.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

NASA is implementing operational efficiencies for Center and Headquarters services, including facilities maintenance and repair and general IT services. This enables the Agency to maximize its investments on mission priorities and reallocates resources to increase Agency IT security activities.

ACHIEVEMENTS IN FY 2012

Cross Agency Support activities provide the workforce and facilities required to conduct NASA's missions. In FY 2012, Cross Agency Support programs:

- Developed a human capital framework designed to create a workforce culture that builds on innovation and was recognized by the Partnership for Public Service as the most innovative agency in government.
- Provided logistics management support to retire and transfer Space Shuttle orbiters and other artifacts to museums, schools, and universities;
- Completed the Strategic Sustainability Performance Plan to guide NASA strategies for greenhouse gas and petroleum use reduction, water use efficiency, pollution prevention, waste reduction, and sustainable acquisition. NASA received a green rating on its most recent OMB scorecard by achieving a 12 percent reduction in petroleum use in its entire vehicle fleet compared to 2005;
- Assessed the Agency's wind tunnels, airfields, rocket test facilities, and thermal vacuum chamber test capabilities against mission requirements and identified seven under-used facilities for disposition; and,
- Reduced Cross Agency Support administrative costs compared to FY 2010 levels. To accomplish this, NASA reduced printing and reproduction, travel, supplies and materials, in support of efficiency initiatives. Savings were used to offset increasing utilities and operational costs and were reinvested in facilities maintenance and other essential activities.

WORK IN PROGRESS IN FY 2013

Cross Agency Support continues its cross-cutting support of the Agency's aeronautics and space activities. Key activities underway include:

- Assessment of the Agency's aircraft and flight simulator capabilities against mission requirements to identify any changes required to the NASA portfolio; and

- Continued consolidation of arc jet test capabilities at Ames Research Center (ARC). Work includes verification and activation of the test equipment already transferred from Johnson Space Center and final transfer of the remaining major test equipment to ARC.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

In FY 2014, Cross Agency Support programs will continue to enable program and institutional capabilities to conduct NASA's aeronautics and space activities. In addition to providing ongoing operations, CAS programs will:

- Fully deploy an enhanced agency-wide recruiting and hiring program targeting recent graduates with the intention of ensuring a robust, diverse pipeline of the next generation of scientists, engineers, and mission support professionals;
- Modernize the Information Technology security assessment and authorization process, define metrics for measuring risk reduction, create dashboards for visualizing and communicating the Agency's cyber security posture, and expand the security operations efforts to provide early warning of cyber vulnerabilities; and
- Increase reliability-centered maintenance and conditioned-based monitoring activities at the Centers to provide early detection and correction of facility maintenance issues.

Themes

CENTER MANAGEMENT AND OPERATIONS

Center Management and Operations provides the ongoing management, operations, and maintenance of NASA Centers and component facilities in nine states. Missions rely on the Centers to provide the skilled staff and specialized infrastructure required to accomplish their objectives.

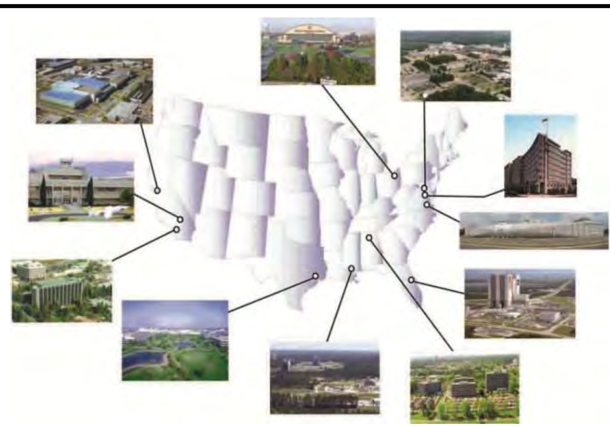
AGENCY MANAGEMENT AND OPERATIONS

Agency Management and Operations (AMO) provides management and oversight of Agency missions and performance of NASA-wide mission support activities. AMO activities at NASA Headquarters ensure that core services are ready and available across the Agency for performing mission roles and responsibilities.

CENTER MANAGEMENT AND OPERATIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	2204.1	--	**2089.7**	2089.7	2089.7	2089.7	2089.7
Center Institutional Capabilities	1707.2	--	**1622.4**	1622.4	1622.4	1622.4	1622.4
Center Programmatic Capabilities	496.9	--	**467.3**	467.3	467.3	467.3	467.3
Change from FY 2012	--	--	**-114.4**				
Percentage change from FY 2012	--	--	**-5.2 %**				



NASA work is performed at Headquarters in Washington, DC, the Jet Propulsion Laboratory, a federally funded research and development center operated under a contract with the California Institute of Technology and nine Centers: Ames Research Center and Dryden Flight Research Center both in CA, Glenn Research Center in OH, Goddard Space Flight Center in MD, Johnson Space Center in TX, Kennedy Space Center in FL, Langley Research Center in VA, Marshall Space Flight Center in AL, and Stennis Space Center in MS.

NASA's Center Management and Operations (CMO) budget funds the ongoing management, operations, and maintenance of nine Centers and three major component facilities in nine states. CMO includes two major activities: Center Institutional Capabilities and Center Programmatic Capabilities.

Institutional capabilities provide the facilities, staff, and administrative support to ensure that Center operations are effective and efficient and that activities meet statutory, regulatory, and fiduciary responsibilities. Program capabilities support scientific and engineering activities at the Centers. These program capabilities ensure that technical skills and assets are ready and available to meet program and project milestones; that missions and research are technically and scientifically sound; and that center practices are safe and reliable. Missions rely on these program and institutional capabilities to provide the skilled staff and specialized infrastructure required to accomplish their objectives.

EXPLANATION OF MAJOR CHANGES

NASA has reduced administrative costs and implemented operational efficiencies for Center services, including facilities maintenance and repair and general Information Technology support.

ACHIEVEMENTS IN FY 2012

Centers aligned their infrastructure to mission requirements and demolished and closed facilities no longer required for the mission.

CENTER MANAGEMENT AND OPERATIONS

NASA reduced Center Management and Operations administrative costs in FY 2012 compared to FY 2010 levels. To accomplish this, Centers reduced printing and reproduction, travel, supplies, and materials, in support of efficiency initiatives. NASA used the savings to offset increasing utilities and operational costs and reinvest in facilities maintenance.

NASA reduced the total number of IT data centers by 31 percent. This initiative lowered energy consumption for data centers by an estimated two to three percent because of more efficient use of the existing conditioned spaces. It implemented best practices for room design, proper temperature settings, optimal rack and floor space densities, and lifecycle replacement of old and inefficient hardware.

WORK IN PROGRESS IN FY 2013

Contractor labor and Center operations costs continue to grow. In FY 2013, NASA is offsetting these increased costs by reducing some services and by improving the efficiency of other Center services and implementing additional energy savings activities. For example, Glenn Research Center invested in mobile cooling towers to reduce water use during annual maintenance periods, and Ames Research Center awarded a Utilities Energy Contract to improve energy efficiency, lower greenhouse gas emissions from boilers, and improve system performance and reliability.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Centers will provide the services, tools, and equipment to complete essential tasks, protect and maintain the security and integrity of information and assets, and ensure that personnel work under safe and healthy conditions. In FY 2014, Center Management and Operations will support:

- Facility maintenance and operations, including utility and custodial support of approximately 4900 buildings and structures with an average age of 38 years and current replacement value of $32 billion;
- IT activities for video, voice, network, IT security, and desktop support at centers;
- Institutional operational safety support to protect personnel and assets, aviation safety, emergency preparedness, nuclear safety, construction safety, and other safety services;
- Physical security, fire protection and response, emergency management, export control, and other basic and specialized protective services;
- Compliance with environmental regulations, executive orders, and related requirements to protect human health and the environment;
- Human resource management including recruitment, hiring, workforce planning, training, and performance management supporting approximately 17,700 civil servants at the Centers;
- Occupational and environmental health and medical support such as industrial hygiene, health physics, hearing conservation, and licensed and credentialed medical personnel and facilities to meet specialized mission requirements;
- Personal property management of more than 1.6 billion items, transportation management, mail management, and other logistical support;
- Duplicating and printing support, video production, audio/visual services, and publications and graphics (includes specialized support for the production and archiving of Scientific and Technical Information);

- Senior leadership and management of the Center, executive staff and administrative support, student programs, and developmental assignments;
- Routine public affairs activities, dissemination of information about NASA programs and projects to the general public, and responses to public inquiries;
- Administration and management of Center financial operations;
- Acquisition and contract management capabilities and practices supporting more than 51,000 procurement actions each year;
- Engineering assessment and safety oversight pertaining to the technical readiness and execution of NASA programs and projects; and
- Analysis, design, research, test services, and fabrication capabilities to enable efficient implementation of the programs and projects.

NASA will continue to seek and implement additional operational efficiencies to enable the Agency to conduct day-to-day technical and business operations. To reduce facility repair costs, Centers will increase reliability-centered maintenance and condition-based monitoring activities. These activities will provide for early detection and correction of facility maintenance issues before costly failures occur.

Program Elements

CENTER INSTITUTIONAL CAPABILITIES

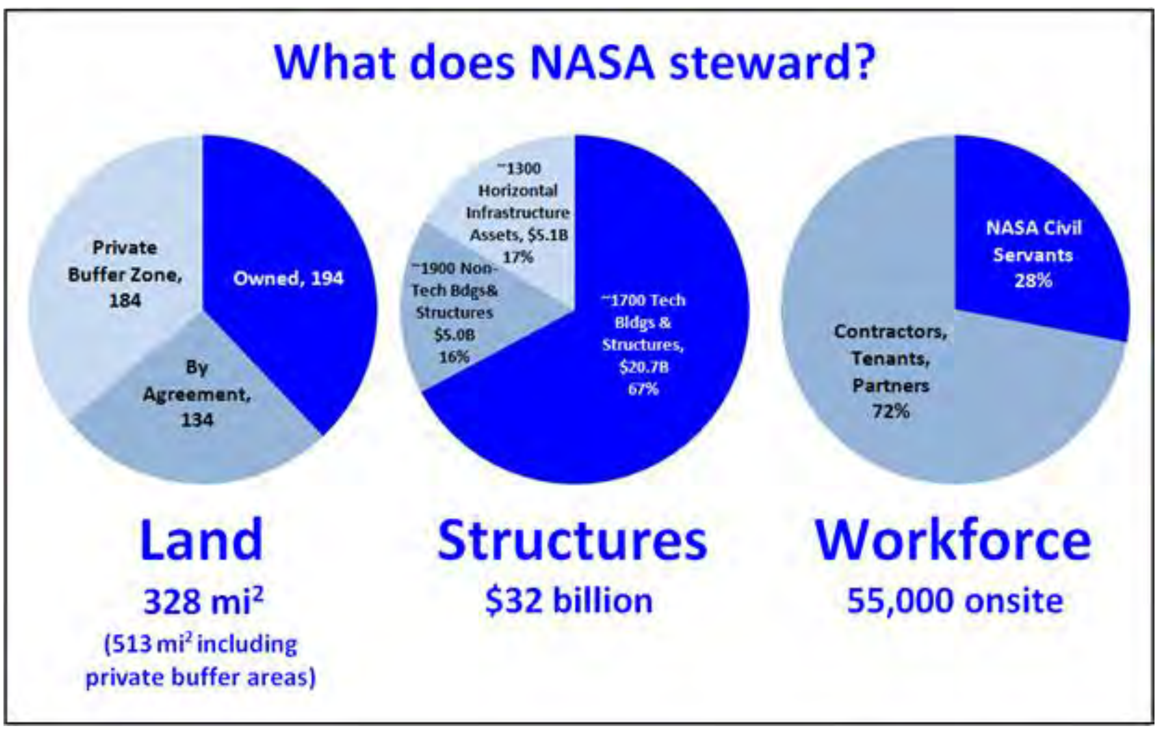


Figure 1: Center Institutional Capabilities manage and sustain the Agency's facilities and staff.

CENTER MANAGEMENT AND OPERATIONS

Center Institutional Capabilities encompasses a diverse set of activities essential for safe and effective operations. These activities provide the ongoing operations of NASA Centers and major component facilities and ensure a safe, healthy, and environmentally responsible workplace. Included are essential operations such as Center security, environmental management and safety services, and facility maintenance and operations. To support the Agency's Center-based workforce, Center Institutional Capabilities provide utilities, IT, legal, occupational health, equal employment opportunity, and human resources services. This capability manages and sustains Center staff, facilities, and operations as illustrated in Figure 1. This coordinated Center approach to institutional management is an essential element in preserving specialized national capabilities that NASA, industry, academia, and other government agencies rely on.

CENTER PROGRAMMATIC CAPABILITIES

NASA's Center Program Capabilities supports the Agency's scientific and engineering activities by providing engineering assessment and safety oversight pertaining to the technical readiness and execution of NASA programs and projects. It also sustains NASA's analysis, design, research, test services, and fabrication capabilities to enable efficient implementation of the programs and projects conducted at the Centers.

A key component of NASA's overall system of checks and balances is provided within Center Programmatic Capabilities. The engineering, safety and mission assurance, and health and medical organizations at the Centers support programs and projects in two ways: (1) they provide, support, and oversee the technical work of matrixed personnel with necessary technical expertise, and (2) these organizations provide formally delegated Engineering (Figure 2) and Safety and Mission Assurance Technical Authorities (Figure 3) at NASA Centers. These technical authorities provide independent oversight and review of programs and projects in support of safety and mission success. Cognizant technical authorities formally review and concur on technical and operational matters involving safety and mission success risk. Concurrence is based on the technical merits of each case and includes agreement that the risks are acceptable. This assures that NASA's activities are implemented safely in accordance with accepted standards of professional practice and applicable NASA requirements.

Engineering Technical Authorities

($ in millions)

Center	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Ames Research Center	7.6	7.6	7.6	7.6	7.6
Dryden Flight Research Center	7.2	7.2	7.2	7.2	7.2
Glenn Research Center	12.0	12.0	12.0	12.0	12.0
Goddard Space Flight Center	12.6	12.6	12.6	12.6	12.6
Johnson Space Center	20.8	20.8	20.8	20.8	20.8
Kennedy Space Center	13.8	13.8	13.8	13.8	13.8
Langley Research Center	17.5	17.5	17.5	17.5	17.5
Marshall Space Flight Center	38.7	38.7	38.7	38.7	38.7
Stennis Space Center	3.3	3.3	3.3	3.3	3.3
Total	**133.5**	**133.5**	**133.5**	**133.5**	**133.5**

Figure 2: Engineering Technical Authorities provide for independently funded engineering assessment of programs.

Safety and Mission Assurance Technical Authorities

($ in millions)

Center	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Ames Research Center	3.5	3.5	3.5	3.5	3.5
Dryden Flight Research Center	4.6	4.6	4.6	4.6	4.6
Glenn Research Center	2.2	2.2	2.2	2.2	2.2
Goddard Space Flight Center	12.7	12.7	12.7	12.7	12.7
Johnson Space Center	7.3	7.3	7.3	7.3	7.3
Kennedy Space Center	9.1	9.1	9.1	9.1	9.1
Langley Research Center	3.4	3.4	3.4	3.4	3.4
Marshall Space Flight Center	8.3	8.3	8.3	8.3	8.3
Stennis Space Center	1.6	1.6	1.6	1.6	1.6
Total	**52.6**	**52.6**	**52.6**	**52.6**	**52.6**

Figure 3: Safety and Mission Assurance Technical Authorities provide for independently funded safety assessment of programs.

HISTORICAL PERFORMANCE

When NASA was established in 1958, it inherited the National Advisory Committee for Aeronautics and other government organizations. This beginning set the stage for the current center structure as it incorporated existing facilities into the new organization. The Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, Lewis Flight Propulsion Laboratory, a space science group in Maryland, and the Army Ballistic Missile Agency in Huntsville, Alabama, all brought existing facilities and capabilities into NASA. Eventually the other centers were created, resulting in the current center structure. This rich history contributes to NASA's successes but also its CMO challenges. These challenges include an infrastructure approaching an average age of 40 years for its constructed assets and a backlog of repair needs and deteriorating facility conditions. Recent efforts to address these challenges by renewing and reducing Center infrastructure and pursuing energy savings initiatives have begun to offset rising operating costs, but continued effort is required to fully meet the challenges of an aging facility base. For example, although NASA reduced energy usage by 17 percent since 1995, unit prices rose 54 percent during that same period (Figure 4).

Unit Energy Costs vs. Consumption

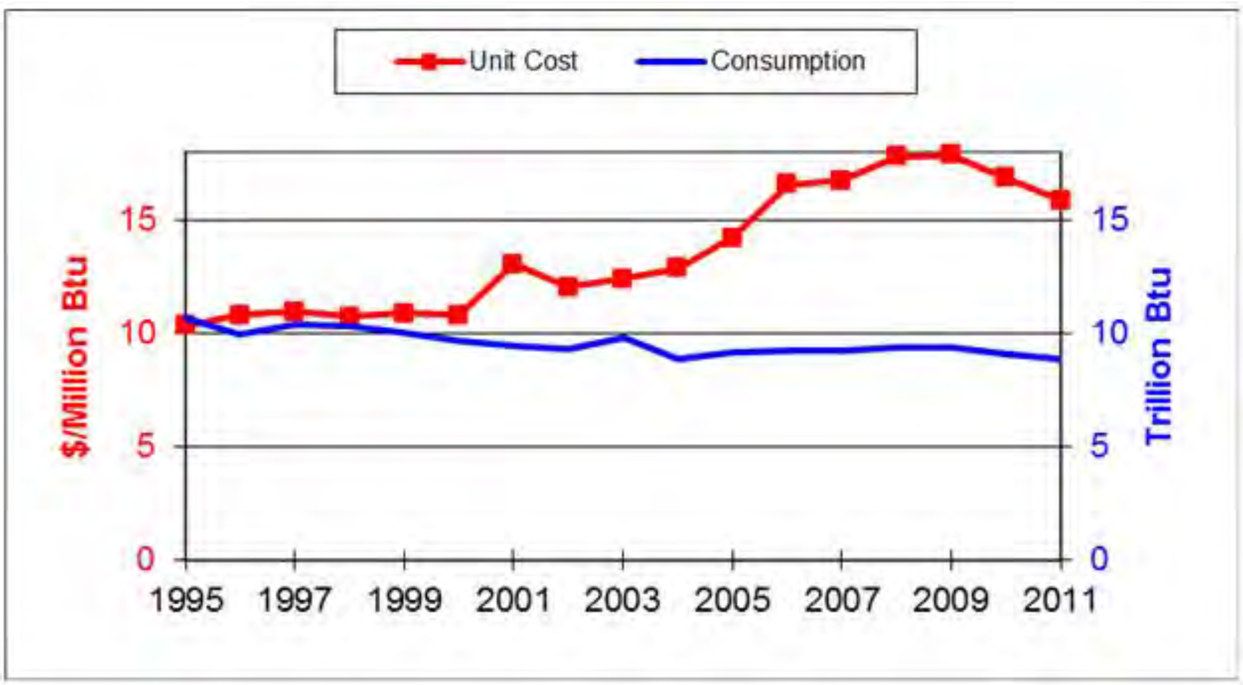


Figure 4. NASA continues to reduce energy consumption to help offset increasing energy costs.

To establish a baseline for its maintenance liability, NASA annually estimates its Deferred Maintenance (DM), which is the total of essential, but unfunded, maintenance work necessary to bring all facilities up to required standards. DM is calculated with a parametric model based on a methodology that satisfies the Federal Accounting Standards Advisory Board standards for Deferred Maintenance Reporting for Federal Facilities. It is designed to provide consistent, auditable DM estimates at the Agency and Center levels and to provide an assessment of the condition of NASA facilities at the system level.

Facility maintenance activities have not kept pace with the Agency's aging facility base as demonstrated by NASA's DM estimate. In FY 2014, funding for facility maintenance is at approximately 67 percent of the amount required to meet minimum service levels as defined by the Agency's 2010 Baseline Service Level Assessment. The Construction and Environmental Compliance and Restoration (CECR) account funds demolition and capital projects that help reduce DM. The FY 2014 request continues these efforts and increases reliability-centered maintenance and condition-based monitoring activities. These efforts will continue to reduce DM (Figure 5) but do not eliminate the Agency's deferred maintenance liability.

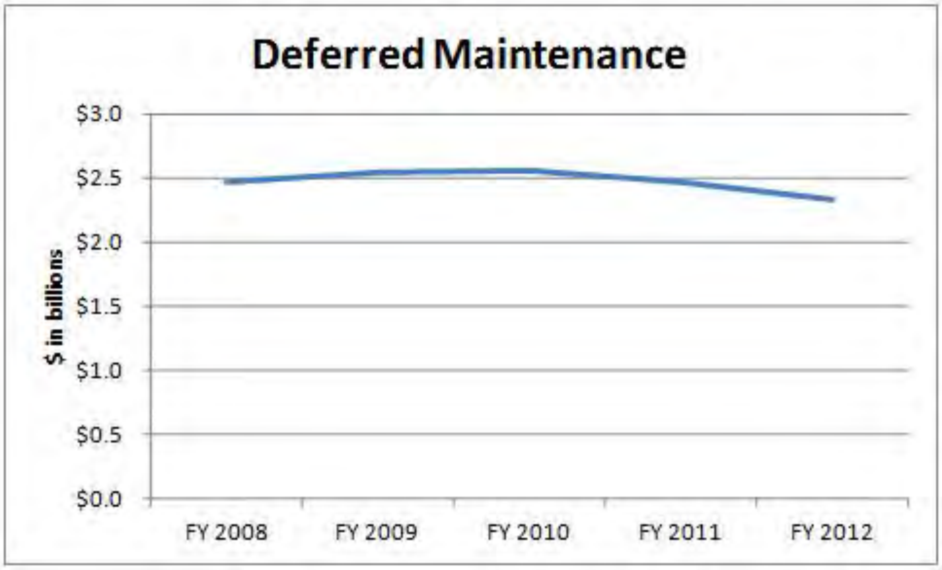


Figure 5. An aggressive recapitalization program has reduced Deferred Maintenance in recent years.

AGENCY MANAGEMENT AND OPERATIONS

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	789.8	--	**760.6**	760.6	760.6	760.6	760.6
Agency Management	403.7	--	**389.5**	389.5	389.5	389.5	389.5
Safety and Mission Success	198.4	--	**175.1**	175.1	175.1	175.1	175.1
Agency IT Services	158.5	--	**168.4**	168.4	168.4	168.4	168.4
Strategic Capabilities Assets Program	29.3	--	**27.6**	27.6	27.6	27.6	27.6
Subtotal	789.9	--	**760.6**	760.6	760.6	760.6	760.6
Rescission of prior-year unob. balances*	-0.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-29.2**				
Percentage change from FY 2012	--	--	**-3.7 %**				

*Note: * Rescission of prior-year unobligated balances from Agency Management pursuant to P.L. 112-55, Division B, sec. 528(f).*

The NASA Workmanship Program, sponsored by the Office of Safety and Mission Assurance, provides sound uniform engineering and technical requirements and training courses for processes, procedures, practices, and methods that have been endorsed for NASA programs and projects. The quality criteria and training results in high quality electrical interconnects critical to the performance and longevity of missions, such as work on this science instrument, the Neutral Mass Spectrometer for the LADEE mission.

Agency Management and Operations (AMO) provides management and oversight of Agency missions and performance of NASA-wide mission support activities. AMO activities at NASA Headquarters ensure that core services are ready and available Agency-wide for performing mission roles and responsibilities; Agency operations are effective and efficient, and activities are conducted in accordance with all statutory, regulatory, and fiduciary requirements.

NASA Headquarters develops policy and guidance for the Centers and provides strategic planning and leadership. Headquarters establishes Agency-wide requirements and capabilities that improve collaboration, efficiency, and effectiveness. Agency management leverages resources and capabilities to meet mission needs, eliminate excess capacity, and scale assets accordingly.

AMO provides for policy-setting, executive management, and direction for all corporate functions. AMO supports the operational costs of the Headquarters installation. The AMO theme is divided into four programs: Agency Management, Safety and Mission Success, Agency Information Technology (IT) Services, and Strategic Capabilities Asset Program.

AGENCY MANAGEMENT AND OPERATIONS

EXPLANATION OF MAJOR CHANGES

NASA reduced administrative costs and implemented operational efficiencies of Headquarters services. This enables the Agency to maximize its investments in the mission and reallocate resources to increase Agency IT security activities.

Programs

AGENCY MANAGEMENT

Agency Management provides functional and administrative management oversight for the Agency and operational support for NASA Headquarters. Agency Management governance and oversight activities include finance, protective services, general counsel, public affairs, external relations, legislative affairs, training, human capital management, procurement, real property and infrastructure, budget management, systems support, internal controls, diversity, equal opportunity, independent program and cost evaluation, and small business programs.

SAFETY AND MISSION SUCCESS

Safety and Mission Success (SMS) programs protect the health and safety of the NASA workforce and improve the likelihood for safety and mission success for NASA's programs, projects, and operations. SMS includes NASA Headquarters programs providing technical excellence, mission assurance, and technical authority. This includes the work managed by the Office of the Safety and Mission Assurance, Independent Verification and Validation Facility, the Office of Chief Engineer, and the Office of the Chief Health and Medical Officer.

AGENCY INFORMATION TECHNOLOGY SERVICES

Agency Information Technology Services (AITS) program is a critical enabling capability dedicated to IT excellence to ensure every mission can achieve success within NASA's complex environment. The AITS mission improves management and security of IT systems while systematically improving the efficiency, collaboration capabilities, and streamlined service delivery and visibility for the entire Agency.

STRATEGIC CAPABILITIES ASSETS PROGRAM

The Strategic Capabilities Assets Program (SCAP) ensures test facilities identified as essential by the Agency are maintained in a state of readiness. SCAP maintains the skilled workforce and performs essential preventative maintenance to keep these facilities available to meet program requirements. Core capabilities supported within SCAP are thermal vacuum chambers, simulators, and the Arc Jet Facility.

AGENCY MANAGEMENT

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	403.6	--	**389.5**	389.5	389.5	389.5	389.5
Subtotal	403.7	--	**389.5**	389.5	389.5	389.5	389.5
Rescission of prior-year unob. balances*	-0.1	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-14.1**				
Percentage change from FY 2012	--	--	**-3.5 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

NASA Headquarters in Washington D.C. provides overall planning and policy direction for Headquarters and the corporate management for all its Field Centers. NASA-wide the workforce includes about 55,000 civil servants employees and on- and near-site contractors.

Agency Management provides functional and administrative management oversight for the Agency and operational support for NASA Headquarters. This program primarily supports ongoing operations. Agency Management support reflects the activities required for being in business in the Federal sector and provides the capability to respond to legislation and other mandates. The Agency Management program supports over 35 discrete operations and mission support activities.

Agency Management provides policies, controls, and oversight across a range of functional and administrative management service areas. Agency Management governance and oversight activities include finance, protective services, general counsel, public affairs, international and interagency relations, legislative affairs, training, human capital management, procurement, real property and infrastructure, budget management, systems support, internal controls, diversity, equal opportunity, evaluation, and small business programs.

The Agency Management program supports operational activities of Headquarters as an installation. These activities include building lease costs, facility operations costs (such as physical security, maintenance, logistics, information technology hardware, and software costs), automated business systems implementation, and operations costs (such as internal control initiatives related to transparency and accountability in government).

AGENCY MANAGEMENT

EXPLANATION OF MAJOR CHANGES

NASA has reduced administrative costs and implemented operational efficiencies of Headquarters services. This enables the Agency to maximize its investments in the Agency's Missions.

ACHIEVEMENTS IN FY 2012

NASA developed an overarching enhanced hiring initiative to refresh the Agency's talent pool, capitalizing on Federal government-level efforts in this area. Key components of the program are the implementation of the Pathways program and the Federal student employment initiative. This initiative enables the Agency to address issues facing the current and future workforce and ensures the Agency has the innovative workforce and the workplace culture needed to accomplish the Agency's Missions.

As part of the retirement of the Space Shuttle, Agency Management coordinated the transfer of orbiters and other artifacts. NASA retired and delivered Space Shuttle orbiters to the Smithsonian's National Air & Space Museum Udvar-Hazy Center in Chantilly, Virginia, the California Science Center in Los Angeles, California, the Kennedy Space Center Visitor's Complex in Florida, and moved Enterprise to the Intrepid Sea, Air, & Space Museum in New York City, New York. Agency Management led activities to clear NASA inventories of 463,071 items of Space Shuttle personal property, screened 34,738 items of personal property as potential historic artifacts, and placed 3,754 items with eligible schools, libraries, and museums. In addition, this program supported Science, Technology, Engineering, and Mathematics (STEM) training in schools by placing 4,049 Space Shuttle tiles and associated lesson plans in all 50 states and territories.

In FY 2012, the Agency received a clean audit opinion of its accounting and financial systems.
The auditor's opinion of an unqualified financial statement asserts the Agency's financial statements accurately represent its financial position and operations. An unqualified opinion is the highest rating that may be received from an external auditor.

NASA was recognized by the Partnership for Public Service as the "Number One" Best Place to Work in the Federal Government based on the 2012 Employee Viewpoint Survey results. The Agency results have been improving since the survey was first conducted in 2002, while the Government-wide average has fallen. NASA was recognized by the Partnership for Public Service as the most innovative agency in government, underscoring that innovation depends on the total environment that leaders create for employees. This survey was conducted by the Office of Personnel Management.

WORK IN PROGRESS IN FY 2013

As part of a renewed lease, the Headquarters office building is being renovated to be Leadership in Energy and Environmental Design (LEED) Silver certified. This renovation will increase energy and workplace efficiency and create a more collaborative work environment. Energy efficiency will be achieved by the replacement of the HVAC system, transitioning to LEED lighting systems, and revamping floor plans that relocates offices away from the exterior walls allowing the heat pumps installed in the exterior walls to be integrated into an overall environmental management system. NASA's Headquarters office building will achieve LEED Silver certification by the end of FY 2014.

AGENCY MANAGEMENT

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The Agency will complete an assessment of all of NASA's facilities. The assessment provides an independent evaluation of the condition of NASA's facilities and completes a reconciliation audit of the real property inventory, in accordance with Federal Accounting Standards Advisory Board requirements. The assessment documents major changes in condition of NASA's facilities. This information will be vital to support the efficient and effective maintenance of NASA's critical facilities to focus limited funding on properly maintaining critical infrastructure.

Program Elements

HEADQUARTERS OPERATIONS

Headquarters Operations manage and sustain the Headquarters employees and contractors, facilities, and operations required for program and institutional execution. Areas include:

- Information Technology and communications infrastructure hardware and software acquisitions and maintenance, and contracted services for IT support of the Headquarters staff;
- Facility operations support, including physical security, custodial, and maintenance services; equipment; expendable supplies; mail services; printing and graphics; motor pool operations; logistics services; emergency preparedness;
- Human resources staffing; employee payroll and benefits processing; retirement services; employee training; employee occupational health, fitness, and medical services; and grants awards processing; and
- Headquarters operations, including support provided by GSFC for accounting and procurement operations; configuration maintenance; automated business and administrative systems; contract close-out services; and payments to the Office of Naval Research for grants management.

MISSION SUPPORT

The Agency Management budget also provides functional leadership of administrative and mission support activities. This diverse set of activities is performed at Headquarters and Centers on behalf of the Agency.

Mission Support activities include:

- Execution and management of the Agency's financial and budget processes and systems. This includes strategic planning, budget and financial management and accountability practices, while providing timely, accurate, and reliable information, and enhancing internal controls;
- Leadership and management of NASA protective services operations. This includes policy formulation; oversight, coordination and management of protective services operations, including security, fire, emergency management, and emergency preparedness; support for Agency counterintelligence and counter-terrorism activities; implementation of the identity, credentials

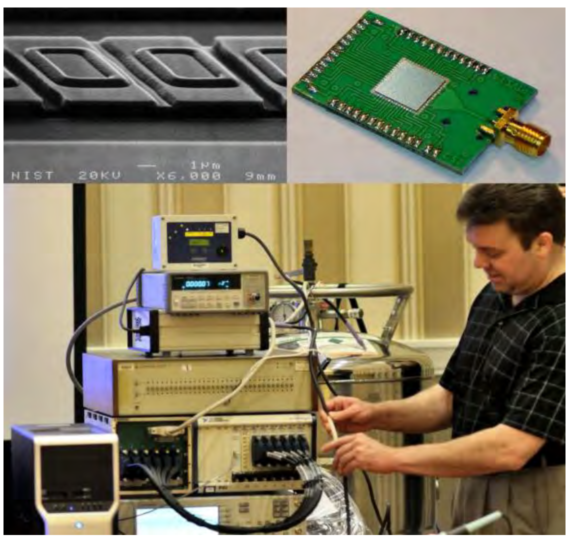
and access management systems and other security systems, including communications; continuity of operations; and national intelligence community services;

- Technical expertise and oversight of the Agency infrastructure and management systems for: aircraft, environmental, real property, logistics, and strategic capabilities programs; and
- Leadership and management of the Agency's human capital resources, and Equal Employment Offices. These offices engage the Agency in proactive equal opportunity and diversity-inclusion initiatives workforce development and alternate dispute resolution services and complaint investigations.

SAFETY AND MISSION SUCCESS

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	198.4	--	**175.1**	175.1	175.1	175.1	175.1
Safety and Mission Assurance	49.4	--	**49.9**	49.9	49.9	49.9	49.9
Chief Engineer	105.2	--	**89.6**	89.6	89.6	89.6	89.6
Chief Health and Medical Officer	4.7	--	**4.3**	4.3	4.3	4.3	4.3
Independent Verification and Validation	39.1	--	**31.3**	31.3	31.3	31.3	31.3
Change from FY 2012	--	--	**-23.3**				
Percentage change from FY 2012	--	--	**-11.7 %**				



Accurate measurement data is crucial to the safety and success of NASA missions. The Programmable Josephson-Voltage System provides NASA a capability to calibrate its Direct Current reference standards at accuracies equivalent to laboratories at the National Institute of Standards and Technology. This tool travels between Centers, providing NASA the highest level of accuracy at significantly reduced cost.

Safety and Mission Success (SMS) programs protect the health and safety of the NASA workforce and improve the likelihood that NASA’s programs, projects, and operations will be completed safely and successfully. Safety and Mission Success includes programs that provide technical excellence, mission assurance, and technical authority. It also includes work managed by the Office of the Safety and Mission Assurance, including the NASA Safety Center and Independent Verification and Validation Facility (IV&V); the Office of Chief Engineer (OCE) including the NASA Engineering and Safety Center; and the Office of the Chief Health and Medical Officer (OCHMO). The elements of SMS reflect the recommendations outlined in many studies and by advisory boards and panels. These programs directly support NASA's core values and serve to improve the likelihood for safety and mission success for NASA's programs, projects, and operations while protecting the health and safety of NASA's workforce.

Safety and Mission Success develops policy and procedural requirements. This program results in recommendations to the Administrator, mission directorates, Center Directors, and program managers who ultimately are responsible for the safety and mission success of all NASA activities and the safety and health of the workforce. SMS resources provide the foundation for NASA's system of checks and balances, enabling the effective application of the strategic management framework and the technical authorities defined in NASA's Strategic Management and Governance Handbook. SMS funds provide training and maintain a competent technical workforce within the disciplines of system engineering (including system safety, reliability, and quality) and space medicine.

SAFETY AND MISSION SUCCESS

SMS resources are essential for evaluating the implications on safety and mission success, including the health and medical aspects of new requirements and departures from existing requirements. With this funding, discipline experts analyze the criticality of the associated risks and evaluate the risks acceptability through an established process of independent reviews and assessments. The information and advice from these experts provide critical data that is used by the technical authorities to develop authoritative decisions related to application of requirements on programs and projects.

EXPLANATION OF MAJOR CHANGES

The NASA Independent Verification and Validation services are at a level that is consistent with current mission requirements. Additional resources have been reallocated to Safety and Mission Assurance to further implement the National Academies' Micrometeoroids and Orbital Debris findings.

ACHIEVEMENTS IN FY 2012

Safety and Mission Assurance instituted a number of advanced surveillance testing methodologies to ensure that the appropriate level of surveillance, inspection, or testing was applied based on the priority and criticality of the product or product attribute and the risk associated with the product failure. These methodologies include:

- Surveillance of research and development organizations which focuses on quality system elements of highest priority;
- Acceptance testing and inspection of commercial-off-the-shelf items which focus only on predetermined critical product attributes of highest risk; and
- Exempting mandatory Government inspections of critical items when statistical process controls that reduce process variation to acceptable limits are employed.

In FY 2012, NASA IV&V provided systems and software expertise and review for 26 projects at 7 NASA Centers. IV&V efforts started prior to Preliminary Design Review (PDR) on 100 percent of new IV&V efforts in FY 2012. This allowed IV&V to identify defects in the life cycle of these projects, enabling efforts to correct such defects at optimal timeframes, reducing costs and rework, and minimizing the potential for schedule delays.

WORK IN PROGRESS IN FY 2013

NASA will add a new capability to the NASA Engineering Network. This will increase the ability of engineering tool users to track local and Agency-wide usage of high value engineering software tools for further implementation of cost savings that result from using Enterprise License Agreements for software procurement. Using these Enterprise License Agreements has increased efficiency and demonstrated reduced cost for engineering tools.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The Safety and Mission Assurance program will include safety reviews and independent technical assessments of NASA missions, including any newly selected missions that may use nuclear systems. The

SAFETY AND MISSION SUCCESS

Office of the Chief Engineer will expand program planning and control activities extending and increasing the use and enhance the quality of Earned Value Management on NASA's projects.

Program Elements

SAFETY AND MISSION ASSURANCE

Safety and Mission Assurance establishes and maintains an acceptable level of technical excellence and competence in safety, reliability, maintainability, and quality engineering within the Agency. SMA assures that the risk presented by either the lack of safety requirements or from the lack of compliance with safety requirements is analyzed, assessed, communicated, and used for proper decision making and risk acceptance by the appropriate organizational leader.

Fundamental to these responsibilities are the definition and execution of a robust and well-understood methodology and process for the application of the safety, reliability and quality in defining the level of risk. SMA conducts a schedule of reviews and assessments that focus on the life cycle decision milestones for crucial NASA programs and projects and safety, reliability, and quality processes. Embodied in this program is a structured development of methodology and investigation into system attributes that improve the probability of mission success.

The NASA Safety Center is an important component of Safety and Mission Assurance and is responsible for consolidating Agency-wide SMA efforts in four key areas: SMA technical excellence, knowledge management, audits and assessments, and mishap investigation support.

OFFICE OF THE CHIEF ENGINEER

The Office of the Chief Engineer promulgates policy and requirements for program and project management for the excellence of the Agency's engineering workforce, system-engineering methodology, and the Agency's system of engineering standards. The office manages the NASA Engineering and Safety Center which is responsible for enabling rapid, cross-Agency response to mission critical engineering, and safety issues at NASA and for improving the state of practice in critical engineering disciplines. Established in FY 2003 in response to the recommendations of the Space Shuttle Columbia Accident Investigation Board, NASA Engineering and Safety Center performs independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success. SMS funding provides for the core NASA Engineering and Safety Center organization of senior engineering experts from across the Agency, including the NASA Technical Fellows, and technical discipline teams comprised of experts from NASA, industry, and academia. As an Agency-wide resource with a reporting path that is independent of the Mission Directorates and independent funding from the OCE, the NASA Engineering and Safety Center helps ensure safety and objective technical results for NASA.

The Office of the Chief Engineer sponsors the Academy of Program/Project and Engineering Leadership to develop program and project management and systems engineering skills. This academy provides a formal training curriculum designed to address four career levels from recent college graduate to executive. The OCE training programs directly support project teams in the field through workshops, coaching, interactions with technical experts, training conferences, forums, and publications. The office enables technical collaboration and information sharing through the NASA Engineering Network, an Agency-wide capability providing single point access to technical standards, communities of practice, and lessons learned in a secure operating environment. The engineering standards program maintains compliance with Office of Management and Budget Advisory Circular 119 and offers a centralized source of required engineering standards for NASA programs and projects at one-fourth the cost of a decentralized approach. In addition, Office of Chief Engineer manages the Space Act authorized Inventions and Contributions Board, which is chartered with recognizing and rewarding innovation within the Agency.

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER

The Office of Chief Health Medical Officer promulgates Agency health and medical policy, standards, and requirements, assuring the medical technical excellence of the Agency. It assures the physical and mental health and well-being of the NASA workforce, and assures the safe and ethical conduct of NASA-sponsored human and animal research. The office monitors the implementation of health and medical related requirements and standards in all developmental human space flight programs through designated discipline experts at NASA Centers. The office provides oversight of medical and health related activities in operational human space flight through Center-based discipline experts and clinical boards. Ongoing medical and health discipline professionalism and licensure are supported through annual certified continuing medical education activities and flight surgeon education. Clinical currency is maintained through sponsored, university-based physician training programs that are sponsored by OCHMO. NASA's biomedical research programs in support of human space flight are guided by NASA-developed health and medical standards.

INDEPENDENT VERIFICATION AND VALIDATION

Independent Verification and Validation is a proven means of ensuring that safety and mission critical software works as desired and reducing the costs to develop the software. IV&V identifies software defects and risks as early as possible, enabling defects to be corrected at optimal timeframes, and minimizing costs and rework. IV&V efforts provide valuable data that serves as input to key lifecycle decisions.

The NASA IV&V program provides software expertise, products, services, and resources to assure the safety and mission success for NASA's programs, missions, and operations. The IV&V program evaluates safety and mission critical software, independent of the developing organization, on NASA's most critical software systems to assure the safety and mission success of those systems.

Throughout a project's system development life cycle, IV&V applies state-of-the-art analytical methods and techniques, complemented with effective software engineering tools and best practices, to confirm the existence of desired safety and mission critical software behaviors via evidence based assurance.

The IV&V Board of Advisors selects projects for IV&V on an annual basis. The board takes into consideration an assessment of the criticality among candidate projects using input from the Mission Directorates, software development and categorization information contained in the OCE’s software inventory and criticality assessments from software assurance personnel at NASA Centers and at the IV&V Facility. The process is flexible and is used to determine the budget required to perform IV&V

work. NASA coordinates and implements the considerations of risk evaluation and minimum threshold for IV&V into a set of project selection guidelines to be used during the board's review process.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose	Outcome	Next Review
Safety	Aerospace Safety Advisory Panel	January 2013	Evaluate NASA's safety performance and advise the Agency on ways to improve that performance.	Recommendations to the NASA Administrator and to Congress. Annual reports located at: http://oiir.hq.nasa.gov/asap/	April 2013

AGENCY IT SERVICES

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	158.5	--	**168.4**	168.4	168.4	168.4	168.4
IT Management	14.6	--	**17.6**	17.6	17.6	17.6	17.6
Applications	67.8	--	**56.0**	56.0	56.0	56.0	56.0
Infrastructure	76.0	--	**94.8**	94.8	94.8	94.8	94.8
Change from FY 2012	--	--	**9.9**				
Percentage change from FY 2012	--	--	**6.2 %**				

NASA's IT Infrastructure Integration Program (I3P) provides greater efficiencies and effectiveness of Agency-wide management, integration, and delivery of information technology (IT) infrastructure services to support mission success. The scope of I3P is broad, entailing consolidation and central management of IT services in the areas of Tier 1 service desk and ordering, Web services and technologies, enterprise business and management applications, integrated network/ communications services, end user services, and data center services.

The Agency Information Technology Services (AITS) program provides many of the Agency's information technology services, including IT security policy and incident monitoring, Web services for the Agency's Web sites, network management, enterprise business applications and end user services. The AITS program provides innovative IT solutions to assist NASA's scientists, engineers and analysts achieve mission success. The program also improves citizen access to NASA scientific data and increases citizen participation in NASA activities.

The AITS program is transforming the IT service model from a decentralized Center-based model to an enterprise model. To achieve this transformation, the AITS program implemented the IT Infrastructure Integration Program (I3P) to improve security, achieve cost efficiencies, and provide standardized services to all users across the Agency. AITS develops and maintains NASA's current and target architectures and service optimization objectives. This program supports federal green IT and data center consolidation efforts. Core capabilities include the NASA Enterprise Application Competency Center, NASA Data Center, Security Operations Center, and the IT Discovery and Application Management Services.

The AITS program manages NASA's Web sites and services which facilitate the Agency's statutory requirement to disseminate information concerning its activities and missions results. NASA Web services consolidates NASA's Web infrastructure, enhance business and technical agility, eliminate vendor specific dependencies, drive down operational overhead for Web presence, drive down the cost of custom Web/on-demand services for missions, programs, and projects, improve NASA IT security, explore shared services across NASA Centers, and improve online customer service delivery through innovative technology. The program also implements services to allow citizens, collaborators, and other partners to use existing social media and other applications to access NASA systems and information.

Under the AITS program, the Agency continues to improve its network security with an enterprise approach to perimeter control and maintenance, including the use of Personal Identification Verification smartcards for both local and remote system access. In addition, AITS is consolidating several NASA Center-specific applications into enterprise-level services, leveraging cloud offerings where possible.

The program recently began an initiative to enable NASA's mobile workforce to work anytime, anywhere using NASA devices or personal devices while ensuring adequate security of NASA's data and information. To ensure that NASA's workforce is secure while working away from the office, the Agency instituted the Data at Rest (DAR) initiative for NASA issued computers. This initiate provides whole disk encryption to help protect NASA data if a computer is lost or stolen. The current scope for DAR protection includes all laptops and any desktop containing Personally Identifiable Information or other sensitive data.

EXPLANATION OF MAJOR CHANGES

NASA has increased its IT security activities to modernize and expand continuous monitoring, implement Personal Identification Verification (PIV) agency-wide, improve intrusion detection through utilization of Trusted Internet Connections (TICs), and increase Web application security scanning.

ACHIEVEMENTS IN FY 2012

NASA evaluated its cybersecurity program and developed a new Cyber Security Strategic Plan (CSSP) to enhance coordination across the Missions and Centers. Implementation of the CSSP will improve the governance, oversight, and functionality of cyber security activities. Additionally, NASA expanded the Web Application Security Program which identified critical vulnerabilities in external facing Web sites and reduced NASA's attack surface.

NASA has reduced the total number of data centers from the original 79 reported to 40. Our revised commitment indicates that we will reduce to approximately 22 data centers by 2015.

Under the Agency Consolidated End-User Services (ACES) program, NASA began deployment to the Agency in a series of implementations beginning in November 2011 through March 2012. Over 45,000 user desktops were transitioned and/or deployed. The establishment of the End User Service Office was completed in March 2012 and is located at Marshall Space Flight Center. Through negotiation with the ACES vendor, the Agency will realize over $15 million in credits or savings over the two years and an estimated 15 percent cost reduction from the previous contract.

Over the past year the Enterprise Service Desk (ESD) supported the I3P initiative and NASA customers 24 hours/day, 7 days/week, 365 days/year. ESD provides a central service desk, service request system, a self-service, Tier 0 Web portal, knowledge sharing capability, ability to centrally capture and provide notifications, and system status capabilities. Since ESD began operating in November 2011, metrics show the progress and success of the project whereby customer satisfaction is at 95 percent; calls answered within 60 seconds is at 84 percent; abandonment rate at 5 percent; and first call resolution on Tier 1 related items at 92 percent. Overall, 250,000 incidents and over 100,000 service requests have been processed.

NASA's IT Labs was named FedScoop's Federal IT Program of the Year for 2012. With support from a diverse team of technical reviewers from across NASA, IT Labs has funded over 25 early-phase IT projects, many of which are now in late-phase prototypes and being prepared for operational deployment. Additional IT Labs products include a collaboration with industry that resulted in a modification to Federal Identity Credential and Access Management policy, the co-development of a Microsoft Labs technology for government repurposing, and the deployment of NASA's first multi-tenant, multi-functional software-as-a-service collaboration system. IT Labs is an innovation platform to engage the brightest minds across the Agency to help guide NASA's IT strategy and investment decisions, and identify IT capabilities that best support NASA's needs in a rapidly changing world. By soliciting proposals in an annual project call, IT Labs funds small-scale IT innovation projects that have Enterprise service potential. This stage-gate approach to IT funding ensures that highly feasible IT products can move into operations for a relatively low cost, and NASA can capture the lessons learned from these endeavors share them to ensure resource savings by reducing duplication of effort.

WORK IN PROGRESS IN FY 2013

As part of the cybersecurity transformation, NASA is evaluating the individual cybersecurity tools, solutions, and services offered by each of the missions and Centers. Leading capabilities will be included in the NASA cybersecurity services catalog and made available to all system owners. This catalog will improve efficiency and efficacy of the cybersecurity program as missions and Centers complete their Service Level Agreements.

NASA has completed the laptop encryption effort for all computers containing personally identifiable information, and international traffic in arms regulations and export administrations regulations information. The installation of this encryption software is required before a laptop can be removed from a NASA facility.

As the flagship initiative for the second version of NASA's Open Government Plan, the Agency is taking a fresh look at its web architecture and processes to manage content in order to build an accessible, participatory and transparent Web environment based on open and interoperable standards. The goal of this effort will be to provide a consistent, capable, and agile cloud-based enterprise infrastructure for internal and external Web applications and a majority of the 1,590 external Web sites using an interoperable, standards-based, and secure environment.

The Agency is working to re-architect NASA's Wide Area Network to establish a defensible Agency network perimeter. This will greatly enhance NASA's security posture. On NASA's mission network, the Agency will complete the replacement of all routers on the core mission backbone and has begun work on consolidating the mission and corporate networks, providing significant cost savings as well as increased security posture.

NASA is replacing its antiquated and unsupported software package for Agency forms management. The updated system will manage over 5,000 forms, be compatible with newer software, enable digital certificate signatures, and comply with Section 508 of the Rehabilitation Act requirements.

AGENCY IT SERVICES

Federal e-Travel services are migrating to a new service provider under an alliance of CW Government Travel Incorporated of San Antonio, Texas, Electronic Data Systems Corporation of Fairfax, Virginia and Northrop Grumman Mission Systems of Fairfax, Virginia. The three companies were awarded the 10-year contract to provide Web-based, travel management services for the federal government. The NASA email system and infrastructure from Exchange 2007 to Exchange 2010 will be completed in March 2013. The modification includes providing end user customers with a one gigabyte mailbox size. This increase will allow storage of more email on the servers, which can be accessed from other mobile devices and leveraging the work from anytime and anywhere.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

NASA is increasing initiatives related to IT Security which include, but are not limited to: (1) modernizing and expand continuous monitoring; governance, risk, and compliance; and penetration testing, (2) deploying intrusion detection systems across mission, corporate, and research networks, (3) increasing Web application security scanning, (4) implementation of PIV on internal and remote access to network and mobile systems, and (5) implementing intrusion prevention systems at trusted Internet connection locations. These activities will improve NASA's IT security and address concerns from NASA's Inspector General, as well as aid NASA in meeting its Cross-Agency Priority (CAP) goals as defined by the Department of Homeland Security (DHS).

NASA will capitalize on its cybersecurity transformation by modernizing the risk management framework (to include Security Assessment and Authorization and continuous monitoring processes), defining metrics for measuring risk reduction, creating dashboards for visualizing and communicating the Agency's cybersecurity posture, and expanding the security operations efforts to provide early warning of cyber vulnerabilities. Specifically, NASA will focus on:

- Improving detection and remediation of vulnerabilities and reducing the number of compromises to NASA Web sites via the enhanced training for application developers and systems owner; scheduled scans and penetration testing of the Agency's IT infrastructure;
- Mitigating vulnerabilities and risks, defending against cyber-attacks, protecting users from malicious software (malware) delivered via email phishing, and better identifying and denying unauthorized exfiltration of data from NASA networks by developing an integrated security framework allowing detection and protection across the enterprise (versus from Center to Center);
- Expanding intrusion detection (on mission, corporate, and research networks), deploy and manage intrusion prevention capabilities that will result in near real-time adaptive security solutions to provide proactive incident mitigation and enhanced threat management for our dynamic networks;
- Completing all phases of the Identity Management PIV Access Implementation Plan. Goal is to enforce PIV on all user and machine objects by the end of FY 2014.
- Providing an integrated asset, configuration, and patch management solution to increase the confidence level of detected vulnerabilities, number and types of assets on our network and to automate remediation by implementing patches for confirmed vulnerabilities; and
- Providing an automated risk and compliance management solution that will enable security experts to quantify their overall security posture, assess security controls, identify critical risks, and validate that processes and capabilities are actively reducing the attack surface for threat actors.

AGENCY IT SERVICES

By focusing on transforming and modernizing its cybersecurity program through improved processes and capabilities focused on network defense, detection of abnormalities, configuration and asset management, and situational awareness, NASA will address Office of Inspector General and Government Accountability Office findings and recommendations for improving underlying and systemic IT security deficiencies and weaknesses. NASA has taken on the challenge to meet the Cross-Agency Priority goals defined by the Department of Homeland Security (DHS), and to achieve 95 percent use of the Administration's priority cybersecurity capabilities on NASA information systems by end of FY 2014, including strong authentication, Trusted Internet Connections (TIC) and Continuous Monitoring. A plan of action to meet the target level for each CAP has been developed.

STRATEGIC CAPABILITIES ASSETS PROGRAM

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	29.3	--	**27.6**	27.6	27.6	27.6	27.6
Change from FY 2012	--	--	**-1.7**				
Percentage change from FY 2012	--	--	**-5.8 %**				

The Center of Curvature Optical Assembly (CoCOA) test fixture for the James Webb Space Telescope (JWST) is being prepared for testing at the X-Ray & Cryogenic Facility (XRCF), Marshall Space Flight Center, Huntsville, AL. The CoCOA contains mechanical and optical instruments that will allow the test team to identify, verify the optical performance, align and test JWST's 18-segment mirror. The XRCF includes a large Class 1,000 (ISO 6) clean room, an optically clean vacuum chamber 75 ft (22.9 meters) long and 24 ft (7.3 meters) in diameter, and a 1,700 ft (518 meter) vacuum tube connecting an x-ray source to the vacuum chamber. The vacuum chamber's thermal control system simulates deep space environment cryogenic temperatures to -424 °F (20 Kelvin) and maintains accurate thermal stability. The test capabilities of NASA's unique facilities have enabled a long line of extremely successful missions.

The Strategic Capabilities Assets Program (SCAP) ensures that test facilities identified as essential by the Agency are in a state of readiness. SCAP maintains the skilled workforce and performs essential preventative maintenance to keep these facilities available to meet program requirements. Core capabilities SCAP supports are thermal vacuum chambers, simulators, and the Arc Jet Facility.

SCAP establishes alliances between all Centers with like assets, makes recommendations on the disposition of capabilities no longer required, identifies re-investment/re-capitalization requirements within and among classes of assets, and implements changes. SCAP reviews the Agency's assets and capabilities each year to ensure that the requirements for the facilities continue to be valid.

SCAP ensures maximum benefit across the Government by broadening its alliances outside the Agency for capabilities (e.g., thermal vacuum chambers). This is facilitated by a collaborative working group, the Space Environment Test Alliance Group, which includes NASA, Department of Defense (DoD), and other partner entities. The group members gain awareness of capabilities across agencies, academia, and industry; share best practices; provide technical support; and refer test programs to facilities best suited to meet test requirements.

EXPLANATION OF MAJOR CHANGES

None.

STRATEGIC CAPABILITIES ASSETS PROGRAM

ACHIEVEMENTS IN FY 2012

SCAP continued to sustain and ensure that the test facilities identified as essential by the Agency were maintained in a state of readiness. SCAP maintained the skilled workforce and performed preventative maintenance necessary to keep these facilities available to meet current and future program requirements.

SCAP's specialized workforce supported the design and relocation of major test equipment from the Johnson Space Center (JSC) arc jet testing capability to the Ames Research Center (ARC). The relocation was completed in FY 2012.

NASA assessed its thermal vacuum chamber testing capabilities across its field Centers. Four under-utilized chambers at the Jet Propulsion Laboratory (JPL), Kennedy Space Center (KSC), and Marshall Space Flight Center (MSFC) were identified for divestment and started the disposition process.

SCAP provided design and final systems check-out and verification support to the upgrades of JSC Thermal Vacuum Chamber A. The Chamber A upgrades were completed and the chamber was verified and readied for James Webb Space Telescope (JWST) testing. The Chamber A upgrades will allow for simulation of deep space temperature conditions down to 12 degrees Kelvin (-438 degrees F). A new air flow management system was also added to maintain ISO Class 7 cleanliness levels to minimize contamination of sensitive hardware when this chamber is at ambient conditions. The combination of capabilities—Chamber A test conditions, maximum test article size, and adjacent clean room—were not available within NASA before the upgrades were performed.

WORK IN PROGRESS IN FY 2013

SCAP's specialized workforce at the ARC arc jet will verify and activate the major test equipment received from the JSC Arc Jet Facility as part of the arc jet capability consolidation effort. In FY 2013, JSC arc jet testing capability will complete its testing obligations, cease operation, and begin final transfer of its remaining major test equipment to ARC. NASA anticipates annual operational cost savings of over $5 million per year to the missions through this consolidation effort.

SCAP assets are supporting the development, testing, verification, and validation for NASA, DoD, National Oceanic and Atmospheric Administration (NOAA), Federal Aviation Administration (FAA), European Space Agency (ESA), and commercial test programs in the following areas:

- Simulators: air traffic management technology demonstration, Unmanned Aerial System airworthiness standards and guidelines, Large Civil Tilt Rotor Experiment, and other ongoing development and testing;
- Thermal vacuum and acoustic chambers: JWST instrument and optical calibration, Space Exploration Technologies (SpaceX) payload fairing testing for the Falcon 9, Commercial Crew and Cargo launch program testing, and other space environmental testing; and
- Arc jet: thermal protection materials and system development and qualification testing.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

SCAP will continue to sustain the strategic technical capabilities needed by NASA to achieve successful missions. In addition, SCAP will continue to develop and implement disposition plans for assets no longer needed to achieve long-term health and sustainment of the remaining NASA assets.

SCAP plans to review and identify conditions that present high risk to the thermal vacuum capability at Goddard Space Flight Center (GSFC) and JPL and the arc jet capability at ARC to assess the condition of these assets.

Program Elements

SCAP maintains the skilled workforce and performs maintenance required to keep essential NASA assets available to meet program requirements.

SIMULATORS

Simulators are critical components of the success of NASA's aeronautics research in the areas of fundamental aeronautics and aviation safety. These capabilities provide scientists and engineers with tools to explore, define, and resolve issues in both vehicle design and missions operations.

This capability includes an array of research and development crewed flight simulator assets that are in the operations phase and includes:

- A Vertical Motion Simulator and its associated laboratories and equipment located at ARC; and
- A Cockpit Motion Facility and its supporting suite of simulators (the differential maneuvering simulator and the visual motion simulator) and central support facilities for aeronautics and spaceflight vehicle research located at Langley Research Center.

THERMAL-VACUUM, VACUUM, AND ACOUSTIC CHAMBERS

This capability includes several assets located at NASA facilities (Glenn Research Center (GRC), GSFC, JPL, JSC, KSC, and MSFC) that simulate conditions during launch and in space environments. These assets have a minimum outline dimension of 10 feet by 10 feet and can accommodate a complete spacecraft. These chambers have the capability of producing pressures down to 0.01 torr or lower and thermal shrouds capable of liquid nitrogen temperatures (-321 degrees F) or lower. Acoustic chambers are capable of generating approximately 150 decibels at frequencies in the range of 25 to 1000 Hertz.

These chambers are used to perform significant risk mitigation for most NASA payloads launched into space as well as many payloads in other government agencies, such as NOAA and DoD. Testing performed in these chambers ensures the assembled spacecraft will meet the strict requirements of harsh launch and space environments. Recent successful space vehicles tested in thermal vacuum and acoustic chambers include: Mars Science Laboratory, Geostationary Operational Environmental Satellites, and Ariane payload fairing separation.

STRATEGIC CAPABILITIES ASSETS PROGRAM

ARC JET

This capability includes assets that provide simulated high-temperature, high-velocity environments and support the design, development, test, and evaluation activities of thermal protection materials, vehicle structures, aerothermodynamics, and hypersonic aerodynamics. A gas (typically air) is heated and accelerated to supersonic/hypersonic speeds using a continuous electrical arc. This high-temperature gas passes over a test sample and produces an approximation of the surface temperature and pressure environments experienced by a vehicle on atmospheric entry.

Arc jet testing was critical in ensuring the safe return from orbit of space shuttles with tile damage and providing essential validation of materials for Mars entry missions, including the Mars Science Laboratory. The Dragon spacecraft, made by the commercial company SpaceX, also completed its heat shield development testing at NASA's Arc Jet Facility.

HEADQUARTERS BUDGET BY OFFICE

AGENCY MANAGEMENT BUDGET BY HEADQUARTERS OFFICE

	Actual		Notional			
($ in millions in full cost)*	**FY 2012**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
Aeronautics Research	6.6	6.7	6.7	6.7	6.7	6.7
Human Exploration and Operations	26.8	26.0	26.0	26.0	26.0	26.0
Science	27.1	27.4	27.4	27.4	27.4	27.4
Space Technology	0.0	4.1	4.1	4.1	4.1	4.1
Mission Directorates	**60.5**	**64.2**	**64.2**	**64.2**	**64.2**	**64.2**
Office of the Administrator	27.1	25.7	25.7	25.7	25.7	25.7
Chief Engineer	4.5	4.5	4.5	4.5	4.5	4.5
Chief Financial Office	25.7	25.4	25.4	25.4	25.4	25.4
Chief Health and Medical Office	1.4	1.6	1.6	1.6	1.6	1.6
Chief Information Office	7.8	8.8	8.8	8.8	8.8	8.8
Chief Scientist	1.0	1.4	1.4	1.4	1.4	1.4
Chief Technologist	5.2	1.6	1.6	1.6	1.6	1.6
Communications	14.0	12.7	12.7	12.7	12.7	12.7
Diversity and Equal Opportunity	3.9	4.3	4.3	4.3	4.3	4.3
Education	2.8	3.1	3.1	3.1	3.1	3.1
General Counsel	8.3	8.4	8.4	8.4	8.4	8.4
International and Interagency Relations	12.3	11.9	11.9	11.9	11.9	11.9
Legislative and Intergovernmental Affairs	3.7	3.3	3.3	3.3	3.3	3.3
Safety and Mission Assurance	6.6	6.2	6.2	6.2	6.2	6.2
Small Business Programs	1.7	1.7	1.7	1.7	1.7	1.7
Staff Offices	**125.9**	**120.6**	**120.6**	**120.6**	**120.6**	**120.6**
NASA Management Office at JPL	6.3	8.1	8.1	8.1	8.1	8.1
Human Capital Management	26.6	27.2	27.2	27.2	27.2	27.2
Headquarters Operations	121.4	113.0	113.0	113.0	113.0	113.0
Strategic Infrastructure	19.9	14.6	14.6	14.6	14.6	14.6
Internal Controls and Management Systems	1.9	2.1	2.1	2.1	2.1	2.1
Procurement	7.2	7.0	7.0	7.0	7.0	7.0
Mission Support Directorate Front Office	2.6	3.1	3.1	3.1	3.1	3.1
NASA Shared Services Center	14.1	13.7	13.7	13.7	13.7	13.7
Protective Services	17.3	16.0	16.0	16.0	16.0	16.0
Mission Support	**217.3**	**204.7**	**204.7**	**204.7**	**204.7**	**204.7**
Total Agency Management	**403.7**	**389.5**	**389.5**	**389.5**	**389.5**	**389.5**

HEADQUARTERS TRAVEL BUDGET BY OFFICE

HEADQUARTERS TRAVEL BUDGET BY OFFICE

	Actual	
($ in millions in full cost)*	**FY 2012**	**FY 2014**
Aeronautics Research*	0.6	0.6
Human Exploration and Operations*	3.0	2.7
Science*	2.0	2.0
Space Technology*	1.4	1.4
Mission Directorates	**7.0**	**6.7**
Office of the Administrator	1.3	1.1
Chief Engineer	1.0	1.1
Chief Financial Office	0.2	0.3
Chief Health and Medical Office	0.1	0.1
Chief Information Office	0.5	0.5
Chief Scientist	0.1	0.1
Chief Technologist**	0.0	0.0
Communications	0.2	0.2
Diversity and Equal Opportunity	0.1	0.1
Education*	0.5	0.5
General Counsel	0.1	0.1
International and Interagency Relations	0.6	0.6
Legislative and Intergovernmental Affairs	0.0	0.0
Safety and Mission Assurance	0.2	0.3
Small Business Programs	0.1	0.1
Staff Offices	**4.9**	**5.2**
NASA Management Office at JPL	0.1	0.1
Human Capital Management	1.0	1.1
Headquarters Operations	0.1	0.1
Strategic Infrastructure	0.4	0.4
Internal Controls and Management Systems	0.0	0.1
Procurement	0.1	0.2
Mission Support Directorate Front Office	0.1	0.1
Protective Services	0.1	0.1
Mission Support	**1.9**	**2.1**
Total Agency Management	**13.7**	**13.9**

** Travel for the Mission Directorates and Education are funded from their respective appropriation accounts. This chart represents the total travel funding at Headquarters (not just in the CAS Agency Management program account).*

*** Chief Technologist travel is embedded in the Space Technology travel budget.*

HEADQUARTERS WORKFORCE BY OFFICE

HEADQUARTERS WORKFORCE BY OFFICE

	Actual				Notional			
	FY 2012				FY 2014			
	FTE	**SES**	**Non-Career**	**Contract WYE**	**FTE**	**SES**	**Non-Career**	**Contract WYE**
Aeronautics Research	38	8		10	38	9		10
Human Exploration and Operations	154	13		76	147	16		76
Science	153	19		50	150	19		50
Space Technology*					23	3		0
Mission Directorates	**345**	**40**	**0**	**136**	**358**	**47**	**0**	**136**
Office of the Administrator	57	8	8	12	52	9	8	12
Chief Engineer	24	7		15	24	8		15
Chief Financial Office	99	8	1	35	98	9	1	35
Chief Health and Medical Office	9	1		4	10	1		4
Chief Information Office	45	7		26	49	8		27
Chief Scientist	4	1			5	3		
Chief Technologist*	30	2		4	9	1		4
Communications	51	5	4	28	48	5	4	28
Diversity and Equal Opportunity	18	3		3	17	3		3
Education	16	3		22	17	5		22
General Counsel	41	5	1		40	6	1	0
International and Interagency Relations	54	8		6	50	8		6
Legislative and Intergovernmental Affairs	27	3	4		24	4	4	
Safety and Mission Assurance	35	6		19	33	6		19
Small Business Programs	5	1		3	5	1		3
Staff Offices	**515**	**68**	**18**	**176**	**481**	**77**	**18**	**177**
NASA Management Office at JPL	25	1		2	25	1		2
Human Capital Management	34	4		7	34	5		7
Headquarters Operations	105	4		304	111	4		293
Strategic Infrastructure	57	4		16	56	6		16
Internal Controls and Management Systems	9			1	9			1
Procurement	34	4			32	4		
Mission Support Directorate Front Office	9	2			9	2		
Protective Services	44	1		8	40	2		8
Mission Support	**317**	**19**		**338**	**316**	**23**		**327**
Total Agency Management	**1,178**	**127**	**18**	**650**	**1,155**	**147**	**18**	**640**

**FTEs were transferred from the Chief Technologist to the Space Technology Mission Directorate after it was established in FY 2013*

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION (CECR)

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	494.5	401.9	**609.4**	440.9	440.9	440.9	440.9
Construction of Facilities	455.0	--	**533.9**	365.4	365.4	365.4	365.4
Environmental Compliance and Restoration	45.0	--	**75.5**	75.5	75.5	75.5	75.5

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION

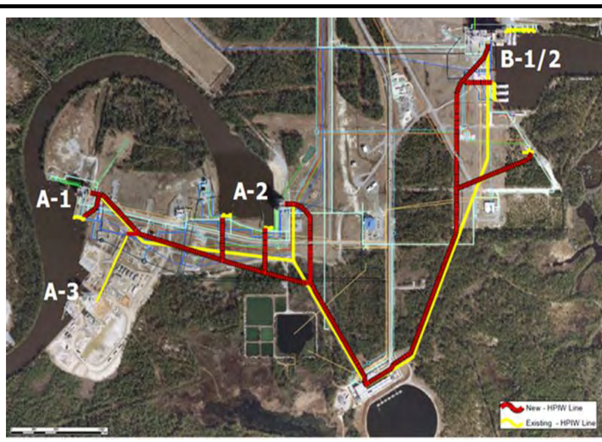
CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION (CECR)

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013***	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	494.5	401.9	**609.4**	440.9	440.9	440.9	440.9
Construction of Facilities	455.0	--	**533.9**	365.4	365.4	365.4	365.4
Environmental Compliance and Restoration	45.0	--	**75.5**	75.5	75.5	75.5	75.5
Subtotal	500.0	407.4	**609.4**	440.9	440.9	440.9	440.9
Rescission of prior-year unob. balances**	-5.5	-5.5	**--**	--	--	--	--
Change from FY 2012	--	--	**114.9**				
Percentage change from FY 2012	--	--	**23.2 %**				

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175). The FY 2013 column for Construction and Environmental Compliance and Restoration also includes $15 million provided by the Disaster Relief Act, 2013 (P.L. 113-2) for Sandy storm recovery.*

*** Rescission of prior-year unobligated balances from Construction of Facilities pursuant to P.L. 112-55, Division B, sec. 528(f).*



The High Pressure Industrial Water (HPIW) system provides cooling water and fire protection for the five test stands in the A & B Complexes at SSC. Constructed in 1965, recent analysis has determined that the system is nearing the end of its service life. Leaks and failures of the existing system will increase just as NASA begins testing the next generation of large thrust engines over the next 20 years. NASA will completely replace the underground piping and valves serving test stand A1 & A2 and the B test complex. The white lines in the picture show the path of the existing HPIW underground piping. The dark lines show the planned new HPIW lines.

NASA designs and implements construction of facilities projects, facility demolition projects, and environmental compliance and restoration activities through its Construction and Environmental Compliance and Restoration account.

Construction of Facilities (CoF) makes capital repairs and improvements to NASA's infrastructure and provides NASA projects and programs with the test, research, and operational facilities required to accomplish their missions. About 82 percent of NASA's infrastructure and facilities are beyond their constructed design life, thus posing elevated and rising risk to current and future missions. Aging, Apollo-era legacy infrastructure is inefficient and costly to maintain and operate, and assets over 40 years old pose a significant risk to NASA's unique research and development mission. To address these challenges, NASA's CoF program focuses on reducing and modernizing NASA's infrastructure into fewer, more efficient and sustainable facilities.

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION (CECR)

Environmental Compliance and Restoration projects clean up pollutants released into the environment during past activities. NASA prioritizes these cleanups to protect human health and the environment, and preserve natural resources for future missions.

Together, these construction and remediation activities help ensure that NASA's assets are ready, available, and appropriately sized to conduct NASA's missions.

EXPLANATION OF MAJOR CHANGES FOR FY 2014

The FY 2014 request for CoF includes funding to achieve Space Launch System, Orion Multi-Purpose Crew Vehicle, Exploration Grounds Systems, 21st Century Space Launch Complex, Space Communications and Navigation, and Launch Systems requirements. FY 2014 funds to support these programmatic construction requirements were moved from Exploration and Space Operations accounts. Funding associated with all program designs and out-year programmatic construction activities remains in program accounts.

ACHIEVEMENTS IN FY 2012

During FY 2012, NASA:

- Received final license termination for the decommissioning of the Plum Brook Reactor Facility, completing more than a decade of work at the site;
- Completed the Launch Facilities Protection project which stabilized the Wallops Island shoreline. During hurricane Sandy, the completed project protected launch assets from loss due to the storm;
- Began repairs to the B-2 Test Stand and Dock at Stennis Space Center to support mission requirements for the Space Launch System program. These upgrades to the existing facility will allow the program to meet emerging human exploration requirements; and
- Completed the demolition of 87 facilities at various sites. Demolition of inactive and obsolete facilities eliminates the cost of maintaining old, abandoned facilities in a safe and secure condition.

WORK IN PROGRESS IN FY 2013

Exploration CoF activities in FY 2013 focus on meeting the requirements of the Space Launch System program. Projects include restoration of the B-2 test stand at Stennis Space Center, modifications at Michoud Assembly Facility and Kennedy Space Center, and construction of test stands at Marshall Space Flight Center.

To support Space Operations activities, work continues on the 21st Century Launch Complex at Kennedy Space Center and the 34-meter antenna system at Canberra.

Planned Institutional CoF projects will protect the Agency’s critical assets, improve mission assurance, reduce mission risk, and maintain mission essential capabilities. These include utility system repairs and replacement of obsolete buildings, such as the administrative building at Kennedy Space Center. The Institutional CoF program will also employ Hurricane Sandy Disaster Relief funds to make much needed sand-related repair and restoration at the Kennedy Space Center (KSC) and Goddard Space Flight Center (GSFC) Wallops Flight Facility.

In FY 2013, NASA's ECR program plans cleanups at all NASA Centers, with priority given to protecting human health and the environment in balance with Environmental Protection Agency and state regulatory agreements and requirements. The continuation of interim soil cleanups at Santa Susana Field laboratory in coordination with the State of California reflects this Agency priority.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Construction activities planned include:

- Major repair by replacement projects at Kennedy Space Center, Langley Research Center, Marshall Space Flight Center, and Glenn Research Center to reduce and renew infrastructure into smaller and more efficient facilities;
- Repairs and upgrades at all Centers to mitigate near-term risk to missions by revitalizing electrical, mechanical, life safety, and utility systems;
- Investments to reduce energy consumption and improve energy efficiency, including upgrades to more efficient lighting and cooling systems;
- Demolition of obsolete facilities;
- Construction for Space Operations activities to support Space Communication and Navigation and the 21st Century Space Launch Center; and
- Construction for Exploration activities to support Space Launch Systems, Exploration Ground Systems, and Launch Service Providers.

Environmental Compliance and Restoration activities planned include: a cleanup of soil contamination and investigation of ground water contamination at Santa Susana Field Laboratory, and continued cleanup and investigation of soil and water contamination at White Sands Test Facility, Kennedy Space Center, Marshall Space Flight Center, and Ames Research Center. Additionally, NASA will:

- Operate and maintain systems to clean up contaminated drinking water emanating from the Jet Propulsion Laboratory;
- Continue operations of treatment systems and monitoring at Stennis Space Center, Wallops Flight Facility, and Dryden Flight Research Center; and
- Complete active cleanup activities and continue long-term monitoring at Glenn Research Center, Goddard Space Flight Center, Langley Research Center, and Johnson Space Center.

CONSTRUCTION OF FACILITIES

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	449.7	--	**533.9**	365.4	365.4	365.4	365.4
Institutional CoF	315.1	--	**365.4**	365.4	365.4	365.4	365.4
Science CoF	12.0	--	**0.0**	0.0	0.0	0.0	0.0
Exploration CoF	71.0	--	**142.3**	0.0	0.0	0.0	0.0
Space Operations CoF	56.9	--	**26.2**	0.0	0.0	0.0	0.0
Subtotal	455.0	--	**533.9**	365.4	365.4	365.4	365.4
Rescission of prior-year unob. balances*	-5.3	--	**--**	--	--	--	--
Change from FY 2012	--	--	**84.2**				
Percentage change from FY 2012	--	--	**18.7 %**				

*Note: * Rescission of prior-year unobligated balances from Institutional CoF, Science CoF, and Space Operations CoF pursuant to P.L. 112-55, Division B, sec. 528(f).*

KSC Replacement Shared Services and Office Building: The Kennedy Space Center (KSC) Shared Services and Office Building is the first phase of a ten-year plan to consolidate and right-size administrative, laboratory, and shared services facilities currently scattered across the industrial area of the KSC. The program will enable deconstruction of approximately 900,000 square feet of physical plant that will be between 50 to 60 years old by the time it is deactivated, and reduce KSC's total square footage by approximately 450,000 square feet. The shared services and office building (Phase 1) will replace administrative and services space and consolidate 4 data centers across the center into an efficient, sustainable central data center, reducing KSC data management energy and operating costs. Phase 1 construction will total just over 200,000 square feet and will house approximately 500 personnel. The project includes improvements to the utilities infrastructure, pedestrian walkways, and limited modifications to the surrounding roads and parking lots.

NASA's CoF program includes programmatic and non-programmatic construction projects that reduce facility-related risk to mission success and increase sustainability.

The Institutional CoF program designs and constructs non-programmatic facilities projects. Utility system repairs and replacements improve the reliability of NASA's infrastructure and reduce operational consumption of energy (steam, electricity, and gas). Refurbishment and repair by replacement projects replace inefficient, deteriorated buildings with efficient high performance facilities. Demolition projects eliminate facilities that are no longer needed. Together these activities help reduce operating costs and develop a sustainable and energy efficient infrastructure to enable NASA's missions.

Programmatic CoF provides critical capabilities in testing and development that directly support NASA's current missions. These projects modify NASA facilities to provide specific technical requirements to manufacture, test, process, or operate hardware for NASA programs. These projects are identified by

CONSTRUCTION OF FACILITIES

NASA flight and research programs as specific changes to NASA technical capabilities essential to the success of NASA programs.

Projects with initial cost estimates between $1 and $10 million are included in the program as minor revitalization and construction projects. Projects with initial cost estimates of $10 million or greater are budgeted as discrete projects. Projects with initial cost estimates of $1 million or less are accomplished by routine day-to-day facility maintenance and repair activities provided for in program and Center Management and Operations budgets.

EXPLANATION OF MAJOR CHANGES

The FY 2014 request for CoF includes funding to achieve Space Launch System, Orion Multi-Purpose Crew Vehicle, Exploration Grounds Systems, 21st Century Space Launch Complex, Space Communications and Navigation, and Launch Systems requirements. FY 2014 funds to support these programmatic construction requirements were transferred from Exploration and Space Operations accounts. Funding associated with all program designs and out-year programmatic construction activities remains in program accounts.

Historical Performance

About 82 percent of NASA’s infrastructure and facilities are beyond their constructed design life, thus posing elevated and rising risk to current and future missions. Aging Apollo-era legacy infrastructure is inefficient and costly to maintain and operate, and assets over 40 years old pose a significant risk to NASA’s unique research and development mission. To address these challenges, NASA is aggressively managing its facility portfolio to consolidate and modernize into fewer, more efficient and sustainable facilities. These efforts have begun to reverse prior growth patterns in the value of the Agency's constructed assets (Figure 1). This is critical because divesting assets of limited value to the Agency enables NASA to focus limited available resources on stewardship of constructed assets with the greatest value to its mission success.

CONSTRUCTION OF FACILITIES

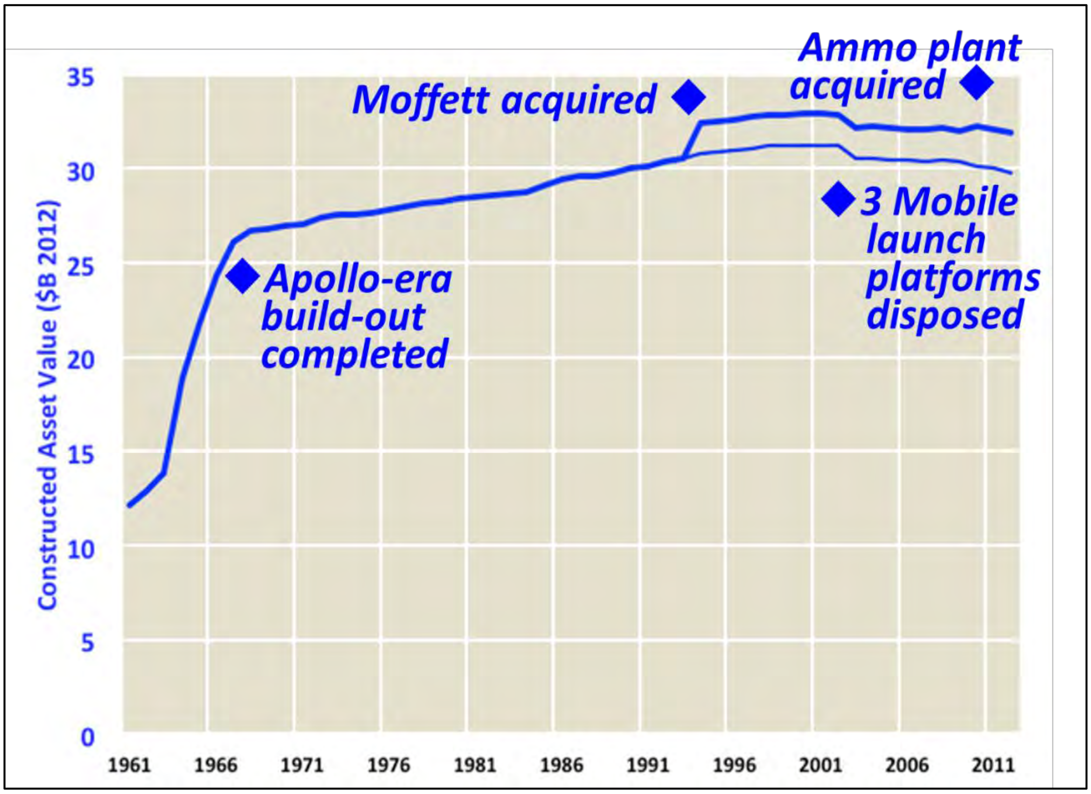


Figure 1. A decade of portfolio management is reversing prior growth patterns in Constructed Asset Value.

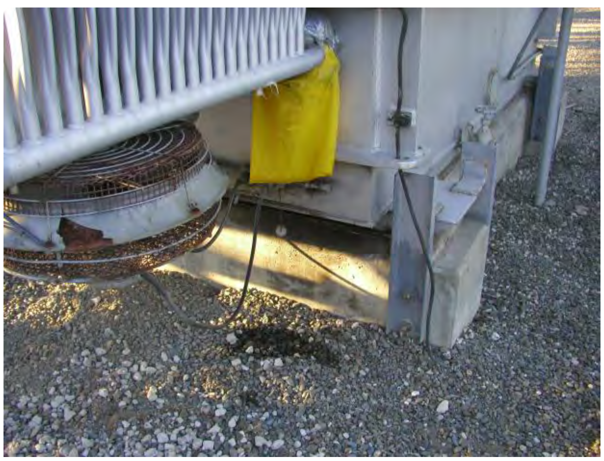
Note: The parallel bold line shows the value if the Moffett Field and Ammo plant acquisitions are included. The light line omits Moffett and the Ammo plant to provide a comparison to "like" content before these major acquisitions increased the asset value.

INSTITUTIONAL COF

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	310.6	--	**365.4**	365.4	365.4	365.4	365.4
Subtotal	315.1	--	**365.4**	365.4	365.4	365.4	365.4
Rescission of prior-year unob. balances*	-4.5	--	**--**	--	--	--	--
Change from FY 2012	--	--	**54.8**				
Percentage change from FY 2012	--	--	**17.6 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*



This electrical transformer at Ames Research Center in Mountain View, CA, is an example of many electrical systems failing because of their age. In some cases, critical electrical components supporting major test facilities are not reliable and are impeding NASA's ability to conduct testing. In 2014, NASA will make electrical reliability repairs at ARC, DFRC, GRC, GSFC, JPL, JSC, LaRC, and MSFC. These projects will improve electrical reliability and electrical safety.

NASA's Institutional CoF program includes programmatic and non-programmatic projects supporting two overarching Agency goals:

- Reduce facility-related risks to mission success, property, and personnel. CoF projects include repairs and/or improvements to NASA's existing facilities based on a prioritized system using a risk informed process; and
- Increase sustainability and environmental friendliness. These projects support NASA's core capabilities within a smaller, more efficient footprint. Projects include replacement of old, obsolete, costly facilities with new, high performance facilities that consolidate core functions and improve flexibility over the life of the facilities. These replacement facilities incorporate new technologies and are designed with flexibility so they can address programmatic requirements, both known and still evolving over the next 40 years.

NASA's demolition program eliminates obsolete, un-needed infrastructure to improve efficiency and eliminate safety and environmental risks.

NASA's recent Institutional CoF program efforts are beginning to demonstrate the intended results. Since 1995, NASA has reduced energy usage by 17 percent. In FY 2012 NASA's deferred maintenance, which is an estimate of the essential but unfunded maintenance work necessary to bring all facilities up to standards, decreased 5.7 percent from FY 2011 levels.

INSTITUTIONAL COF

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

In FY 2012, NASA began construction of the following projects:

- Construction of the Integrated Services Building at Langley Research Center that consolidates activities from obsolete buildings into an efficient, sustainable facility;
- Renovation of the East Test Water Industrial Area at Marshall Space Flight Center that will replace the existing 30-inch steel distribution main and branches to various test stands and test facilities; and
- Replacement of the Potable Water System at Stennis Space Center that provides drinking water to the Center.

WORK IN PROGRESS IN FY 2013

In FY 2013, NASA plans to begin construction on projects to revitalize critical assets such as the Ames Research Center Arc Jet. This project will support consolidation and modernization of the Agency's arc jet capability.

Utility system repairs and replacements will improve reliability throughout NASA's infrastructure and reduce the risk of utility caused failures.

Construction will begin on the replacement of the administrative building at Kennedy Space Center. This project and other planned repair-by-replacement projects will replace old, inefficient buildings with smaller, more efficient buildings.

Demolition projects are underway to dispose of unneeded facilities.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Planned CoF activities are detailed below.

Institutional Discrete Construction of Facility Projects

Discrete construction of facilities projects are those with initial cost estimates of $10 million or greater.

REPLACE ASBESTOS SIDING (BUILDINGS 4755/4619)

Location: Marshall Space Flight Center, Alabama
FY 2014 Construction Estimate: $12.4 million

Scope/Description

This project will replace the exterior asbestos-transite siding on Building 4755 (Flight Hardware Development Facility) and Building 4619 (Structures, Dynamics & Thermal Vacuum Lab) with new insulated metal siding that will provide a safer, healthier and more energy efficient facilities. This project will be planned, designed, and constructed incorporating sustainable design principles to reduce lifecycle costs, implement pollution prevention, minimize impact on natural resources, and maximize occupant health, safety, and productivity to the maximum extent possible.

Basis of Need

Buildings 4755 and 4619 are ranked as "Critical" on the Mission Dependency Index. Recent asbestos siding failures have heightened the concern for the potential of more extensive failures. The aged siding on both B4619 and B4755 was designed in accordance with early 1960 design codes and has weakened over the years due to age. Current codes would require the siding to withstand a wind load that is over 25 percent higher than those of the 1960's. Failures in these critical facilities supporting multiple functions including environmental critical rooms and development areas would have a major impact on mission and program requirements. These buildings provide a strong Research and Development and manufacturing technology/innovation organization of skilled scientists and engineers with one-of-a-kind facilities in which to develop new technologies that are applicable to a broad spectrum of programs and projects. These buildings include more than 60 research cells. Due to the nature of the hardware that is handled in this area, the risk to property damage is extremely high should the siding fail. The recent damage to the B4619 asbestos siding was not caused by what would be considered very severe weather for this region. The wind speeds that damaged the building were recorded at 45 miles per hour.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$0.7M	Design	02/2012	02/2013
Related Equipment	N/A	Construction	03/2014	09/2015
Activation	N/A	Activation	N/A	N/A

INSTITUTIONAL COF

CENTRAL CAMPUS PHASE 1 CONSTRUCT REPLACEMENT SHARED SERVICES AND OFFICE BUILDING AND KENNEDY DATA CENTER

Location: Kennedy Space Center, Merritt Island, Florida
FY 2014 Construction Estimate: $39.0 million; Total Construction FY 2013 to FY 2014 is $84 million

Scope/Description

Central Campus Phase 1 provides for the design, construction, and outfitting of an administrative office building and a shared services facility, and the Kennedy Data Center (KDC). It is estimated to cost $84 million and is budgeted over a two-year period ($45 million in FY 2013 and $39 million in FY 2014). The project will use a design-bid-build acquisition strategy. The new administrative building will be capable of easily adding future phases with minimal disruptions to occupants. Site improvements include upgrades to the utilities infrastructure and existing pedestrian walkways, and limited modifications to the surrounding roads and parking lots. All Central Campus facilities will strive to achieve platinum certification requirements of the United States Green Building Council Leadership in Energy and Environmental Design (LEED). This project is in alignment with the approved Agency Master Plan.

Basis of Need

Central Campus is a twelve-year approximately $300 million project to replace, consolidate and right-size administrative, laboratory, shared services facilities and data centers currently scattered across the industrial area of the Kennedy Space Center. The project will enable deconstruction of approximately 900,000 square feet of physical plant that will be between 50 to 60 years old by the time it is deactivated and deconstructed.

These facilities have obsolete, unreliable, and inefficient facility systems that frequently break down and disrupt operations. Most of these facilities do not have sprinkler systems and many of the fire alarms, smoke detection systems, and fire exits are not code compliant. These buildings typically have hazardous materials such as asbestos, polychlorinated biphenyls ballasts, mercury thermostats, and lead, chromium, and cadmium based paints. These hazardous materials make major renovations and routine maintenance activities very costly.

Central Campus replaces about fifty percent of the demolished square footage with modern, energy efficient and environmentally responsible facilities in a pedestrian friendly campus environment. Each phase of Central Campus will be a complete and usable segment of the overall plan and will not rely on future funding for its implementation. The plan is formulated to provide very flexible options for the future. Future phases will only be pursued in response to firm housing and technical requirements, and the plan can be easily modified to react to future funding availability.

INSTITUTIONAL COF

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$3.4M	Design (Design-Bid-Build)	08/2012	07/2013
Related Equipment	$0.2M	Construction	01/2014	06/2016
Activation	$0.2M	Activation	01/2015	12/2016
Other	$1.4M			

SANITARY SEWER SYSTEM RECAPITALIZATION

Location: Stennis Space Center, MS
FY 2014 Construction Estimate: $10.0 million

Scope/Description

This project provides for refurbishments to the sanitary sewer system at Stennis Space Center, including the following items:

- Refurbishment of the South Lagoon to accommodate flow requirements and to increase retention time for proper sewage treatment;
- Replace and upgrade Energy Management and Control System, electrical and mechanical equipment as required; (c) Modify gravel access road as necessary; and
- Replacement of outdated lift stations and deteriorated sections of sewage piping.

Basis of Need

Existing piping and equipment is original construction, has exceeded life cycle, and has become unreliable and beyond economic repair. Replacement of equipment is required to provide continued reliability, accommodate current flows, maintain proper retention time, and prevent environmental excursions. Also, under the current configuration, retention time within the lagoon has been less than required through Environmental Protection Agency permitting on many occasions. There is loss of reliability with many lift stations because the old concrete and steel wells are deteriorating and need to be replaced with new fiberglass wells. Installation of EMCS capability for approximately 40 lift stations site-wide is needed to prevent excursions from high levels. Also, deterioration of piping has allowed for inflow and infiltration in the base gravity system allowing for excess storm water to be transferred into the lagoons. When excursions do occur, fines of $25,000 per day per excursion can be incurred and potential shutdown of entire system.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$0.7M	Design (Design-Bid-Build)	01/2013	04/2013
		Construction	05/2013	07/2015

INSTITUTIONAL COF

B1194 RENOVATION: DATA CENTER AND HIGH DENSITY OFFICE SPACE

Location: Langley Research Center, Hampton, VA
FY 2014 Construction Estimate: $26 million

Scope/Description

This project will renovate the B1194 Floyd L. Thompson Technical Library into a mixed-use facility consisting of a consolidated center-wide data center and high-density office space. This three story structure totaling approximately 50,000 square feet, was originally constructed in 1942, and includes two additions executed between 1985 and 1990. The renovation will pursue U.S. Green Building Council LEED silver certification at a minimum. The plan includes modifications to maximize the usable space inside the existing building shell, including extending the second floor across the width of the building. Once completed this project will allow the colocation of numerous Center personnel in B1209 and B1268, and will relocate and consolidate the computer data centers currently housed in B1268. B1209 will be demolished and the vacated space in B1268 will be repurposed. While the net yearly cost savings will be modest, only about $0.4 million net, the project will significantly reduce the Center footprint by 67,500 square feet.

Basis of Need

In 2011 Langley Research Center (LaRC) commissioned a study of LaRC data centers focused on consolidation in support of the June 10, 2010 Presidential Memorandum, "Disposing of Unneeded Federal Real Estate”.

The LaRC study identified 37 data centers, including the Science Mission Directorate’s Atmospheric Science Data Center that could be consolidated into a single location. Consolidation allows advanced monitoring systems and results in improved efficiencies in the areas of power consumption (decreasing the center’s Power Use Effectiveness from 3.0 to 1.6), cooling and humidity control requirements, reliability and capacity optimization. At present, there is no single facility at LaRC with the necessary infrastructure and 18,000 sq. ft. necessary to meet the full requirements for consolidation. Building 1194 is the prime candidate for renovation in support of the data center consolidation effort as it is structurally sound, underutilized, and located within the Center’s core campus area.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$1.0M	Design	02/2013	01/2014
Outfitting	$5.0M	Construction	03/2014	12/2015
Activation	N/A	Activation	01/2016	03/2016

INSTITUTIONAL COF

REPAIR BY REPLACEMENT OFFICE BUILDING 4221

Location: Marshall Space Flight Center, Alabama
FY 2014 Construction Estimate: $39.4 million

Scope/Description

The Repair by Replacement Office Building 4221 is the second major replacement building in Marshall Space Flight Center's (MSFC) Main Administrative Complex. This facility completes the northern end of the North Campus consistent with the Center Master Plan. Building 4221 will replace the 50 year old Building 4201 with an energy and operationally efficient office structure. The building will provide state-of-the-art office space for approximately 450 people. The facility will meet LEED Silver criteria, as well as the MSFC standard energy conservation requirements to ensure low operating costs for the life of the facility. This project will include the demolition of building 4201 in FY 2016, totaling approximately 111,000 square feet and will eliminate over $4.5 million of deferred maintenance.

Basis of Need

The new building will replace a deteriorated, high-maintenance, high operating cost building. It will provide state-of-the art offices to allow the efficient consolidation and co-location of a multi-discipline work force that has been widely dispersed throughout MSFC thereby improving functional efficiency and coordination between the various operations. Building 4201 was originally constructed in 1964 and is not suitable for a renovation due to its advanced age, its configuration, the presence of friable asbestos, and code compliance issues. A replacement facility is a cost effective solution that will provide significant operating and energy cost savings, will eliminate numerous environmental and Americans with Disabilities Act (ADA) compliance problems, will provide a state-of-the-art office facility at MSFC, and will eliminate significant deferred maintenance. Construction of this new building at this location and the subsequent demolition of Building 4201 are both consistent with the MSFC Master Plan.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$1.0M	Design	02/2013	01/2014
Outfitting	$5.0M	Construction	03/2014	12/2015
Activation	N/A	Activation	01/2016	03/2016

INSTITUTIONAL COF

REPAIR BY REPLACEMENT OF THE LOGISTICS AND MAINTENANCE BUILDING 351 PHASE 2

Location: Glenn Research Center, Cleveland, Ohio
FY 2014 Construction Estimate: $12.2 million; Total Construction FY 2013 to FY 2014 is $19 million

Scope/Description

This project will replace the aging Maintenance and Repair Building 107. The project work scope includes the construction of approximately 43,100 square feet of maintenance, shop, office, warehouse, and laboratory space to be located in the Glenn Research Center (GRC) West Campus along Cryogenic Road. The project consists of building additions to the east and west sides of the Logistics and Maintenance Building 351. These additions include high-bay shop, warehouse and vehicle storage areas, maintenance areas, office and storage areas and laboratory facilities. Included in the project scope are site work, surface parking, and access for maintenance and employee vehicles, and the extension of underground utilities. The building additions will be designed to achieve a minimum LEED Gold rating and to comply with current Life Safety and ADA requirements. This project is phase two of an overall $19 million project.

Basis of Need

The Maintenance and Repair Building 107, constructed in 1963, is inefficient and beyond its useful life. This building houses maintenance employees and equipment but does not have a fire suppression system. The building is also plagued with drainage problems. In addition, the approved Glenn Research Center Master Plan places a high priority on the relocation of all facilities and operations currently located on the eastern property line. This property line is adjacent to the publicly accessible West Airport Hangar Road, and the facilities there create a security risk to GRC. Building 107 is located within a few feet of this public access road, which leaves GRC extremely vulnerable to threat. Demolition of Building 107 will mitigate the security and safety concerns posed by this situation and eliminate the backlog of maintenance and repair requirements.

Funding for this project will advance the Master Plan goals of consolidating maintenance and warehousing operations into the West Area. It will allow for the replacement of inefficient buildings with new sustainable facilities. This repair by replacement project will also allow GRC to get closer to its goals related to the reduction of real property and infrastructure and advance the consolidation of research support functions to promote efficient Center Operations.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$0.9M	Design	09/2012	09/2013
Related Equipment	N/A	Construction	03/2014	04/2015
Activation	$1.0M	Activation	05/2015	08/2015

INSTITUTIONAL COF

UPGRADE SYSTEMS, INDUSTRIAL AREA CHILLER PLANT (IACP)

Location: Kennedy Space Center, FL
FY 2014 Construction Estimate: $11.5 million

Scope/Description

This project provides upgrades for mechanical and electrical systems at the Industrial Area Chiller Plant (IACP). The scope consists of chilled water production upgrades including; replacing the three-celled O&C cooling tower B, replacing motor control centers and variable frequency drives, replacing refrigerant-22 chillers, performing safety modifications to the interconnecting primary pumps, adding additional facilities to the Industrial area loop, and building modifications to increase chilled water supply temperature. The project has an option to construct a 6.4 million gallon concrete chilled water thermal energy storage system that will reduce chilled water production cost. The additional chilled water storage will also provide emergency loop fill capability in the event of an unplanned water loss.

The project will replace existing chillers with smaller and more efficient machines that will allow a more flexible operation that more accurately matches load profiles to reduce equipment wear and operational costs; replace cooling tower B with a larger and more efficient type, adding additional sustainable technologies such as drift eliminating louvers and variable speed drives; and increase reliability, reduce safety hazards, and reduce energy burdens on the center.

Basis of Need

This project is necessary to allow the continued operations of the KSC Industrial Area Chiller Plant to supply vital chilled water and compressed air to major Industrial Area Program direct processing, research labs and administrative facilities. The chiller plant currently serves approximately 3,800 personnel in the following facilities: Space Station Processing Facility (SSPF), Operations and Checkout Facility (O&C), Headquarters, Communication and Instrumentation Facility, Payload Support Building, Training Auditorium, Engineering Development Laboratory, and the Occupational Health Facility. The new Central Campus and Kennedy Data Center (KDC) will receive chilled water for HVAC and dry compressed air for labs and workshops in its entirety from the Industrial Area Chiller Plant. Failure of the IACP would adversely affect processing of mission essential flight hardware in the SSPF and O&C, sensitive lab environments, and administrative facilities located throughout the Industrial Area.

Originally constructed in 1964, Cooling Tower B supplies condenser water to the chiller plant’s six chillers. The existing cooling tower B structure and fill is fatigued with extensive spalling and cracking. Repeated sealing of the concrete has not successfully protected underlying rebar and full replacement is necessary to repair damaged columns. There is no full capacity back up, or redundancy, during peak operations. Tower B currently limits the plant’s overall redundancy due to its smaller capacity. Loss of a single cell impacts the plant’s cooling capabilities. Mechanical and electrical rotating equipment related to the cooling tower are severely deteriorated and unsupported by the manufacturer, requiring custom rebuilds by on-site shops. Equipment can only be re-built a finite number of times before requiring full replacement.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$1.5M	Design	09/2012	09/2013
Related Equipment	$0.2M	Construction	12/2013	10/2015
Activation	$0.1M	Activation	09/2015	04/2016

Minor Revitalization and Construction of Facilities

Minor revitalization and construction of facilities projects have initial cost estimates between $1 million and $10 million. These projects revitalize and construct facilities at NASA facility installations and government-owned industrial plants. Revitalization and modernization projects provide for the repair, modernization, and/or upgrade of facilities and collateral equipment. Repair projects restore facilities and components to a condition substantially equivalent to the originally intended and designed capability. Repair and modernization work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. Modernization and upgrade projects include restoration of current functional capability and enhancement of the condition of a facility so that it can more effectively accomplish its designated purpose, increase its functional capability, or so that it can meet new building, fire, and accessibility codes.

The FY 2014 request includes $20 million dollars for projects focused on investments to improve the energy efficiency of existing facilities and operations.

The minor revitalization and construction projects that comprise this request are of the highest priority, based on relative urgency, and expected return on investment. During the year, some rearrangement of priorities may be necessary, which may cause a change in some of the items to be accomplished.

EnergySavings Investments, $20 million
Utility metering, primarily gas/steam, VariousCenters
Energy efficiency improvements, Langley Research Center
Greening Building 1100, Stennis Space Center
Upgrade Building 24 plant controls, Goddard Space Flight Center
Lighting and Occupancy Sensors, Glenn Research Center
Water Treatment and Eliminating single-pass cooling, Marshall Space Flight Center
Retro commissioning Buildings 4487 and 4610, Marshall Space Flight Center

INSTITUTIONAL COF

Minor Revitalization and Construction Projects by Center, $141.5 million

Ames Research Center (ARC), $25.5 million
Restore Electrical Reliability for Multiple Facilities
Restore Power Supply Reliability of Arc Jet Facility
Reduce Seismic Risk to Unitary Plan Wind Tunnel Make Up Air System
Restore Electrical Distribution System-High Voltage

Dryden Flight Research Center (DFRC), $27.0 million
Revitalize Radar & Telemetry Tracking Infrastructure
Repair Research Aircraft Integration Facility Mechanical Systems
Repair Aircraft Hangar Fire Protection Systems
Repair by Replacement: Vehicle & Aircraft Ground Equipment Maintenance

Glenn Research Center (GRC), $19.4 million
Lewis Field Storm Sewer System Repair, Phase 1
Repair Electrical Distribution Systems, Phase 2
Repair Central Compressed Air Equipment, Phase 1

Goddard Space Flight Center (GSFC), $20.2 million
Modifications to Building X-75, Wallops Flight Facility
Upgrades to Main Base Water Treatment System, Wallops Flight Facility
Replace Island Primary Electrical Feeder, Wallops Flight Facility
Replace Primary Electrical System Infrastructure, Greenbelt
Replace Fire Island Station, Wallops Flight Facility

Jet Propulsion Laboratory (JPL), $4.5 million
Upgrade/Repair Critical 16.5 KV Electrical Distribution System

Johnson Space Center (JSC), $9.2 million
Replace High Voltage Electrical Feeders and Switches, Site Utility Tunnel
Replace Central Heating and Cooling Plant Boilers and Associated Blowdown Equipment (24)

Langley Research Center (LaRC), $12.5 million
Electrical Distribution System Upgrades
Repair by Renovation of the Sensor Systems Lab in B1200

Marshall Space Flight Center (MSFC), $15.0 million
Revitalize Building Electrical System (4619)
Revitalize Building Mechanical System (4755)

Stennis Space Center, $8.2 million
Refurbish Canal Lock Water Replenishment Pumping System
Refurbish Hydrogen Generation System
Repair Bascule Bridge

INSTITUTIONAL COF

Demolition of Facilities

FY 2014 Estimate: $20.0 million

NASA will use the requested funding to eliminate inactive and obsolete facilities that are no longer required for NASA's mission. Abandoned facilities pose potential safety and environmental liabilities and are eyesores at the Centers. The Agency must maintain the these facilities at minimal levels to prevent increasing safety and environmental hazards and these recurring maintenance costs impose a drain on the limited maintenance dollars available at the Centers. Demolishing these abandoned facilities allows the Agency to avoid non-productive operating costs required to keep abandoned facilities safe and secure. Furthermore, demolition is the most cost-effective way to reduce the Agency deferred maintenance.

NASA identifies facilities for the demolition program through special studies to determine if the facility is required for current or future missions. Facilities that are no longer needed are included in a five-year demolition plan that sets project schedules based on last need, annual costs avoided, potential liability, and project execution factors. Individual project schedules may be adjusted due to consultation with states on historic properties, changes in operational schedules, environmental remediation, funding profiles, local market forces, and the value of recycled materials.

Facility Planning and Design

FY 2014 Estimate: $33.4 million

Facility planning and design funds provide for advance planning and design activities, special engineering studies, facility engineering research, preliminary engineering efforts required to initiate design-build projects, preparation of final designs, construction plans, specifications, and associated cost estimates associated with non-programmatic construction projects. This includes master planning; value engineering studies; design and construction management studies; facility operation and maintenance studies; facilities utilization analyses; engineering support for facilities management systems; and capital leveraging research activities. Funding also supports participation in facilities-related professional engineering associations and organizations.

The facilities planning and design activity is crucial to the implementation of NASA recapitalization strategy. These recapitalization projects are necessary to make progress toward required sustainability, energy, and stewardship goals.

EXPLORATION COF

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	71.0	--	**142.3**	0.0	0.0	0.0	0.0
Change from FY 2012	--	--	**71.3**				
Percentage change from FY 2012	--	--	**100.4 %**				

The "clean pad" design concept for Launch Complex-39B at KSC will improve NASA's flexibility to support different classes of launch vehicles (LV) at the same launch complex. With less overall permanent infrastructure to operate and maintain, it requires a "mobile launcher" component where all prelaunch assembly and servicing of a LV and spacecraft occurs elsewhere and is then brought to the launch pad. Only propellant loading and final countdown operations happen at the pad, eliminating the need for large access and auxiliary service equipment. The Ares I mobile launcher, shown mounted at the pad, will be modified to support NASA's Space Launch System and commercial launch vehicles.

Exploration CoF provides construction required to achieve Space Launch System (SLS), Orion Multi-Purpose Crew Vehicle (MPCV), and Exploration Grounds Systems program activities. Funds required for the planning and design of out-year programmatic construction remain in the applicable program accounts.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

NASA demolished platforms in high bay 3 of the Vehicle Assembly Building (VAB) that supported the Space Shuttle Program, paving the way for new platforms to be installed to support SLS vehicle integration. Additional Vehicle Assembly Building work included an upgrade of the 175-ton Transfer Aisle Crane controls and minor safety-related structural repairs.

NASA demolished the Fixed Service System and Rotating Service System at Launch Complex 39B (LC-39B). The demolition allows for a "clean pad" for use by the SLS and future commercial spacecraft. Additional work at LC-39B included:

- Repairs to the 300,000-gallon, 285-foot tall water tower;
- Roof repair and replacement of the fire extinguishing and water piping; and
- Design for the demolition of the Flame Deflector and Flame Trench Area.

Modifications and upgrades to the Multi-Payload Processing Facility at Kennedy Space Center to a Class 100,000 clean room began, which will allow for processing of the Orion MPCV spacecraft at the Center. At Michoud Assembly Facility (MAF), modifications required to transition from legacy tooling and manufacturing of the Space Shuttle External Tank to tooling and manufacturing necessary for the SLS

EXPLORATION COF

Core Stage began. Initial modifications at the facility included the modifications to building 131 to support thermal protections systems application, as well as the cleaning and priming of liquid oxygen and liquid hydrogen tanks. NASA also modified Building 451 to support liquid hydrogen tank proof testing.

Restoration of the B-2 Test Stand at Stennis Space Center to support SLS proto-flight testing began with the demolition of unsafe structures throughout the Test Stand. Funding for the first phase of this $168.0 million discrete project was approved through two operating plan changes in FY 2012.

WORK IN PROGRESS IN FY 2013

Much of the work started in FY 2012 on the B-2 Test Stand continues into FY 2013. The majority of the construction work will occur in FY 2013 and will include completion of necessary demolition work. The level 7 new rolling deck will be completely replaced, and the derrick crane, flame deflector bucket, thrust takeout, support structures, ancillary structures, propellant systems, piping systems, mechanical systems, electrical systems, and data systems will all be modified and refurbished. Finally, a new structure will be added to top of the test stand to accommodate the length of the SLS Core Stage. Funding for the proposed FY 2013 work was approved in December 2012.

The modifications to LC-39B will continue to be a major effort at Kennedy Space Center with work on the flame deflector and flame trench area. Work at the Vehicle Assembly Building, Launch Control Complex, and Utility Annex will also continue in FY 2013 to prepare for SLS and other commercial customers.

At MAF, modifications to existing facilities to support SLS Core Stage manufacturing will continue. This includes major structural changes to the main manufacturing building at MAF, building 103, and modifications to building 110 cells E and F for Core Stage tank cleaning.

SLS will begin construction of two new Structural Test Stands at the Marshall Space Flight Center (MSFC). Test Stand 4693 will support testing of the SLS Core Stage liquid Hydrogen tank and Test Stand 4697 will support testing of the SLS Core Stage liquid Oxygen tank.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Major work in FY 2014 includes the construction of the new platforms in VAB High Bay-3 to support the SLS vehicle. The project utilizes an adjustable platform concept for High Bay-3 instead of the traditional fixed platforms for a specific spacecraft. The new platforms will adjust in height to accommodate servicing the SLS or other vehicles, such as other commercial spacecraft. Additionally, chiller and boiler upgrades at the Utility Annex are also planned.

Major work planned for the LC-39B complex includes the refreshment of the Environmental Control System and Ground Cooling Systems necessary to support SLS and other Commercial launch vehicles on the Pad.

At Stennis Space Center, the final phase of the High Pressure Industrial Water piping replacement is planned. This phase will completely replace the large diameter underground piping and valves that provide fire protection and cooling water to the entire A-test complex at Stennis Space Center.

EXPLORATION COF

Discrete Projects

Discrete projects are construction projects with initial cost estimates greater than $10 million.

MODIFICATIONS TO LAUNCH COMPLEX 39-B

Location: Kennedy Space Center,
FY 2014 Construction Estimate: $13.9 million, Total Project FY 2010 to FY 2016 is $86.5 million

Scope/Description

The project modifies and upgrades Launch Complex 39 Area to support launching of the NASA SLS, Orion MPCV crew vehicle, and other launch vehicles. This project repairs and modifies selected facility systems at Launch Complex 39B to enable SLS and Orion processing and launch operations. Examples of project work elements include repairs to the pad surface and catacomb roof, modifications to the sound suppression system, modifications to replace the liquid oxygen vaporizer system, pad modifications to the interfaces with the new Mobile Launcher, replacement of fire and potable water piping systems, and refurbishment of the HVAC and control systems. Other planned work elements include modifications to the lightning protection and weather systems, refurbishment and modification of the flame trench, and replacement of the main flame deflector system.

This is the third phase of a four-phased project budgeted at $86.5 million. This phase includes Modification of Ground Cooling System, Refurbishment of Environmental Control System and Upgrade Communication Infrastructure, LC-39B.

As SLS technical requirements mature, NASA may add, delete, or substitute, individual work elements within the project. NASA will update the scope/description of the project in the President’s budget for each subsequent year if any such adjustments are made.

Basis of Need

The modifications and new construction are mandatory to transform the Launch Complex 39 from the Shuttle Program to meet the requirements for SLS, Orion MPCV, and other multi user launch vehicle operations and programs. Launch Complex 39 is over 40 years old and the deteriorated condition and inadequate configuration of many of the systems and infrastructure will not support use for the new launch program without the extensive repairs, modifications, and upgrades identified above. Failure to implement this project will seriously impact our ability to transition and sustain the use of this launch complex to support SLS and Orion MPCV.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$8.0M	Design	04/2009	06/2012
Related Equipment	$0.5M	Construction	04/2011	05/2012
Activation	$3.5M	Activation	04/2015	06/2016

EXPLORATION COF

MODIFICATIONS TO VEHICLE ASSEMBLY BUILDING, LAUNCH CONTROL CENTER, & VAB UTILITY ANNEX AREA

Location: Kennedy Space Center,
FY 2014 Construction Estimate: $99.2 million, Total Project FY 2010 to FY 2016 is $138.9 million

Scope/Description

This project repairs and modifies selected facility systems in the VAB, Launch Control Center (LCC), and Vehicle Assembly Building Utility Annex area to enable SLS, Orion MPCV, and other customer's processing and launch operations. Examples of project work elements in the VAB and LCC include demolition and removal of the existing Shuttle platforms and installation of a new platform system in High Bay 3, replacement of the fire suppression water supply distribution system supporting the VAB, refurbishment of the low voltage systems in Towers D & F of the VAB, repair of the VAB concrete ceiling, refurbishment of the VAB 175-ton bridge crane, repair and modification of the chilled/hot/potable water piping systems in the VAB, and a variety of other miscellaneous infrastructure and facility system repairs throughout the VAB and LCC complex including modification of the fire suppression water supply to the LCC. The project also includes system upgrades in the UA to improve energy efficiency, reduce operations and maintenance costs, and provide right-sized equipment capacity to support future program needs.

This is the third of a 5-phased project currently budgeted at $138.9 million, including $13.3 million in FY 2012, $15.7 million in FY 2013, $99.2 million in FY 2014, $5.7 million in FY 2015 and $5.0 million in FY 2016. This phase is to construct a re-configurable high bay facility to process, integrate and the assembly of the SLS launch vehicle and other future customers.

As SLS technical requirements mature, NASA may add, delete, or substitute, individual work elements within the project. NASA will update the scope/description of the project in the President's budget for each subsequent year if any such adjustments are made.

Basis of Need

The VAB is a 50-story building with multi-level access platforms and associated support infrastructure. Facility systems such as power, water, compressed gasses, communications, and fire suppression, are located inside the building to support rocket assembly operations. The Utility Annex supplies the Vehicle Assembly Building, LCC, and other facilities in the LC-39 area with hot water, chilled water, compressed air, and fire suppression water. Launch operations are controlled within the LCC, which is physically attached to the building. The repairs and modifications provided by this project must be completed in time to support future SLS and Orion MPCV launches because there are no other facilities that have the size or capabilities necessary to otherwise support SLS and Orion MPCV assembly operations.

The VAB is uniquely designed to receive, assemble, integrate, process, and service large, complex launch vehicles. No other facility in the United States has this basic capability. The VAB must be reconfigured from the current Shuttle-support configuration to a configuration that can support the SLS, Orion MPCV, and other potential customers. This includes modifications of the supporting utility systems as well as the facility itself. In addition, the fire suppression system in the VAB is about 50 years old and the piping has experienced significant internal corrosion, affecting the flow capacity and causing leaks that cumulatively amount to about 5,000 gallons per week. The system is no longer serviceable in its current state and NASA will restore it to meet National Fire Protection Association life-safety code standards.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$9.0M	Design	04/2011	02/2013
Related Equipment	$1.0M	Construction	06/2012	06/2016
Activation	$4.0M	Activation	05/2015	09/2016

HIGH PRESSURE INDUSTRIAL WATER PIPING REPLACEMENT

Location: Stennis Space Center, MS
Estimated Costs: $22.0 million, Total Project FY 2012 to FY 2014 is $48.0 million

Scope/Description

This project will completely replace the High Pressure Industrial Water (HPIW) underground piping servicing the A and B Test Complexes. The B Test Complex piping system will be replaced including the 96-inch valve/valve pit up to and including the B Test Stand manifold and risers. The A Test Complex piping system will be replaced, including the 75-inch valve and valve pit , the A2 isolation valve, A1 isolation valve, and piping up to the base of the A1 and A2 Test Stands. This construction effort will be phased on a non-interference basis and will be performed over a 3-year period with minimal impact to testing activities in support of NASA's mission.

Basis of Need

The HPIW system provides cooling water and fire protection for the five test stands in the A & B Complexes (A-1, A-2, A-3, B-1, and B-2), which are planned to conduct testing over the next 20 years and beyond. The HPIW system is a critical facility that was activated in 1965 and is necessary to support all of Stennis Space Center's engine system static test stands in the A & B Complexes. Based on a recent analysis (2009), the life expectancy of the current HPIW system is expected to be approximately seven to eight years.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$3.0M	Design	08/2010	10/2012
Related Equipment	N/A	Construction B-Leg	02/2013	10/2014
Activation	N/A	Activation B-Leg	10/2014	10/2014
Other	N/A	Construction A-Leg	01/2015	08/2016
		Activation A-Leg	08/2016	08/2016

EXPLORATION COF

Exploration Minor Revitalization and Construction Projects, $7.2 million

Construction projects with initial cost estimates between $1 million and $10 million are included as minor revitalization and construction projects. These projects provide for the repair, modernization, or upgrade of facilities and collateral equipment required by Exploration activities. Repair projects restore facilities and components to a condition substantially equivalent to the originally intended and designed capability. Repair and modernization work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. Modernization and upgrade projects include both restoration of current functional capability and enhancement of the condition of a facility, so that it can more effectively accomplish its designated purpose, increase its functional capability, or so that it can meet new building, fire, and accessibility codes. Planned projects are:

- Replace Production Wastewater Process Tanks, Phase 2, MSFC/MAF;
- Rehab Chilled Water/Steam Distribution Piping, MSFC/MAF;
- Replace Containment Area Liners, MSFC/MAF; and
- Modifications LAS Facility, Phase II, KSC.

SPACE OPERATIONS COF

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
FY 2014 President's Budget Request	56.7	--	**26.2**	0.0	0.0	0.0	0.0
Subtotal	56.9	--	**26.2**	0.0	0.0	0.0	0.0
Rescission of prior-year unob. balances*	-0.2	--	**--**	--	--	--	--
Change from FY 2012	--	--	**-30.5**				
Percentage change from FY 2012	--	--	**-53.8 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

High Bay 3 in the Vehicle Assembly Building (VAB) at KSC is being transformed into a state-of-the-art vehicle integration facility to support future launch vehicles. Eight box-like support structures that surrounded the shuttles during stacking, like the ones pictured here, had to be removed and demolished. They will be replaced with new stands that can be configured to accommodate integration of a variety of new launch vehicles over the next 30 years. This work is part of a five-year project to refurbish and modernize the VAB.

Space Operations CoF provides construction to support 21st Century Space Launch Complex (21st CSLC), Space Communications and Navigation (SCaN), and Launch Systems. Funds required for planning and design of out-year programmatic construction remain in the applicable program accounts.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

21st Century Improvements for the Kennedy Launch Complex included upgrades of lighting and mechanical systems at various facilities that reduce energy and operations costs. NASA awarded the contract for Modifications and Improvements to the 48-year-old gravel path utilized for a special tracked vehicle to transport the mobile launcher, with the stacked rocket and spacecraft, from the VAB to the launch pad. Work will begin on this project in FY 2013.Designs were completed to replace cooling towers and other major HVAC systems at the Booster Fabrication Facility. Many other designs were completed to improve the infrastructure along with environmental studies and assessments that will aid in the remediation of hazardous areas throughout the Center.

SPACE OPERATIONS COF

For SCaN, the new Canberra, Australia 34-meter antenna pedestal was completed and the azimuth track and pintle bearing were installed. At Goldstone, the HVAC Energy Savings Contract was completed, and the Site Wide Uninterruptible Power Supply became fully operational. In Madrid, the Fire Detection and Fire Protection projects were completed.

WORK IN PROGRESS IN FY 2013

Much of the work started in FY 2012 continues into FY 2013.

Other minor construction projects at the KSC will improve the KSC launch infrastructure to transition the center into the 21st Century. These include mechanical, electrical, and lighting upgrades throughout KSC.

Work on the 34-meter antenna at Canberra will continue, as will fire protection upgrades for the Canberra complex. Work on the 80KW transceiver for the DSS-26 Facility in Goldstone will commence.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

The minor program will continue the effort to turn NASA's former Space Shuttle launch facilities at the Kennedy Space Center into a 21st Century launch complex to efficiently and effectively support programs, such as SLS, Orion MPCV and other commercial operators.

At Goldstone, the planned work is to replace the azimuth tracks for two 34-meter antennas, as well as repair the spur roads and parking lots. Construction will continue on facilities to support the new high power transmitter at one of the 34-meter antennas. At Madrid, construction will start on facilities to support the new high power transmitter at one 34-meter antenna. Additionally, a network-wide start to replace the 34-meter antenna chilled water systems is planned.

Discrete Projects

Discrete projects are construction projects with initial cost estimates greater than $10 million.

CONSTRUCTION OF 34 METER BEAM WAVE GUIDE ANTENNAS

Location: Canberra Deep Space Communications Complex, Canberra, Australia
FY 2014 Construction Estimate: $11.0 million, Total Project FY 2010 to FY 2017 is $79.8 million

Scope/Description

This project constructs two new 34-meter beam wave guide (BWG) antennas at the Canberra Deep Space Communications Complex (CDSCC) with an option to build a third. The basic contract provides for the initial construction two 34-meter BWG antennas, DSS-35 and DSS-36. The third antenna, DSS-33, will be an option to the contract. As DSS-33 is an option, actual location and approach to construction for this antenna are yet to be determined.

The project is divided into three contracts: excavation and roads, site infrastructure, and antenna related facilities. The funding for fiscal year 2014 is $11.0 million dollars of the total $79.8 million.

The project includes the fabrication and installation of the antenna structures, panels, gearboxes, bearings, electric drives, encoders, beam waveguide mirrors, sub-reflectors and positioners, and related servomotors. The project also includes the construction of the pedestals, as well as all facilities in and around the antennas, including the paved access road, trenches, drainage, flood control devices, water main and distribution system, antenna apron, perimeter security fence, HVAC systems, electrical power distribution, fire detection and suppression system, and surveillance system assembly.

Basis of Need

The construction of these antennas is planned as Phase 1 of the SCaN 70-meter Antenna Replacement Project. Analysis of outer planet declinations reveals a growing bias toward the southern declination well into the 2020's. It is projected that spacecraft mission needs in the southern hemisphere will begin to overload the capacity at the CDSCC by 2015. This project is necessary to allow beam wave guide antennas to add resilience in the southern hemisphere for the Deep Space Network. Additionally, the 70-meter antennas at each Complex are reaching end of service. This project will support additional mission loading from projects currently under development and scheduled for launch in 2015 and beyond.

Other Related Costs	Amount	Estimated Schedule	Start	Complete
Studies/Design	$0.5M	Design	09/2009	10/2010
Related Equipment	N/A	Construction, DSS-35	09/2010	10/2013
Activation	N/A	Activation, DSS-35	09/2014	09/2014
Other	N/A	Construction, DSS-36	10/2012	11/2015
		Activation, DSS-36	12/2016	12/2016

Space Operations Minor Revitalization and Construction Projects, $15.2 million

Construction projects with initial cost estimates between $1 million and $10 million are included as minor revitalization and construction projects. These projects provide for the repair, modernization, or upgrade of facilities and collateral equipment required by Space Operations activities. Repair projects restore facilities and components to a condition substantially equivalent to the originally intended and designed capability. Repair and modernization work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. Modernization and upgrade projects include both restoration of current functional capability and enhancement of the condition of a facility, so that it can more effectively serve its designated purpose, increase its functional capability, or so that it can meet new building, fire, and accessibility codes.

- Replace BWG Azimuth Tracks 34m Subnet, Goldstone Deep Space Communications Complex (GDSCC)

SPACE OPERATIONS COF

- Repair Road and Erosion Control, GDSCC
- DSS-26 Facilities for 80 kW TXR, GDSCC
- Replace BWG Chillers 34m Subnet, GDSCC
- Lighting Upgrades, KSC
- Mechanical Upgrades, KSC
- Waste Management/Reutilization, KSC
- 21st CSLC Dune Restoration, KSC - Restore and repair of sand dunes along the shore line south of LC-39
- Repair of Interior Renovations/Bldg. 840 Restroom, VAB

ENVIRONMENTAL COMPLIANCE AND RESTORATION

FY 2014 Budget

	Actual			Notional			
Budget Authority (in $ millions)	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	44.8	--	**75.5**	75.5	75.5	75.5	75.5
Subtotal	45.0	--	**75.5**	75.5	75.5	75.5	75.5
Rescission of prior-year unob. balances*	-0.2	--	**--**	--	--	--	--
Change from FY 2012	--	--	**30.7**				
Percentage change from FY 2012	--	--	**68.5 %**				

*Note: * Rescission of prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).*

NASA is working with the Los Angeles County Regional Water Quality Control Board to remove soil from the hillside areas at the Santa Susana Field Laboratory that was contaminated by DOD and NASA rocket engine testing in the 1950s and 1960s. This action prevents runoff of the soil into offsite creeks when it rains and keeps contaminants from leaching into the groundwater. Great care was taken to minimize disturbance to areas with sensitive habitats and to preserve trees.

NASA's Environmental Compliance and Restoration (ECR) program cleans up hazardous materials and wastes that have been released to the surface or groundwater at NASA installations, NASA-owned industrial plants supporting NASA activities, current or former sites where NASA operations have contributed to environmental problems, and other sites where the Agency is legally obligated to address hazardous pollutants. ECR program activities include projects, studies, assessments, investigations, sampling, plans, designs, construction, related engineering, program support, monitoring, and regulatory Agency oversight. Funding also covers land acquisitions necessary to ensure operation of remedial treatment processes and sites as part of remediation and cleanup measures.

For additional information concerning NASA's ECR program, go to: http://www.nasa.gov/offices/emd/home/ecr.html.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

In FY 2012, NASA received final license termination from the Nuclear Regulatory Commission for its recently completed Plum Brook Reactor Facility decommissioning project. This culminated thirteen years of work to safely remove and dispose of materials and structures that remained at the facility after the reactor was shut down in 1973. The decommissioning process at Plum Brook included demolishing the remaining buildings and structures and returning the site to green space (protected area of undeveloped landscape).

As part of other cleanup activities in FY 2012, at the Santa Susana Field Laboratory, the ECR program:

- Completed 90 percent of the soil characterization efforts for the site, which included close coordination with the State of California and five public technical meetings;
- Received closure approval from California for the former groundwater treatment systems; and
- Completed all biological surveys (flora, fauna, habitat, wetlands).

WORK IN PROGRESS IN FY 2013

Major restoration project achievements planned for FY 2013 include:

- Continuation of interim soil cleanups and publication of the environmental impact statement for final soil cleanup at Santa Susana Field Laboratory;
- Implementation of soil and groundwater cleanup actions at MSFC; and
- Completion of source area investigations at White Sands Test Facility.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Key projects and achievements in the FY 2014 request include:

- $20.6 million for investigation and cleanup of contaminated groundwater, soils, and demolition at Santa Susana Field Laboratory in accordance with the consent order with the State of California; planned achievements include completion of the interim soil removal actions, completion of the Environmental Impact Statement, and begin implementing demolition of facilities;
- $12.5 million to operate and maintain systems to clean up contaminated groundwater emanating from Jet Propulsion Laboratory; achievements include installation of 2 new recovery wells, connection of existing backwash system to the treatment facility, and continued operations of the Lincoln Avenue and Monk Hill drinking water treatment systems;
- $9.8 million for continuing investigation and cleanup of groundwater and soil contamination at Kennedy Space Center in accordance with State of Florida requirements; key achievements planned include the installation of 3 new groundwater treatment systems, investigation of 5 additional sites for potential contamination, continued sampling of over 400 monitoring wells, and continued operations of 10 groundwater cleanup systems;
- $11.6 million for continuing cleanup of ground water contamination and investigation of soil contamination at White Sands Test Facility, to comply with the facility permit issued by the State of New Mexico; key achievements include completion of closure activities at 5 sewage lagoons, implementation of the 400 Area Resource Conservation and Recovery Act facility investigation, and continued operation of the plume front and mid-plume ground water treatment systems; and
- $6.8 million to complete the cleanup of the peninsula solid waste disposal site at the Ames Research Center.
- $4.4 million for Functional leadership efforts, including environmental audits required by executive order and hazardous material replacement initiatives in support of NASA mission requirements.

- $8.3 million for continuation and completion of smaller soil and groundwater cleanup projects at multiple centers

Program Elements

RESTORATION

Restoration projects address cleanup liabilities at all NASA Centers and component facilities. As of the start of FY 2012, known liabilities totaled $1.048 billion with many of the individual cleanup projects estimated to take more than 25 years to complete. NASA policy is to address these liabilities using a "worst first" approach to ensure human health and the environment are protected and to facilitate mission readiness. Plans for FY 2014 are based on a prioritized, risk-based approach for incrementally addressing NASA's cleanup portfolio. Projects are ranked according to the relative urgency and the potential health and safety hazards related to each individual cleanup. As studies, assessments, investigations, plans, regulatory approvals, and designs progress, and as new discoveries or regulatory requirements change, NASA expects that program priorities may change.

ENVIRONMENTAL COMPLIANCE & FUNCTIONAL LEADERSHIP

These projects invest in environmental methods and risk reduction practices that ensure NASA may continue to carry out its scientific and engineering missions. This includes methodologies for sustainably reducing energy intensity and greenhouse gas emissions, and supporting operational activities by ensuring that advances in chemical risk management are incorporated early in mission design phases. For example, NASA is working with the European Space Agency on an international agreement to qualify citric acid for passivation of stainless steel, testing environmentally friendly corrosion coatings for launch structures, and qualifying solvent alternatives for precision cleaning processes. Citric acid is considered "environmentally friendly" and would replace more corrosive and hazardous materials, like nitric acid.

Budget Authority (in $ millions)	Actual FY 2012	FY 2013	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	38.3	38.2	**37.0**	37.0	37.0	37.0	37.0

INSPECTOR GENERAL

FY 2014 Budget

Budget Authority (in $ millions)	Actual FY 2012	FY 2013*	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request	38.3	38.2	**37.0**	37.0	37.0	37.0	37.0
Subtotal	38.3	38.5	**37.0**	37.0	37.0	37.0	37.0
Rescission of prior-year unob. balances**	--	-0.3	**--**	--	--	--	--
Change from FY 2012	--	--	**-1.3**	--	--	--	--
Percentage change from FY 2012	--	--	**-3.4%**	--	--	--	--

*Note: * The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175).*

*** Rescission against unobligated American Recovery and Reinvestments Act balances (P.L. 111-203, the "Dodd-Frank Act")*

For FY 2014, the NASA Office of Inspector General (OIG) requests $37.0 million. This request will support the work of 195 auditors, investigators, analysts, specialists, lawyers, and support staff located at NASA Headquarters in Washington, D.C. and 11 other locations throughout the United States

The OIG conducts audits, reviews, and investigations of NASA programs to prevent and detect fraud, waste, abuse, and mismanagement and to assist NASA management in promoting economy, efficiency, and effectiveness.

The OIG Office of Audits conducts independent and objective audits of NASA programs, projects, operations, and contractor activities. In addition, the Office of Audits oversees the work of the independent public accounting firm that conducts the annual audit of NASA's financial statements. Office of Audits reviews target high-risk areas and Agency management challenges, responds to NASA's changing needs and priorities, and provides measurable results that help NASA achieve its space exploration, scientific, and aeronautics research missions.

The Office of Investigations pursues allegations of cybercrime, fraud, waste, abuse, and misconduct related to NASA programs, projects, operations, and resources. The Office of Investigations refers its findings to the Department of Justice for criminal prosecution and civil litigation or to NASA management for administrative action. Through its investigations, the Office of Investigations develops recommendations for NASA management to reduce the Agency's vulnerability to criminal activity. Given that NASA spends approximately 85 percent of its budget on contracts and grants, the Office of Investigations targets its resources to maintaining the integrity of NASA's procurement process and the safety of NASA's missions and information systems. In the procurement area, the Office of Investigations' caseload includes investigations of suspected false claims submitted by NASA contractors, product substitution and counterfeit parts, and conflict of interest cases involving NASA employees who place private gain before public service.

Finally, the Office of Investigations seeks to prevent and deter misconduct at NASA through an aggressive "lessons learned" approach with NASA management. To this end, the OIG works with NASA officials to remedy vulnerabilities within their programs and operations that may have allowed misconduct to occur.

EXPLANATION OF MAJOR CHANGES

None.

ACHIEVEMENTS IN FY 2012

In FY 2012, the Office of Audits issued 27 audit products, and identified $2.5 million in questioned costs and $32.8 million in funds that could have been put to use more effectively.

The OIG's audit products included reports on:

- Cultural and programmatic challenges to meeting cost, schedule, and performance goals across NASA projects;
- NASA's efforts to improve its computer security incident handling capability;
- NASA's ability to transfer technology to the government and private sectors; and
- Oversight of NASA's purchase and travel card programs.

In FY 2012, the Office of Investigations investigated a wide variety of criminal and administrative matters involving procurement fraud, theft, counterfeit parts, ethics violations, and computer intrusions, leading to more than $20 million in criminal, civil, and administrative penalties and settlements. More than $10.4 million of these funds were returned directly to NASA. Overall, Office of Investigations work resulted in 36 indictments, 22 convictions, 26 sentencings, 4 civil settlements, 40 administrative actions, and 7 suspensions and debarments.

Examples of the Office of Investigations' work over the past year include:

- Sentences of 12 and 6 months imprisonment, 3 and 5 years' probation, and over $390,000 in restitution for owners of a company that received more than $3 million in Small Business Innovative Research contracts from NASA;
- $3.3 million civil settlement on allegations that a company included unallowable costs in calculating overhead rates for NASA and national defense-related contracts;
- Indictments of six Estonian nationals and one Russian national in the Southern District of New York for their part in an international computer crime network that hijacked Internet Domain Name System (DNS) servers and manipulated Internet advertising to generate at least $14 million in illicit fees; and
- A sentence of 3 years' probation for a business owner who pleaded guilty to making a false statement concerning space vehicle parts his business supplied to NASA for use on the International Space Station.

WORK IN PROGRESS IN FY 2013

During FY 2013, the OIG will continue to conduct audits, reviews, and investigations of NASA programs and operations to prevent and detect fraud, waste, abuse, and mismanagement and to assist NASA in promoting economy, efficiency, and effectiveness. Ongoing Office of Audits work involves oversight of (1) current and future NASA infrastructure requirements, along with efforts to reduce underutilized technical facilities; (2) organizational barriers to implementation of an effective governance structure for Agency IT resources; and (3) NASA grant management programs, including efforts to reduce duplicative grants. Ongoing Office of Investigations work includes an initiative that proactively investigates high-impact matters affecting NASA, such as counterfeit parts, procurement fraud, and unlawful intrusions into NASA's information systems.

KEY ACHIEVEMENTS PLANNED FOR FY 2014

Going forward, the OIG will focus its audit work in the areas identified by the OIG in November 2012 as NASA's top management and performance challenges:

- Future of U.S. Human Space Flight
- Project Management
- Infrastructure and Facilities Management
- Acquisition and Contract Management
- Information Technology Security and Governance

In the longer term, the OIG expects to focus on a range of cross cutting topics, including the overall health and viability of the space system industrial base; the adequacy and effectiveness of NASA's cost estimating process for science and aeronautics programs; and the sufficiency of controls in place to support the facilities and technology assets for the Deep Space Network. In addition, the OIG will continue work assessing NASA's information technology security and overseeing the work of the independent accounting firm that performs the audit of NASA's financial statements.

The FY 2014 request is $37.0 million. OIG will continue to identify opportunities to promote efficient and effective spending in accordance with the November 2011 Executive Order on "Promoting Efficient Spending" to meet the funding level. Specifically, the FY 2014 request includes:

- $31.0 million (84 percent) for personnel and related costs, including salaries, benefits, monetary awards, workers' compensation, permanent change of station costs, and Government contributions for Social Security, Medicare, health and life insurance, retirement accounts, and Thrift Savings Plan accounts. Salaries include the required additional 25 percent law enforcement availability pay for criminal investigators.
- $1.0 million (3 percent) for travel, per diem at current rates, and related expenses. The OIG staff is located at 12 offices on or near NASA installations and contractor facilities.
- $2.8 million (7 percent) for the annual audit of the Agency's financial statements.
- $2.2 million* (6 percent) for operations expenses, including equipment, training, government vehicles, special equipment for criminal investigators, transit subsidies, and information technology equipment unique to the OIG.

**In accordance with Public Law 110-409, the Inspector General Reform Act of 2008, the Inspector General certifies that $0.4 million for staff training satisfies all known training requirements.*

SUPPORTING DATA

FUNDS DISTRIBUTION BY INSTALLATION

FUNDS BY MISSION BY NASA CENTER

Budget Authority ($ in millions)	FY 2014*
Science	$177.0
Aeronautics Research	$131.1
Space Technology	$103.6
Exploration	$58.5
Space Operations	$19.0
Education	$1.0
Cross-Agency Support	$204.6
Construction & Environmental Compliance & Restoration	$37.8
Ames Research Center	**$732.5**
Science	$71.8
Aeronautics Research	$61.2
Space Technology	$25.4
Exploration	$5.6
Space Operations	$0.0
Education	$0.8
Cross-Agency Support	$65.1
Construction & Environmental Compliance & Restoration	$31.9
Dryden Flight Research Center	**$261.9**
Science	$20.2
Aeronautics Research	$138.6
Space Technology	$168.0
Exploration	$50.2
Space Operations	$53.5
Education	$1.0
Cross-Agency Support	$215.1
Construction & Environmental Compliance & Restoration	$37.3
Glenn Research Center	**$683.9**
Science	$2,172.1
Aeronautics Research	$0.0
Space Technology	$77.6
Exploration	$3.5
Space Operations	$259.3
Education	$1.3
Cross-Agency Support	$426.8
Construction & Environmental Compliance & Restoration	$31.3
Goddard Space Flight Center	**$2,971.9**

FUNDS DISTRIBUTION BY INSTALLATION

Science	$881.2
Aeronautics Research	$0.0
Space Technology	$61.2
Exploration	$7.4
Space Operations	$159.9
Education	$0.0
Cross-Agency Support	$18.9
Construction & Environmental Compliance & Restoration	$37.3
Jet Propulsion Laboratory	**$1,165.9**
Science	$20.6
Space Technology	$40.7
Exploration	$1,161.3
Space Operations	$2,877.8
Education	$1.5
Cross-Agency Support	$367.2
Construction & Environmental Compliance & Restoration	$24.6
Johnson Space Center	**$4,493.7**
Science	$393.8
Space Technology	$19.9
Exploration	$1,126.5
Space Operations	$187.3
Education	$0.9
Cross-Agency Support	$368.0
Construction & Environmental Compliance & Restoration	$192.3
Kennedy Space Center	**$2,288.7**
Science	$176.8
Aeronautics Research	$210.5
Space Technology	$106.0
Exploration	$39.7
Space Operations	$0.5
Education	$1.4
Cross-Agency Support	$294.1
Construction & Environmental Compliance & Restoration	$46.1
Langley Research Center	**$875.1**

FUNDS DISTRIBUTION BY INSTALLATION

Science	$122.2
Aeronautics Research	$0.0
Space Technology	$58.6
Exploration	$1,321.2
Space Operations	$183.7
Education	$1.0
Cross-Agency Support	$386.5
Construction & Environmental Compliance & Restoration	$107.7
Marshall Space Flight Center	**$2,180.9**
Science**	$980.6
Aeronautics Research	$24.3
Space Technology	$74.8
Exploration	$104.6
Space Operations	$108.0
Education	$84.8
Cross-Agency Support	$448.8
Construction & Environmental Compliance & Restoration	$15.9
Office of Inspector General	$37.0
NASA Headquarters and IG	**$1,878.8**
Science	$1.6
Space Technology	$6.8
Exploration	$37.0
Space Operations	$33.9
Education	$0.6
Cross-Agency Support	$55.2
Construction & Environmental Compliance & Restoration	$47.3
Stennis Space Center	**$182.3**
Total	**$17,715.4**

*Note: *Totals may not add due to rounding.*

***Funds will not be fully distributed to Centers until after future acquisition decisions are made. Thus, Center FY 2014 allocations should not be considered final or directly comparable to FY 2013 allocations.*

CIVIL SERVICE FULL-TIME EQUIVALENT DISTRIBUTION

The civil service staffing level proposed in the FY 2014 budget supports NASA's traditional investments in space exploration, aeronautics research, space technology development, science investigation, and sharing the results of Agency activities with the public and educators. It includes scientists, engineers, researchers, managers, technicians, educators, and business operations workforce at all NASA Centers, Headquarters, and NASA-operated facilities.

The Agency will apply its civil service capabilities to the range of mission, research, and technology work while continuing to reshape and realign workforce skills to adjust to changing requirements and a leaner fiscal environment. The Agency will adjust the mix of skills where appropriate. NASA anticipates offering buyouts in selected surplus skill areas, and is prepared to identify, recruit and retain employees who possess skills critical to the Agency.

While a civil service workforce is critical for conducting mission-essential work in research and technology, some reduction to workforce levels is necessary. NASA will reduce the size of the civil service workforce by more than 250 full-time equivalents (FTE) from FY 2013 to FY 2014, stabilizing the workforce at approximately 17,700 FTE. This ceiling decline addresses workforce at several Centers affected by changes in the human spaceflight portfolio, and takes into account a hiring slowdown across most Centers in response to Agency budget reductions.

CIVIL SERVICE FULL-TIME EQUIVALENT DISTRIBUTION BY CENTER

	Actuals*	FTE Estimates**					
	FY12	**FY13**	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**
ARC	1,213	1,218	1,200	1,182	1,182	1,182	1,182
DFRC	547	551	551	551	551	551	551
GRC	1,635	1,628	1,595	1,571	1,571	1,571	1,571
GSFC	3,318	3,366	3,331	3,292	3,292	3,292	3,292
JSC	3,184	3,151	3,098	3,045	3,045	3,045	3,045
KSC	2,085	2,050	2,025	2,001	2,001	2,001	2,001
LaRC	1,908	1,911	1,881	1,853	1,853	1,853	1,853
MSFC	2,435	2,446	2,407	2,372	2,372	2,372	2,372
SSC	295	318	313	313	313	313	313
HQ	1,181	1,190	1,155	1,133	1,133	1,133	1,133
NSSC	141	145	142	139	139	139	139
NASA Total	**17,941**	**17,974**	**17,698**	**17,452**	**17,452**	**17,452**	**17,452**
OIG	204	213	213	213	213	213	213

**Includes 269 student FTE*

***Includes 285 student FTE each FY*

CIVIL SERVICE FULL-TIME EQUIVALENT DISTRIBUTION

FY 2014 FTE DISTRIBUTION BY ACCOUNT BY CENTER

	Science	Aeronautics	Space Technology	Exploration	Space Operations	Education	Cross Agency Support	Reimbursable / Working Capital Fund*	NASA-Funded Total	Agency TOTAL
ARC	149	237	108	116	20	6	544	22	1,178	1,200
DFRC	99	165	27	15	0	5	225	15	536	551
GRC	81	367	143	220	155	7	619	3	1,592	1,595
GSFC	1,227	-	112	13	156	7	1,591	224	3,107	3,331
JSC	32	-	92	872	1,217	7	878	-	3,099	3,099
KSC	1	-	76	689	369	7	869	14	2,011	2,025
LaRC	209	513	165	133	3	8	840	10	1,871	1,881
MSFC	131	-	106	950	204	7	1,010	-	2,407	2,407
SSC	7	-	9	65	40	5	148	39	275	313
HQ	-	-	-	-	-	-	1,155	-	1,155	1,155
NSSC	-	-	-	-	-	-	-	141	-	141
NASA Total	**1,936**	**1,282**	**838**	**3,074**	**2,163**	**59**	**7,879**	**467**	**17,231**	**17,698**
OIG										213

**Includes 146 FTE funded by Working Capital Fund and 321 FTE funded by reimbursable customers*

WORKING CAPITAL FUND

The NASA Working Capital Fund (WCF) was established to satisfy specific recurring needs for goods and services through use of a business-like buyer and seller approach under which NASA's WCF entities provide goods or services pursuant to contracts and agreements with their customers. The overarching aim of WCF is to promote economy, efficiency, and accountability with fully reimbursed rates by focusing on streaming operations, extending resources, measuring performance, and improving customer satisfaction.

NASA's WCF is comprised of three entities:

- NASA Shared Services Center (NSSC);
- Solutions for Enterprise-Wide Procurement (SEWP) Government-Wide Acquisition Contract; and
- Information Technology (IT) Infrastructure Integration Program (I3P).

WORKING CAPITAL FUNDS BUDGET SUMMARY

Spending Authority from Offsetting Collections ($ millions)	Actual FY 2012	Estimate FY 2013	Request FY 2014
NSSC	86	99	76
SEWP	10	11	10
I3P	181	307	302
Total Spending Authority	**277**	**417**	**388**
Unobligated Brought Forward, Oct. 1	5	7	16
Recoveries of Prior Yr. Unpaid Obligations	0	7	0
Total Budgetary Resources	**282**	**431**	**404**
NSSC	84	92	76
SEWP	10	10	11
I3P	181	305	303
Total Obligations	**275**	**407**	**390**
Unobligated Balance (end-of-year)*	**7**	**24**	**14**

**Unobligated balance end-of-year is budgetary resources less obligation*

NASA SHARED SERVICES CENTER (NSSC)

NSSC opened in March 2006 to provide centralized administrative processing services and customer contact center operations for support of human resources, procurement, financial management, Agency information technology (IT), and Agency business support services. NASA established NSSC, a function under the NASA Headquarters Mission Support Directorate, as a public/private partnership. NSSC has awarded its major business management and IT services contract to Computer Sciences Corporation. Typical expenditures are related to civil service workforce, support contractor, other direct procurements, and Agency training purchases.

NSSC is located on the grounds of SSC and operates in a manner that provides for transparency and accountability of costs and services. NASA has reduced its administrative costs through centralized processing at NSSC. The work performed by NSSC frees Agency resources that can then be redirected to NASA's mission of space exploration, scientific discovery, and aeronautics research.

NSSC's revenue streams include funding from the NASA Centers, mission directorates, and various NASA mission support offices. During FY 2014, NSSC will continue to offer similar services as in FY 2013 with no significant scope changes anticipated.

SOLUTIONS FOR ENTERPRISE-WIDE PROCUREMENT (SEWP)

SEWP refers to operations related to the Government-Wide Acquisition Contract that was established under the authority of section 5112 of the Information Technology Management Reform Act (40 U.S.C. 1412(e)) enacted in 1996, under which NASA is designated by the Office of Management and Budget as a Federal government Executive Agent for SEWP contracts.

SEWP was established as a WCF entity to allow all Federal agencies use of a best value tool to purchase IT product solutions and services. Under this approach, the buying power of Federal Agencies is combined to acquire best value for IT products and services very efficiently. Typical acquisitions include a wide range of advanced technologies such as UNIX-Linux, and Windows-based desktops and servers, along with peripherals, network equipment, storage devices, security tools, software, and other IT products and product-based solutions.

SEWP promotes aggressive pricing using online tools to obtain multiple, competitive quotes from vendors. On average for FY12, SEWP quotes have a 20 percent savings for any Federal customer using SEWP contracts. In addition, SEWP offers a low surcharge to recover NASA's costs to operate the program with an average 0.37 percent fee as compared to the Government standard of 0.75 percent. SEWP revenue is generated solely from the surcharge fees on all transactions processed. For FY 2013, the Federal government is projected to save about $8 million in service fees (based on the difference between General Service Administration and SEWP surcharge fees) and $31 million in overall costs for IT product solutions and services using NASA SEWP contracts.

IT INFRASTRUCTURE INTEGRATION PROGRAM (I3P)

WCF operations supporting I3P began in early FY 2012. WCF enables I3P to improve the efficiency and economy in which contract services and management are provided to support NASA's IT strategic initiatives and to increase visibility into NASA's IT budget and expenditures. Under I3P, NASA has consolidated 19 separately managed contracts into four centrally managed ones described as follows:

- The Enterprise Applications Service Technologies contract supports NASA Enterprise Applications Competency Center (NEACC) applications hosted by MSFC. The NEACC operates and maintains a broad spectrum of NASA's enterprise applications, with an emphasis on fully integrating business process expertise with application and technical knowledge. A small team of civil servants and support contractors sustain operations, implement new applications and capabilities, and provide business readiness support to the stakeholders and end-users.
- The NASA Integrated Communications Services contract provides wide and local area network, telecommunications, video, and data services hosted at MSFC.
- The Web Enterprise Service Technologies contract will provide public Web site hosting, Web content management and integration, and search services. Services are planned to be hosted by GSFC and ARC. However, this contract is not yet awarded.
- The Agency Consolidated End-User Services contract provides program management, provisioning and support of desktops, laptops cell phones, personal digital assistants, office automation software, and video conferencing. Services are hosted by NSSC.

I3P's consolidated contracting approach benefits NASA by providing cost saving opportunities such as the reduction in administrative burden involved with the business management of contracts and a significant reduction in procurement request transaction volume. Other I3P benefits include: the streamlining of budgeting, funding, and costing I3P services; achieving transparency through the provision of detailed customer monthly billings; and providing consolidated, consistent reporting of Agency-wide consumption of I3P-related goods and services.

I3P is unique in that revenue streams and expenditures are limited to contract costs for its four service contracts. Revenue streams include funding from the NASA Centers, NASA Mission Directorates, and various NASA mission support offices. In FY 2014, the I3P WCF will continue to offer similar services as in FY 2013, with no significant scope changes anticipated. Note that FY 2013 amounts are higher than FY 2012 due to the initial phase-in period of Centers across the different I3P contracts at different times throughout FY 2012. FY 2013 is the first full year of operations for the following I3P contracts: Enterprise Applications Service Technologies, NASA Integrated Communications Services, and Agency Consolidated End-User Services. FY 2014 is the first full year of operations for the Web Enterprise Services Technologies contract.

BUDGET BY OBJECT CLASS

Code	FY 2014 Estimated Direct Discretionary Obligations ($ millions) Object Class	Science	Aeronautics	Space Technology	Exploration	Space Operations	Education	Cross Agency Support	Construction & Environmental Compliance & Restoration	Office of Inspector General	NASA Total
11.1	Full-time permanent	224	142	97	349	250	6	893	0	24	1,985
11.3	Other than full-time permanent	13	7	5	7	4	0	30	0	0	66
11.5	Other personnel compensation	2	0	1	1	1	0	30	0	0	35
11.8	Special personal service payments	0	0	0	0	0	0	1	0	0	1
11.9	*Subtotal Personnel Compensation*	*239*	*149*	*103*	*357*	*255*	*6*	*954*	*0*	*24*	*2,087*
12.1	Civilian personnel benefits	66	40	29	102	72	2	253	0	8	572
13	Benefits to former personnel	0	0	0	1	1	0	9	0	0	11
	Total Personnel Compensation & Benefits	**305**	**189**	**132**	**460**	**328**	**8**	**1216**	**0**	**32**	**2670**
21	Travel & transport. Of persons	20	6	5	13	12	1	17	0	1	75
22	Transportation of things	3	1	1	1	1,024	0	5	0	0	1,035
23.1	Rental payments to GSA	0	0	0	0	0	0	34	0	0	34
23.2	Rental payments to others	2	0	0	0	2	0	3	0	0	7
23.3	Communications, utilities & misc.	4	7	0	8	5	0	79	0	0	103
24	Printing and reproduction	1	0	0	0	1	0	4	0	0	6
25.1	Advisory and assistance services	110	10	26	221	106	3	194	28	0	698
25.2	Other services	217	23	21	26	94	6	299	12	4	702
25.3	Other purchases of goods & services from Gov accounts	194	8	4	41	44	0	48	15	0	354
25.4	Operation and maint. of facilities	16	32	5	143	102	1	251	136	0	686
25.5	R and D contracts	3,413	194	496	2,809	1,869	6	162	40	0	8,989
25.6	Medical care	0	0	0	0	0	0	7	0	0	7
25.7	Operation and maint. of equip.	82	27	6	74	238	1	396	5	0	829
26.0	Supplies and materials	28	10	5	25	22	0	19	0	0	109
31.0	Equipment	35	24	7	18	15	0	38	1	0	138
32.0	Land and structures	6	5	0	5	8	0	58	295	0	377
41.0	Grants, subsidies, and contrib.	583	30	25	68	18	72	21	0	0	817
	Other Object Classes	**4,714**	**377**	**601**	**3,452**	**3,560**	**90**	**1,635**	**532**	**5**	**14,966**
	NASA Total, Direct	**5,019**	**566**	**733**	**3,912**	**3,888**	**98**	**2,851**	**532**	**37**	**17,636**

STATUS OF UNOBLIGATED FUNDS

The table below displays actual and estimated unobligated balances of direct discretionary budget authority in each NASA appropriation account at the end of each fiscal year. Data is presented on a non-comparable basis (i.e., based solely on an appropriation account's activity or projected activity, with no adjustment to the FY 2012 or FY 2013 amounts to make them comparable to the budget structure underlying the FY 2014 request).

UNOBLIGATED FUNDS SUMMARY BY APPROPRIATIONS ACCOUNT

Budget Authority ($ millions)	Unobligated Balances Sept. 30, 2012	Estimated Unobligated Balances Sept. 30, 2013	Estimated Unobligated Balances Sept. 30, 2014
Science	64	64	63
Aeronautics	17	17	17
Space Technology	13	14	19
Exploration	91	93	96
Space Operations	62	62	57
Education	18	14	10
Cross-Agency Support	18	18	17
Construction and Environmental Compliance and Restoration	172	139	213
Science, Exploration, & Aeronautics	1	0	0
Office of Inspector General	1	1	0
Total NASA	**439**	**422**	**496**

Note: The end of FY 2014 unobligated balance estimates are based on historical performance of the account.

REIMBURSABLE ESTIMATES

Reimbursable agreements are agreements where the NASA costs associated with the undertaking are borne by the non-NASA partner. NASA undertakes reimbursable agreements when it has equipment, facilities, and services that it can make available to others in a manner that does not interfere with NASA mission requirements. As most reimbursable requests to NASA do not occur until the year of execution, the FY 2013 to FY 2014 estimates are based on an annual survey of Centers' anticipated reimbursable agreements. NASA separately budgets for and executed the 4 categories of reimbursable agreements listed below. Supporting data for Enhanced Use Leasing is provided on pages SD-13 to SD-15 of this section.

REIMBURSABLE ESTIMATES BY APPROPRIATIONS ACCOUNT

Spending Authority from Offsetting Collections ($ millions)	Actual FY 2012	FY 2013	FY 2014
Cross Agency Support (non-EUL)	2,555.6	2,625.0	2,654.7
Cross Agency Support (EUL)	6.6	8.7*	9.8
Office of Inspector General	0.9	1.8	1.8
Total	**2,563.1**	**2,635.5**	**2,666.3**

** Due to operations under the Continuing Resolution, anticipated spending authority from offsetting collections apportioned as of March 31, 2013 is reported here. An updated FY 2013 estimate will be provided in the Agency's Annual Report on NASA's Enhanced Use Leasing for FY 2012.*

ENHANCED USE LEASING

In 2003, NASA Congress authorized NASA to demonstrate leasing authority and collections at two Centers. In 2007 and in 2008, Congress amended that authority such that NASA may enter into leasing arrangements at all Centers after December 2008. After deducting the costs of administering the leases, Centers are then permitted to retain 65 percent of net receipt revenue, and the balance is made available agency-wide for NASA. These funds are in addition to annual appropriations. To ensure annual oversight and review, the 2010 Consolidated Appropriations Act, P.L. 111-117 contains a provision that requires NASA to submit an estimate of gross receipts and collections and proposed use of all funds collected in the annual budget justification submission to Congress. There are no civil servants funded from Enhanced Use Leasing (EUL) income. The table below depicts the estimated FY 2014 EUL expenses and revenues. The amounts identified under Capital Asset Account Expenditures may be adjusted between projects listed based on actual contract award.

SUMMARY OF FY 2014 EUL ACTIVITY

FY2014 EUL Expenses and Revenues ($ thousands)	ARC	GRC	GSFC	KSC	MSFC	SSC	Agency	Total
Base Rent	5,487.7	193.0	26.9	318.5	1,243.2	460.1		7,729.4
Institutional Support Income	1,876.6	3.9	4.9	62.5		155.1		2,103.0
Additional Reimbursable Demand Services Requested by Lessees (including overhead)	3591.4	0.0	0.0	31.7	74.9	0.0	0.0	3698.0
Total Lease Income	**10,955.7**	**196.9**	**31.8**	**412.7**	**1,318.1**	**615.2**	**0.0**	**13,530.4**
Institutional Support Costs	(1,876.6)	(3.9)	(4.9)	(62.5)		(155.1)		(2,103.0)
Lease Management and Administration								
Tenant Building Maintenance and Repair	(1,788.9)	(117.1)			(1,097.1)			(3,003.1)
Cost to Fulfill Reimbursable Demand Services (including overhead)	(3,591.4)			(31.7)	(74.9)			(3,698.0)
Total Cost Associated with Leases	**(7,256.9)**	**(121.0)**	**(4.9)**	**(94.2)**	**(1,172.0)**	**(155.1)**		**(8,804.1)**
Net Revenue from Lease Activity	**3,698.8**	**75.9**	**26.9**	**318.5**	**146.1**	**460.1**		**4,726.3**
Beginning Balance, Capital Asset Account	**1,326.7**		**35.4**	**5.3**	**48.7**	**12.3**	**2,156.2**	**3,584.6**
Net Revenue from Lease Activity Retained at Center	**2,404.2**	**49.3**	**17.5**	**207.0**	**95.0**	**299.1**	**1,654.18**	**4,726.3**
Total Available, Capital Assets Account	**3,730.9**	**49.3**	**52.9**	**212.3**	**143.7**	**311.4**	**3,810.4**	**8,310.9**
Planned Maintenance, Various Buildings	1,774.0							1,774.0
Replace Roofs on Various Buildings	630.2							630.2
GEWA Activities			17.5					17.5
Replace Batteries, Sunwise Solar Battery Bank L7-0071				57.0				57.0
Purchase/Install SafeTraxx Fall Protection K6-1996D				34.6				34.6
Repair Deteriorated Culverts, 10th St.				16.5				16.5
Replace worn and damaged exit doors 1200, framework, OSB1				122.6				122.6

Lead remediation building 9101						40.5		40.5
Repair 1000' of sewage pipe building 9752						150.0		150.0
Repair potable water leak building 9760						75.0		75.0
Refurbish switchgear, secure all power feeds						33.5		33.5
Energy and Sustainability Upgrades, Various Buildings (Various Centers)							2,500.0	2,500.0
Unobligated Carryover To Complete Prior Year Projects								
Capital Asset Account Expenditures	**2,404.2**		**17.5**	**230.7**		**299.0**	**2,500.0**	**5,451.4**
Capital Asset Account Ending Balance	**1,326.7**	**49.3**	**35.4**	**(18.4)**	**143.7**	**12.4**	**1,310.4**	**2,859.4**
Cost to Fulfill Reimbursable Demand Services (including overhead)	(3,591.4)	0.0	0.0	(31.7)	(74.9)	0.0	0.0	(3,698.0)
Net activity due to Reimbursable Demand Services								
In Kind Activity				**30.0**				**30.0**

ENHANCED USE LEASING

DEFINITIONS

Base Rent

Revenue collected from tenant for rent of land or buildings.

Institutional Support Costs

Cost for institutional shared services such as fire, security, first responder, communications, common grounds, road, and infrastructure maintenance, and routine administrative support and management oversight (i.e., environmental).

Total Rental Income

Total gross proceeds from EUL activities for expenses due to renting NASA property.

In-Kind

Consideration accepted in lieu of rent payment. (Only applies to selected leases signed prior to January 1, 2009.)

Reimbursable Demand Services

Services such as janitorial, communications, and maintenance that solely benefit the tenant and provided for their convenience. There is no net income received by NASA, as these payments may only cover the costs of NASA and its vendors providing these services.

Overhead

General and administrative costs associated with management of the specified demand services.

BUDGET FOR MICROGRAVITY SCIENCES

BUDGET FOR INTERNATIONAL SPACE STATION RESEARCH

The Human Exploration and Operations Mission Directorate supports research which takes advantage of the unique environment of reduced gravity on International Space Station (ISS). Research is conducted in two broad categories of Exploration ISS Research and Non-Exploration ISS Research.

BUDGET SUMMARY

Budget Authority ($ millions)	Actual FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Exploration ISS Research	137	144	131	127	134	136	138
Non-Exploration ISS Research	131	135	139	146	147	149	155
Total	**269**	**279**	**270**	**272**	**281**	**285**	**293**
% of Non-Exploration to Total	49%	48%	52%	53%	52%	52%	53%

Note: The FY 2012 figure reflects actual budget authority, FY 2013 estimates are based on a full year Continuing Resolution, and FY 2015 through FY 2018 are notional.

Non-Profit Organization

Having launched the U.S. and international partner elements, and established six-person crew capability, the ISS program focus is now primarily on research. During FY 2012, NASA awarded a cooperative agreement to an independent non-profit organization (NPO) with responsibility to further develop national uses of the ISS. The NPO will oversee all research involving organizations other than NASA, and transfer current NASA biological and physical research to the NPO in future years. Space Operations oversight of existing research projects will be phased out and NPO will co-select/manage new peer-reviewed projects. As on-going work within the NASA research project offices is completed in future years, extension/renewal decisions should be made by the NPO.

Through the management partnership, research opportunities will be expanded to conduct research in life sciences, material sciences, biotechnologies, condensed matter physics and thermal sciences (e.g., fluid mechanics, thermodynamics, heat transfer and combustion). NASA will continue to support research to meet NASA requirements for exploration including astronaut health and serve as a test bed for the development and demonstration of technology for future space exploration missions.

Exploration ISS Research

Exploration ISS Research supports the Agency's need for improved knowledge about working and living in space to enable future long-duration human exploration missions.

The Human Research Program provides research results which reduce risks to crew health and performance that stem from prolonged exposure to reduced gravity, space radiation, and isolation during exploration missions. Risk mitigation is being achieved by conducting ISS research in human health countermeasures, space human factors and habitability, behavioral health and performance, and exploration medicine, tools, and technologies.

BUDGET FOR MICROGRAVITY SCIENCES

ISS Research investigates the underlying gravity-dependent phenomena in the following areas: fire prevention, detection, and suppression; boiling; multiphase flow of fluids; and capillary driven flow. These applied research investigations will provide needed data that is useful in the future design of the following space technology areas: life support systems; propellant storage; power generation; thermal control; and advanced environmental monitoring and control.

Funding for the Multi-User System Support (MUSS), which supports Exploration ISS Research, is included in the table above. The MUSS function is responsible for all payload physical, analytical and operations integration activities; projecting available utilization resources and accommodations; tactical planning; and execution of the day-to-day ISS integrated research plan for all payloads, including NASA, international partners, and non-NASA users.

Non-Exploration ISS Research

NASA allocates at least 15 percent of the funds budgeted for ISS research to ground-based, free-flyer, and ISS life and physical science research that is not directly related to supporting the human space exploration program, in accordance with Section 204 of the NASA Authorization Act of 2005. The purpose is to ensure the capacity to support ground-based research leading to space-based basic and applied scientific research in a variety of disciplines with potential direct national benefits and applications that can be advanced significantly from the uniqueness of microgravity and the space environment. Additionally, this allocation allows basic ISS research in fields including physiological research, basic fluid physics, combustion science, cellular biotechnology, low-temperature physics, cellular research, materials science, and plant research to be carried out to the maximum extent possible. This research helps to sustain existing U.S. scientific expertise and capability in microgravity research.

The Non-Exploration ISS Research line the above table also includes the Alpha Magnetic Spectrometer (AMS), and costs for MUSS support. The AMS is a particle physics and astrophysics experiment, planned for the ISS, which is searching for dark matter, anti-matter, and strange matter.

Center for the Advancement of Science in Space (CASIS)

The Center for the Advancement of Science in Space (CASIS), the organization selected to manage the non-NASA use of the ISS National Laboratory in conformance with direction in the 2010 NASA Authorization Act, made important progress in establishing building an organization capable of formulating a strategic vision for expanding participation in space research. A new Board of Directors has been established that includes international leaders in scientific research and university presidents. A scientific advisory board has reviewed the results of past space experiments for probable value from a non-NASA and commercial perspective, and has made priority recommendations that have been reviewed and approved by the new Board. The first solicitation for research based on the priority recommendations has already been completed, with three projects selected. CASIS continues to explore new opportunities to develop new research concepts for the ISS, and to implement a value-driven utilization program that brings new users to the ISS research community.

BUDGET FOR SAFETY OVERSIGHT

The following table provides the safety and mission assurance budget estimates. This includes the agency-wide safety oversight functions as well as the estimated project specific safety, reliability, maintainability and quality assurance elements embedded within individual projects. NASA does not have a single safety oversight budget line item, but instead estimates are embedded in program, project, and mission support budgets.

BUDGET SUMMARY FOR SAFETY OVERSIGHT

Budget Authority ($ millions)	FY2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Safety and Mission Assurance (AMO)	49.4		50.0	50.0	50.0	50.0	50.0
Institutional Operational Safety (CMO)	30.6		30.0	30.0	30.0	30.0	30.0
SMA Technical Authority (CMO)	50.0		52.6	52.6	52.6	52.6	52.6
Agency-wide Safety Oversight	**130.0**		**132.6**	**132.6**	**132.6**	**132.6**	**132.6**
Program Specific	**295.0**		**300.0**	**300.0**	**300.0**	**300.0**	**300.0**
NASA Total, Safety	**425.0**		**432.6**	**432.6**	**432.6**	**432.6**	**432.6**

DEFINITIONS

Agency-Wide Safety Oversight

Agency level programs and activities that support the overarching NASA Safety and Mission Success program.

Safety and Mission Assurance

The Safety and Mission Assurance program administers and refines the pertinent policies, procedural requirements, and technical safety standards. The program participate in forums that provide advice to the Administrator, Mission Directorates, Program Managers and Center Directors who are ultimately accountable for the safety and mission success of all NASA programs, projects, and operations. Specific program responsibility include, among other activities, managing NASA's Orbital Debris program, NASA's Electronic Parts program and the NASA Safety Center.

Institutional Operational Safety

NASA's institutional operational safety program is driven by OSHA 29 CFR 1960, OSHA Standards, NPR 8715.1, NASA Safety and Health Handbook Occupational Safety and Health Programs, NPR 8715.3, and NASA's general safety program requirements. The program includes construction safety, mishap prevention program including reporting and investigations, safety training, safety awareness, the voluntary protection program, safety metrics and trend analysis, contractor insight/oversight, support to safety boards and committees, support to emergency preparedness and fire safety program, aviation safety, explosives and propellants safety, nuclear safety requirements, radiation safety protection, confined space entry, fall protection, lifting devices, pressure vessel safety, hazard reporting and abatement systems, cryogenic safety, electrical safety requirements (lock out/tag out), facility systems

BUDGET FOR SAFETY OVERSIGHT

safety, risk management, institutional safety policy development, visitor and public safety, and institutional safety engineering. The institutional operational safety program requires significant federal state and local coordination.

S&MA Technical Authority and S&MA Support

The S&MA technical authority program includes travel and labor only for all S&MA supervisors, branch chiefs or above and designated deputies. In addition, where the principal job function of a non-supervisory S&MA person consists of rendering authoritative decisions on S&MA requirements matters relating to the design or operation of a program or project, that person's salary is included. These positions often are the lead S&MA manager positions for large programs where the decision making process is nearly a full time demand. This category does not include salary for those whose work only occasionally falls as an authority task. This includes travel funds in direct support of these individuals.

S&MA is mission support, including administrative support, which cannot be directly charged to a program. This budget includes policy development across the programs, range safety, payload safety (ground processing), independent assessments, metrology and calibration (for center), reliability and maintainability policy, center wide S&MA program integration and analysis, business and administrative support to S&MA Directorates, and quality assurance for facilities and ground support hardware.

Program Specific

Project specific safety and mission assurance costs are included in individual project budgets. These costs include the technical and management efforts of directing and controlling the safety and mission assurance elements of the project. This incorporates the design, development, review, and verification of practices and procedures and mission success criteria intended to assure that the delivered spacecraft, ground systems, mission operations, and payload(s) meet performance requirements and function for their intended lifetimes. This element excludes mission and product assurance efforts directed at partners and subcontractors other than a review/oversight function, and the direct costs of environmental testing.

PHYSICIAN'S COMPARABILITY ALLOWANCE

The Physicians' Comparability Program permits agencies to provide allowances to certain Federal physicians who enter into service agreements with their agencies to address recruitment and retention problems. Physicians' comparability allowances (PCAs) are critical to NASA's ability to retain flight surgeons and physicians, as well as support NASA's goal of maintaining a stable, high quality physician workforce. NASA's physicians are required to acquire and maintain specialized experience vital to supporting the Agency's missions on the ISS. JSC, NASA's primary user of PCAs is located in Houston, Texas and competes with some of the best medical facilities in the country. The following report summarizes NASA's use of this authority.

PCA DATA SUMMARY

		Actual	Estimates	
		PY 2012	CY 2013	BY 2014*
1) Number of Physicians Receiving PCAs		29	26	26
2) Number of Physicians with One-Year PCA Agreements		29	26	26
3) Number of Physicians with Multi-Year PCA Agreements				
4) Average Annual PCA Physician Pay (without PCA payment)		$155,568	$155,082	$155,406
5) Average Annual PCA Payment		$17,049	$20,377	$20,429
6) Number of Physicians Receiving PCAs by Category (non-add)	Category I Clinical Position	26	23	23
	Category II Research Position			
	Category III Occupational Health	1	1	1
	Category IV-A Disability Evaluation			
	Category IV-B Health and Medical Admin.	2	2	2

Note: FY 2014 data will be approved during the FY 2015 Budget cycle.

MAXIMUM ANNUAL PCA AMOUNT PAID TO EACH CATEGORY OF PHYSICIAN

The allowance amount authorized will be the minimum amount necessary to address the recruitment or retention problem and will be determined by considering the factors listed in 5 CFR 595.105(a). Allowance amounts may not exceed:

- $14,000 per annum if the employee has served as a Government physician for 24 months or less;
- $24,000 per annum if the employee has served as a Government physician for 24-48 months; or
- $30,000 per annum if the employee has served as a Government physician for more than 48 months.

PHYSICIAN'S COMPARABILITY ALLOWANCE

RECRUITMENT AND RETENTION ISSUES

Category 1 Clinical Positions

There are a number of recruitment and retention challenges at JSC in Houston, TX.

- The Houston area has world-renowned medical facilities with considerably higher physician salaries than NASA is able to offer at JSC.
- Time and effort to train a new physician to fully support a mission is approximately two years.
- JSC's pre-PCA attrition rate was 9 percent with many physicians terminating employment with less than three years of service.

JSC's current need for clinical physicians continues to be re-evaluated in the post-Space Shuttle era.

- Active astronauts who retire from NASA convert to the Lifetime Surveillance of Astronaut Health Program which is managed by the JSC physician staff. Therefore, although active astronaut numbers are decreasing, the patient population in the program increases.
- JSC is in the process of selecting new astronauts, with 9-12 selections expected by the end of CY 2012.

JSC filled two clinical positions in FY 2012 and the ability to offer PCA was an important factor in the candidates' accepting the employment offers. One candidate who was offered a physician position declined because JSC was not able to match a private sector employment offer.

Category IV-B Occupational Health

This position is at Goddard Space Flight Center (GSFC) and is in the Occupational Medicine field, which is in high demand. In the Washington, DC/Baltimore area, the salary range for experienced private sector physicians in Occupational Medicine is $190-$210 thousand. The maximum GS-15 salary of $155,500 is well below private sector salaries.

Category IV-B Health and Medical Administration

NASA currently has two physicians receiving PCA at Kennedy Space Center (KSC) and PCA has been an effective retention tool.

HOW PCA ALLEVIATES RECRUITMENT AND RETENTION PROBLEMS

PCA has been very effective at NASA. The attrition rate at JSC for FY 2011 was 7 percent (two losses including one death); for FY 2012 it was 11.5 percent (three losses including two transfers and one retirement). JSC was able to fill two critical physician positions in FY 2012 by using PCA to compete with higher compensation in the private sector.

KSC in not currently experiencing retention issues due to the use of PCA. KSC plans to continue the current PCA amounts in FY 2013 and decrease them in FY 2014 when it will not have a negative impact on the net income of the two physicians.

BUDGET FOR PUBLIC RELATIONS

The NASA budget for Public Affairs is funded within Cross-Agency Support under Center Management and Operations and Agency Management and Operations. All the Installations listed below, except for Headquarters, are in the Center Management and Operations account and the Headquarters budget is in the Agency Management and Operations account.

These budgets include dissemination of information to the news media and the general public concerning NASA programs. Content includes support for public affairs/public relations, Center newsletters, internal communications, guest operations (including bus transportation), public inquiries, NASA TV, the http://www.nasa.gov portal, and other multimedia support.

NASA PAO BUDGET SUMMARY, BY CENTER

	Actual	Estimate			Notional		
Budget Authority ($ millions)	**FY2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**
Ames Research Center	2.6	2.7	2.7	2.7	2.7	2.7	2.7
Dryden Flight Research Center	1.4	1.3	1.4	1.4	1.4	1.4	1.4
Glenn Research Center	2.8	3.1	3.1	3.1	3.1	3.1	3.1
Goddard Space Flight Center	6.4	5.1	5.0	5.0	5.0	5.0	5.0
Headquarters	13.0	14.8	14.7	14.7	14.7	14.7	14.7
Johnson Space Center	7.7	7.3	6.8	6.8	6.8	6.8	6.8
Kennedy Space Center	5.1	5.6	5.7	5.7	5.7	5.7	5.7
Langley Research Center	3.1	2.5	2.5	2.5	2.5	2.5	2.5
Marshall Space Flight Center	4.4	4.6	4.7	4.7	4.7	4.7	4.7
Stennis Space Center	1.8	1.9	2.0	2.0	2.0	2.0	2.0
NASA Total	**48.2**	**48.9**	**48.6**	**48.6**	**48.6**	**48.6**	**48.6**

Note: Public Affairs per baseline service level definition, as part of the Cross Agency Support Budget

CONSULTING SERVICES

NASA uses paid experts and consultants to provide advice and expertise beyond that which is available from its in-house civil service workforce. Management controls ensure that there is ample justification for consulting services before these services are obtained. Much of the Agency's expert and consultant support is for the NASA Advisory Council and the Aerospace Safety Advisory Panel. NASA uses experts and consultants to provide expertise on the selection of experiments for future space missions. The use of these experts and consultants provides the Agency with an independent view that assures the selection of experiments likely to have the greatest scientific merit. Other individuals provide independent views of technical and functional problems in order to provide senior management with the widest possible range of information to support making major decisions.

NASA CONSULTING SERVICES BUDGET SUMMARY

	Actual	Estimate	
Expert/Consultants ($ millions)	FY 2012	FY 2013	FY 2014
Number of Paid Experts and Consultants	32.0	32.0	32.0
Annual FTE Usage	5.0	5.0	5.0
Salaries	0.2	0.2	0.2
Total Salary and Benefits Costs	0.2	0.2	0.2
Travel Costs	0.2	0.2	0.2
Total Costs	0.4	0.4	0.4

Note: FY 2012 represents actual obligations. FY 2013 and FY 2014 are estimated Budget Authority

A broader definition of consulting services could include the total object class "Advising and Assistance Services" as shown in the Supporting Data Budget by Object Class section of this volume.

	Actual	Estimate	
(Cost in $ millions)	FY 2012	FY 2013	FY 2014
Advisory and Assistance Services	749.0	670.0	670.0

DEFINITIONS*

Consultant

A person who can provide valuable and pertinent advice generally drawn from a high degree of broad administrative, professional, or technical knowledge or experience. When an agency requires public advisory participation, a consultant also may be a person who is affected by a particular program and can provide useful views from personal experience.

Expert

A person who is specially qualified by education and experience to perform difficult and challenging tasks in a particular field beyond the usual range of achievement of competent persons in that field. An

CONSULTING SERVICES

expert is regarded by other persons in the field as an authority or practitioner of unusual competence and skill in a professional, scientific, technical, or other activity.

** These definitions are located under 5 CFR 304.102. The appointments are made under 5 U.S.C. 3109, and the use of this authority is reported annually to Office of Personnel Management (OPM).*

E-GOV INITIATIVES AND BENEFITS

E-GOVERNMENT FUNDING CONTRIBUTIONS AND SERVICE FEES BY INITIATIVE

NASA is providing funding contributions in FY 2014 for each of the following E-Government initiatives:

Initiative	2014 Contributions (Includes In-Kind) ($ millions)	2014 Service Fees* ($ millions)
E-Rulemaking 026-999990060		10,000
Grants.gov 026-999990160	155,066	10,000
Grants Management LoB (Research.gov) 026-999991300		275,000
E-Training 026-999991217		1,500,000
Recruitment One-Stop 026-999991218		121,150
Enterprise HR Integration 026-999991219		308,800
E-Payroll 026-9999991221		4,132,100
E-Travel 026-999990220		2,563,428
Integrated Acquisition Environment (IAE) 026-999990230	1,729,154	50,000
IAE-Loans and Grants 026-999994300	105,000	
Financial Management LoB 026-999991100	124,236	
Human Resources Management LoB 026-999991200	65,217	500,000
Geospatial LoB 026-999993100	15,000	
Budget Formulation and Execution LoB 026-999993200	105,000	
Performance Management LoB**	$87,000	
NASA Total	**2,298,673**	**9,470,478**

*Note: *Service fees are estimates as provided by the E-Government initiative managing partners*

***Final FY 2014 funding sources, commitments, and details regarding the shared solution will be determined by a Performance Management LoB Executive Steering Committee*

After submission of the budget, NASA will post FY 2014 Exhibit 300 IT business cases on the IT Dashboard, located at: http://it.usaspending.gov/.

The E-Government initiatives serve citizens, businesses, and federal employees by delivering high quality services more efficiently at a lower price. Instead of expensive "stove-piped" operations, agencies work together to develop common solutions that achieve mission requirements at reduced cost, thereby making resources available for higher priority needs. Benefits realized through the use of these initiatives for NASA in FY 2014 are described in the following.

eRulemaking (Managing Partner EPA) FY 2014 Benefits

NASA's benefits for the eRulemaking initiative are largely focused on public benefits by providing one-stop access to NASA and other federal agency information on rulemakings and non-rulemaking activities on Regulations.gov.

E-GOV INITIATIVES AND BENEFITS

In addition to the process benefits the eRulemaking solution offers, it is estimated to provide cost avoidance benefits over traditional baseline paper processes to a level of $30 million over five years. The electronic docket solution selected by eRulemaking governance bodies is a centralized architecture that is configurable for each participating entity allowing role-based access to develop workflow and collaboration processes to manage their content. This centrally managed solution is estimated to save a range of $106 – $129 million over five years as compared to other alternatives that seek the same benefits but are based on decentralized architectures. These figures were calculated in the summer of 2007 by an independent economist hired by the eRulemaking Program to develop a Cost-Benefit Model.

NASA benefits through its participation and reliance on FDMS and Regulations.gov. NASA reaps substantial benefits by improving the transparency of its rulemaking actions while increasing public participation in the regulatory process. Direct budget cost savings and cost avoidance result from NASA's transition to Federal Document Management System and Regulations.gov, enabling the Agency to discontinue efforts to develop, deploy, and operate specific individual online docket and public comment systems. Over a five-year period, NASA is estimated to save over $700,000 over alternative options that would provide similar services.

Grants.gov (Managing Partner HHS) FY 2014 Benefits

The Grants.gov initiative benefits NASA and its grant programs by providing a single location with broader exposure to publish grant (funding) opportunities and application packages, making the process easier for applicants to apply to multiple agencies. All 26 major Federal grant making agencies posted 100 percent of their synopses for discretionary funding opportunity announcements on Grants.gov.

In addition, Grants.gov provides a single site for the grantee community to apply for grants using a standard set of forms, processes and systems giving greater access and ability to apply for Federal funding. Through the use of Grants.gov, NASA is able to reduce operating costs associated with online posting and application of grants. Additionally, the Agency is able to improve operational effectiveness through the use of Grants.gov by increasing data accuracy and reducing processing cycle times.

Grants Management LoB (Managing Partner NSF) FY 2014 Benefits

The Grants Management LoB provides NASA with a centralized location for the research community to track awards to closeout, locate policy, news and events, and results of research. NASA and the grantee community have benefited from participation in the Grants Management LoB by having greater visibility into the research efforts awarded by NASA. Implementation of the Research Performance Progress Reports and other standard post-award reports will help to decrease the number of unique agency-specific reporting requirements.

In addition, the Grants Management LoB Consortium lead agencies will spread the operations and maintenance costs, and development, modernization, and enhancement costs across agencies, decreasing the burden that any one agency must bear.

e-Training (Managing Partner OPM) FY 2014 Benefits

The e-Training initiative provides access to premier electronic training systems and tools that support the training and development of the Federal workforce. The initiative advanced the accomplishment of agency missions through simplified and one-stop access to e-Training products and services. The availability of an electronic training environment enhances the ability of the Federal government and NASA to attract, retain, manage, and educate the highly skilled professionals needed for a flexible and high-performing government workforce.

The e-Training initiative benefits NASA by reducing redundancies and achieving economies of scale in the purchase and/or development of e-learning content and in the purchase of learning technology infrastructure. In 2006, NASA streamlined three online training systems into one centralized, learning management system: SATERN, a “one-stop” approach offering Web-based training and career development resources. This centralized approach allows NASA to reduce and leverage training costs through the elimination of unique systems and standardization of training processes.

Through SATERN, employees can view required training, launch online content, view training history, and self-register for approved courses and conferences. In addition, the system allows NASA officials to identify groups and individuals who have not met basic training requirements and ensure accountability for mission critical and federally mandated training and development. SATERN also offers employees access to career planning tools, individual development plans, and competency management assistance. Currently SATERN offers learners access to more than 2,000 online courses and 10,000 online books and training videos. SATERN is available at all times and can be accessed from work or at home.

Recruitment One-Stop (Managing Partner OPM) FY 2014 Benefits

USAJOBS simplifies the Federal Job Search Process for Job Seekers and Agencies. The USAJOBS.gov website provides a place where citizens can search for employment opportunities throughout the Federal Government. USAJOBS is a fully operational, state of the art recruitment system that simplifies the Federal job search process for job seekers and agencies. Through USAJOBS.gov users have access to:

- A centralized repository for all competitive service
- Job vacancies;
- A resume repository used by agencies to identify critical skills;
- A standardized online recruitment tool and services;
- A standard application Process; and
- Intuitive job searches including e-mail notifications for jobs of interest.

Integration with Recruitment One-Stop allows NASA to better attract individuals who can accomplish the Agency’s mission. The USAJOBS interface allows job seekers to view and apply for all NASA employment opportunities, as well as those from other federal agencies. On average, USAJOBS.gov has over 400,000 visitors per day (the online portal serviced over 21 million applications during FY 2010) and over 500,000 resumes are created monthly.

NASA adopted the USAJOBS resume as the basic application document for all NASA positions, except for astronaut positions (in 2005). To date NASA has not identified any specific savings, either in terms of budgeted savings or cost avoidance. Although the Agency believes that implementation of Recruitment One-Stop has resulted in significant intangible benefits in terms of providing better vacancy information to applicants, it has not resulted in any specific cost savings to NASA. However, the numerous intangible benefits Recruitment One-Stop provides to NASA and other agencies include:

- Decreasing hiring time for managers;
- Providing an integrated solution to agency applicant assessment systems;
- Providing a cost effective marketing and recruitment tool;
- Realizing cost savings over commercial job posting boards;
- Reducing the delay associated with filling critical agency vacancies; and
- Enhancing competition with the private sector for the best and brightest talent for Federal service.

Enterprise HR Integration (Managing Partner OPM) FY 2014 Benefits

The Enterprise HR Integration (EHRI) Program supports the strategic management of human capital by providing agency customers with access to timely and accurate federal workforce data. In support of this objective, EHRI has the following goals: 1) Streamline and automate the exchange of federal employee human resources (HR) information Government wide; 2) Provide comprehensive knowledge management and workforce analysis, forecasting, and reporting across the Executive Branch; 3) Maximize cost savings captured through automation; and 4) Enhance retirement processing throughout the Executive Branch.

A key initiative of EHRI is the electronic Official Personnel Folder (eOPF), a web-based application capable of storing, processing, and displaying the OPFs of all current, separated, and retired Federal Employees. When fully implemented, the eOPF will cover the entire Executive Branch as well as other Federal and Local Governments with a total user population of more than 1.9M. The system will replace the existing manual process by automating the Federal Government's HR processes and thereby creating a streamlined Federal HR system for all Federal Employees. The initiative is achieving cost savings that are recognized on a per-folder basis. The total cost avoidance per folder is estimated at $55.56.

Specific EHRI/eOPF benefits to NASA include improved convenience in searching, better security and safety to electronic files, more economical, streamlined business processes, and the ability to have a central repository of OPF records for the Agency. During FY 2010, NASA also deployed the eOPF capability of electronic transfer of eOPFs between agencies. Specific NASA employee benefits include secure online access to OPFs, automatic notification when documents are added, exchange of retirement and HR data across agencies and systems, and the elimination of duplicate and repetitive personnel data in personnel folders. NASA completed its implementation to eOPF in March 2008, and transitioned personnel actions processing to the NASA Shared Service Center.

E-Payroll (Managing Partner OPM) FY 2014 Benefits

The E-Payroll Initiative standardizes and consolidates government-wide federal civilian payroll services and processes by simplifying and standardizing human resources (HR)/payroll policies and procedures and better integrating payroll, HR, and finance functions. Prior to beginning the initiative, 26 federal agencies provided payroll services. Four providers were selected to furnish payroll services for the Executive branch.

In 2004, the Department of Interior began serving as NASA's payroll provider, using their system, the Federal Personnel and Payroll System, to process NASA's human resources and payroll transactions and supply all key delivery aspects of its payroll operation functions. The E-Payroll initiative benefits NASA by permitting the Agency to focus on its mission related activities, rather than on administrative payroll functions. Payroll processing costs are reduced through economies of scale and avoiding the cost of duplicative capital system modernization activities. The initiative also promotes standardization of business processes and practices and unified service delivery.

E-Travel (Managing Partner GSA) FY 2014 Benefits

The E-Gov Travel Service (ETS) is a government-wide web-based service that provides standardized travel management practices to consolidate federal travel, minimize cost and produce customer satisfaction. From travel planning and authorization to the review and approval of post-travel reimbursement, this end-to-end service streamlines travel management and will enable the government to capture real-time visibility into the buying choices of travelers and assist agencies in optimizing their travel budgets while saving taxpayers money.

The benefits of the ETS include:

- Increased cost savings associated with overall reduction in Travel Management Center transaction service fees;
- Improved strategic source pricing through cross-government purchasing agreements;
- Improved business process functionality as a result of streamlined travel policies and processes;
- Enhanced security and privacy controls for the protection of government and personal data; and
- Improved agency oversight and audit capabilities.

As the ETS is a fully integrated, end-to-end travel solution, program cost avoidance is realized by a reduction of traveler and manager time for planning, arranging, authorizing, approving and post-travel reimbursement processing. Travelers also benefit from ETS' increased efficiency in the end-to-end electronic solution as their reimbursements are expedited. Additional initiative savings are realized from the elimination of costly paper-based systems, the decommissioning of legacy travel systems and the reduction of agency overhead by consolidating the number of travel contracts.

NASA completed migration of its travel services to HP Enterprise Services (formerly Electronic Data Systems Corporation), one of the three designated E-Travel service providers, in mid-2009. Completing this migration has allowed NASA to provide more efficient and effective travel management services. Potential benefits include cost savings associated with cross-government purchasing agreements and improved functionality through streamlined travel policies and processes, strict security and privacy controls, and enhanced Agency oversight and audit capabilities. NASA employees are also benefitting through more efficient travel planning, authorization, and reimbursement processes. Prior to ETS, the estimated overall government-wide on-line adoption rate for travel reservations was approximately 6 percent. To date, the on-line booking engine adoption rate is over 64 percent resulting in dramatic cost savings as a result of lowering travel agent service fees.

Integrated Acquisition Environment (Managing Partner GSA) FY 2014 Benefits

The Integrated Acquisition Environment (IAE) initiative is designed to streamline the process of reporting on subcontracting plans and provide agencies with access to analytical data on subcontracting performance. Use of the IAE common services allows agencies to focus on agency-specific needs such as strategy, operations, and management while leveraging shared services for common functions. Furthermore, use of a government-wide business focused service environment reduces funding and resources for technical services and support for acquisition systems originally housed by individual agencies.

IAE facilitates and supports cost-effective acquisition of goods and services by agencies. The IAE initiative provides common acquisition functions and shared services that benefit all agencies, such as the maintenance of information about business-partner organizations (e.g., banking, certifications, business types, capabilities, performance). IAE provides benefits to the government and business-partner organizations by improving cross-agency coordination that helps to improve the government's buying power, while providing business partners maximum visibility and transparency into the process. IAE provides various services, tools and capabilities that can be leveraged by the acquisition community including buyers, sellers, and the public to conduct business across the federal government space.

Government buyers can:

- Search for commercial and government sources
- Post synopses and solicitations
- Securely post sensitive solicitation documents
- Access reports on vendors' performance
- Retrieve vendor data validated by SBA and Internal Revenue Service (IRS)
- Identify excluded parties
- Report contract awards

Business suppliers can:

- Search business opportunities by product, service, agency, or location
- Receive e-mail notification of solicitations based on specific criteria
- Register to do business with the federal government
- Enter representations and certifications one time
- Revalidate registration data annually
- Report subcontracting accomplishments

Citizens can:

- Retrieve data on contract awards
- Track federal spending
- Search to find registered businesses
- Monitor business opportunities

Through adoption of the tools and services provided by IAE, NASA improves its ability to make informed and efficient purchasing decisions and allows it to replace manual processes. If NASA did not use IAE systems, the Agency would need to build and maintain separate systems to record vendor and contract information, and to post procurement opportunities. Agency purchasing officials would not have access to databases of important information from other agencies on vendor performance and could not use systems to replace paper-based and labor-intensive work efforts.

E-GOV INITIATIVES AND BENEFITS

Integrated Acquisition Environment – Loans & Grants FY 2014 Benefits

All agencies participating in the posting and/or awarding of Contracts and Grants & Loans are required by the Federal Funding Accountability and Transparency Act (FFATA) of 2006 as well as the American Recovery and Reinvestment Act of 2009 (ARRA) reporting requirements to disclose award information on a publicly accessible website. FFATA requires OMB to lead the development of a single, searchable website through which the public can readily access information about grants and contracts provided by Federal government agencies[1].

Based on the recommendations of the Transparency Act Taskforce, the website leverages functionality provided by the Integrated Acquisition Environment (IAE) initiative to provide Data Universal Numbering System (DUNS) numbers as the unique identifier. An existing IAE Dun and Bradstreet (D&B) transaction-based contract for the contract community was expanded to provide government-wide D&B services for the Grants & Loans community. These services include parent linkage, help desk support, world database lookup, business validation and linkage monitoring, matching services, as well as the use of DUNS numbers. The enterprise D&B contract provides substantial savings to the participating agencies over their previous agency transaction-based D&B contracts.

On December 14, 2007, OMB launched www.USASpending.gov to meet the Federal Funding Accountability and Transparency Act (FFATA) statutory requirements, ahead of schedule. Since that launch, OMB has and will continue to work with agencies to improve the quality, timeliness, and accuracy of their data submissions and has released a series of enhancements to the site. USASpending.gov complements other websites providing the public Federal program performance information (e.g., USA.gov, Results.gov and ExpectMore.gov).

USASpending.gov provides:

- The name of the entity receiving the award;
- The amount of the award;
- Information on the award including transaction type, funding agency, etc.;
- The location of the entity receiving the award;
- A unique identifier of the entity receiving the award.

All agencies participating in the posting and/or awarding of Contracts and Grants & Loans are required by the FFATA as well as the American Recovery and Reinvestment Act of 2009 (ARRA) reporting requirements to disclose award information on a publicly accessible website. Cross government cooperation with OMB's Integrated Acquisition Environment initiative allows agencies and contributing bureaus to meet the requirements of the FFATA by assigning a unique identifier, determining corporate hierarchy, and validating and cleaning up incorrect or incomplete data.

The FY 2014 funding requirements as it relates to the IAE – Loans and Grants funding line supports the FFATA for the relationship with D&B and DUNS support services. In addition to provision of DUNS numbers, D&B is now providing business and linkage data seamlessly, and the business arrangement

[1] *More information on the development of this website can be found at: http://www.federalspending.gov.*

supports the quality of data by real-time updates. NASA and other agencies will leverage the linkages to corporate organizational rollups based on parental and subsidiary relationships.

LINES OF BUSINESS

Financial Management LoB (Managing Partners DOE and DOL) FY 2014 Benefits

The Financial Management Line of Business (FM LoB) leverages shared service solutions that improve the quality of federal financial data and decrease known inefficiencies—and costs—that are typical of redundant financial management systems. FM LoB's Shared Services Providers (SSPs) offer participating agencies the economies of scale and expertise in IT and financial reporting not always available within a single agency. An emphasis is being placed on greater standardization, transparency and business process improvements as opposed to solely technology improvements.

The FM LoB initiative uses standard business practices and meets federal accounting standards for financial reporting. This level of standardization across all federal agencies would provide executive decision makers with accurate information from which to assess program performance and risks, evaluate costs, and improve stewardship across the Federal government.

Current OMB FM LoB policy requires agencies to conduct a competition among Federal and Commercial Shared Services Providers (SSPs) before attempting to modernize financial systems. Commercial SSPs have not yet been designated to support the same range of services provided by Federal SSPs. NASA has expressed an interest in becoming an SSP, but awaits OMB direction on the future of the FM LoB.

Human Resources Management LoB (Managing Partner OPM) FY 2014 Benefits

The HR LoB vision is to create government-wide, modern, cost-effective, standardized, and interoperable HR solutions to provide common core functionality to support the strategic management of Human Resources through the establishment of Shared Service Centers (SSCs). Driven from a business perspective, the solutions will address distinct business improvements enhancing the government's performance of HR and payroll services in support of agency missions delivering services to citizens. The HR LoB concept of operations calls for agencies to receive core services from an HR LoB provider. These core services are defined as personnel action processing, compensation management (payroll) and benefits management. Leveraging shared services solutions will allow the HR LoB to significantly improve HR and payroll service delivery, save taxpayer dollars, and reduce administrative burdens.

NASA works in partnership with one of the approved service providers, the Department of Interior's National Business Center. Through this partnership, NASA shares and receives "best-in-class" HR solutions. The National Business Center delivers NASA-developed solutions to their customer agencies, enabling improved efficiencies and system integrations at a fraction of the cost and delivery time than similar solutions could have been produced by National Business Center. NASA achieves the benefits of "best-in-class" HR solutions through implementation and integration of National Business Center and NASA-developed HR solutions. NASA's participation in HR LoB allows the agency to participate in the implementation of modern HR solutions and benefit from best practices and government-wide strategic HR management.

Geospatial LoB (Managing Partner DOL) FY 2014 Benefits

The Geospatial LoB will better serve the agencies' missions and the Nation's interests developing a more strategic, coordinated, and leveraged approach to producing, maintaining, and using geospatial data and services across the Federal government. Specific goals of the Geospatial LoB include establishing a collaborative governance mechanism, coordinating a government-wide planning and investment strategy, and optimizing and standardizing geospatial data and services.

Contributing agencies and bureaus will receive value from the development of the LoB primarily through improved business performance and cost savings. Enhanced governance processes, improved business planning and investment strategies, and optimization and standardization of geospatial business data and services will produce the following results:

- Collaborative management of geospatial investments will be made more adaptable, proactive and inclusive;
- Enterprise business needs and agency core mission requirements will be identified, planned, budgeted, and exploited in a geospatial context;
- Long-term costs of geo-information delivery and access will be reduced while minimizing duplicative development efforts;
- Effective, yet less costly commercial off the shelf systems and contractual business support operations will replace legacy geospatial applications; and
- Business processes will be optimized and knowledge management capabilities will exist for locating geospatial data and obtaining services.

As a science agency, the work of NASA's science and mission professionals is inherently different from duties and functions performed by operational agencies. These differences lead NASA to organize and manage data to best facilitate science activities rather than a central focus of data dissemination. Scientific inquiry often leads scientist to use different schemas for analyzing data and information produced from remote sensing data (e.g. a common grid or projection). NASA will continue to apply the elements of Federal Geographic Data Committee standards where these are appropriate. In FY 2008, NASA signed an MOU with the Department of Labor to continue its active participation in the Geospatial LOB.

Budget Formulation & Execution LOB (Managing Partner Education) FY 2014 Benefits

The Budget Formulation and Execution LoB (BFELoB) provides benefits to NASA and other partner agencies by encouraging best practices crossing all aspects of Federal budgeting -- from budget formulation and execution to performance to human capital needs. To benefit all agencies, BFELoB continues to support the idea of shared service budget systems. The Agency has not chosen to move to a new budget system; however, NASA is looking into some of the BFELoB components, such as MAX Collect and Analytics to complement its current budgeting tools.

BFELoB's "MAX Federal Community", a secure government-only collaborative website, provides significant benefits for collaboration across and within agencies, as well as knowledge management. The Community site is commonly used for sharing information, collaboratively drafting documents (including the direct-editing of documents posted on the site), supporting workgroups, submitting central reports, and much more. NASA currently has well over 900 users that are registered and eligible to take advantage of the MAX Federal Community. During FY 2010 year end planning, NASA made extensive use of the MAX Wiki capability to facilitate work group collaborations and document reviews.

The BFELoB released MAX Collect to facilitate the rapid collection and reporting of agency information. In November 2010, NASA successfully completed its first Agency-wide MAX Collect exercise. Among the benefits NASA derived from the exercise were reduced errors, and reduced time spent manually consolidating and publishing data by using MAX Collect's data collection capabilities. NASA also benefited from using MAX Collect and its publishing capabilities to collect, store, process and publish information from multiple sources in an extremely efficient and effective manner, producing professional quality output. Additionally, to enhance decision-making within its organization, NASA can benefit from using MAX Analytics' data visualization tools.

In Oct, 2009, the Budgeting Capabilities Self-Assessment Tool was published, providing agency budget managers and their staff with a simple survey-like method to assess and gain perspective on how their current operations and processes compare against best practices in a broad range of budgeting capability categories, allowing managers to strategically focus improvement efforts on areas of highest value to their particular organization's activities. NASA will be exploring the benefit from using the tool to assess organizational practices and develop strategic plans to address areas of need.

BFELoB's Human Capital Federal Budget Core Competency Framework is a resource for NASA to use in their internal workforce planning initiatives. BFELoB is working toward adding proficiency levels to each Core Competency as well as aligning training with competencies and proficiencies to assist budget professionals in determining a training roadmap for development. During FY 2010, the BFELoB released a self-paced Budget Formulation video training course to users of the MAX Community. In addition, the BFELoB Human Capital work group offers multiple technical and developmental training opportunities throughout the year. NASA staff have benefitted substantially from these BFELoB sponsored training opportunities, as well as through participation in BFELoB work groups.

COMPARABILITY ADJUSTMENT TABLES

EXPLANATION OF COMPARABILITY TABLES

As requested by Congress in House Report 112-284, the FY 2012 actual and FY 2013 estimates have been adjusted to display their budgets in a presentation that is "comparable" to the content of items proposed in the FY 2014 budget. This presentation allows direct comparability of yearly budget data associated with an investment, regardless of the account (or theme, program, etc.) in which it was, or is currently being, executed.

At the time of budget publication, NASA was operating under a Continuing Resolution (CR), and executing FY 2013 in the FY 2012 budget structure. The FY 2013 figures in all tables represent budget authority provided by the CR at the full-year rate for operations (amounts per section 101 of P.L. 112-175), the Agency $15 million appropriation provided by the Disaster Relief Act, 2013 (P.L. 113-2), and the $0.3 million rescission of remaining American Recovery and Reinvestment Act of 2009 (ARRA) unobligated balances required by the Dodd-Frank Wall Street Reform and Consumer Protection Act (P.L. 111-203).

The following pages provide detailed crosswalks of non-comparable FY 2012 actual and FY 2013 estimates to their comparable amounts. The following guidelines will assist in interpreting the tables.

- The gray title box in the upper left hand corner indicates the fiscal year in which budget and accounts are being addressed.
- The budget structure running on top of the table is the FY 2014 structure that is used in the rest of this volume. The layers in the structure from the top down are for the account, theme, program, and reporting attribute. Note that when theme, program or reporting attribute titles are identical they are combined to simplify the display. The amounts displayed under this budget structure "block" are comparable (adjusted) amounts for the reporting attribute you see in the tables in the rest of this volume.
- The budget structure running on the left side of the table is that fiscal year's operating plan budget structure. Note that when titles are identical they were often combined to simplify the display. The amounts to the right of the structure are the unadjusted amounts from the fiscal year's operating plan with the proposed allocation of the Public Law 112-55 rescission displayed separately for FY 2012. The rescission of unobligated ARRA funds applied to the Office of the Inspector General, per section 1306 of the Dodd-Frank act is presented in the same fashion.
- The amounts in the matrix are the adjustments to the unadjusted amounts used to derive the comparable budget presentation you see in the tables in the rest of this volume.
- No table for the Construction and Environmental Compliance and Restoration account was prepared because there are no adjustments related to that account.

FY 2012 Operating Plan Recast to FY 2014 Structure: Science

Budget Authority
($ millions)

FY 2012 Current Operating Plan[1] in FY 2012 Structure	Recast FY 2012 Amounts: Pre-Resc. Level	Rescission	Current Op Plan[1]	FY 2012 Current Operating Plan, in FY 2014 Structure, Adjusted for Rescission																											
				SCIENCE -- $5,073.7																											
				EARTH SCIENCE $1,760.5													PLANETARY SCIENCE $1,501.4														
				EARTH SCIENCE RESEARCH $441.1		EARTH SYSTEMATIC MISSIONS $879.8					EARTH SYSTEM SCIENCE PATHFINDER $183.3			EARTH SCIENCE MULTI-MISSION OPERATIONS	EARTH SCIENCE TECHNOLOGY	APPLIED SCIENCES $36.4	PLANETARY SCIENCE RESEARCH $174.1				LUNAR QUEST PROGRAM $140.0			DISCOVERY $172.6		NEW FRONTIERS $143.7		MARS EXPLORATION $587.0		OUTER PLANETS $122.1	TECHNOLOGY $161.9
				Earth Science Research & Anaysis	Computing & Management	Global Precipitation Measurement	Ice, Cloud & Land Elevation Satellite (ICE SAT-II)	Soil Moisture Active & Passive	GRACE FO	Other Missions & Data Analysis[2,3]	OCO-2	Venture Class Missions	Other Missions & Data Analysis[2]			Pathways	Planetary Science Research & Analysis	Education & Directorate Management	Near Earth Object Observations	Other Missions & Data Analysis	Lunar Science	Lunar Atmosphere & Dust Environment Explorer	Surface Science Lander Technology	InSight	Other Missions & Data Analysis[2,3]	Origins Spectral Interpretation Resource	Other Missions & Data Analysis[3]	MAVEN	Other Missions & Data Analysis[2]		
				333.3	107.7	87.9	130.5	214.2	42.3	404.9	93.4	53.6	36.3	168.6	51.2	36.4	122.3	4.0	20.4	27.4	66.8	70.4	2.8	42.1	130.5	99.8	43.9	245.7	341.4	122.1	161.9
SCIENCE	**5,079.0**	**(5.2)**	**5,073.8**																												
EARTH SCIENCE	**1,765.7**	**(5.2)**	**1,760.5**																												
Earth Science Research	**441.1**		**441.1**																												
Earth Science Research and Analysis	333.3		333.3	333.3																											
Computing and Management	107.7		107.7		107.7																										
Earth Systematic Missions	**880.9**	**(1.1)**	**879.8**																												
Global Precip. Measurement (GPM)	87.9		87.9			87.9																									
Landsat Data Cont. Mission (LDCM)	123.5		123.5							123.5																					
NPOESS Preparatory Project (NPP)	6.0		6.0							6.0																					
Ice, Cloud & Land Elev. Sat. (ICESat-II)	130.5		130.5				130.5																								
Soil Moisture Active & Passive (SMAP)	214.2		214.2					214.2																							
Other Missions and Data Analysis	318.8	(1.1)	317.7						42.3	275.4																					
Earth System Science Pathfinder	**187.4**	**(4.1)**	**183.3**																												
Aquarius	4.2	(4.1)	0.1										0.1																		
OCO-2	93.4		93.4								93.4																				
Other Missions and Data Analysis	36.2		36.2										36.2																		
Venture Class Missions	53.6		53.6									53.6																			
Earth Science Multi-Mission Ops	**168.6**	**0.0**	**168.6**																												
Earth Science Multi-Mission Operations	168.6		168.6											168.6																	
Earth Science Technology	**51.2**	**0.0**	**51.2**																												
Earth Science Technology	51.2		51.2												51.2																
Applied Sciences	**36.4**	**0.0**	**36.4**																												
Pathways	36.4		36.4													36.4															
PLANETARY SCIENCE	**1,501.4**	**0.0**	**1,501.4**																												
Planetary Science Research	**174.1**		**174.1**																												
Planetary Science Research and Analysis	122.3		122.3														122.3														
Education and Directorate Management	4.0		4.0															4.0													
Near Earth Object Observations	20.4		20.4																20.4												
Other Missions and Data Analysis	27.4		27.4																	27.4											
Lunar Quest Program	**140.0**	**0.0**	**140.0**																												
Lunar Science	66.8		66.8																		66.8										
Lunar Atmosphere and Dust Environment Explorer	70.4		70.4																			70.4									
International Lunar Network	2.8		2.8																				2.8								
Discovery	**172.6**	**0.0**	**172.6**																												
GRAIL	29.8		29.8																						29.8						
Other Missions and Data Analysis	142.8		142.8																					42.1	100.7						
New Frontiers	**143.7**	**0.0**	**143.7**																												
Juno	14.4		14.4																								14.4				
Other Missions and Data Analysis	129.4		129.4																							99.8	29.5				
Mars Exploration	**587.0**	**0.0**	**587.0**																												
2009 Mars Science Lab	174.0		174.0																										174.0		
MAVEN	245.7		245.7																									245.7			
Other Missions and Data Analysis	167.4		167.4																										167.4		
Outer Planets	**122.1**	**0.0**	**122.1**																											122.1	
Technology	**161.9**	**0.0**	**161.9**																												161.9

[1]Current operating plan in effect as of publication (April 10, 2013).

[2]Recast reflects the movement of a project and associated dollars from an independently reported "in development" budget line to an "Other Missions and Data Analysis" budget line. This typically reflects movement of mission into the "operations" stage after successful launch. (Aquarius, GRAIL, Juno, MSL, NPP)

[3]Recast reflects the movement of a project and associated dollars from "pre-formulation" in "Other Missions and Data Analysis" or other R&A program to an independent reportable item. (Grace FO, InSight, OSIRIS-Rex)

FY 2012 Operating Plan Recast to FY 2014 Structure: Science

Budget Authority ($ millions)

FY 2012 Current Operating Plan, in FY 2014 Structure, Adjusted for Rescission

SCIENCE -- $5,073.7

Theme				ASTROPHYSICS $648.4									JAMES WEBB SPACE TELESCOPE $518.6	HELIOPHYSICS $644.8										
Program				ASTROPHYSICS RESEARCH $165.5			COSMIC ORIGINS $239.9			PHYSICS OF THE COSMOS $108.3	EXOPLANET EXPLORATION $50.8	ASTRO EXPLORER $83.9		HELIOPHYSICS RESEARCH $166.7				LIVING WITH A STAR $196.3			SOLAR TERRESTRIAL PROBES $216.0		HELIOPHYSICS EXPLORER PROGRAM $65.8	
Project	Recast FY 2012 Amounts: Pre-Resc. Level	Rescission	Current Op Plan[1]	Astrophysics Research & Analysis	Balloon Project	Other Missions & Data Analysis	Hubble Space Telescope	Stratospheric Observatory for Infrared Astronomy	Other Missions & Data Analysis	Other Missions & Data Analysis	Other Missions & Data Analysis	Other Missions & Data Analysis[2,4]	JAMES WEBB SPACE TELESCOPE	Heliophysics Research & Analysis	Sounding Rockets	Research Range	Other Missions & Data Analysis	Solar Probe Plus	Solar Orbiter Collaboration[3]	Other Missions & Data Analysis[2]	Magnetospheric Multiscale (MMS)	Other Missions & Data Analysis	IRIS	Other Missions & Data Analysis[2,5,6]
Totals				68.6	31.6	65.3	98.3	84.2	57.4	108.3	50.8	83.9	518.6	32.9	52.4	20.1	61.3	52.6	19.7	123.9	194.6	21.5	0.0	65.8
SCIENCE	5,079.0	(5.2)	5,073.8																					
ASTROPHYSICS	648.4	0.0	648.4																					
Astrophysics Research	165.5	0.0	165.5																					
Astrophysics Research and Analysis	68.6		68.6	68.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Balloon Project	31.6		31.6	--------	31.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Other Missions and Data Analysis	65.3		65.3	--------	--------	65.3	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Cosmic Origins	239.9	0.0	239.9																					
Hubble Space Telescope	98.3		98.3	--------	--------	--------	98.3	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Strat. Obs. for IR Astronomy (SOFIA)	84.2		84.2	--------	--------	--------	--------	84.2	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Other Missions and Data Analysis	57.4		57.4	--------	--------	--------	--------	--------	57.4	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Physics of the Cosmos	108.3	0.0	108.3	--------	--------	--------	--------	--------	--------	**108.3**	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Exoplanet Exploration	50.8	0.0	50.8	--------	--------	--------	--------	--------	--------	--------	**50.8**	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Astrophysics Explorer	83.9	0.0	83.9																					
Nuclear Spec.Telescope Array (NuStar)	15.6		15.6	--------	--------	--------	--------	--------	--------	--------	--------	15.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Gravity & Extreme Magnetism (GEMS)	33.2		33.2	--------	--------	--------	--------	--------	--------	--------	--------	33.2	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Other Missions and Data Analysis	35.1		35.1	--------	--------	--------	--------	--------	--------	--------	--------	35.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
JAMES WEBB SPACE TELESCOPE	518.6	0.0	518.6																					
James Webb Space Telescope	518.6	0.0	518.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	**518.6**	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
HELIOPHYSICS	644.8	0.0	644.8																					
Heliophysics Research	175.2		175.2																					
Heliophysics Research and Analysis	32.9		32.9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	32.9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Sounding Rockets	52.4		52.4	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	52.4	--------	--------	--------	--------	--------	--------	--------	--------	--------
Research Range	20.1		20.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	20.1	--------	--------	--------	--------	--------	--------	--------	--------
Other Missions and Data Analysis	69.9		69.9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	61.3	--------	--------	--------	--------	3	--------	5.6
Living with a Star	196.3	0.0	196.3																					
Radiation Belt Storm Probes (RBSP)	86.1		86.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	86.1	--------	--------	--------	--------
Solar Probe Plus	52.6		52.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	52.6	--------	--------	--------	--------	--------	--------
Other Missions and Data Analysis	57.5		57.5	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	19.7	37.8	--------	--------	--------	--------
Solar Terrestrial Probes	213.0	0.0	213.0																					
Magnetospheric Multiscale (MMS)	194.6		194.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	194.6	--------	--------	--------
Other Missions and Data Analysis	18.5		18.5	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	18.5	--------	--------
Heliophysics Explorer Program	60.2	0.0	60.2																					
IRIS	39.1		39.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	39.1
Other Missions and Data Analysis	21.1		21.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	21.1

FY 2012 Current Operating Plan[1] in FY 2012 Structure

[1]Current operating plan in effect as of publication (April 10, 2013).

[2]Recast reflects the movement of a project and associated dollars from an independently reported "in development" budget line to an "Other Missions and Data Analysis" budget line. This typically reflects movement of mission into the "operations" stage after successful launch. (NuSTAR, RBSP)

[3]Recast reflects the movement of a project and associated dollars from "pre-formulation" in "Other Missions and Data Analysis" or other R&A program to an independent reportable item. (SOC)

[4]Recasts the GEMS budget line to "Other Missions and Data Analysis" due to project termination.

[5]Recast reflects movement of project and associated dollars from Heliophysics Research program to other programs in the Science Heliophysics theme.

[6]Recast reflects realignment of IRIS mission from an independently reported project in development to a small project in development under "Other Missions and Data Analysis".

FY 2012 Operating Plan Recast to FY 2014 Structure: Exploration, Space Operations, Space Technology, & Cross Agency Support Accounts

Budget Authority ($ millions)

FY 2012 Current Operating Plan, in FY 2014 Structure, Adjusted for Rescission

FY 2012 Current Operating Plan[1] in FY 2012 Structure

Budget Authority ($ millions)	Pre-Resc. Level	Rescission	Current Op Plan[1]	EXPLORATION -- $3,707.3								SPACE OPERATIONS -- $4,184.0														SPACE TECHNOLOGY - $573.7				CROSS AGENCY SUPPORT -- $2,993.9										
				EXPLORATION SYSTEMS DEVELOPMENT $3,001.6					COM. SPACE.	EXPLORATION R&D - $299.7		SPACE SHUTTLE $596.2				INTERNATIONAL SPACE STATION (ISS) $2,789.9			SPACE & FLIGHT SUPPORT $797.9							SPACE TECHNOLOGY $573.7				CENTER MANAGEMENT OPERATIONS $2,204.1		AGENCY MANAGEMENT OPERATIONS $789.8								
				MULTI-PURPOSE CREW VEHICLE $1,200.0		SPACE LAUNCH SYSTEM $1,497.1		EXPLORATION GROUND SYSTEMS	COMMERCIAL CREW[3]	HUMAN RESEARCH PROGRAM	ADVANCED EXPLORATION SYSTEMS								21ST CENTURY SPACE LAUNCH COMPLEX	SPACE COMMUNICATIONS & NAVIGATION $442.9			HUMAN SPACEFLIGHT OPERATIONS	LAUNCH SERVICES	ROCKET PROPULSION TESTING	PARTNERSHIPS DEVELOPMENT & STRATEGIC INTEGRATION[2]	SBIR & STTR[2]	CROSS CUTTING SPACE TECHNOLOGY DEVELOPMENT[2]	EXPLORATION TECHNOLOGY DEVELOPMENT[2]			AGENCY MANAGEMENT & OPERATIONS $403.6	SAFETY & MISSION SUCCESS $198.4				AGENCY IT SERVICES $158.5			STRATEGIC CAPABILITIES ASSETS PROGRAM $29.3
				Crew Vehicle Development	MPCV Program Integration & Support	Launch Vehicle Development	SLS Program Integration & Support					SPOC Pension Liability	Program Integration	Flight & Ground Ops.	Flight Harware	ISS Systems O&M	ISS Research	ISS Crew & Cargo Transport.		Space Communications Networks	Space Communications Support	TDRS Replenishment								CENTER INSTITUTIONAL CAPABILITIES	CENTER PROGRAMMATIC CAPABILITES		Safety & Mission Assurance	Chief Engineer	Chief Health & Medical Officer	Independent Verification & Validation	IT Management	Applications	Infrastructure	
Recast FY 2012 Amounts				1,159.8	40.2	1,450.7	46.4	304.5	406.0	157.7	142.0	515.0	57.4	19.0	4.8	1,378.7	225.5	1,185.7	123.5	355.4	72.0	15.4	106.9	81.0	43.6	29.5	171.6	183.5	189.1	1,707.2	496.9	403.6	49.4	105.2	4.7	39.1	14.6	67.8	76.0	29.3
EXPLORATION	3,718.8	(3.7)	3,715.1																																					
HUMAN EXPLORATION CAPABILITIES	3,007.6	0.0	3,007.6																																					
Orion Multi-Purpose Crew Vehicle	1,200.0	0.0	1,200.0																																					
Crew Vehicle Development	1,159.8		1,159.8	1,159.8																																				
MPCV Program Integration & Support	40.2		40.2		40.2																																			
Space Launch System	1,802.0	(0.4)	1,801.6																																					
Launch Vehicle Development	1,451.1	(0.4)	1,450.7			1,450.7																																		
SLS Program Integration & Support	46.4		46.4				46.4																																	
Ground Systems Development & Operations	304.5		304.5					304.5																																
COMMERCIAL SPACE FLIGHT	406.0	0.0	406.0																																					
Commercial Crew	392.0		392.0						392.0																															
Commercial Cargo[3]	14.0		14.0						14.0																															
EXPLORATION RESEARCH & DEVELOPMENT	310.8	(3.3)	307.5																																					
Human Research Program	157.7		157.7							157.7																														
Advanced Exploration Systems[2]	153.1	(3.3)	149.8								142.0																		7.8											
SPACE OPERATIONS	4,204.2	(10.4)	4,193.8																																					
SPACE SHUTTLE	559.3	(3.1)	556.2																																					
Space Shuttle Program	599.3	(3.1)	596.2																																					
SPOC Pension Liability	515.0		515.0									515.0																												
Program Integration	60.5	(3.1)	57.4										57.4																											
Flight & Gound Operations	19.0		19.0											19.0																										
Flight Hardware	4.8		4.8												4.8																									
INTERNATIONAL SPACE STATION (ISS)	2,789.9	0.0	2,789.9																																					
Interational Space Station Program	2,789.9	0.0	2,789.9																																					
ISS Systems Operations & Maintenance	1,378.7		1,378.7													1,378.7																								
ISS Research	225.5		225.5														225.5																							
ISS Crew & Cargo Transportation	1,185.7		1,185.7															1,185.7																						
SPACE & FLIGHT SUPPORT	815.0	(7.3)	807.7																																					
21st Century Space Launch Complex	130.0	(6.5)	123.5																123.5																					
Space Communications & Navigation	443.4	(0.5)	442.9																																					
Space Communications Networks	355.6	(0.2)	355.4																	355.4																				
Space Communications Support	72.3	(0.3)	72.0																		72.0																			
TDRS Replenishment	15.4		15.4																			15.4																		
Human Spaceflight Operations	107.2	(0.3)	106.9																				106.9																	
Launch Services	81.0	0.0	81.0																					81.0																
Rocket Propulsion Test	43.6	0.0	43.6																						43.6															
Space Technology[2]	9.8	0.0	9.8																							0.7		7.8	1.3											
SPACE TECHNOLOGY	548.5	(1.3)	547.2																																					
SPACE TECHNOLOGY	548.5	(1.3)	547.2																																					
SBIR & STTR	165.4		165.4																								165.4													
Partnerships Devel. & Strategic Integration	26.4		26.4																							26.4														
Crosscutting Space Tech. Development	176.7	(1.3)	175.4																									175.4												
Exploration Technology Development	180.0		180.0																										180.0											
CROSS AGENCY SUPPORT	3,002.9	(0.1)	3,002.8																																					
CENTER MANAGEMENT & OPERATIONS	2,204.1	0.0	2,204.1																																					
Center Management & Operations	2,204.1		2,204.1																																					
Center Institutional Capabilities	1,707.2		1,707.2																											1,707.2										
Center Programmatic Capabilities	496.9		496.9																												496.9									
AGENCY MANAGEMENT & OPERATIONS	798.8	(0.1)	798.7																																					
Agency Management	403.7	(0.1)	403.6																													403.6								
Safety & Mission Success	198.4	0.0	198.4																																					
Safety and Mission Assurance	49.4		49.4																														49.4							
Chief Engineer	105.2		105.2																															105.2						
Chief Health and Medical Officer	4.7		4.7																																4.7					
Independent Verification and Validation	39.1		39.1																																	39.1				
Agency IT Services	158.5	0.0	158.4																																					
IT Management	14.6		14.6																																		14.6			
Applications	67.8		67.8																																			67.8		
Infrastructure	76.0		76.0																																				76.0	
Innovative Partnerships Program[2]	8.9	0.0	8.9																							2.4	6.2	0.3												
Strategic Capabilities Assets	29.3	0.0	29.3																																					29.3

[1]Current operating plan in effect as of publication (April 10, 2013).

[2]Recast reflects realignment of programmatic content and associated dollars to Space Technology account.

[3]Recast reflects consolidation of Commercial Cargo content and associated dollars into Commercial Crew program.

FY 2013 to FY 2014 COMPARABILITY ADJUSTMENTS[1]

Budget Authority ($ millions)

FY 2013 Current Operating Plan Recast to FY 2014 Structure, Adjusted for Rescission

FY 2013 Operating Plan, Unadjusted	Pre-Resc. Level	Rescission	Current Op Plan	SPACE TECHNOLOGY	SPACE OPERATIONS[2]
Recast FY 2013 Amounts				577.2	4,249.1
SPACE TECHNOLOGY	578.5	0.0	578.5	577.2	1.3
SPACE OPERATIONS	4,259.5	(11.7)	4,247.8	----------	4,247.8

[1]The FY 2013 top-level operating structure for the Agency remains unchanged for FY 2014.

[2]Reflects partial rescoring ($1.3M) of rescission pursuant to P.L. 112-55, Division B, Sec. 528(f) from Space Operations account to Space Technology.

FY 2014 PROPOSED APPROPRIATIONS LANGUAGE

SCIENCE

For necessary expenses, not otherwise provided for, in the conduct and support of science research and development activities, including research, development, operations, support, and services; maintenance and repair, facility planning and design; space flight, spacecraft control, and communications activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$4,911,200,000]*$5,017,800,000*, to remain available until September 30, [2014]*2015*[, of which up to $14,500,000 shall be available for a reimbursable agreement with the Department of Energy for the purpose of re-establishing facilities to produce fuel required for radioisotope thermoelectric generators to enable future missions]. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

AERONAUTICS

For necessary expenses, not otherwise provided for, in the conduct and support of aeronautics research and development activities, including research, development, operations, support, and services; maintenance and repair, facility planning and design; space flight, spacecraft control, and communications activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$551,500,000]*$565,690,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

SPACE TECHNOLOGY

For necessary expenses, not otherwise provided for, in the conduct and support of space research and technology development activities, including research, development, operations, support, and services; maintenance and repair, facility planning and design; space flight, spacecraft control, and communications activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$699,000,000]*$742,600,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

FY 2014 PROPOSED APPROPRIATIONS LANGUAGE

EXPLORATION

For necessary expenses, not otherwise provided for, in the conduct and support of exploration research and development activities, including research, development, operations, support, and services; maintenance and repair, facility planning and design; space flight, spacecraft control, and communications activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$3,932,800,000]*$3,915,500,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

SPACE OPERATIONS

For necessary expenses, not otherwise provided for, in the conduct and support of space operations research and development activities, including research, development, operations, support and services; space flight, spacecraft control and communications activities, including operations, production, and services; maintenance and repair, facility planning and design; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$4,013,200,000]*$3,882,900,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

EDUCATION

For necessary expenses, not otherwise provided for, in carrying out aerospace and aeronautical education research and development activities, including research, development, operations, support, and services; planning and interagency coordination of education activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$100,000,000]*$94,200,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

FY 2014 PROPOSED APPROPRIATIONS LANGUAGE

CROSS AGENCY SUPPORT

For necessary expenses, not otherwise provided for, in the conduct and support of science, aeronautics, exploration, space operations and education research and development activities, including research, development, operations, support, and services; maintenance and repair, facility planning and design; space flight, spacecraft control, and communications activities; program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed $63,000 for official reception and representation expenses; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, [$2,847,500,000]*$2,850,300,000*, to remain available until September 30, [2014]*2015*. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION

For necessary expenses for construction of facilities including repair, rehabilitation, revitalization, and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, and restoration, and acquisition or condemnation of real property, as authorized by law, and environmental compliance and restoration, [$619,200,000]*$609,400,000*, to remain available until September 30, [2018]*2019*: *Provided*, That *hereafter,* notwithstanding section 315 of the National Aeronautics and Space Act of 1958 (51 U.S.C. 20145) *and Public Law 112-55*, all proceeds from leases entered into under that section shall be deposited into this account and shall be available for a period of 5 years: [*Provided further*, That such proceeds referred to in the previous proviso shall be available for obligation for fiscal year 2013 in an amount not to exceed $3,791,000:] *Provided further*, That each annual budget request shall include an annual estimate of gross receipts and collections and proposed use of all funds collected pursuant to section 315 of the National Aeronautics and Space Act of 1958 (51 U.S.C. 20145). *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

OFFICE OF THE INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General in carrying out the Inspector General Act of 1978, $37,000,000, of which $500,000 shall remain available until September 30, [2014]2015. *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

FY 2014 PROPOSED APPROPRIATIONS LANGUAGE

ADMINISTRATIVE PROVISIONS

Funds for announced prizes otherwise authorized shall remain available, without fiscal year limitation, until [the] *a* prize is claimed or the offer is withdrawn.

Not to exceed 5 percent of any appropriation made available for the current fiscal year for the National Aeronautics and Space Administration in this Act may be transferred between such appropriations, but no such appropriation, except as otherwise specifically provided, shall be increased by more than 10 percent by any such transfers: *Provided*, That any funds transferred to "Construction and Environmental Compliance and Restoration" for construction activities shall not increase that account by more than 20 percent: *Provided further*, That balances so transferred shall be merged with and available for the same purposes and the same time period as the appropriations to which transferred : *Provided further*, That any transfer pursuant to this provision shall be treated as a reprogramming of funds under section 505 of this Act and shall not be available for obligation except in compliance with the procedures set forth in that section.

Section 30102(c) of title 51 of the United States Code, is amended by striking "and" at the end of paragraph (2) and inserting before the period at the end: "; and (4) refunds or rebates received on an on-going basis from a credit card services provider under the National Aeronautics and Space Administration's credit card programs." *Note.--A full-year 2013 appropriation for this account was not enacted at the time the budget was prepared; therefore, this account is operating under a continuing resolution (P.L. 112-175). The amounts included for 2013 reflect the annualized level provided by the continuing resolution.*

ACRONYMS AND ABBREVIATIONS

21CSLC	21st Century Space Launch Complex
AA	Associate Administrator
AA-#	Designation of ascent abort test
AAAC	Astronomy and Astrophysics Advisory Committee
AAR	Airport arrival rate
ACC	Accelerometer
ACCESS	Advanced Collaborative Connections for Earth System Science
ACE	Advanced Colloids Experiment
ACE	Advanced Composition Explorer
ACE	Aerosol cloud ecosystems
ACES	Agency Consolidated End-User Services IT contract
ACRIMSat	Active Cavity Radiometer Irradiance Monitor Satellite
ACS	Advanced Camera for Surveys (Hubble Space Telescope instrument)
ACSI	American Customer Satisfaction Index
ACT	Advanced component technology
ACT	Atacama Cosmology Telescope
ADA	Americans with Disabilities Act
ADAP	Astrophysics Data Analysis Program
ADCAR	Astrophysics Data Curation and Archival Research program
ADS	Astrophysics Data System
ADS-B	Automatic Dependent Surveillance-Broadcast
AES	Advanced Exploration Systems program
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AHP	Anti-Harassment Program
AIM	Aeronomy of Ice in the Mesosphere
AirMOSS	Airborne Microwave Observatory of Subcanopy and Subsurface
AIRS	Advanced Infrared Sounder
AIST	Advanced Information Systems Technology program
AITS	Agency Information Technology Services
ALHAT	Autonomous Landing and Hazard Avoidance Technology
ALI	Advanced Land Imager
AMELIA	Advanced Model for Extreme Lift and Improved Aeroacoustics
AMMOS	Advanced Multi-Mission Operations System
AMMP	Aircraft Maintenance and Modification Program
AMO	Agency Management and Operations
AMS	Alpha Magnetic Spectrometer
AMSR-E	Advanced Microwave Scanning Radiometer for the Earth Observing System
AMSU	Advance Microwave Sounding Unit
AO	Announcement of Opportunity (type of solicitation)

ACRONYMS AND ABBREVIATIONS

AOC	Airspace Operations Challenge
APG	Annual performance goal
APL	Applied Physics Laboratory (Johns Hopkins University)
APMC	Agency Program Management Council
APP	Annual Performance Plan
APPEL	Academy of Program/Project and Engineering Leadership
APRET	Astrophysics Research and Enabling Technology program (replaces APRA)
APR	Annual Performance Report
APRA	Astrophysics Research and Analysis
APS	Aerosol Polarimetry Sensor
ARC	Ames Research Center
ARCD	Aerospace Research and Career Development program
ARED	Advanced Resistive Exercise Device
ARMD	Aeronautics Research Mission Directorate
ARTEMIS	Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun
ASAP	Aerospace Safety Advisory Panel
ASCENDS	Active Sensing of Carbon dioxide Emissions over Nights, Days and Seasons
ASEB	Aeronautics and Space Engineering Board of the National Academies
ASP	Airspace Systems Program
ASPERA-3	Analyzer of Space Plasma and Energetic Atoms-3
ASM	Aeronautics Strategy and Management
ASRG	Advanced Stirling Radioisotope Generator
ASTER	Advanced Spaceborne Thermal Emission Reflection Radiometer
ATD	Air Traffic Management Technology Demonstration
ATI	Advanced technology initiatives
ATK	Alliant Techsystems Inc.
ATLAS	Advanced Topographic Laser Altimeter System
ATLO	Assembly, test, launch operations
ATMS	Advanced Technology Microwave Sounder (NPOESS Preparatory Project instrument)
ATP	Aeronautics Test Program
ATP	Astrophysics Theory Program
ATTREX	Airborne Tropical Tropopause Experiment
ATV	Automated Transfer Vehicle
AU	Astronomical units (distance measurement)
AURA	Association of Universities for Research in Astronomy
AVIRIS	NASA's Airborne Visible/Infrared Imaging Spectrometer
AvSP	Aviation Safety Program
BA	Budget authority
BAA	Broad Agency Announcement (type of solicitation)

ACRONYMS AND ABBREVIATIONS

BARREL	Balloon Array for RBSP Relativistic Electron Losses
BATC	Ball Aerospace and Technology Corporation
BCAT	Binary Colloidal Alloy Test
BHP	Behavioral Health and Performance program
BIRA	Belgian Space Agency
BIRD	Barrier Infrared Detector
BMAR	Back-log maintenance and repair
BPR	Baseline Performance Review
BR	Budget request
BRIC	Biological Research In Canisters
BTA	Boilerplate test article
BWB	Blended wing body
BWG	Beam wave guide
C.F.R	Code of Federal Regulations
C.R..	Continuing Resolution
C&DH	Command and Data Handline (instrument)
C&T	Communications and tracking
C2NOC	Consolidated Corporated Network Operations Center
C3S	Command, Control, and Communication Segment
CADRe	Cost analysis data requirement
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations
CAP	Cross-agency priority goals
CARA	California Association for Research in Astronomy
CARVE	Carbon in Arctic Reservoirs Vulnerability Experiment
CAS	Cross-Agency Support
CASIS	Center for the Advancement of Science in Space
CAST	Commercial Aviation Safety Team
CATS	Cloud-Aerosol Transport System
CC	Centennial Challenges Program
CCAFS	Cape Canaveral Air Force Station
CCDev	Commercial Crew Development
CCiCap	Commercial Crew integrated Capability
CCLC	21st Century Community Learning Centers (Department of Education)
CCMC	Community Coordinated Modeling Center
CCP	Commercial Crew Program
CCS	Cuts, Consolidations, and Savings (volume of the Federal budget)
CCSP	Climate Change Science Program
CDC	Centers for Disease Control
CDR	Critical Design Review

ACRONYMS AND ABBREVIATIONS

CDSCC	Canberra Deep Space Communications Complex
CECR	Construction and Environmental Compliance and Restoration
CEOS	Committee on Earth Observation Satellites
CERES	Clouds and the Earth's Radiant Energy System
CESR	Centre d'Etude Spatiale des Rayonnements Mars exploration
CEVIS	Cycle Ergometer with Vibration Isolation and Stabilization
CFD	Computational fluid dynamics
CFE	Capillary Flow Experiment
CFI	Claes-Fornell International Group
CFO	Chief Financial Officer
CHeCS	Crew Health Systems program
ChemCam	Chemistry Camera
CHS	Crew Health and Safety program
CIDP	Central Instrument Data Processor
CIF	Center Innovation Fund program
CINDI	Coupled Ion Neutral Dynamics Investigation
CIO	Chief Information Officer
CIPAIR	Curriculum Improvements Partnership Award for the Integration of Research
CJ	Congressional Justification (Budget)
CL	Confidence level
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CLSRB	Current Launch Schedule Review Board
CMAP	Center's Merged Analysis of Precipitation
CMC	Ceramic matrix composites
CME	Coronal mass ejection
CMO	Center Management Operations
CMP	Conflict Management Program
CMS	Carbon Monitoring System
CNES	Centre Nationale D'Etudes Spatiale (French Space Agency)
CO2	Carbon dioxide
CoCOA	Center of Curvature Optical Assembly
CoF	Construction of Facilities
CONAE	Argentina's National Committee of Space Activities
CoNNeCT	Communications, Navigation, and Networking reConfigurable Test Bed
CoSTEM	OSTP interagency Committee on STEM Education
COTS	Commercial Orbital Transportation Services
CPC	Certification Products Contract
CPS	Cryogenic propulsion stage
CPST	Cryogenic Propellant Storage and Transfer project
CPT	Comprehensive performance test

ACRONYMS AND ABBREVIATIONS

CPU	Computer processing units
CRF	Capability reliance framework
CRI	Center for Rotorcraft Innovation
CRS	Commercial Resupply Services program
CrIS	Cross-track Infrared Sounder (NPOESS Preparatory Project instrument)
CRYOSTAT	Cryogenic Propellant Storage And Transfer
CSA	Canadian Space Agency
CSC	Computer Sciences Corporation
CSSP	Cyber Security Strategic Plan
CSTD	Crosscutting Space Technology Development
CT	Crawler Transporter
CTC	Chief Technologist Council
CTS	Crew Transportation System
CxP	Constellation Program
CY	Calendar Year
CYGNSS	Cyclone Global Navigation Satellite System
CSPE	Colorimetric Solid Phase Extraction
D&I	Diversity and inclusion
DAAC	Distributed Active Archive Centers
DAEP	DSN Aperture Enhancement Project
DAN	Dynamic Albedo of Neutrons
DAR	Data at Rest (DAR) cybersecurity initiative
DARPA	Defense Advanced Research Projects Agency
dB	Decibel (unit of sound measurement)
DCAA	Defense Contract Audit Agency
DCMA	Defense Contract Management Agency
DDT&E	Design, development, test, and evaluation
DESDynI	Deformation, Ecosystem Structure, and Dynamics of Ice
DFRC	Dryden Flight Research Center
DISCOVER-AQ	Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DIXI	Deep Impact Extended Investigation
DLR	Deutches Zentrum für Luft- Raumfahrt (German Aerospace Center)
DM	Deferred maintenance
DME	Development, modernization, and enhancement (of IT investments)
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DORIS	Doppler Orbitography by Radiopositioning Integrated by Satellite (Ocean Surface Topography Mission instrument)
DOT	Department of Transportation

ACRONYMS AND ABBREVIATIONS

DPMC	Directorate Program Management Council
DPR	Dual-frequency Precipitation Radar (Global Precipitation Measurement instrument)
DR	Decommissioning Review
DRS	Disturbance Reduction System
DSAC	Deep Space Atomic Clock
DSCOVR	Deep Space Climate Observatory
DSI	Deutsches SOFIA Institut
DSN	Deep Space Network
DSS	Deep Space Station
DSS	Dual Spacecraft System
DSX	Deployable Structures Experiment
DTN	Disruption tolerant networking
DWR	Dynamic weather rerouting
E/PO	Education and public outreach
EAI	Excalibur Almaz, Inc.
EAST	Enterprise Applications (IT service under I3P)
EC	Executive Council
ECLIPSE	Environment for Cyber-Learning Integrating Problem Solving Experiences
ECLSS	Environmental Control and Life Support System
ECR	Environmental Compliance and Restoration
ECT	Energetic Particle, Composition and Thermal Plasma
ED	Department of Education
ED	NASA Education
EDA	Efficient Descent Advisor
EDL	Entry, descent, and landing
EDLT	Entry, Descent and Landing Technologies project
EDR	Environmental data record
EDSN	Edison Demonstration of Smallsat Networks project
EEE	Evolution of EOSDIS Elements
EELV	Evolved Expendable Launch Vehicle
EEO	Equal employment opportunities
EEOC	U.S. Equal Opportunity Commission
EFB	Earth flyby
EFW	Electric Field and Waves Instrument
EFT	Exploration Flight Test
EGS	Exploration Ground Systems program
EHRS	Electronic Health Records System
ELC	ExPRESS Logistics Carrier
ELV	Expendable launch vehicle
ELVIS	ELV Integrated Support contract
EM	Engineering model

ACRONYMS AND ABBREVIATIONS

EM	Exploration Mission
EM2	Electronics Box Engineering Model 2
EMCS	Energy Management and Control System
EMFISIS	Electric and Magnetic Field Instrument Suite and Integrated Science
EMTGO	ExoMars Trace Gas Orbiter
EMU	Extravehicular mobility unit
ENSO	El Niño–Southern Oscillation
EO	Equal opportunity
EO	Earth Observing mission series
EONS	Education Opportunities in NASA STEM (solicitation)
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EMC	Electromagnetic capability
EMI	Electromagnetic interference
EMTGO	ExoMars Trace Gas Orbitor
ENA	Energetic neutral atom
EPA	Environmental Protection Agency
EPOCh	Extrasolar Planet Observations and Characterization
EPOXI	Extrasolar Planet Observation and Deep Impact Extended Investigation
EPS	Electrical power system
EPS	Energy per storm
EPSCoR	Experimental Program to Stimulate Competitive Research project
ERA	Environmentally Responsible Aviation project
ERD	Exploration Research and Development program
EROS	Earth Resources and Science Center
ERV	Earth Return Vehicle
ES	Exploration account
ESA	European Space Agency
ESD	Earth Science Division
ESD	Enterprise Service Desk (IT service under I3P)
ESD	Exploration Systems Development
ESDN	Edison Demonstration of Smallsat Network project
ESDR	Earth system data records
ESM	Earth Systematic Missions
ESMP	Earth Systematic Missions Program
ESS	Earth Science Subcommittee (of the NASA Advisory Committee)
ESSP	Earth System Science Pathfinder program
ESTO	Earth Science Technology Office
ESTP	Earth Science Technology Program
ETD	Exploration Technology Development program

ACRONYMS AND ABBREVIATIONS

ETDD	Enabling Technology Development and Demonstration
ETM+	Enhanced Thematic Mapper Plus
ETU	Engineering Test Unit
eTS	(Federal) e-Travel Services, to migrate to a new service provider (eTS2)
EUL	Enhanced use lease
EUMETSAT	European Meterological Satellite
EUV	Extreme ultraviolet variability
EV	Earth Venture
EVA	Extravehicular activity
EVE	EUV Variability Experiment
EVI	Earth (Science) Venture Class Instruments
EVR	Extra-vehicular robotics
EVS	Employee Viewpoint Survey
EVM	Earth Venture (small) Missions
EVS	Earth (Science) Venture Class Sub-orbital projects
EX	Explorer Missions
ExEP	Exoplanet Exploration Program
EXES	Echelon-Cross-Echelle Spectrograph
ExMC	Exploration Medical Capability
EXPRESS	EXpedite PRocessing of Experiments to the Space Station
FA	Fundamental Aeronautics
FAA	Federal Aviation Administration
FAP	Fundamental Aeronautics Program
FAR	Federal Acquisition Regulation
FCC	Federal Communications Commission
FCE	Flight crew equipment
FCF	Fluids and Combustion Facility (ISS)
FDCCI	Federal Data Center Consolidation Initiative
FGM	Fluxgate Magnetometer (Thermal Emission Imaging System instrument)
FGS	Fine Guidance Sensor
FGS-TF	Fine Guidance Sensor - Tunable Filter
FIFI LS	Field Imaging Far-Infrared Line Spectrometer
FINESSE	First Infrared Exoplanet Spectroscopy Survey Explorer
FIRST	For Inspiration and Recognition of Science and Technology (student robotics competition)
FLEX	FLame Extinguishment EXperiment
FLITECAM	First Light Infrared Test Experiment Camera
FMI	Finnish Meteorological Institute
FO	Flight Opportunities Program
FO	Follow on (to a mission)
FOC	Full operational capability

ACRONYMS AND ABBREVIATIONS

FOIA	Freedom of Information Act
FOR	Flight Operations Review
FORCAST	Faint Object InfrRed CAmera for the SOFIA Telescope
FPA	Focal plane array
FPB	Flight Planning Board
FPD	Flight Projects Directorate
FPI	Fast Plasma Investigation
FRR	Flight Readiness Review
FTE	Full time equivalency
FUV	Far ultraviolet
FY	Fiscal year
GALEX	Galaxy Evolution Explorer
GAO	Government Accountability Office
GCD	Game Changing Development program
GDP	Gross Domestic Product
GE	General Electric
GEMS	Gravity and Extreme Magnetism
GENIE	Guidance Embedded Navigator Integration Environment
GEO	Geostationary Earth orbit
GEO-CAPE	GEOstationary Coastal and Air Pollution Events
GES DAAC	GSFC Earth Science Distributed Active Archive Center
GeV	Gigaelectron volt (unit of measurement)
GFZ	German Research Centre for Geosciences
GHz	Gigahertz (unit of measurement)
GLAS	Geoscience Laser Altimeter System
GLAST	Gamma–ray Large Area Space Telescope (now Fermi Gamma-ray Space Telescope)
GLOBE	Global Learning and Observations to Benefit the Environment (education project)
GMI	GPM Microwave Imager (Global Precipitation Measurement instrument)
GN&C	Guidance and navigation
GNSS	Global Navigation and Satellite Systems
GOES	Geostationary Operational Environmental Satellite
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Measurement
GPRA	Government Performance and Results Act
GPRA-MA	Government Performance and Results Act Modernization Act of 2010.
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GRAIL	Gravity Recovery and Interior Laboratory
GRC	Glenn Research Center
GRC-PBS	Glenn Research Center–Plum Brook Station

ACRONYMS AND ABBREVIATIONS

GREAT	German Receiver for Astronomy at Terahertz
GRGT	Guam Remote Ground Terminal
GRIP	Genesis and Rapid Intensification Processes
GSDO	Ground Systems Development and Operations
GSFC	Goddard Space Flight Center
GTA	Ground test article
GUSSTO	Galactic/Xgalactic Ultra long duration balloon Spectroscopic Stratospheric THz Observatory
GWAC	Government wide acquisition Contracts
H.R.	House of Representatives (bill)
HASP	High Altitude Student Platform
HAVT	Hypersonic air-breathing vehicle technologies
HAWC	High-resolution Airborne Wideband Camera
HB	High bay
HBCU	Historically Black Colleges and Universities
HCPA	Hot Plasma Composition Analyzer
HEC	Human Exploration Capability (former theme in Exploration)
HECC	High End Computing Capability
HEO	Human Exploration and Operations
HEOMD	Human Exploration and Operations Mission Directorate
HEPS	High Efficiency Power Supply (MAVEN)
HET	Human Exploration Telerobotics
HgCdTe	Mercury-Cadmium-Telluride (type of array used in many instruments)
HH&P	Human Health & Performance
HHC	Health and Human Countermeasures
HIAD	Hypersonic Inflatable Aerodynamic Decelerator
HIPAA	Health Insurance Portability and Accountability Act
HIPO	High-speed Imaging Photometer for Occultation
HIRDLS	High Resolution Dynamic Limb Sounder
HIRES	High Resolution Echelle Spectrometer
HIRS	High Resolution Infrared Radiation Sounder
HIS	Heavy Ion Sensor
HiTL	Human-in-the-loop
HiVHAc	High Voltage Hall Accelerator
HLV	Heavy lift vehicle
HOPE	Hands-on Project Experience
HP3	Heat Flow and Physical Properties Package
HPIW	High pressure industrial water
HPPG	High priority performance goal
HQ	NASA Headquarters

ACRONYMS AND ABBREVIATIONS

HRJ	Hydro-treated Renewable Jet fuel
HRP	Human Research Program
HSF	Human Space Flight program
HSFO	Human Space Flight Operations program
HSI	Hispanic Serving Institution
HSPD	Homeland Security Presidential Directive
HST	Hubble Space Telescope
HTV	H-II Transfer Vehicle
HVAC	Heating, ventilating, and air-conditioning
HWB	Hybrid wing body
HyspIRI	Hyperspectral Infrared Imager
I&T	Integration and test
I3P	Information Technology Infrastructure Integration Program
IAA	International Academy of Astronautics
IACP	Industrial Area Chiller Plant
IASI	Infrared Atmospheric Sounding Interferometer
IBEX	Interstellar Boundary Explorer
IBPD	Integrated Budget and Performance Document
ICA	Innovative Concepts for Aviation
IceBridge	NASA Science Airborne mission
ICD	Interface Control Documentation
ICESat	Ice, Cloud, and Land Elevation Satellite
ICESCAPE	Impacts of Climate change on the Eco-Systems and Chemistry of the Arctic Pacific Environment
ICPS	Interim Cryogenic Propulsion Stage
ICRP	Independent Comprehensive Review Panel
IDEA	Integrated Design and Engineering Analysis software
IDIQ	Indefinite date/indefinite quantity contract type
IDPS	Interface Data Processing Segment
IE	Innovations in Education (NASA, Education)
IG	Inspector General
IHMC	Institute for Human and Machine Cognition
IIP	Instrument Incubator project
IIR	Imaging Infrared Radiometer
ILN	International Lunar Network
INPE	Brazilian Institute for Space Research
InSight	Interior Exploration using Seismic Investigations, Geodesy and Heat Transport
INSPIRE	Interdisciplinary National Science Project Incorporating Research and Education Experience (education project)
INTA	Instituto Nacional de Técnica Aerospacial
INTEGRAL	International Gamma-Ray Astrophysics Laboratory

ACRONYMS AND ABBREVIATIONS

IOC	Initial operational capability
IOM	Institute of Medicine
IPWG	Interagency Partnerships Working Group
IPAC	Infrared Processing and Analysis Center
IPAO	Independent Program Assessment Office
IPCC	International Panel on Climate Change
IPO	Integrated Program Office
IPP	Innovative Partnerships Program
IPWG	Interagency Partnerships Working Group
IR	Infrared
IRAC	Integrated Resilient Aircraft Controls
IRIS	Interface Region Imaging Spectrograph
IRR	Investigation Readiness Reviews
IRSA	NASA/IPAC Infrared Science Archive
IRT	Independent review team
IRVE	Inflatable Reentry Vehicle Experiment
ISAS	Institute of Space and Astronautical Science
ISIM	Integrated Science Instrument Module
ISO	International Organization for Standardization (management standard)
ISP	In space propulsion
ISRO	Indian Space Research Organisation
ISRP	Integrated Systems Research Program
ISRU	In-situ resource utilization
ISS	International Space Station
ISSMP	International Space Station Medical Project
ISTP	International Solar Terrestrial Physics program
iSWA	Integrated Space Weather Analysis system
IT	Information technology
ITIL	Information Technology Infrastructure Library
ITT	ITT Exelis Corp.
IUVS	Imaging UltraViolet Spectrometer
IV	Intravenous
IV&V	Independent verification and validation
IXO	International X-ray Observatory
J-2X	Upper Stage Engine (Pratt & Whitney Rocketdyne, Inc)
JADE	Jovian Auroral Distributions Experiment
JAXA	Japan Aerospace Exploration Agency
JCL	Joint confidence level (cost and schedule)
JDEM	Joint Dark Energy Mission
JEDI	Jupiter Energetic particle Detector Instrument

ACRONYMS AND ABBREVIATIONS

JHU	John Hopkins University
JHU-APL	Johns Hopkins University–Applied Physics Laboratory
JOI	Jupiter orbit insertion
JPDO	Joint Planning and Development Office
JPFP	Jenkins Pre-Doctoral Fellowship Project
JPL	Jet Propulsion Laboratory
JPSS	Joint Polar Satellite System
JSC	Johnson Space Center
JRPA	Joint Robotic Precursor Activities project
JUICE	Jupiter Icy Moons Explorer
JWST	James Webb Space Telescope
$K	Dollars in thousands
K-12	Elementary and secondary (education)
KDC	Kennedy Data Center
KDP	Key Decision Point (review)
Kg	Kilogram (unit of measurement)
KHz	Kilohertz (unit of measurement)
KI	Keck Interferometer
KSA	Keck Single Aperture
KSC	Kennedy Space Center
KuPR	K-band precipitation radar
L2	Second Sun-Earth libration, or Lagrange point
L3	L-3 Communications Corporation
LADEE	Lunar Atmosphere and Dust Environment Explorer
LANCE	Land Atmosphere Near real-time Capability for EOS
LaRC	Langley Research Center
LASCO	Large Angle and Spectrometic Coronagraph
LASER	Lunar Advanced Science and Exploration Research
LASP	Laboratory for Atmospheric and Space Physics (University of Colorado, Boulder)
LBT	Large Binocular Telescope
LBTI	Large Binocular Telescope Interferometer
LC	Launch complex
LCAS	Low-cost access to space
LCC	Launch Control Center
LCC	Life cycle cost
LCCE	Life cycle cost estimate
LCPSO	Land Cover Project Science Office
LCRD	Laser Communications Relay Demonstration
LDEX	Lunar Dust EXperiment
LDCM	Landsat Data Continuity Mission
LDSD	Low Density Supersonic Decelerators

ACRONYMS AND ABBREVIATIONS

LDT	Long duration test
LEED	Leadership in Energy and Environment Design (building efficiency designation)
LEO	Low Earth orbit
LH2	Liquid Hydrogen
LIO	Low Inclination Observatory
LISA	Laser Interferometer Space Antenna
LL	Lincoln Laboratory
LLC	Limited liability company
LLCD	Lunar Laser Communications Demonstration
LM	Lockheed Martin
LoB	Line of business
LOX	Liquid Oxygen
LPW	Lunamuir Probe and Waves
LQP	Lunar Quest Program
LRD	Launch Readiness Date
LRO	Lunar Reconnaissance Orbiter
LRR	Launch Readiness Review
LSAH	Lifetime Surveillance of Astronaut Health
LSM	Land Surface Model
LSP	Launch Services Program
LTO	LTO NOx subsonic
LV	Launch vehicle
LVC	Live, virtual, constructive (description of software)
LVC-DE	Live Virtual Constructive-Distributive Environment (description of software)
LWS	Living with a Star
$M	Dollars in millions
M.S.	Master of Science
M3	Moon Mineralogy Mapper
MA	Multiple access
MACPEX	Mid-latitude Airborne Cirrus Properties Experiment
MAF	Michoud Assembly Facility (NASA, managed by MSFC)
MagEIS	Magnetic Electron Ion Spectrometer instruments
MAGNET	Manufacturing Advocacy and Growth Network
MARSIS	Mars Advanced Radar for Subsurface and Ionospheric Sounding
MAV	Mars Assent Vehicle
MAVEN	Mars Atmosphere and Volatile EvolutioN
HAZMAT	Hazardous materials
MCR	Mission Concept Review
MD	Mission directorate
MDR	Mission Definition Review

ACRONYMS AND ABBREVIATIONS

MDSA	Multi-sensor Data Synergy Advisor
MEaSUREs	Making Earth System data records for Use in Research Environments
MEDLI	Mars Science Laboratory Entry, Descent, and Landing Instrument
MER	Mars Exploration Rover
MERRA	Modern-Era Retrospective Analysis For Research And Applications
MESSENGER	Mercury Surface, Space Environment, Geochemistry and Ranging
METI	Ministry of Economy Trade and Industry (Japan)
MEX	Mars Express
MI	Minority serving institutions
MIB	Mishap Investigation Board
MICINN	Spanish Space Agency
MIDAS-FAST	Machine Integration Design and Analysis System–Function Allocation Simulation Tool
MIDEX	Medium-Class Explorer
MIRI	Mid-Infrared Instrument (James Webb Space Telescope instrument)
MISSE-X	Materials International Space Station Experiment-X
MISR	Multi-angle Imaging SpectroRadiometer
MIT	Massachusetts Institute of Technology
MLM	Multipurpose Laboratory Module
MLS	Microwave Limb Sounder
MMEEV	Multi-Mission Earth Entry Vehicle
MMO	Mars Mission Operations
MMOD	Micrometeoroid and orbital debris
MMRTG	Multi-Mission Radioisotope Thermoelectric Generator
MMS	Magnetospheric Multiscale
MMSEV	Multi-Mission Space Exploration Vehicle
MO	Missions of Opportunity (solicitation)
MODIS	Moderate Resolution Imaging Spectroradiometer
MOE	Mission Operations Element
MOMA	Mars Organics Molecule Analyzer
MOPITT	Measurements of Pollution in the Troposphere
MOR	Mission Operations Review
MOU	Memorandum of Understanding
MPAR	Major Program Annual Report
MPCV	Multi-Purpose Crew Vehicle, called Orion MPCV
MPLM	Multi-Purpose Logistics Module
MPPF	Multi-Payload Processing Facility
MRI	Magnetic Resonance Imaging
MRO	Mars Reconnaissance Orbiter
MRR	Mission requirement request

ACRONYMS AND ABBREVIATIONS

MSA	MUREP Small Activities
MSC	Mission Support Council
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSI	Minority serving institution
MSL	Mars Science Laboratory
MSP	MUREP Small Projects
MUREP	Minority University Research and Education Project
MUSS	Multi-User Systems and Support
MUST	Motivating Undergraduates in Science and Technology (education project)
MWI	Microwave Instrument
MWR	Microwave Radiometer
N+3	Three generations beyond the current state-of-the-art (generation N)
N/A	Not applicable
NAC	NASA Advisory Committee
NACA	National Advisory Committee on Aeronautics
NAR	Non-Advocacy Review
NARL	Native American Research Laboratories
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NCAS	NASA Contract Assurance Services
NC2MS	NICS Consolidated Configuration Management System
NCI	National Cancer Institute (National Institutes of Health)
NCMS	NICS Configuration Management System
NEA	Near-Earth asteroid
NEACC	NASA Enterprise Applications Competency Center
NEBULA	NASA's Cloud Computing Platform
NED	NASA Extragalactic Database
NEEMO	NASA Extreme Environment Mission Operations
NEN	Near Earth Network
NEO	Near-Earth object
NEOO	Near-Earth Object Observations program
NEOWISE	Near-Earth Object Wide-field Infrared Survey Explorer
NEPA	National Environmental Policy Act
NES	NASA Explorer Schools (education project)
NESC	NASA Engineering and Safety Center
NESSF	NASA Earth System Science Fellowships
NETS	NASA Educational Technology Services (education project)
NextGen	Next Generation Air Transportation System

ACRONYMS AND ABBREVIATIONS

NEXT	NASA Evolutionary Xenon Thruster
NExScI	NASA Exoplanet Science Institute
NF	New Frontiers Future Missions solicitation
NFS	National Forest System
NGAS	Northrup Grumman Aerospace Systems
NGIMS	Neutral Gas and Ion Mass Spectrometer
NGO	Non-governmental organization
NGST	Northrop Grumman Space Technology
NH	Northern hemisphere
NIAC	NASA Innovative Advanced Concepts
NICE	NASA Innovations in Climate Education (education project)
NICER	Neutron star Interior Composition ExploreR
NICS	NASA Information Configuration Services
NICS-Networking	Communications (IT service under I3P)
NIH	National Institute for Health
NIP	New Investigator Program
NIR	Near-infrared
NIRCam	Near-Infrared Camera
NIRSpec	Near-Infrared Spectrometer
NISN	NASA Integrated Services Network
NISP	Near-Infrared Spectrometer and Photometer
NIST	National Institute of Standards and Technology
NISTAR	National Institute of Standards and Technology Advanced Radiometer
NIVR	Netherlands Agency for Aerospace Programs
NLR	National Aerospace Laboratory of the Netherlands
NLS	NASA Launch Services contract
NLSI	NASA Lunar Science Institute
NMS	Neutral Mass Spectrometer
NMSU	New Mexico State University
NNMI	National Network of Manufacturing Innovation
NO	Nitric oxide
NO2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen oxide
NPAT	National Partnership for Aeronautic alTesting
NPD	NASA Policy Directive
NPO	Non-profit organization
NPOESS	National Polar–orbiting Operational Environmental Satellite System
NPP	Suomi National Polar orbiting Partnership (new name for NPOESS)

ACRONYMS AND ABBREVIATIONS

NPR	NASA Procedural Requirement
NPS	National Park Service
NRA	NASA Research Announcement (solicitation type)
NRC	National Research Council
NRCC	National Research Council Canada
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office
NRPTA	National Rocket Propulsion Test Alliance
NSBRI	National Space Biomedical Research Institute
NSC	NASA Safety Center
NSF	National Science Foundation
NSPD	National Space Policy Directive
NSSC	NASA Shared Services Center
NSSDC	National Space Science Data Center
NSTC	National Science and Technology Council
NSTI-MI	NASA Science and Technology Institute for Minority Institutions (education project)
NSWPC	National Space Weather Program Council
NTC	NASA technical capabilities
NTDC	NASA Technical Capabilities Database
NTEC	NASA Technology Executive Council
NTIA	National Telecommunications and Information Administration
NTSB	National Transportation Safety Board
NuSTAR	Nuclear Spectroscopic Telescope Array
NUV	Near ultraviolet
NWP	Numerical weather prediction
NWS	National Weather Service
O2	Oxygen
O&C	Operations and Checkout Facility
OA	Office of Audits (in Office of Inspector General)
OCAMS	OSIRIS-REx Camera Suite
OCE	Office of the Chief Engineer
OCFO	Office of Chief Financial Officer
OCHMO	Office of the Chief Health and Medical Officer
OCIO	Office of Chief Information Officer
OCO	Orbiting Carbon Observatory
OCT	Office of the Chief Technologist
ODEO	Office of Diversity and Equal Opportunity
OGC	Office of General Counsel
OH	Hydroxide ion, a proxy for water on Mars
OHCM	Office of Human Capital Management

ACRONYMS AND ABBREVIATIONS

OI	Office of Investigations (in Office of Inspector General)
OIG	Office of Inspector General
OIIR	Office of International and Interagency Relations
OLA	OSIRIS-REx Laser Altimeter
OLI	Operational Land Imager (Landsat Data Continuity Mission instrument)
OLS	Operational Linescan System
OMB	Office of Management and Budget
OMC	Operations Management Council
OM&DA	Other Mission and Data Analysis project
OMEGA	Offshore Membrane Enclosures for Growing Algae
OMI	Ozone Monitoring Instrument
OMPS	Ozone Mapping and Profiler Suite (NPOESS Preparatory Project instrument)
ONERA	Office National d'Études et de Recherches Aérospatiales
OORT	Operations Optimization Review Team
OPF	Orbital Processing Facility
OPM	Office of Personnel Management
ORNL	Oak Ridge National Laboratory
ORD	Operational Readiness Date
ORR	Operations Readiness Review
OSC	Orbital Sciences Corporation
OSCAT	Indian Space Agency's scatterometer instrument
OSHA	Occupational and Safety and Health Administration
OSI	Office of Strategic Infrastructure
OSIRIS-REx	Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer
OSMA	Office of Safety and Mission Assurance
OSP	Orbital/Suborbital Program (of the US Air Force)
OSSI	One Stop Shopping Initiative for NASA Internships, Fellowships, and Scholarships (education)
OSTM	Ocean Surface Topography Mission
OSTP	Office of Science and Technology Policy
OSTST	Ocean Surface Topography Science Team
OTE	Optical Telescope Element
OTES	OSIRIS-REx Thermal Emission Spectrometer
OTIS	Optical Telescope Element/ Integrated Science Module
OVIRS	OSIRIS-REx Visible and Infrared Spectrometer
OVWST	Ocean Vector Winds Science Team
P.L.	Public law
P&F	Particles and fields
PACE	Pre-Aerosols, Carbon and Ecosystems
Pan-STARRS	USAF Panoramic Survey Telescope and Rapid Reporting System

ACRONYMS AND ABBREVIATIONS

PAR	Performance and Accountability Report
PAR	Program Acceptance Review
PARASOL	Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
PART	Program Assessment Rating Tool
PB	President’s Budget
PBR	President’s Budget Request
PBS	President’s Budget Submit
PCA	Physicians’ Comparability Allowance
PCAD	Propulsion Cryogenics Advanced Development
PCBs	Polychlorinated biphenyls
PCOS	Physics of the Cosmos program
PDR	Preliminary Design Review
PDRC	Precision departure release capability
PDS	Planetary Data System
PECASE	Presidential Early Career Award for Scientists and Engineers
PER	Pre-Environmental Review
Ph.D.	Doctor of Philosophy
PI	Principal investigator
PICS	Partnerships, Innovation and Commercial Space
PIP	Payload Interface Processor
PIR	Program Implementation Review
PIV	Personal Identification Verification
PLAR	Post Launch Assessment Review
PLSS	Portable life support system
PMA	President's Management Agenda
PMC	Program Management Council
PNAR	Preliminary Non-Advocate Review
PNT	Positioning, navigation, and timing
POES	Polar Orbiting Environmental Satellites
POLDER	POLarization and Directionality of the Earth's Reflectances
POWER	Protecting Our Workers and Ensuring Reemployment (national initiative)
PPS	Precipitation Processing System
PR	Precipitation radar
PRSEUS	Pultruded Rod Stitched Efficient Unitized Structure
PSBR	Proton Spectrometer Belt Research
PSC	Polar Stratospheric Cloud
PSD	Planetary Science Division
PSL	Propulsion Systems Laboratory
Pu-238	Plutonium isotope used as a heat source in radioisotope thermoelectric generators
PVTCS	Photovoltaic Thermal Control System

ACRONYMS AND ABBREVIATIONS

PWC	Price Waterhouse Coopers
PWR	Pratt & Whitney Rocketdyne
Q, or QTR	Quarter
QM	Qualification motor
QuikSCAT	Quick SCATerometer
R&A	Research and analysis
R&D	Research and development
R2	Robonaut 2
RAD	Radiation Assessment Detector
RAP	Robotics Alliance Project (education)
RATS	Desert Research and Technology Studies
RBA	Reflector Boom Assembly
RBSP	Radiation Belt Storm Probes mission, now called Van Allen Probes
RBSPICE	Radiation Belt Science of Protons, Ions, Composition, and Electrons
RCA	Rapid cycle amine
READI	Real-time Earthquake Analysis for Disaster Mitigation
RELM	Regional earthquake likelihood models
RESOLVE	Regolith & Environment Science and Oxygen & Lunar Volatile Extraction
REU	Research Experience for Undergraduates (education)
RF	Radio frequency
RFI	Request for information
RFP	Request for proposal
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
RISE	Rotation and Interior Structure Experiment
RMP	Risk Mitigation Phase
Roscosmos	Russian Federal Space Agency
ROSES	Research Opportunities in Space and Earth Science (solicitation type in Science)
RPS	Radioisotope Power System
RPS	Relativistic Proton Spectrometer
RpK	Rocketplane-Kistler
RPT	Rocket Propulsion Test program
RR	Readiness Review
RS-25d	Core stage engine (Pratt & Whitney Rocketdyne, Inc)
RS	Russian Segment
RSAS	Raytheon Space and Airborne Systems
RSDO	Rapid Spacecraft Development Office
RSP	Research Scanning Polarimeter
RSRB	Reusable Solid Rocket Booster
RSRM	Reusable Solid Rocket Motor
RTAX	A field programmable gate array on RSBP

ACRONYMS AND ABBREVIATIONS

RTEMS	Real-Time Executive for Multiprocessor Systems
RTMM	Real Time Mission Monitor
RTT	Research transition teams
RVT	Reference vehicle design
RWA	Reaction wheel assemblies
RXTE	Rossi X-Ray Timing Explorer
S.	Senate (bill)
S/A	Solar array
S&M	Structures and Mechanisms
S&MA	Safety and Mission Assurance
S, R and Q	Safety, reliability, and quality
SA	Single access
SA/SPaH	Sample Acquisition, Processing, and Handling (drill for MSL)
SAA	Space Act Agreement
SAC-D	Satellite de Aplicaciones Cientificas–D (Argentina)
SADA	Solar Array Drive Assembly
SAGE	Stratospheric Aerosol and Gas Experiment
SALMON	Stand Alone Missions of Opportunity (solicitation type)
SAM	Sample Analysis at Mars
SAM	Stratospheric Aerosol Measurement
SAO	Smithsonian Astrophysical Observatory
SAP	NASA's core financial system
SAR	Synthetic Aperture Radar
SAS	Solar Aspect System
SAT	Strategic Astrophysics Technology program
SAU	Strategic airspace usage
SBC	Single board computer
SBIR	Small Business Innovative Research
SBRS	Santa Barbara Remote Sensing (Division of Raytheon)
SCADA	Supervisory Control and Data Acquisition
SCAMP	Supersonics Caustic Analysis and Measurement Program
SCaN	Space Communications and Navigation program
SCAP	Shared Capability Assets Program
SCEM	"The Scientific Context for Exploration of the Moon," NRC Planetary Science report
SCNS	Space Communications Network Services
SDO	Solar Dynamics Observatory
SDP	Spin-plane Double Probe
SDR	System Definition Review
SE&I	System engineering and integration
SEA	STEM Education and Accountability program

ACRONYMS AND ABBREVIATIONS

SEAC4RS	Southeast Asia Composition, Cloud, Climate Coupling Regional Study
SEAO	STEM Education and Accountability Project
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEIS	Seismic Experiment for Interior Structure
SEMAA	Science Engineering Mathematics Aerospace Academy
SEP	Solar energetic particles
SEP	Solar electric propulsion
SERENA	Search for Esospheric Refilling and Emitted Natural Abundances
SES	Senior Executive Service
SET	Space Environment Testbeds
SETAG	Space Environment Test Alliance Group
SEWP	Solutions for Enterprise-Wide Procurement (Government-wide acquisition contract)
SFCO	Space Flight Crew Operations
SFS	Space and Flight Support
SFW	Subsonic fixed wing
SGSS	Space Network Ground Segment Sustainment
SH	Southern hemisphere
SGLT	Space-to-Ground Link Terminals
SGSS	Space Network Ground Segment Sustainment
SFEM	Suborbital Flight Environment Monitor
SI	Strategic Integration
SIAD	Supersonic inflatable aerodynamic decelerator
SIM	Space Interferometry Mission
SIR	System Integration Review
SKG	Strategic knowledge gap
SKILL	Scientific Knowledge for Indian Learning and Leadership (education project)
SLICE	Structure and Liftoff In Combustion Experiment
SLPSRA	Space, Life and Physical Sciences Research and Applications
SLPSRAD	Space Life and Physical Sciences Research and Applications Division
SLS	Space Launch System
SMA	Safety and Mission Assurance
SMAP	Soil Moisture Active/Passive
SMART-OP	Stress Management And Resilience Training for Optimal Performance (on long duration missions)
SMC	Strategic Management Council
SMC/TEL	Space and Mission Command/Test and Evaluation Directorate
SMD	Science Mission Directorate
SMEX	Small Explorer
SMS	Safety and Mission Success
SN	Space Network

ACRONYMS AND ABBREVIATIONS

SNC	Sierra Nevada Corporation
SNGG	Space Network Ground Segment Sustainment
SoI	Summer of Innovation (education project)
SOC	Security Operations Center
SOC	Solar Orbiter Collaboration
SOFIA	Stratospheric Observatory for Infrared Astronomy
SOHO	Solar Heliospheric Observer
Sol	Martian day
SoloHI	Solar Orbiter Heliospheric Imager
SORCE	Solar Radiation and Climate Experiment
SOST	Subcommittee on Ocean Science and Technology
SpaceX	Space Exploration and Technology Corp.
SPARC	Stratosphere-troposphere Processes And their Role in Climate
SPF	Space Power Facility
SPHERES	Synchronized Position Hold, Engage, Reorient, Experimental Satellites
SPOC	Space Program Operations Contract
SPoRT	Short-term Prediction Research and Transition Center
SPP	Solar Probe Plus
SR	Senior Review
SR	Space radiation
SR&T	Supporting research and technology
SRB	Senior Review Board
SRB	Standing Review Board
SRC	Sample Return Capsule
SRG	Stirling Radioisotope Generator
SRM	Solid rocket motor
SRR	System Requirement Review
SRW	Subsonic rotary wing
SSPF	Space Station Processing Facility
SSC	Stennis Space Center
SSD	Solar Sail Demonstration
SSL	Space Sciences Laboratory
SSME	Space Shuttle Main Engines
SSP	Space Shuttle Program
SSS	Sea surface salinity
SST	Small Spacecraft Technology Program
SSTIP	Strategic Space Technology Investment Plan
ST	Space Technology
ST7	Space Technology 7 mission
STD	Standard technical design

ACRONYMS AND ABBREVIATIONS

STEM	Science, Technology, Engineering, and Mathematics (a discipline of education)
STEREO	Solar TErrestrial RElations Observatory
STI	Scientific and technical information
STP	Solar Terrestrial Probes
STP	Space Technology Program
STRG	Space Technology Research Grants Program
STS	Space Transportation System
STScI	Space Telescope Science Institute
STTR	Small Business Technology Transfer Program
Suomi NPP	Suomi National Polar orbiting Partnership, formerly the NPOESS Preparatory Project or NPP
SWEA	Solar Wind Electron Analyzer
SWIA	Solar Wind Ion Analyzer
SWIR	Short wave infrared
SWORDS	Soldier-Warfighter Operationally Responsive Deployer for Space project
SWOT	Surface Water and Ocean Topography
SwRI	Southwest Research Institute
SXS	High-Resolution Soft X-Ray Spectrometer
T&R	Transition and retirement (space shuttle activity)
TAT	Test Assessment Team (JWST)
TBD	To be determined
TCS	Thermal systems
TCU	Tribal colleges and universities
TCUP	Tribal Colleges and Universities Project
TDEM	Technology Development for Exoplanet Missions
TDM	Technology Demonstration Mission
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEMPO	Tropospheric Emissions: Monitoring of Pollution
TES	Transform Spectrometer
TESS	Transiting Exoplanet Survey Satellite
TES	Tropospheric Emission Spectrometer
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIC	Trusted Internet connections
TIM	Total Irradiance Monitor
TIMED	Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics
TIMS	Thermal Infrared Multispectral Scanner
TIRS	Thermal Infrared Sensor
TMI	TRMM Microwave Imager
TOF	Time of flight

ACRONYMS AND ABBREVIATIONS

TOPS	Terrestrial Observation and Prediction System
TPS	Thermal Protection System
TRACE	Transition Region and Coronal Explorer
TRL	Technology readiness level
TRMM	Tropical Rainfall Measuring Mission
TSDIS	TRMM Science Data and Information System
TSI	Total solar irradiance
TSIS	Total Solar Irradiance Sensor
TT&C	Tracking telemetry and command (flight)
T-TSAFE	Terminal-Tactical Separation Assured Flight Environment
TWINS	Two Wide–angle Imaging Neutral–atom Spectrometers
TXR	Targeted x-ray
U.K.	United Kingdom
U.S.	United States
U.S.C.	United States Code
UA	Utility Annex (at KSC)
UAS	Unmanned Aircraft Systems
UAV	Unmanned aerial vehicle
UAVSAR	Uninhabited Aerial Vehicle Synthetic Aperture Radar
UCLA	University of California at Los Angeles
UCT	Universal coordinated time
UHB	Ultra high bypass
UHF	Ultra high frequency
ULA	United Launch Alliance
ULS	United Launch Services
URC	University Research Centers
USA	United Space Alliance
USAF	United States Air Force
USAID	U.S. Agency for International Development
USDA	United States Department of Agriculture
USE	Upper Stage Engine
USFWS	US Fish and Wildlife Service
USGBC	U.S. Green Building Council
USGCRP	U.S. Global Change Research Program
USGS	United States Geological Survey
USGS-EDC	United States Geological Survey EROS Data Center
USOS	U.S. On-orbit Segment (ISS)
USPI	U.S. Participating Investigators (Explorer)
USR	Undergraduate student research
USRA	Universities Space Research Association

ACRONYMS AND ABBREVIATIONS

UV	Ultraviolet
UVS	UV spectrometer
V&V	Verification and validation
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VAO	Virtual Astronomical Observatory
VCL	Vegetation Canopy Lidar
VGA	Venus Gravity Assist
VIIP	Visual Impairment/Intra-cranial Pressure (VIIP) Syndrome
VIIRS	Visible-Infrared Imager Radiometer Suite (Suomi NPP instrument)
VIPR	Vehicle Integrated Propulsion Research
VIS	Visible Instrument
VLC	Vertical Lift Consortium
VLRS	Vehicle-Level Reasoning System
VOR	Variable Oxygen Regulator
W-TPS	Woven Thermal Protection System
WCF	Working Capital Fund
WCRP	World Climate Research Programme
WEST	Web services (IT service under I3P)
WFC	Wide Field Camera
WFF	Wallops Flight Facility (NASA, managed by GSFC)
WFIRST	Wide-Field Infrared Survey Telescope
WIMP	Weakly interacting massive particle
WISE	Wide-field Infrared Survey Explorer
WMAP	Wilkinson Microwave Anisotropy Probe
WMS	Web Mapping Service
WRP	Wide Range Pump
WRF-Chem	Weather Research and Forecasting model with Chemistry
WSC	White Sands Complex
WSPR	Waveform and Sonic Boom Perception and Response
WSTF	White Sands Test Facility, (NASA, managed by JSC)
XCVR	Transceiver
XMM	X-ray Multi-mirror Mission (Newton Observatory)
XPI	X-ray Polarimeter Instrument