National Aeronautics and Space Administration
President's FY 2011 Budget Request Summary

Budget Authority, $ in million	FY 2009 Actual	Recovery Act	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Science	**4,503.0**	**400.0**	**4,493.3**	**5,005.6**	**5,248.6**	**5,509.6**	**5,709.8**	**5,814.0**
Earth Science	1,377.3	325.0	1,420.7	1,801.8	1,944.5	2,089.5	2,216.6	2,282.2
Planetary Science	1,288.1	0.0	1,341.3	1,485.7	1,547.2	1,591.2	1,630.1	1,649.4
Astrophysics	1,229.9	75.0	1,103.9	1,076.3	1,109.3	1,149.1	1,158.7	1,131.6
Heliophysics	607.8	0.0	627.4	641.9	647.6	679.8	704.4	750.8
Aeronautics and Space Research and Technology	**500.0**	**150.0**	**507.0**	**1,151.8**	**1,596.9**	**1,650.1**	**1,659.0**	**1,818.2**
Aeronautics Research	500.0	150.0	507.0	579.6	584.7	590.4	595.1	600.3
Space Technology	0.0	0.0	0.0	572.2	1,012.2	1,059.7	1,063.9	1,217.9
Exploration	**3,505.5**	**400.0**	**3,779.8**	**4,263.4**	**4,577.4**	**4,718.9**	**4,923.3**	**5,179.3**
Exploration Research and Development	0.0	0.0	0.0	1,551.4	2,577.4	3,318.9	3,623.3	3,979.3
Commercial Spaceflight	0.0	0.0	0.0	812.0	1,400.0	1,400.0	1,300.0	1,300.0
Constellation Transition	0.0	0.0	0.0	1,900.0	600.0	0.0	0.0	0.0
Constellation Systems	3,033.2	400.0	3,325.8	0.0	0.0	0.0	0.0	0.0
Advanced Capabilities	472.3	0.0	454.0	0.0	0.0	0.0	0.0	0.0
Space Operations	**5,764.7**	**0.0**	**6,180.6**	**4,887.8**	**4,290.2**	**4,253.3**	**4,362.6**	**4,130.5**
Space Shuttle	2,979.5	0.0	3,139.4	989.1	86.1	0.0	0.0	0.0
International Space Station	2,060.2	0.0	2,317.0	2,779.8	2,983.6	3,129.4	3,221.9	3,182.8
Space and Flight Support	725.0	0.0	724.2	1,119.0	1,220.6	1,123.9	1,140.7	947.7
Education	**169.2**	**0.0**	**183.8**	**145.8**	**145.8**	**145.7**	**145.7**	**146.8**
Cross-Agency Support	**3,356.4**	**50.0**	**3,095.1**	**3,111.4**	**3,189.6**	**3,276.8**	**3,366.5**	**3,462.2**
Center Mgmt & Ops	2,024.3	0.0	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3
Agency Mgmt & Ops	921.2	0.0	941.7	841.2	842.2	849.1	856.8	867.9
Institutional Investments	293.7	50.0	23.4	0.0	0.0	0.0	0.0	0.0
Congressionally Directed Items	67.2	0.0	63.0	0.0	0.0	0.0	0.0	0.0
Construction and Environmental Compliance and Restoration	**0.0**	**0.0**	**448.3**	**397.3**	**363.8**	**366.9**	**393.5**	**398.5**
Construction of Facilities	0.0	0.0	381.1	335.2	316.3	319.5	344.6	349.0
Environmental Compliance and Restoration	0.0	0.0	67.2	62.1	47.5	47.4	48.9	49.5
Inspector General	**33.6**	**2.0**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**	**40.5**
NASA FY 2011	**17,782.4**	**1,002.0**	**18,724.3**	**19,000.0**	**19,450.0**	**19,960.0**	**20,600.0**	**20,990.0**
Year to Year Change			5.3%	1.5%	2.4%	2.6%	3.2%	1.9%

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National Aeronautics and Space Administration
President's FY 2011 Budget Request Detail

Budget Authority, $ in million	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Science	**4,903.0**	**4,493.3**	**5,005.6**	**5,248.6**	**5,509.6**	**5,709.8**	**5,814.0**
Earth Science	**1,702.3**	**1,420.7**	**1,801.8**	**1,944.5**	**2,089.5**	**2,216.6**	**2,282.2**
Earth Science Research	*437.4*	*383.3*	*438.1*	*489.6*	*513.6*	*523.4*	*543.3*
Earth Science Research and Analysis	313.7	278.9	324.6	348.2	365.9	391.0	406.4
Computing and Management	123.7	104.4	113.5	141.4	147.8	132.4	136.9
Earth Systematic Missions	*893.7*	*723.4*	*809.3*	*993.9*	*1,120.8*	*1,226.8*	*1,223.5*
Global Precipitation Measurement (GPM)	143.8	155.6	128.8	125.7	90.0	52.8	35.7
Glory Mission	61.0	27.1	21.9	5.5	7.7	8.3	8.6
Landsat Data Continuity Mission (LDCM)	200.9	120.6	156.8	157.9	69.5	3.1	3.1
NPOESS Preparatory Project (NPP)	42.2	104.6	64.4	5.2	5.1	5.1	5.4
Ice, Cloud, and land Elevation Satellite (ICESat-2)	38.8	39.2	68.5	116.0	178.6	153.9	94.9
Soil Moisture Active and Passive (SMAP)	103.3	70.0	82.5	139.0	163.8	80.0	10.0
Other Missions and Data Analysis	303.6	206.3	286.5	444.7	606.0	923.6	1,065.9
Earth System Science Pathfinder	*122.1*	*86.0*	*303.8*	*204.3*	*196.4*	*190.1*	*228.9*
Aquarius	46.9	18.3	17.0	5.4	5.2	2.4	4.6
OCO-2	0.0	25.0	171.0	91.0	51.0	13.0	4.0
Venture Class Missions	21.0	12.9	79.5	75.1	106.9	140.5	185.3
Other Missions and Data Analysis	54.3	29.8	36.2	32.7	33.4	34.2	35.0
Earth Science Multi-Mission Operations	*146.0*	*149.9*	*161.2*	*164.5*	*160.5*	*165.8*	*169.8*
Earth Science Multi-Mission Operations	146.0	149.9	161.2	164.5	160.5	165.8	169.8
Earth Science Technology	*55.3*	*45.9*	*52.8*	*53.9*	*57.1*	*64.7*	*68.0*
Earth Science Technology	55.3	45.9	52.8	53.9	57.1	64.7	68.0
Applied Sciences	*47.8*	*32.2*	*36.6*	*38.3*	*41.1*	*45.9*	*48.7*
Pathways	47.8	32.2	36.6	38.3	41.1	45.9	48.7
Planetary Science	**1,288.1**	**1,341.3**	**1,485.7**	**1,547.2**	**1,591.2**	**1,630.1**	**1,649.4**
Planetary Science Research	*166.2*	*160.7*	*180.4*	*190.8*	*195.2*	*214.2*	*240.9*
Planetary Science Research and Analysis	135.6	132.1	131.0	139.0	142.4	147.4	150.4
Other Missions and Data Analysis	19.5	21.4	23.9	23.7	23.4	30.2	29.0
Education and Directorate Management	7.4	1.4	5.1	7.7	8.9	16.0	40.8
Near Earth Object Observations	3.7	5.8	20.3	20.4	20.5	20.6	20.7
Lunar Quest Program	*69.1*	*103.6*	*136.6*	*136.4*	*131.7*	*109.7*	*110.5*
Lunar Science	28.9	33.3	74.7	77.6	108.7	105.4	103.9
Lunar Atmosphere and Dust Environment Explorer	30.2	55.3	57.9	54.7	18.7	0.0	0.0
International Lunar Network	10.0	15.0	4.0	4.1	4.2	4.3	6.6
Discovery	*234.8*	*209.2*	*202.0*	*216.8*	*235.9*	*263.0*	*312.9*
Gravity Recovery and Interior Laboratory (GRAIL)	152.9	124.1	104.8	41.4	4.7	0.0	0.0
Other Missions and Data Analysis	81.9	85.1	97.2	175.4	231.2	263.0	312.9

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Budget Authority, $ in million	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
New Frontiers	*279.0*	*264.1*	*223.8*	*229.5*	*237.9*	*247.7*	*258.5*
Juno	260.1	237.2	184.2	46.4	17.8	18.1	16.8
Other Missions and Data Analysis	19.0	26.9	39.6	183.1	220.1	229.6	241.6
Mars Exploration	*361.7*	*416.1*	*532.8*	*514.8*	*549.9*	*569.6*	*485.8*
2009 Mars Science Lab	229.3	204.0	231.6	91.8	42.0	38.5	0.0
MAVEN	6.7	53.4	161.2	210.9	170.5	25.8	18.4
Other Missions and Data Analysis	125.7	158.7	140.0	212.1	337.4	505.3	467.3
Outer Planets	*104.8*	*98.6*	*103.5*	*157.9*	*152.0*	*144.0*	*155.8*
Outer Planets	104.8	98.6	103.5	157.9	152.0	144.0	155.8
Technology	*72.4*	*89.0*	*106.5*	*101.1*	*88.7*	*82.0*	*85.1*
Technology	72.4	89.0	106.5	101.1	88.7	82.0	85.1
Astrophysics	**1,304.9**	**1,103.9**	**1,076.3**	**1,109.3**	**1,149.1**	**1,158.7**	**1,131.6**
Astrophysics Research	*136.0*	*149.0*	*156.1*	*178.1*	*188.4*	*194.6*	*199.6*
Astrophysics Research and Analysis	60.0	60.0	60.2	64.7	65.8	67.4	69.1
Balloon Project	25.6	26.7	27.1	32.4	32.7	35.3	36.8
Other Missions and Data Analysis	50.4	62.3	68.7	80.9	89.8	91.9	93.7
Cosmic Origins	*850.0*	*684.1*	*687.7*	*669.4*	*667.5*	*640.5*	*599.2*
Hubble Space Telescope (HST)	203.1	112.6	102.7	104.5	99.8	98.0	98.6
James Webb Space Telescope (JWST)	466.9	440.3	444.8	379.2	335.2	259.3	119.2
Stratospheric Observatory for Infrared Astronomy (SOFIA)	77.4	72.8	79.6	80.1	79.2	81.1	81.3
Other Missions And Data Analysis	102.5	58.4	60.6	105.7	153.4	202.2	300.1
Physics of the Cosmos	*111.1*	*116.8*	*103.3*	*114.4*	*151.7*	*176.4*	*202.0*
Other Missions and Data Analysis	111.1	116.8	103.3	114.4	151.7	176.4	202.0
Exoplanet Exploration	*72.1*	*46.2*	*42.5*	*54.1*	*83.0*	*93.8*	*117.6*
Other Missions and Data Analysis	72.1	46.2	42.5	54.1	83.0	93.8	117.6
Astrophysics Explorer	*135.7*	*107.9*	*86.7*	*93.3*	*58.5*	*53.3*	*13.2*
Nuclear Spectroscopic Telescope Array (NuStar)	38.7	59.9	32.1	10.8	6.2	0.0	0.0
Gravity and Extreme Magnetism	1.7	0.0	21.0	57.7	44.7	40.8	2.1
Other Missions and Data Analysis	95.2	48.0	33.6	24.8	7.6	12.6	11.1
Heliophysics	**607.8**	**627.4**	**641.9**	**647.6**	**679.8**	**704.4**	**750.8**
Heliophysics Research	*204.7*	*173.0*	*166.9*	*165.4*	*168.7*	*172.9*	*172.9*
Heliophysics Research and Analysis	31.5	31.0	31.7	32.2	33.0	33.8	34.2
Sounding Rockets	45.1	65.3	48.9	49.7	51.8	53.0	53.8
Research Range	32.3	19.2	19.6	20.1	20.6	21.1	21.4
Other Missions and Data Analysis	95.8	57.5	66.7	63.4	63.4	65.0	63.5
Living with a Star	*222.6*	*240.2*	*214.3*	*207.9*	*216.5*	*243.0*	*288.8*
Radiation Belt Storm Probes (RBSP)	154.4	129.1	140.0	92.2	30.2	22.0	9.1
Solar Probe Plus	18.0	40.0	14.1	49.7	104.3	104.4	148.2
Other Missions and Data Analysis	50.2	71.1	60.2	66.0	82.0	116.6	131.5

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Solar Terrestrial Probes	*143.0*	*143.0*	*162.9*	*175.1*	*178.5*	*161.7*	*121.4*
Magnetospheric Multiscale (MMS)	115.9	118.6	143.8	155.8	158.9	141.4	96.1
Other Missions and Data Analysis	27.1	24.4	19.1	19.3	19.6	20.3	25.3
Heliophysics Explorer Program	*34.8*	*69.4*	*97.7*	*99.2*	*116.1*	*126.8*	*167.8*
IRIS	15.0	0.0	69.0	37.6	9.2	7.3	1.2
Other Missions and Data Analysis	19.8	69.4	28.7	61.6	106.9	119.5	166.5
New Millennium	*2.7*	*1.8*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*
New Millennium	2.7	1.8	0.1	0.0	0.0	0.0	0.0
Aeronautics and Space Research and Technology	**650.0**	**507.0**	**1,151.8**	**1,596.9**	**1,650.1**	**1,659.0**	**1,818.2**
Aeronautics Research	**650.0**	**507.0**	**579.6**	**584.7**	**590.4**	**595.1**	**600.3**
Aviation Safety	*89.3*	*75.0*	*79.3*	*78.9*	*81.2*	*81.9*	*82.7*
Airspace Systems	*121.5*	*80.0*	*82.2*	*82.9*	*85.9*	*86.6*	*87.4*
Fundamental Aeronautics	*307.6*	*220.0*	*228.5*	*231.4*	*236.0*	*241.8*	*244.6*
Aeronautics Test	*131.6*	*72.0*	*76.4*	*76.4*	*75.6*	*77.4*	*78.2*
Integrated Systems Research	*0.0*	*60.0*	*113.1*	*115.1*	*111.7*	*107.4*	*107.4*
Space Technology	**0.0**	**0.0**	**572.2**	**1,012.2**	**1,059.7**	**1,063.9**	**1,217.9**
Early Stage Innovation	*0.0*	*0.0*	*298.6*	*304.4*	*300.4*	*305.1*	*314.7*
Space Technology Research Grants	0.0	0.0	70.0	70.0	70.0	70.0	70.0
NIAC Phase I and Phase II	0.0	0.0	3.0	6.0	7.0	7.0	8.0
Center Innovations Fund	0.0	0.0	50.0	50.0	50.0	50.0	50.0
SBIR/STTR	0.0	0.0	165.6	168.4	163.4	168.1	176.7
Centennial Challenges	0.0	0.0	10.0	10.0	10.0	10.0	10.0
Game Changing Technology	*0.0*	*0.0*	*129.6*	*359.3*	*349.1*	*349.1*	*424.2*
Game-Changing Developments	0.0	0.0	123.6	329.3	319.1	319.1	394.2
Small Satellite Subsystem Technologies	0.0	0.0	6.0	30.0	30.0	30.0	30.0
Crosscutting Capability Demonstrations	*0.0*	*0.0*	*102.0*	*302.0*	*362.0*	*362.0*	*424.0*
Technology Demonstration Missions	0.0	0.0	75.0	265.0	325.0	325.0	387.0
Edison Small Satellite Demonstration Missions	0.0	0.0	10.0	20.0	20.0	20.0	20.0
Flight Opportunities	0.0	0.0	17.0	17.0	17.0	17.0	17.0
Partnership Development and Strategic Integration	*0.0*	*0.0*	*42.0*	*46.5*	*48.2*	*47.7*	*55.0*
Partnership Development and Strategic Integration	0.0	0.0	42.0	46.5	48.2	47.7	55.0

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Budget Authority, $ in million	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Exploration	**3,905.5**	**3,779.8**	**2,363.4**	**3,977.4**	**4,718.9**	**4,923.3**	**5,179.3**
Exploration Research and Development	**0.0**	**0.0**	**1,551.4**	**2,577.4**	**3,318.9**	**3,623.3**	**3,979.3**
Technology Demonstration	*0.0*	*0.0*	*652.4*	*1,262.4*	*1,807.9*	*2,013.3*	*2,087.3*
Heavy Lift and Propulsion Technology	*0.0*	*0.0*	*559.0*	*594.0*	*597.0*	*598.0*	*754.0*
Robotic Precursor Missions	*0.0*	*0.0*	*125.0*	*506.0*	*699.0*	*797.0*	*923.0*
Human Research	*0.0*	*0.0*	*215.0*	*215.0*	*215.0*	*215.0*	*215.0*
Commercial Spaceflight	**0.0**	**0.0**	**812.0**	**1,400.0**	**1,400.0**	**1,300.0**	**1,200.0**
Commercial Cargo	*0.0*	*0.0*	*312.0*	*0.0*	*0.0*	*0.0*	*0.0*
Commercial Crew	*0.0*	*0.0*	*500.0*	*1,400.0*	*1,400.0*	*1,300.0*	*1,200.0*
Constellation Transition	**0.0**	**0.0**	**1,900.0**	**600.0**	**0.0**	**0.0**	**0.0**
Constellation Systems	**3,433.2**	**3,325.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Constellation Systems	*3,190.1*	*3,286.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Commercial Crew and Cargo	*243.0*	*39.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Advanced Capabilities	**472.3**	**454.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Human Research Program	*151.9*	*151.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Exploration Technology Development	*264.1*	*283.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Lunar Precursor Robotic Program	*56.3*	*19.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Space Operations	**5,764.7**	**6,180.6**	**4,887.8**	**4,290.2**	**4,253.3**	**4,362.6**	**4,130.5**
Space Shuttle	**2,979.5**	**3,139.4**	**989.1**	**86.1**	**0.0**	**0.0**	**0.0**
Space Shuttle Program	*2,979.5*	*3,139.4*	*989.1*	*86.1*	*0.0*	*0.0*	*0.0*
Program Integration	458.5	678.1	284.8	25.1	0.0	0.0	0.0
Flight and Ground Operations	1,037.4	1,035.1	373.2	28.6	0.0	0.0	0.0
Flight Hardware	1,483.6	1,426.2	331.1	32.3	0.0	0.0	0.0
International Space Station	**2,060.2**	**2,317.0**	**2,779.8**	**2,983.6**	**3,129.4**	**3,221.9**	**3,182.8**
International Space Station Program	*2,060.2*	*2,317.0*	*2,779.8*	*2,983.6*	*3,129.4*	*3,221.9*	*3,182.8*
ISS Operations	1,594.9	1,689.0	1,923.0	1,797.8	1,903.9	1,934.2	1,971.2
ISS Cargo Crew Services	465.2	628.0	856.8	1,185.7	1,225.5	1,287.6	1,211.6

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Space and Flight Support (SFS)	**725.0**	**724.2**	**1,119.0**	**1,220.6**	**1,123.9**	**1,140.7**	**947.7**
21st Century Space Launch Complex	*0.0*	*0.0*	*428.6*	*500.0*	*400.0*	*400.0*	*200.0*
21st Century Space Launch Complex	0.0	0.0	428.6	500.0	400.0	400.0	200.0
Space Communications and Navigation	*582.9*	*485.3*	*452.9*	*478.0*	*479.5*	*488.4*	*489.6*
Space Communications Networks	342.2	372.8	371.2	404.7	412.3	429.2	436.1
Space Communications Support	86.7	86.6	62.6	50.7	53.8	59.2	53.5
TDRS Replenishment	154.0	26.0	19.0	22.6	13.4	0.0	0.0
Human Space Flight Operations	*0.0*	*102.3*	*114.4*	*115.8*	*117.7*	*118.1*	*121.0*
Human Space Flight Operations	0.0	102.3	114.4	115.8	117.7	118.1	121.0
Launch Services	*91.7*	*83.8*	*78.9*	*82.6*	*82.5*	*86.0*	*87.9*
Launch Services	91.7	83.8	78.9	82.6	82.5	86.0	87.9
Rocket Propulsion Test	*41.8*	*44.3*	*44.3*	*44.2*	*44.2*	*48.2*	*49.2*
Rocket Propulsion Testing	41.8	44.3	44.3	44.2	44.2	48.2	49.2
Crew Health & Safety	*8.6*	*8.6*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Crew Health and Safety	8.6	8.6	0.0	0.0	0.0	0.0	0.0
Education	**169.2**	**183.8**	**145.8**	**145.8**	**145.7**	**145.7**	**146.8**
Education	**169.2**	**183.8**	**145.8**	**145.8**	**145.7**	**145.7**	**146.8**
Higher Ed. STEM Education	*107.7*	*121.2*	*81.0*	*81.0*	*81.0*	*81.0*	*81.0*
STEM Opportunities (Higher Education)	9.5	12.4	16.9	16.9	16.9	16.9	16.9
NASA Space Grant	40.0	45.5	27.7	27.7	27.7	27.7	27.7
Experimental Program to Stimulate Competetive Research	20.0	24.9	9.3	9.3	9.3	9.3	9.3
Minority University Research & Education Program	28.2	28.4	27.2	27.2	27.2	27.2	27.2
Global Climate Change Education	10.0	10.0	0.0	0.0	0.0	0.0	0.0
K-12 STEM Education	*47.5*	*46.5*	*62.8*	*62.8*	*62.7*	*62.7*	*63.8*
STEM Student Opportunities (K-12)	15.2	17.2	46.1	46.1	46.1	46.1	46.1
STEM Teacher Development (K-12)	16.3	14.3	16.7	16.7	16.6	16.6	17.7
K-12 Competitive Educational Grant Program	16.0	15.0	0.0	0.0	0.0	0.0	0.0
Informal STEM Education	*14.0*	*16.1*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*
Science Museums and Planetarium Grants	7.0	7.0	0.0	0.0	0.0	0.0	0.0
NASA Visitor Centers	7.0	6.4	0.0	0.0	0.0	0.0	0.0
NASA Informal Education Opportunities	0.0	2.7	2.0	2.0	2.0	2.0	2.0

National Aeronautics and Space Administration
President's FY 2011 Budget Request Detail

Budget Authority, $ in million	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Cross-Agency Support	**3,356.4**	**3,095.1**	**3,111.4**	**3,189.6**	**3,276.8**	**3,366.5**	**3,462.2**
Center Management and Operations	**2,024.3**	**2,067.0**	**2,270.2**	**2,347.4**	**2,427.7**	**2,509.7**	**2,594.3**
Center Management and Operations	*2,024.3*	*2,067.0*	*2,270.2*	*2,347.4*	*2,427.7*	*2,509.7*	*2,594.3*
Center Institutional Capabilities	1,542.1	1,591.7	1,776.1	1,830.5	1,890.9	1,956.3	2,021.8
Center Programmatic Capabilities	482.2	475.3	494.0	516.8	536.8	553.4	572.5
Agency Management and Operations	**921.2**	**941.7**	**841.2**	**842.2**	**849.1**	**856.8**	**867.9**
Agency Management	*389.3*	*398.9*	*432.0*	*451.1*	*455.8*	*460.6*	*467.0*
Agency Management	389.3	398.9	432.0	451.1	455.8	460.6	467.0
Safety and Mission Success	*179.8*	*192.9*	*201.6*	*203.8*	*205.8*	*206.6*	*208.7*
Safety and Mission Assurance	44.3	48.2	49.0	49.5	49.9	50.5	51.2
Chief Engineer	87.0	101.1	103.6	105.2	106.8	106.9	108.4
Chief Health and Medical Officer	3.6	3.6	4.1	4.1	4.1	4.1	4.2
Independent Verification and Validation	45.0	40.0	45.0	45.0	45.0	45.0	45.0
Agency IT Services (AITS)	*163.9*	*145.3*	*177.8*	*157.5*	*157.7*	*159.5*	*161.7*
IT Management	18.1	28.6	16.1	16.6	16.4	16.7	17.0
Applications	64.0	68.4	79.1	70.6	70.9	71.7	72.6
Infrastructure	81.8	48.3	82.6	70.4	70.4	71.1	72.1
Innovative Partnerships Program	*160.2*	*175.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Technology Infusion	9.1	10.0	0.0	0.0	0.0	0.0	0.0
Small Business Innovative Research	113.4	124.1	0.0	0.0	0.0	0.0	0.0
Small Business Technology Transfer Research	13.6	14.1	0.0	0.0	0.0	0.0	0.0
Innovation Incubator	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Future Centennial Challenges	0.0	4.0	0.0	0.0	0.0	0.0	0.0
Partnership Development	24.1	20.0	0.0	0.0	0.0	0.0	0.0
Innovative Technology	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Strategic Capabilities Assets Program	*28.0*	*29.4*	*29.8*	*29.8*	*29.8*	*30.1*	*30.5*
Simulators	11.5	11.7	11.7	11.7	11.7	11.8	12.2
Thermal Vacuum Chambers	7.2	8.3	8.4	8.4	8.4	8.5	8.5
Arc Jets	9.3	9.4	9.7	9.7	9.7	9.8	9.8
Institutional Investments	**343.7**	**23.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Institutional Construction of Facilities	*268.9*	*23.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Institutional Construction Of Facilities	268.9	23.4	0.0	0.0	0.0	0.0	0.0
Environmental Compliance and Restoration	*74.8*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Environmental Compliance and Restoration	74.8	0.0	0.0	0.0	0.0	0.0	0.0
Congressionally Directed Items	**67.2**	**63.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Congressionally Directed Items	*67.2*	*63.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Congressionally Directed Items	67.2	63.0	0.0	0.0	0.0	0.0	0.0

National Aeronautics and Space Administration
President's FY 2011 Budget Request Detail

Budget Authority, $ in million	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Construction and Environmental Compliance and Restoration	**0.0**	**448.3**	**397.3**	**363.8**	**366.9**	**393.5**	**398.5**
Construction of Facilities	**0.0**	**381.1**	**335.2**	**316.3**	**319.5**	**344.6**	**349.0**
Institutional CoF	*0.0*	*249.3*	*280.8*	*316.3*	*319.5*	*344.6*	*349.0*
Institutional CoF	0.0	249.3	280.8	316.3	319.5	344.6	349.0
Science CoF	*0.0*	*13.7*	*40.5*	*0.0*	*0.0*	*0.0*	*0.0*
Science CoF	0.0	13.7	40.5	0.0	0.0	0.0	0.0
Exploration CoF	*0.0*	*90.8*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Exploration CoF	0.0	90.8	0.0	0.0	0.0	0.0	0.0
Space Operations CoF	*0.0*	*27.3*	*14.0*	*0.0*	*0.0*	*0.0*	*0.0*
Space Operations CoF	0.0	27.3	14.0	0.0	0.0	0.0	0.0
Environmental Compliance and Restoration	**0.0**	**67.2**	**62.1**	**47.5**	**47.4**	**48.9**	**49.5**
Environmental Compliance and Restoration	*0.0*	*67.2*	*62.1*	*47.5*	*47.4*	*48.9*	*49.5*
Environmental Compliance and Restoration	0.0	67.2	62.1	47.5	47.4	48.9	49.5
Inspector General	**35.6**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**	**40.5**
Inspector General	**35.6**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**	**40.5**
IG Program	*35.6*	*36.4*	*37.0*	*37.8*	*38.7*	*39.6*	*40.5*
Inspector General	35.6	36.4	37.0	37.8	38.7	39.6	40.5
NASA FY 2011	**18,784.4**	**18,724.3**	**19,000.0**	**19,450.0**	**19,960.0**	**20,600.0**	**20,990.0**

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Message from the Administrator

I am proud to submit the President's Fiscal Year 2011 Budget Request of $19.0 billion for NASA. At NASA, we are incredibly excited that the President's budget provides $6B in new funding over the next 5 years, and a significant increase in FY2011. This investment is a testament to our innovative workforce, our forward looking programs, and our ability to connect our work with societal needs to drive prosperity for people across the Nation. With President Obama's new direction to NASA, we will be investing in the best peer-reviewed research, innovative new technologies, dramatic flight demonstrations, and in building an inclusive new space industry. All of these investments are designed to continue NASA's world leadership in space exploration with humans and robots, push the frontiers of knowledge and capability, and focus NASA on key national needs, while driving innovation and facilitating the creation of new jobs for the future.

Before embarking on the discussion of the future Programs contained in the President's Budget Request, I would like to take this opportunity to reflect on the end of the Space Shuttle Program, which is scheduled to complete its final flight this year. Speaking from four personal experiences as a Shuttle crew member, I can say that this Nation owes deep thanks to the tens of thousands of men and women who made this program a reality. The Shuttle (originally Space Transportation System) has served our Nation well, teaching us what humans can achieve on orbit, launching and servicing iconic satellites like the Hubble Space Telescope, allowing school children to fly experiments in space and teachers to travel there, and enabling us to construct the spectacular orbiting laboratory that is the International Space Station (ISS). The Shuttle has also borne painful lessons about safety and reminded us of the human risks we take when we choose to be a space-faring Nation. As we move ahead to the next era of space exploration, we will be standing on the shoulders of those early Shuttle designers, engineers, and technicians who gave us this marvelous technological achievement. The Space Shuttle will be forever recognized as a symbol of American innovation, ingenuity, and courage and a gateway to international collaboration in space.

NASA remains on track to safely fly out the remaining Space Shuttle manifest by the end of calendar year 2010. The FY 2011 budget provides the additional resources required to do so, ensuring that the Shuttle workforce will be fully utilized during that time. The budget request places the International Space Station on an exciting path, extending it to at least 2020, allowing us to utilize it as the national lab it was envisioned to be. We will make full use of its incredible potential, enhancing the utilization of research and development capabilities on-board. We will fly payloads for Earth Science, significantly expand our Human Research Program, and use the ISS as a technology test bed to pave the way for future human exploration beyond low Earth orbit.

NASA is a world leader in climate change research, and this budget dramatically expands NASA's climate research and observations capability. We will accelerate several of our most relevant climate change missions, consistent with the recommendations of the National Academy of Sciences. We will initiate a re-flight of the Orbiting Carbon Observatory, to be launched in 2013, and invest in additional carbon monitoring capabilities. With this knowledge, NASA and others will be able to better assess the potential global impacts of climate change.

Our Space Science programs will continue to operate dozens of missions across the solar system, and support development of missions to understand the Sun, Moon, Mars and the broader Universe. The budget request also seeks to expand research and development efforts in NASA's Aeronautics Program, emphasizing the Next Generation Air Transportation System (NextGen) and new "green aviation" research. These investments will enable safer and cleaner air travel in the future.

This budget request seeks to cancel the Constellation Program, which the independent Augustine Committee concluded faced steep challenges to achieve its stated goals of returning humans to the Moon by 2020. While we seek to implement this guidance, we gratefully acknowledge the hard work and dedication of the NASA and contractor workforce that made significant contributions through this Program. Their commitment has brought great value to the agency, and the knowledge gained will have a pivotal role to play in our future path.

This budget proposes a number of transformative technology programs, focusing on inventing and demonstrating a myriad of new space exploration capabilities that are required as we seek to send humans deeper into the solar system beyond our own moon where we previously triumphed in the Cold War era. We will seek bold, new ideas from many sources, seed innovation across the country, and create a space exploration program for the 21st Century. We will invest in the search for game-changing technologies such as advanced engines for launch and in-space travel; super light-weight space materials; new types of space habitats; new entry, descent, and landing systems; space resource processing; and radiation protection for people and space systems. We will seed activities ranging from fundamental space technology research to flagship technology demonstrations in space and on other planets. These activities will draw new innovators to NASA, revitalizing our capabilities for the decades to come. It is with these capabilities that humans will venture out into the solar system and, eventually, beyond.

And as we invest in the most cutting-edge research and technology to enable human exploration beyond Earth, we will also work to cultivate an expanded space exploration industry through a commercial crew program that seeks to spur competition and innovation in American industry, ultimately resulting in commercial human spaceflight services. Once established, these services will not only allow astronauts to travel to the International Space Station, they will ultimately open space travel to many more people across the globe.

All of these accomplishments will be buoyed by a robust STEM education program to support the President's *Educate to Innovate Initiative* promoting teacher competence and student achievement in the areas of STEM education needed to assure NASA, and the nation, an increased supply of scientists and engineers in the decades ahead when world technological leadership will become increasingly competitive.

There is no doubt that this budget seeks bold, and sometimes difficult, changes at NASA. I stand ready to work with Congress to as we look towards a compelling, sustainable future in space.

Charles F. Bolden Jr.
NASA Administrator

Overview

NASA's Science Mission Directorate (SMD) conducts scientific exploration enabled by the use of space observatories and space probes that view the Earth from space, observe and visit other bodies in the solar system, and peer out into our Galaxy and beyond. NASA's science program seeks answers to profound questions that touch us all:

- What are the origin and destiny of the universe?
- How did the planets and life originate?
- Are we alone?
- What is waiting to be discovered in the solar system?
- How is our planet changing, and what are the consequences for life and human civilization?

From space, NASA satellites can view the Earth as a planet and enable its study as a complex, dynamic system with diverse components: the oceans, atmosphere, continents, ice sheets, and life itself. The nation's scientific community can thereby observe and track global-scale changes, connecting cause to effects, and 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 forecast and decision support systems, NASA improves national capabilities to predict climate, weather, and natural hazards, manage resources, and craft environmental policy.

NASA extends humankind's virtual presence throughout the Solar System via robotic space probes to other planets and their moons, to asteroids and comets, and to icy bodies of the outer solar system. SMD is completing humankind's first basic reconnaissance of the Solar System by sending one mission to fly by Pluto and another that will visit two world-sized asteroids, Ceres and Vesta. SMD is also in the midst of a large-scale investigation of Mars, launching a series of ever more capable orbiters, landers, and rovers, with the long-term goal of a sample return mission. In addition, SMD is focusing on certain moons of the giant planets where current NASA missions see intriguing signs of surface activity and of liquid water within, knowing that on Earth, where there is water and an energy source there is also life.

Our solar system is governed by the Sun, a main-sequence star midway through its life. The Sun's influence is wielded through its gravity, radiation, solar wind, and magnetic fields as they interact with the masses, fields, and atmospheres of planetary and small bodies. Through the eyes of multiple spacecraft, the scientific community sees the solar system as a "heliosphere," another kind of interconnected system with diverse components. Using a fleet of sensors on various spacecraft in Earth orbit and throughout the solar system, SMD seeks to understand how and why the Sun varies, how planetary systems respond, and how human activities are affected. The science of Heliophysics enables the space weather predictions necessary to safeguard the outward journeys of human and robotic explorers.

Some of the greatest minds of the last century discovered wondrous things about our 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 the limits of our 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 also seek to understand the relationship between the smallest of subatomic particles and the vast expanse of the cosmos. With hundreds of planets around other stars now known, scientists are using current NASA missions in conjunction with ground-based telescopes to seek Earth-like planets in other solar systems.

This is NASA's science vision: to achieve a deep scientific understanding of our planet, other planets and solar system bodies, our star system in its entirety, and the universe beyond. SMD lays the intellectual foundation for the robotic and human expeditions of the future while meeting today's needs for scientific information to address national concerns on global change, space weather, and education.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**4,903.0**	**4,493.3**	**5,005.6**	**5,248.6**	**5,509.6**	**5,709.8**	**5,814.0**
Earth Science	1,702.3	1,420.7	1,801.8	1,944.5	2,089.5	2,216.6	2,282.2
Planetary Science	1,288.1	1,341.3	1,485.7	1,547.2	1,591.2	1,630.1	1,649.4
Astrophysics	1,304.9	1,103.9	1,076.3	1,109.3	1,149.1	1,158.7	1,131.6
Heliophysics	607.8	627.4	641.9	647.6	679.8	704.4	750.8
FY 2010 President's Budget Request	**4,903.0**	**4,477.2**	**4,747.4**	**4,890.9**	**5,069.0**	**5,185.4**	**--**
Earth Science	1,704.6	1,405.0	1,500.0	1,550.0	1,600.0	1,650.0	--
Planetary Science	1,325.6	1,346.2	1,500.6	1,577.7	1,600.0	1,633.2	--
Astrophysics	1,281.2	1,120.9	1,074.1	1,042.7	1,126.3	1,139.6	--
Heliophysics	591.6	605.0	672.6	720.5	742.7	762.6	--
Total Change from FY 2010 President's Budget Request	**0.0**	**16.1**	**258.2**	**357.7**	**440.6**	**524.4**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Science

Earth Science

New Initiatives:

Funding is included for an Orbiting Carbon Observatory replacement, with a planned launch readiness date of February 2013.

The budget includes an increase of $2.1 billion in FY 2011-2015 for a global climate initiative, enabling significant mission accelerations and program expansions. This initiative will accelerate selected Decadal Survey missions; expand and accelerate the new Venture-class competitive program; enable development of "gap-filler" climate sensors and missions, including a GRACE follow-on mission and early instrument flights on ISS; and support enhanced investments in new technologies, modeling, data systems, and decision support systems.

The Decadal Survey Tier-1 Soil Moisture Active-Passive (SMAP) and Ice, Cloud and Land Elevation Satellite 2 (ICESat-2) missions are now planned for launched as early as November 2014 and October 2015, respectively. With the infusion of funds for the global climate initiative, these launch dates are not limited by budget availability; the missions will be completed and launched as rapidly as possible, based on technical considerations alone. CLARREO, DESDynI and selected Decadal Tier 2 and 3 missions will be accelerated; CLARREO and DESDynI may launch as soon as 2017, approximately two years earlier than previously planned.

NASA initiated a new series of small, rapid-development, competed "Venture-class" missions in FY 2010. These missions, which may include suborbital payloads (to be flown on sounding rockets, balloons, aircraft, or unmanned aerial vehicles), instruments to be flown on non-NASA spacecraft, or small dedicated spacecraft, will be selected via an Announcement of Opportunity (AO) in FY 2010, and the first science results will be returned in FY 2011. As a result of the global climate initiative, future AOs will be released annually, instead of every other year, doubling the output of this exciting new program.

Major Changes:

None, other than the new initiatives discussed above.

Major Highlights for FY 2011

OCO-2 will complete KDP-C and enter into development

Glory will have its Launch Readiness Review, followed by the launch of the spacecraft.

The NPOESS Preparatory Project (NPP) will complete its satellite pre-ship review and is scheduled to launch in FY 2011.

LDCM will complete its spacecraft integration and test, and the Operational Land Imager (OLI) instrument will be delivered to the spacecraft in FY 2012, in preparation for launch in FY 2013.

The Decadal Tier-1 mission of Soil Moisture Active-Passive (SMAP) will complete KDP-C and enter into development, while the Ice Satellite 2 (ICESat-2) project will complete KDP-B and initiate the spacecraft contract.

All operating spacecraft which are beyond their prime mission will be reviewed for potential missions extensions, as part of the FY 2011 Senior Review.

The budget supports robust Research and Analysis and Technology programs.

Planetary Science

New Initiatives:

Within the Lunar Quest Program, $15M is included for the restart of U.S. plutonium production capability, in support of future deep space missions. A similar amount is also included within the Department of Energy budget.

The Near Earth Object Observations (NEOO) project has been augmented by $16M/year, to accelerate progress on the detection and characterization of NEOs less than 1km in diameter. In FY 2011, this will support the analysis of archived data from the Wide-Field Infrared Spectroscopic Explorer (WISE) mission.

Major Changes:

NASA has engaged the European Space Agency in discussions regarding collaboration on future robotic Mars missions. Concept studies for partnership missions launching in the 2016 and 2018 windows will be completed, and the 2016 mission will enter into formulation phase, by the end of FY 2011.

Major Highlights for FY 2011

Stardust NExT will arrive at comet Tempel 1 in February 2011 to see how it has evolved since the Deep Impact encounter in 2005.

Having completed its third fly-by of Mercury, MESSENGER will prepare for Mercury orbit insertion in March 2011 while it continues its analyses of valuable data from the three flybys.

The Dawn spacecraft will encounter the asteroid Vesta in May 2011.

Juno will deliver all hardware to Florida, in preparation for a launch in August 2011.

GRAIL will be in Assembly, Test, and Launch Operations (ATLO) by the end of CY 2010 and prepare for its launch in September 2011.

MSL will complete ATLO, and deliver all hardware in preparation for a launch in October to December 2011.

In addition to further definition study and technology development efforts for the Europa Jupiter System Mission (EJSM) throughout FY 2011, NASA will also continue to negotiate the details of a potential partnership with the European Space Agency (ESA) should they select the Ganymede Jupiter System Mission from among the major mission candidates under consideration in Europe.

Following a Discovery Announcement of Opportunity released in early CY 2010, and a step 1 or concept study selection in late CY 2010, NASA will make final selection(s) by the end of FY 2011.

Following the completion of New Frontiers 3 concept studies, NASA will make a New Frontiers 3 mission selection by the end of FY 2011.

The budget will fund operations of approximately 13 ongoing Planetary Science missions in FY2010, while maintaining robust Research and Analysis and Technology programs.

Astrophysics

New Initiatives:

None

Major Changes:

The James Webb Space Telescope (JWST) has entered development phase, in preparation for launch in June 2014.

In June 2009, NASA selected the Gravity and Extreme Magnetism SMEX (GEMS), as a Small Explorer, planned for launch no later than 2015. GEMS is an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than Earth's.

The Herschel, Planck, Kepler and Wide-field Infrared Spectroscopic Explorer (WISE) missions were all launched in CY 2009, and are now in prime operations.

Major Highlights for FY 2011

Four Astrophysics missions will be in development or formulation: JWST, the Nuclear Spectroscopic Telescope Array (NuSTAR), the SXS instrument on the Japanese Astro-H mission, and GEMS. The Stratospheric Observatory for Infrared Astronomy (SOFIA) will be conducting science operations as progress toward full capability continues. Planning will be underway on the top-priority missions identified by the Astro2010 decadal survey report from the National Reseach Council.

The budget will support approximately eleven operating Astrophysics missions in FY 2011, including Fermi, HST, Spitzer Space Telescope, Chandra X-ray Observatory, Swift, Suzaku, Galaxy Evolution Explorer (GALEX), Wilkinson Microwave Anisotropy Probe (WMAP), Herschel, Planck, and Kepler. The budget also maintains robust Research and Analysis and Scientific Balloon programs.

Heliophysics

New Initiatives:

None

Major Changes:

The budget for the Solar Probe Plus mission has been increased, to accommodate higher-than-expected launch vehicle and instrument costs. Solar Probe Plus is now scheduled for launch no later than FY 2018, which is the most desirable launch window attainable.

The European Space Agency announced a delay in the launch of the Solar Orbiter Collaboration mission to 2017.

In June 2009, NASA selected the Interface Region Imaging Spectrograph (IRIS) as a Small Explorer, planned for launch in December 2012. IRIS will use a solar telescope and spectrograph to explore the solar chromosphere, a 2000 kilometer thick layer of gas just above the visible surface of the Sun. IRIS' unique instrument capabilities, coupled with state of the art 3-D modeling, will explore this dynamic region in detail.

Major Highlights for FY 2011

NASA will award instrument contracts for the Solar Probe Plus mission.

An Announcement of Opportunity for the next Explorer missions will be developed and prepared for release.

The budget will fund operation and data analysis of approximately 16 ongoing Heliophysics missions (comprising 27 spacecraft) in FY 2011, while maintaining robust Research and Analysis and Sounding Rocket operations programs.

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Mission Directorate:	Science
Theme:	Earth Science

Theme Overview

NASA's Earth Science Theme advances knowledge of the integrated Earth systems. NASA's activities encompass the global atmosphere; the global oceans including sea ice; land surfaces including snow and ice; ecosystems; and interactions between the atmosphere, oceans, land, and ecosystems, including humans. A key strategic element is sustained simultaneous observations to unravel the complexity of the global integrated Earth system. The program has four major elements: Flight Programs (Earth Systematic Missions and Earth System Science Pathfinder) develop satellite missions; Earth Science Research advances scientific understanding and identifies the foci for the next generation of missions; Technology develops new technology and enables the next generation of effective satellite and airborne instruments; and Applied Sciences advances the effective use of Earth science measurements and scientific understanding by other Federal, state, local and tribal organizations.

The President's budget significantly advances NASA's climate-related activities through expansions of targeted activities in the Research, Applied Sciences, and Technology areas as well as acceleration of launches and selected additions to the flight portfolio. The budget enables launch of all Tier-1 Decadal Survey missions by late CY2017, expands the Venture-class competitive program with annual solicitations, initiates development of key climate continuity missions to mitigate data gaps, and identifies and accelerates Tier-2 Decadal Survey and related missions for flights on selected platforms including the ISS.

NASA presently operates fifteen satellite missions; thirteen are acquiring well-calibrated global observations with high-spatial and high-temporal resolution, while two (ICESAT, QuiKSCAT) recently ended their main scientific missions and are providing degraded measurements for use in cross-calibration and engineering investigations. NASA aircraft and surface-based instruments calibrate, complement, and enhance interpretation of satellite measurements. NASA supports computing capability and capacity for global integrated Earth system modeling. NASA missions produce nearly 4 terabytes of data every day, and NASA maintains the world's largest scientific data and information system for collecting, processing, archiving, and distributing Earth system data to worldwide users.

NASA has seven missions in formulation and development. With this FY2011 budget, the first two Decadal Survey missions (SMAP, ICESAT-2) have accelerated launch readiness dates of late CY2014 and late CY2015 respectively and scientifically focused CLARREO and DESYDynI (both Radar and Lidar) missions will be launched by the end of CY2017. Launch of all four Decadal Survey Tier-1 missions is achieved by 2017 and within a three-year span allowing on-orbit overlap. Selected Tier-2 Decadal Survey climate-focused missions will be identified by NASA in conjunction with the US Global Change Research Program, and initiated in this budget period for launch in the 2019-2020 timeframe. Recognizing the broad societal and policy impact of NASA's Earth observations, NASA will initiate development of two missions to continue and enhance climate time series. NASA will start the refurbishment of an atmospheric chemistry instrument to be hosted by the International Space Station as early as 2013, and will initiate a GRACE Follow-on mission to continue the gravity measurements provided by the aging Gravity Recovery and Climate Experiment (GRACE), for a launch in late FY2016.

Mission Directorate:	Science
Theme:	Earth Science

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**1,702.3**	**1,420.7**	**1,801.8**	**1,944.5**	**2,089.5**	**2,216.6**	**2,282.2**
Earth Science Research	437.4	383.3	438.1	489.6	513.6	523.4	543.3
Earth Systematic Missions	893.7	723.4	809.3	993.9	1,120.8	1,226.8	1,223.5
Earth System Science Pathfinder	122.1	86.0	303.8	204.3	196.4	190.1	228.9
Earth Science Multi-Mission Operations	146.0	149.9	161.2	164.5	160.5	165.8	169.8
Earth Science Technology	55.3	45.9	52.8	53.9	57.1	64.7	68.0
Applied Sciences	47.8	32.2	36.6	38.3	41.1	45.9	48.7
FY 2010 President's Budget Request	**1,704.6**	**1,405.0**	**1,500.0**	**1,550.0**	**1,600.0**	**1,650.0**	**--**
Earth Science Research	437.4	397.5	407.5	404.2	416.8	412.1	--
Earth Systematic Missions	898.9	715.5	725.4	786.4	818.8	867.6	--
Earth System Science Pathfinder	118.3	63.9	128.8	114.2	121.4	119.1	--
Earth Science Multi-Mission Operations	148.1	149.9	160.3	165.4	161.3	165.5	--
Earth Science Technology	54.1	45.9	47.2	48.2	49.5	52.7	--
Applied Sciences	47.8	32.2	30.7	31.5	32.2	33.1	--
Total Change from FY 2010 Request	**-2.2**	**15.7**	**301.8**	**394.5**	**489.5**	**566.6**	**--**

Plans for FY 2011

Earth Science Research

NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat and ICESat-2 data. This activity, focusing on changes in Greenland and arctic ice, will continue in FY 2010 and beyond.

The Science Mission Directorate will issue Research Opportunities in Space and Earth Science 2010 (ROSES-10), a research announcement covering all of the planned research solicitations in Earth Science Research. The FY 2011 budget will fund research competitively selected in FY 2010 under this ROSES call. Roughly a third of the Earth Science Research budget is competed each year through ROSES. The resulting grants are generally funded for three years following the selections. Given the average of a three-year funding cycle, many of the research activities carried out in FY 2011 will be tasks initiated in FY 2009 and FY 2010 based on solicitations included in ROSES-08 and ROSES-09, respectively. Selections based on ROSES 08 and 09 solicitations are on-going and are addressing a number of Earth Science research areas, including biodiversity, ocean salinity, hurricane and precipitation science, remote sensing of water quality, atmospheric composition, and interdisciplinary science.

In addition, the Research Program develops and tests experimental techniques and algorithms that contribute to future Decadal Survey missions. The FY 2011 President's Budget will enhance support for interdisciplinary science and NASA contribution to observational and model-based contributions to national and international climate assessments as well as support increased investments in scientific computing and space geodesy.

Plans for FY 2011

Earth Systematic Missions

In FY 2011, the President's budget accelerates or initiates Systematic Missions recommended by the National Research Council's 2007 Decadal Survey. The Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat-2) missions will be accelerated for launches in late CY 2014 and late CY 2015 respectively. Phase A formulation activities will be initiated for the remaining Tier-1 Decadal Survey missions, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), for accelerated launches in CY 2017. In addition, in conjunction with the USGCRP, NASA will identify at least one key climate-related Tier-2 Decadal Survey missions and initiate pre-formulation activities toward a late CY 2017 launch.

The following other activities will be undertaken or accomplished in FY 2011:

- GPM will complete its SIR and KDP-D;

- NPP will complete its satellite pre-ship review and is scheduled to launch (Sep 2011);

- Glory spacecraft will launch;

- LDCM will deliver the Operational Land Imager (OLI) instrument to the spacecraft;

- LDCM will complete its spacecraft integration and test;

- SMAP will complete KDP-C and enter into development;

- ICESat-2 will complete KDP-B and initiate the spacecraft contract;

- DESDynI and CLARREO will enter in Phase A formulation;

- The new GRACE Follow-on continuity mission will complete a pre-formulation phase and enter in Phase A formulation;

- The SAGE III instrument will begin refurbishment and will complete ISS accommodation assessment;

- Production of a dual payload adapter capability for the NASA launch services EELV fleet will be initiated, allowing dual-launch of DESDynI Radar and Lidar spacecraft; and

- A biannual Senior Review of all operating Earth research missions beyond their baseline mission duration will be conducted to optimize operating mission resources allocations in light of mission technical issues, time series continuity priorities, and mission contributions to non-NASA national imperatives such as improved weather forecasts.

Plans for FY 2011

Earth System Science Pathfinder

The Earth System Science Pathfinder (ESSP) Program plans for FY 2011 include completion of Aquarius/SAC-D observatory environmental testing, delivery to the launch site and launch of the Aquarius/SAC-D mission, and the start of the first series of Venture-class airborne science PI missions, selected in FY 2010. FY 2011 will see the completion of preparations for two additional competitive announcements within the Venture line in the ESSP program, one for a orbital mission and a second for an instrument of opportunity. In FY 2011, NASA will initiate the accelerated development of an Orbiting Carbon Observatory (OCO) Reflight (OCO-2) mission in October 2010, with the objective to launch in Feb 2013.

The following other activities will be undertaken or accomplished in FY 2011:

- The Aquarius/SAC-D mission will complete its environmental tests and launch from the Vandenberg Air Force Base (VAFB);

- The Orbiting Carbon Observatory - 2 (OCO-2) mission will conduct its confirmation review in October 2010, followed by the start of the mission development, leading to a target launch readiness date of Feb 2013;

- The start of the 1st Venture class missions, the EV-1 selections, in airborne science for sustained campaigns;

- Complete preparations for the 2nd Venture mission call and for the release of a Venture flight instrument AO, both to be released at the start of FY 2012; and

- GRACE, CloudSat, and CALIPSO will continue operations as determined by the 2009 Senior Review process, with extensions approved through the end of FY 2011. These missions will complete an additional Senior Review cycle in FY 2011 for operations in FY 2012 and beyond.

Earth Science Multi-Mission Operations

The Earth Science Multi-Mission Operations Program will continue operation of the Earth Observing System Data and Information System (EOSDIS), the Distributed Active Archive Centers (DAACs) and their accompanying functions, as well as Core System Science Data Processing Systems. The maintenance of these systems is important to the collection of data from Earth Science satellites in orbit, as well as to the continuity of Earth Science research efforts. NASA plans to continue the support of the Evolution of EOSDIS Elements effort to enable a service oriented architecture between now and FY 2015.

Five-year MEaSUREs Projects began work in FY 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. An Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation was released in NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009), and selections were made for new ACCESS Projects beginning in FY 2010. A third program solicitation, Earth System Data Records Uncertainty, is being readied for ROSES-2010, with selections planned to begin in FY 2011. These Cooperative Agreements are proving very valuable for keeping research and modeling communities actively involved with the EOSDIS architecture, and informing core infrastructure evolution decisions.

Plans for FY 2011

Earth Science Technology

ESTP will plan and implement development of new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements and data system capabilities. Planning will start with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess measurement options for meeting technology performance requirements. Implementation will be performed through managing awarded tasks from competed solicitations in the three project areas: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives. The FY 2011 President's Budget supports expansion of the currently planned activities.

For FY 2011, new work will be solicited in the Advanced Information Systems Technology and Advanced Component Technology areas. This FY 2011 solicitation will be part of the ROSES-2011 NASA Research Announcement. Both calls will support the NRC Decadal Survey missions and measurements.

Applied Sciences

In FY 2011, the Applied Sciences Program will continue or initiate projects across a range of application areas, including agriculture, air quality, climate, ecological forecasting, public health, natural disasters, water resources, and weather. These projects are competitively selected through NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2007, 2008, 2009, and 2010. In FY 2011, the Program will feature increased joint solicitations with research and end-user organizations, representation in satellite mission teams, and continuation of capacity building efforts to build skills and capabilities on how to access and apply Earth observations data to benefit society. The FY 2011 President's Budget enables the Program to introduce a new solicitation, increase the number of project selections, increase end-user involvement in early phase mission planning, and expand the SERVIR network.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The 2008 NASA Authorization Act and 2006 National Space Policy charged NASA to develop unique capabilities in global Earth observations and models to discover fundamental scientific knowledge of the integrated Earth system. NASA activities contribute substantially to two Presidential Initiatives: Integrated Global Earth Observations and Ocean Action Plan; three Congressional Initiatives: National Oceanographic Partnership Program, Global Change Research Act, and Clean Air Act Amendments; and, two United Nations Assessments: Intergovernmental Panel on Climate Change and Ozone Depletion. NASA is the largest funding contributor to the 13-agency U.S. Global Change Research Program. U.S. science community priorities are expressed in National Research Council's decadal survey report Earth Observations and Applications from Space: National Imperatives for the Next Decade and Beyond (NRC, 2007). NASA is working to implement the recommendations of in this report.

NASA coordinates with the U.S. Geological Survey on the Landsat Data Continuity Mission and with the Department of Defense and National Oceanic and Atmospheric Administration (NOAA) on the National Polar-orbiting Operational Environmental Satellite System. NASA develops, on a reimbursable basis with NOAA, the Geostationary Operational Environmental Satellite and Polar Orbiting Environmental Satellite programs. In FY 2009, NASA and the French space agency declared the Ocean Surface Topography Mission to be operational and transferred satellite command and control operations to NOAA, marking an important milestone in the transition of a research satellite measurement capability to an operational capability.

Relevance to education and public benefits:

NASA develops innovative programs to educate and train scientists in understanding the global integrated Earth system and infuse NASA observations and scientific results in the public and all venues of learning. NASA is the largest contributor to the Global Learning and Observations to Benefit the Environment (GLOBE), an international program that involves students in making hands-on observations of the Earth's environment and sharing them as part of an international community of learners. The DEVELOP program (not an acronym) is a national high school and university student-led, student-run internship activity. NASA's Earth System Science Fellowship Program trains graduate students, while the New Investigator Program targets early-career scientists and engineers. NASA Earth Science discoveries are reported almost daily through the world's media to motivate students and young scientists to pursue challenging careers in Earth science and technology.

NASA Earth Science improves public understanding of the complexity of the global integrated Earth system. Guided primarily by the 2007 National Research Council Decadal Survey, NASA is executing an ambitious plan to answer questions regarding why and how the environment is changing, define the impacts of environmental change on humans, and identify how humans can mitigate the impact of environmental hazards. Through its work with other Federal agencies to improve their operational services, NASA Earth Science advances capabilities in such areas as weather and air quality forecasting, climate prediction, and natural hazard and land use assessment.

Performance Achievement Highlights:

A team of NASA researchers at the Goddard Institute for Space Studies found that two greenhouse gases, methane and carbon monoxide, have a significantly more powerful warming impact than previously thought. In a paper published in October, the team conducted one of the first modeling experiments to rigorously quantify the impact of greenhouse gas-aerosol interactions on climate and air quality. The study found that methane's global warming impact has been underestimated, and that the combined impact of emissions that cause both warming and air pollution have as much warming effect as carbon dioxide. This improved knowledge of the warming effect of these greenhouse gases will help policymakers devise more efficient climate change mitigation strategies, which to date have concentrated only on curbing carbon dioxide.

Using NASA satellite data, scientists found that groundwater levels in northern India have been declining by as much as 1 foot per year over the past decade. A team of hydrologists led by Matt Rodell of NASA's Goddard Space Flight Center found that northern India's underground water supply is being pumped and consumed by human activities, such as irrigating cropland, and is draining aquifers faster than natural processes can replenish them. The finding is based on data from NASA's Gravity Recovery and Climate Experiment (GRACE), a pair of satellites that sense changes in Earth's gravity field. These changes directly relate to changes mass distribution, including water masses stored above or below Earth's surface.

NASA's Operation Ice Bridge, a six-year airborne field campaign, is the largest airborne survey of Earth's polar ice ever flown. It will yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves and sea ice. NASA completed the campaign's first Arctic survey in November 2009 from a base in Greenland and its first Antarctic survey this fall from Chile. Data collected during the campaign will help bridge the gap in critical space-based observations between the imminent end of NASA's Ice, Cloud, and Land Elevation Satellite (ICESat) mission, and ICESat-2, which is scheduled to launch in CY 2015.

Over its 10 years in orbit, NASA's Terra Earth-observing satellite has turned up trends and science results that are helping researchers better understand the complex Earth system. Researchers have updated Earth's energy budget, showing the world is cloudier than we thought, aerosols have an ambiguous yet critical role in climate, and not all urban areas attract and store heat in the same way. Other atmospheric discoveries have helped researchers show how high and far pollution travels.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council (NAC)	10/2009	NASA Advisory Council (NAC) - Review science strategy and implementation strategy for the Earth Science programs	02/2010
Relevance	National Research Council	01/2007	National Research Council - Decadal Survey of effectiveness and quality of the Earth Science programs. First time a Decadal Survey was developed for Earth Science. For more information: http://www.nap.edu/catalog.php?record_id=11820	2016

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	437.4	383.3	438.1	489.6	513.6	523.4	543.3
Earth Science Research and Analysis	313.7	278.9	324.6	348.2	365.9	391.0	406.4
Computing and Management	123.7	104.4	113.5	141.4	147.8	132.4	136.9
FY 2010 President's Budget Request	437.4	397.5	407.5	404.2	416.8	412.1	--
Earth Science Research and Analysis	313.7	281.7	300.3	294.2	304.4	296.5	--
Computing and Management	123.7	115.8	107.2	110.0	112.4	115.6	--
Changes from FY 2010 Request	0.0	-14.2	30.5	85.3	96.8	111.3	--

Program Overview

The Earth Science Research Program advances our knowledge of the global distribution of a range of important environmental parameters related to the Earth's atmosphere, hydrosphere, biosphere, cryosphere, and land surface; to understand the processes that drive and connect them; and to improve our capability to predict the future evolution of the Earth system, including climate, weather, and natural hazards.

Earth Science Research funds basic research and modeling efforts, the Airborne Science Project (which conducts research using airplanes and Uninhabited Air Systems), supercomputing efforts that support a variety of agencies, and education and outreach.

For more information, please see http://nasascience.nasa.gov/earth-science/.

Plans For FY 2011

The R&A project constitutes the core of the program and accounts for roughly half of the total budget. It is mostly competed via the Science Mission Directorate Research Opportunities in Space and Earth Science 2010 (ROSES-10), a research solicitation released February 2010. Solicited research in CY 2010 will generally result in grants funded with FY 2011 funding and two subsequent years, and includes ocean biology and biogeochemistry, physical oceanography, and other field experiments. It will also continue funding research solicited in ROSES-09 and ROSES-08 as they have progressed in their 2nd and 3rd year, respectively. The research portfolio includes the Interdisciplinary Science project, also competed in ROSES, with the focus to continue funding research in interdisciplinary areas, such as sea level change, water and energy cycle impacts of biomass burning and integrated earth system responses to extreme disturbances. Other competitive grant projects are the carbon cycle science team and the Earth science education and outreach activity. The remaining activities include primarily directed funding to NASA Centers for space geodesy (funding the development and operation of the geodetic networks), high end computing, scientific computing and global modeling and data assimilation.

The FY 2011 President's budget enhances support for interdisciplinary science, increase NASA's contribution to observational and model-based contributions to national and international climate assessments as well as support increased investments in scientific computing and space geodesy.

Project Descriptions and Explanation of Changes

Earth Science Research and Analysis

The Earth Science Research Program area consists of multiple projects and science teams which support the overall diverse R&A goals:

Research and Analysis Project: The Earth Science Research and Analysis (R&A) Project is the core of the R&A Program and funds research in all six Earth Science focus areas: 1) Climate variability and change; 2) Atmospheric composition; 3) Carbon cycle, ecosystems, and biogeochemistry; 4) Water and energy cycles; 5) Weather; and 6) Earth surface and interior. Additionally, the R&A Project addresses the Earth system and the interactions of its components, characterizing them on a broad range of spatial and temporal scales to understand the naturally occurring and human-induced processes that drive the overall system. The FY 2011 President's budget will enable a new investment in support of national and international climate assessments

Airborne Science: Airborne Science funds NASA's Earth science aircraft, both manned and unmanned. The project supports the operation of a catalog of NASA-owned and leased aircraft, including the ER-2, DC-8, WB-57, P-3, Twin Otter, B-200, Aerosonde, Global Hawk, and other UAS aircraft. These assets are deployed in campaigns conducted around the world to characterize extreme weather events (e.g., hurricanes), observe Earth system processes, capture data for Earth science modeling activities, and calibrate the instruments flying aboard Earth science spacecraft. NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat and ICESat-2 data. This activity, focusing on changes in Greenland, Arctic, and Antarctic ice, will continue in FY 2011 and beyond.

Interdisciplinary Science: Interdisciplinary Science funds science teams, support for which will be increased as part of the FY 2011 President's budget, as well as calibration and validation activities that ensure the utility of spaceborne measurements. In addition, it supports focused field work (e.g. airborne campaigns) and specific facility instruments, which are heavily relied upon in fieldwork.

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

Global Modeling and Assimilation Office: The Global Modeling and Assimilation Office, located at Goddard Space Flight Center, creates global climate and environmental models using data from Earth science satellites and aircraft. These products can then be used by investigators worldwide to further their research.

Ozone Trends Science: The Ozone Trends Science project has an overall goal of producing consistent, calibrated ozone time series that can be used for trend analyses and other studies.

Earth Science Research and Analysis (continued)

Education and Outreach Activity: The Education and Outreach Activity supports NASA's educational outcomes and communicates the results from Earth science missions and research. It also continues the worldwide implementation and U.S. coordination of the Global Learning and Observations to Benefit the Environment (GLOBE) Program, NASA's support for which will be increased as part of the FY 2011 President's budget.

Fellowships and New Investigators: The Fellowships and New Investigators project supports graduate and early-career research, respectively, that is relevant of Earth system research and applied science.

Space Geodesy: The Space Geodesy Project provides global geodetic positioning and supports the establishment of the needed geodetic reference frames in support of climate change and geohazards research and applications and their associated missions. The FY 2011 President's budget will support the construction of the pilot for the next generation ground station for this network, development of which has taken place over recent years.

Computing and Management

The Computing and Management area consists of three projects:

High-End Computing Capability (HECC): The High-End Computing Capability (HECC) project at Ames Research Center is focused around the Columbia supercomputer and the associated network connectivity, data storage, data analysis and visualization, and application software support. The Science Mission Directorate currently funds and manages the HECC resources, which serves the supercomputing needs of all NASA Mission Directorates as well as principle investigators at universities. Science Mission Directorate funding supports the operation, maintenance, and upgrade of NASA's supercomputing capability, while the Strategic Capabilities Assets Program exercises the oversight and insight functions. In 2008, a new approximately 40,000 processors supercomputer system "Pleiades" was acquired. The new system,currently ranked the world's sixth fastest supercomputer, supports NASA's aeronautics, exploration, space operation and science missions.

Scientific Computing: Scientific Computing funds NASA's Earth Science "Discover" computing system, software engineering, and user interface projects at Goddard Space Flight Center, including the assessment modeling carried out at the Goddard Institute for Space Studies. The Scientific Computing Project's primary purpose is to support Earth science modeling activities based on data collected by Earth science spacecraft. The FY 2011 President's budget provides increased support for hardware procurement and development of software systems designed to facilitate use of NASA computational hardware for its scientific challenges

Directorate Support: The Directorate Support Project is the institutional budget for the Science Mission Directorate. It funds Headquarters institutional activities that impact the Mission Directorate (i.e. Space Studies Board, NASA Peer Review, printing and graphics, IT budget, NASA Postdoctoral Program, working group support, independent assessment studies, and other administrative tasks with Mission Directorate impact).

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Issue competed, peer-reviewed research awards.	Research and Analysis; Airborne Science (flight opportunities)	None
Maximize resource utilization (i.e., computing cycles) in supercomputer projects.	Scientific Computing; HECC	None
Initiate the first-ever competitively selected science team.	Glory Mission of ESM Program; science team will be within R&A Program.	None
Competitively selected airborne mission teams.	Tropical photochemistry and Aerosol Airborne Campaign - R&A	None
Competitively selected airborne mission teams.	Hurricane Field Experiment - R&A	None

Implementation Schedule

Project	Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	Phase Dates	Beg	End
R&A, IDS Science, Carbon Cycle Science, Ozone Trends, Global Modeling and Assimilation Office, Space Geodesy, Education and Outreach, and Fellowships & New Investigators (all ongoing research efforts)		Tech		
		Form		
		Dev		
		Ops		
		Res	Jan-90	Dec-23
Airborne Science		Tech		
		Form		
		Dev		
		Ops	Jan-90	Dec-23
		Res		
Scientific Computing		Tech		
		Form		
		Dev		
		Ops	Jan-95	Dec-23
		Res		
HECC		Tech		
		Form		
		Dev	Jan-05	Aug-05
		Ops	Sep-05	Dec-23
		Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Program Management

The Earth Science Theme manages the Research Program. GSFC implements Scientific Computing and ARC implements HECC.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
R&A	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	U.S. Global Change Research Program (USGCRP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies.
Interdisciplinary Science	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	U.S. Global Change Research Program (USGCRP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Carbon Cycle Science Team	Earth Science Theme, Science Mission Directorate	GSFC, JPL, ARC	U.S. Global Change Research Program (USGCRP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Ozone Trends Science	Earth Science Theme, Science Mission Directorate	GSFC and LaRC	U.S. Global Change Research Program (USGCRP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Airborne Science	Earth Science Theme, Science Mission Directorate	GSFC/Wallops Flight Facility, DFRC, and ARC are the primary Centers involved in this project.	The Federal Aviation Administration, the Department of Defense, the Department of Energy, the National Science Foundation, and the National Oceanic and Atmospheric Administration (Department of Commerce).
High-End Computing Capability	Earth Science Theme, Science Mission Directorate	NASA Advanced Supercomputing, Ames Research Center	Department of Energy and the Department of Defense.
Scientific Computing	Earth Science Theme, Science Mission Directorate	NASA Center for Computational Sciences, Goddard Space Flight Center	Department of Energy and the Department of Defense.
Global Modeling and Assimilation Office (formerly Data Assimilation Office)	Earth Science Theme, Science Mission Directorate	Goddard Space Flight Center	None.
Space Geodesy	Earth Science Theme, Science Mission Directorate	Goddard Space Flight Center and Jet Propulsion Laboratory	None.
Earth Science Education and Outreach Activity	Science Mission Directorate	N/A (various non-NASA organizations)	National Science Foundation's Component of the Global Learning and Observations to Benefit the Environment (GLOBE).
Fellowships and New Investigators	Science Mission Directorate	N/A (various non-NASA organizations)	None.

Acquisition Strategy

The Earth Science Research Program is based on full and open competition. Grants are peer reviewed and selected based on NASA Research Opportunities in Space and Earth Sciences (ROSES)and other related announcements.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC Earth Science Subcommittee	2009	The NASA Advisory Council Science Subcommittee reviews content and progress towards Earth Science sub-goal in the NASA Strategic Plan of at least one Science Focus Area per year. During its 2009 meeting, the ESS reviewed and rated the ESD Science Metrics based on the submitted accomplishments and peer-reviewed publications for FY 2009. All six Science Focus Area metrics were rated "green" as documented in the FY 2009 Annual Performance Report (APR).	2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	893.7	723.4	809.3	993.9	1,120.8	1,226.8	1,223.5
Global Precipitation Measurement (GPM)	143.8	155.6	128.8	125.7	90.0	52.8	35.7
Glory Mission	61.0	27.1	21.9	5.5	7.7	8.3	8.6
Landsat Data Continuity Mission (LDCM)	200.9	120.6	156.8	157.9	69.5	3.1	3.1
NPOESS Preparatory Project (NPP)	42.2	104.6	64.4	5.2	5.1	5.1	5.4
Ice, Cloud, and land Elevation Satellite (ICESat-II)	38.8	39.2	68.5	116.0	178.6	153.9	94.9
Soil Moisture Active and Passive (SMAP)	103.3	70.0	82.5	139.0	163.8	80.0	10.0
Other Missions and Data Analysis	303.6	206.3	286.5	444.7	606.0	923.6	1,065.9
FY 2010 President's Budget Request	898.9	715.5	725.4	786.4	818.8	867.6	--
Global Precipitation Measurement (GPM)	157.8	159.5	127.6	137.5	111.2	80.4	--
Glory Mission	50.7	27.1	10.1	4.4	1.9	0.0	--
Landsat Data Continuity Mission (LDCM)	200.9	120.6	137.4	165.0	90.0	15.0	--
NPOESS Preparatory Project (NPP)	57.1	112.8	33.8	5.3	5.2	5.1	--
Ice, Cloud, and land Elevation Satellite (ICESat-II)	38.8	39.2	74.6	99.1	126.9	161.7	--
Soil Moisture Active and Passive (SMAP)	104.3	70.0	132.2	180.4	135.0	40.0	--
Decadal Survey Missions	82.3	0.0	10.9	8.8	161.1	374.6	--
Other Missions and Data Analysis	206.9	186.3	198.9	186.0	187.5	190.8	--
Changes from FY 2010 Request	-5.2	7.8	83.9	207.5	302.0	359.1	--

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Program Overview

The Earth Systematic Missions (ESM) Program (ESMP) is responsible for developing facility (non-Principal Investigator-led) Earth observing research satellite missions; supporting and overseeing the operation of NASA facility research missions once on orbit; and producing standard mission products in support of NASA and national research, applications, and policy communities. In contrast with the PI-led missions in the Earth System Science Program which are generally smaller and have highly focused scientific objectives, Earth Systematic Missions are designed to provide measurements and support for a wide a range of NASA science foci, given programmatic and technical constraints. Ten of the fifteen presently on-orbit research missions for which NASA had development responsibility are operated under ESMP oversight (the US Geological Survey operates Landsat-7, and operational responsibility for OSTM/Jason-2 was transferred to NOAA as planned during FY2009, and the Earth System Science Pathfinder (ESSP) Program manages GRACE, CloudSat and CALIPSO). Four of the five foundational missions presently in development are in the Earth Systematic Mission Program (Glory, NPP, LDCM, and GPM). The Earth Science and Applications Decadal Survey identifies 15 additional systematic NASA research missions which will be developed in the ESMP. Of these Decadal Survey missions, the President's FY11 budget provides funds for developing all four Tier-1 systematic missions (SMAP, ICESAT-2, DESDynI, and CLARREO) for launch by 2017. In consultation with the US Global Change Research Program, NASA will identify and begin development of several Tier-2 Decadal Survey climate missions. Additionally, the President's Budget allows expansion of the ESMP mission portfolio to include the potential development of a SAGE-III instrument on the ISS (2013), the development and launch of a GRACE-FO mission (late 2015 launch), and selected Tier-II Decadal Survey missions.

Interagency and international partnerships play key roles in the ESMP. Seven 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 involved significant international or interagency collaboration in development, and the 5-satellite A-Train formation-flying constellation (Aqua, CloudSat, CALIPSO, Aura, PARASOL) consists of both NASA and international missions. Two of the four ESMP foundational missions presently in development involve interagency collaboration (NPP, LDCM), while GPM is a joint development between NASA and the Japanese space agency JAXA.

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

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Plans For FY 2011

The President's budget enables a wide range of significant Earth Systematic Mission Program activities during FY 2011. The foundational systematic missions Glory and NPOESS Preparatory Project (NPP) will launch early and late in the fiscal year, respectively. All four Tier-1 Decadal Survey missions will pursue accelerated implementation activities and milestone reviews targeting launches in early FY 2015 (SMAP), early FY 2016 (ICESat-2), and late CY 2017 (CLARREO, DESDynI). ESMP activities will increase consistent with the expansion of the mission portfolio enabled by the budget, including initiation of the GRACE Follow-on (GRACE FO) mission (FY 2016 launch target) and refurbishment activities to allow the SAGE-III instrument to be ready for flight on the ISS by early CY 2014). Early work will be pursued on selected Tier-2 Decadal Survey and continuity missions identified by NASA and the US Global Change Research Program for accelerated launches in the CY 2017-2020 time frame.

The following specific activities will be undertaken or accomplished in FY 2011:

- Glory will launch (Nov 2010), complete its checkout and scientific validations, and begin routine data acquisition;

- GPM will complete its SIR and KDP-D;

- NPP will complete its satellite pre-ship review and is scheduled to launch (Sep 2011);

- LDCM will complete its spacecraft integration and test, and the Operational Land Imager (OLI) instrument will be delivered to the spacecraft;

- SMAP will complete KDP-C and enter into development;

- ICESat-2 will complete KDP-B and initiate the spacecraft contract;

- DESDynI and CLARREO will enter in Phase A formulation;

- The GRACE FO mission will complete a pre-formulation phase and enter in Phase A formulation;

- The SAGE III instrument will begin refurbishment and will complete ISS accommodation assessment; and

- Production of a dual payload adapter capability for the NASA launch services EELV fleet will be initiated, enabling, among other possibilities, a dual-launch in late CY 2017 of the DESDynI Radar and Lidar spacecrafts.

The regularly scheduled biennial Senior Review of all on-orbit NASA Earth research missions at or soon to be beyond the end of their baseline missions will be conducted during FY 2011.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Project Descriptions and Explanation of Changes

Global Precipitation Measurement (GPM) Mission

Extending precipitation measurements beyond the current Tropical Rainfall Measuring Mission (TRMM), the foundational mission GPM will provide detailed, frequent measurements of precipitation including rain rates and droplet size distributions. A joint mission between NASA and JAXA, GPM's two instruments will make valuable direct precipitation measurements and allow precise characterization of many other on-orbit NASA and partner instruments, enabling first-ever, accurate, near-global precipitation maps to be produced. GPM data will contribute to improved operational meteorological predictions as well as to advances in the NASA science focus areas of climate variability and change, water and energy cycles, and weather. Additional GPM information is available under the Development section.

Glory Mission

Glory will provide unique measurements of the global distributions and scattering properties of natural and anthropogenic aerosols, as well as continue the nearly 30-year time series of total solar irradiance measurements. The NASA science focus areas advanced by Glory data include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; and water and energy cycles. Additional Glory information is available under the Development section.

Landsat Data Continuity Mission (LDCM)

The Landsat Data Continuity Mission (LDCM), a collaboration between NASA and the US Geological Survey, will provide moderate-resolution (15m-120m, depending on spectral frequency) measurements of the Earth's terrestrial and polar regions in the visible, near-infrared, and thermal infrared. LDCM will provide continuity with the 34-year long Landsat land imaging data set. In addition to widespread routine use for water use monitoring, land use planning and monitoring on regional to local scales, and support of disaster response and evaluations, LDCM measurements directly serve NASA research in the Earth surface/interior, and carbon cycle, ecosystems, water cycle, and biogeochemistry focus areas. NASA's LDCM responsibilities include development of the LDCM visible/near-infrared and thermal infrared instruments, provision of the spacecraft and launch vehicle, and design/implementation of the USGS-funded Mission Operations Element. LDCM is being managed to a target December 2012 launch date. Additional LDCM information is available under the Development section.

NPOESS Preparatory Project (NPP)

NPP is a NASA research mission involving a collaboration between NASA, NOAA, and DoD, designed to extend selected scientific data sets initiated by the NASA Earth Observing System and to serve as risk reduction demonstrations for key instruments to be used in the nation's future operational meteorological satellite systems. Owing to delays in development and deployment of the NPOESS system, NPP scheduled to launch in September, 2011, will also serve a critical role to ensure continuity in the nation's operational meteorological measurements from the afternoon orbit. The five instruments on NPP will provide visible and infrared multi-spectral global imagery, measurements of atmospheric temperature and moisture profiles, measurements of total ozone and stratospheric ozone profiles, and measurements of the Earth's radiation balance. In addition to a wide range of applications studies, the NASA science focus areas served by NPP will include: atmospheric composition; climate variability and change; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; and weather. Additional NPP information is available under the Development section.

Ice, Cloud, and land Elevation Satellite (ICESat-2)

ICESat-2, a Tier-1 Decadal Survey mission which entered into formulation in FY 2010 and is being developed for a target launch in late CY 2015, will continue the time series of precision ice topography measurements initiated by ICESAT and extended in selected areas by the ICEBRIDGE campaigns. Time series of land ice topography in particular address a key open issue in climate modeling and prediction, the detailed mechanisms controlling ice sheet dynamics, and how these may change with changing climate. ICESAT-2 measurements of land ice topography, sea ice extent and freeboard, and vegetation canopy height will address a range of NASA science investigations in the areas of cryossopheric science; climate variability and change; and carbon cycle, ecosystems, and biogeochemistry. ICESat-2 is the planned follow-on mission to ICESat, measuring elements of ice-sheet mass balance and land surface topography to quantify the contribution to the current and recent sea level changes from changes in the ice quantities, and to establish linkages to climate change. Additional ICESat-2 information is available under the Formulation section.

Soil Moisture Active and Passive (SMAP)

The Soil Moisture Active and Passive (SMAP) mission, Tier-1 Decadal Survey mission, will provide unprecedented global measurements of new information on global soil moisture and land its freeze/thaw state at high latitudes, enabling new advances in hydrospheric science and applications. Direct measurements of soil moisture and freeze/thaw state will are needed to improve understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Soil moisture and freeze/thaw information provided by SMAP will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. The President's FY 2011 budget accelerates the launch of SMAP into late CY 2014. Additional SMAP information is provided in available under the Formulation section.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Climate Absolute Radiance and Refractivity Observatory (CLARREO)

The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission, Tier-1 Decadal Survey mission, is designed to make precision, stable measurements to enable rapid detection of long-term changes in the climate system and its radiation-related feedback mechanisms. The President's FY 2011 budget provides for accelerated development and launch by CY 2017 of a scientifically focused CLARREO spacecraft (one of two planned). In FY 2011 the CLARREO mission will complete its Acquisition Strategy Meeting (ASM) and its System Requirements Review (SRR) and transition to Formulation Phase.

Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI)

The Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) mission is a Tier-1 Decadal Survey mission which will acquire global measurements using both an L-band Synthetic Aperture Radar (SAR) instrument and a vegetation lidar on separate spacecraft. The President's FY 2011 budget accelerates development of a scientifically and programmatically focused DESDynI mission for a late CY 2017 launch of both spacecraft on a single large EELV launch vehicle. The overall DESDynI radar/lidar mission will greatly advance studies and understanding of climate through measurements of ice sheet velocities and quantification of terrestrial vegetation biomass, of critical importance to closing the global carbon cycle. The mission's interferometric SAR data will be vital to investigation of solid Earth processes and natural hazards such as earthquakes and volcanoes through the observation of accumulated stresses in the solid Earth. DESDynI will enter into formulation at the start of FY 2011 and complete an Acquisition Strategy Meeting during FY 2011.

Stratospheric Aerosol and Gas Experiment (SAGE III) on the ISS

The Stratospheric Aerosol and Gas Experiment (SAGE III) instrument is an existing grating spectrometer that measures ultraviolet/visible energy. In 2009, the SAGE-III instrument was removed from storage and it successfully passed initial aliveness tests. The President's FY 2011 budget provides an opportunity to refurbish and recalibrate the instrument for possible flight on the ISS by late CY 2013. Observing from the International Space Station (ISS) SAGE III will provide near-global, long-term measurements of key components of the 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 will also provide unique stratospheric and mesospheric temperature 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 radiative and chemical processes. In FY 2011 NASA will complete accommodation studies for the instrument on the ISS.

Gravity Recovery and Climate Experiment - Follow On (GRACE FO)

GRACE, the Gravity Recovery and Climate Experiment, mission launched in March 2002 has acquired precision measurements of the Earth's time-varying gravitational field with a precision that has enabled the measurement of the time variable gravity field, and has led to great discoveries in understanding the Earth system and hold significant keys to climate change research and future climate adaptation. GRACE FO will continue to map the Earth's gravitational field and its monthly variability by making accurate measurements of the distance between the two satellites, using GPS and a microwave ranging system. In FY 2011 the GRACE FO mission will complete its Acquisition Strategy Planning Meeting and its KDP-A transition into Formulation.

Other Missions and Data Analysis

Ocean Surface Topography Mission (OSTM) - OSTM measures sea surface height to an accuracy of less than four centimeters every 10 days. The science focus areas served by OSTM will include: climate variability and change; and water and energy cycles. This mission is a follow-on to Jason, and is currently in its prime phase through June 2011.

Terra - Terra collects global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation and with one another. The science focus areas served by Terra include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; earth surface and interior; water and energy cycles; and weather. Terra is a joint mission with Japan and Canada.

Aqua - Aqua monitors atmospheric, land, ocean, and ice variables for improved understanding of the Earth's water cycle and improved understanding of the intricacies of the climate system. The science focus areas served by Aqua include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; water and energy cycles; and weather. Aqua is a joint mission with Brazil and Japan.

Aura - Aura measures atmospheric chemical composition, tropospheric/stratospheric exchange of energy and chemicals, chemistry-climate interactions, and air quality. The science focus areas served by Aura include: atmospheric composition; climate variability and change; and weather. Aura is a joint mission with the Netherlands, Finland, and the United Kingdom.

Tropical Rainfall Measuring Mission (TRMM) - TRMM measures precipitation, clouds, lightning, and radiation processes over tropical regions. TRMM is one of several spacecraft currently extending the long-term radiation budget record begun in the mid-1980s. The science focus areas served by TRMM include: climate variability and change; water and energy cycles; and weather. TRMM is a joint mission with Japan.

Mission Directorate:	Science
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Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat) - ACRIMSat monitors total solar irradiance. The science focus areas served by ACRIMSat include: climate variability and change; and water and energy cycles. Because ACRIMSAT has continued to operate beyond its original planned base mission, it now provides similar measurements to its operating follow-on mission, SORCE.

Quick Scatterometer (QuikSCAT) - QuikSCAT measures ocean surface wind vectors using the SeaWinds instrument. QuikSCAT is now five years beyond its design life, and the rotating antenna has stalled due to normal aging of the lubricant and bearings of the spin mechanism. With the antenna stalled, science data can still be collected, but coverage is greatly reduced, severely limiting its operational usage. Research use continues. The science focus areas served by QuikSCAT include: climate variability and change; and weather.

Earth Observing-1 (EO-1) - The EO-1 spacecraft collects data to allow paired scene comparisons between the EO-1 Advanced Land Imager (ALI) and the Landsat-7 Enhanced Thematic Mapper Plus (ETM+). The science focus areas served by EO-1 include: carbon cycle, ecosystems, and biogeochemistry; and earth surface and interior.

Ice, Clouds, and Land Elevation Satellite (ICESat) - ICESat measures elements of ice-sheet mass balance, cloud-top and land-surface topography, and vertical profiles of aerosol and cloud properties. The last remaining laser on ICESat has failed, and the satellite will be decommissioned in FY 2011. The science focus areas served by ICESat include: climate variability and change; earth surface and interior; and water and energy cycles.

Jason - Jason monitors ocean height to support the study of ocean circulation. The science focus areas served by Jason include: climate variability and change; and water and energy cycles. Jason is a joint mission with France.

Solar Radiation and Climate Experiment (SORCE) - SORCE measures the total and spectral solar irradiance incident at the top of Earth's atmosphere. The science focus areas served by SORCE include: atmospheric composition; climate variability and change; and water and energy cycles.

Instrument and Mission Science Teams - Instrument science teams help define the scientific requirements for their respective instruments and generate the algorithms used to process the data into useful data products for the investigations. Additionally, the science teams are responsible for validating their own algorithms and data products. The Earth Systematic Missions Program is supported by the Precipitation Science Team, the Ocean Winds Science Team, and the Landsat Science Project Office.

Earth Systematic Missions Senior Review - NASA's Earth Science Division uses Senior Reviews, which are held every two years, to assess the continued science value of missions in operation. These reviews are comprehensive; evaluating the technical status of the satellites, and the value and quality of the data they produce. The Senior Review helps inform decisions related to extending the missions into the future, and the funding level required for each.

Earth Science Program Management - Provides program management support for Earth Science missions, investigations, and activities. Additionally, provides funding for the Earth Systematic Missions (ESM) Program Office and the Earth System Science Pathfinder (ESSP) Program Office, which assist in the overall management and execution of the Earth Science formulation, development, and operating missions.

Mission Directorate:	Science
Theme:	Earth Science
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Earth Observation Systems (EOS) Research - The EOS research project funds science for the EOS missions, currently Terra, Aqua, Aura, ICESat and Land Cover missions. These individual-investigator, competitively selected research projects analyze data from the missions to address the related science questions. Some funded projects continue algorithm improvement and validation for the EOS Instruments data products, while overall the selected activities focus on science data analyses and the development of Earth System Data Records (ESDRs), including Climate Data Records (CDRs) relevant to NASA's research program. Studies using ICESat and CryoSat-2 are solicited in the ROSES 2009 sub-element. CryoSat-2 is a European Space Agency satellite that is due to be launched in FY 2010 and will be operating in the observational gap between ICESat and ICESat-2.

Earth Systematic Missions (ESM) Research - The ESM research project funds science teams for the Earth Systematic missions, currently NPP and Glory missions . These are individual investigator competitively selected research to analyze data from the missions to address the related science questions. In particular, the NPP science investigations are focused on developing climate data records from EOS observations continued by the NPOESS operational observing system. The first science for the Glory mission is solicited in ROSES 2009 sub-element.

Ocean Vector Winds Science Team (OVWST) - This project utilizes scientific data received from the QuikSCAT (Quick Scatterometer) Mission satellite which measures ocean surface wind vectors by sensing ripples caused by winds near the ocean's surface, from which scientists can compute the winds' speed and direction, acquiring hundreds of times more observations of surface wind velocity each day than can ships and buoys. Previously this project was associated with the Earth Systematic Mission area wherein the QuikSCAT mission is managed.

Ocean Surface Topography Science Team (OSTST) - This project utilizes scientific data received from the Ocean Surface Topography Mission (OSTM) satellite which measures global sea surface height. Previously this project was associated with the Earth Systematic Mission area wherein the OSTM mission is managed.

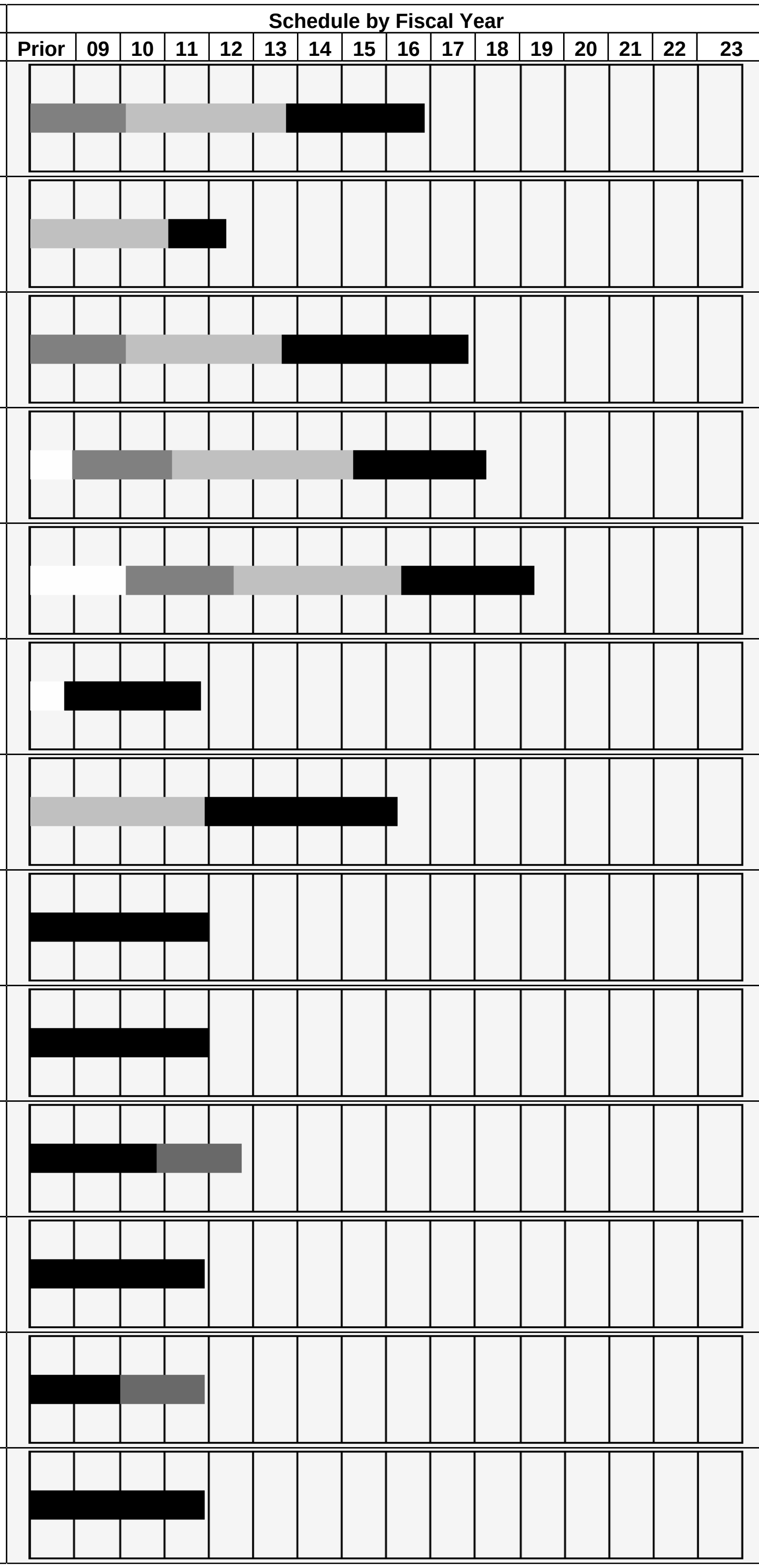
Precipitation Science Team - This project utilizes scientific data received from the Tropical Rainfall Measuring Mission (TRMM) satellite to improve the forecasting of weather and severe storm events. Previously this project was associated with the Earth Systematic Mission area wherein the TRMM is managed. This science team also supports development of mission supporting algorithms for the Global Precipitation Measurement (GPM) mission.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Complete planned operations of currently operating missions.	Operating missions	No change
Launch 2 additional Earth Systematic Mission (ESM) missions.	Glory	Launch in FY 2011
Launch 2 additional Earth Systematic Mission (ESM) missions.	NPP	Launch in FY 2011

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Implementation Schedule



Project	Phase	Beg	End
Global Precipitation Measurement Mission (GPM)	Tech		
	Form	Jul-02	Nov-09
	Dev	Dec-09	Jun-13
	Ops	Jul-13	Jul-16
	Res		
Glory	Tech		
	Form	Oct-03	Nov-05
	Dev	Nov-05	Nov-10
	Ops	Nov-10	Mar-12
	Res		
Landsat Data Continuity Mission (LDCM)	Tech		
	Form	Oct-03	Nov-09
	Dev	Dec-09	Jun-13
	Ops	Jun-13	Jul-17
	Res		
SMAP	Tech		
	Form	Sep-08	Nov-10
	Dev	Dec-10	Dec-14
	Ops	Jan-15	Jan-18
	Res		
ICESat-2	Tech		
	Form	Dec-09	Apr-12
	Dev	May-12	Jan-16
	Ops	Feb-16	Jan-19
	Res		
Ocean Surface Topography Mission (OSTM)	Tech		
	Form	Dec-02	Mar-06
	Dev	Mar-06	Jun-08
	Ops	Jul-08	Jul-11
	Res		
NPOESS Preparatory Project (NPP)	Tech		
	Form	Mar-00	Nov-03
	Dev	Dec-03	Sep-11
	Ops	Sep-11	Jan-16
	Res		
Terra	Tech		
	Form		
	Dev		
	Ops	Oct-99	Sep-11
	Res		Sep-11
Aqua	Tech		
	Form		
	Dev		
	Ops	May-02	Sep-11
	Res		Sep-11
Aura	Tech		
	Form		
	Dev		
	Ops	Jul-04	Jul-10
	Res		Jul-12
Tropical Rainfall Measuring Mission (TRMM)	Tech		
	Form		
	Dev		
	Ops	Nov-97	Sep-11
	Res		Sep-11
Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat)	Tech		
	Form		
	Dev		
	Ops	Dec-99	Sep-09
	Res		Sep-11
Quick Scatterometer (QuikSCAT)	Tech		
	Form		
	Dev		
	Ops	Jun-99	Sep-11
	Res		Sep-11

Mission Directorate:	Science
Theme:	Earth Science
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Project	Phase	Start	End
Earth Observing-1 (EO-1)	Tech		
	Form		
	Dev		
	Ops	Nov-00	Sep-11
	Res		
Jason	Tech		
	Form		
	Dev		
	Ops	Dec-01	Sep-11
	Res		
Ice, Clouds, and Land Elevation Satellite (ICESat)	Tech		
	Form		
	Dev		
	Ops	Jan-03	Sep-11
	Res		Sep-11
Solar Radiation and Climate Experiment (SORCE)	Tech		
	Form		
	Dev		
	Ops	Jan-03	Sep-11
	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Program Management

GSFC manages NPP, LDCM, Glory, GPM, Terra, Aqua, Aura, TRMM, EO-1, SORCE, ICESat, and ICESat-2. JPL manages OSTM, ACRIMSat, SMAP, QuikSCAT, and Jason.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
GPM	GSFC	GSFC	JAXA - provides the dual frequency precipitation radar and a launch vehicle for GPM.
Glory	GSFC	GSFC	None.
LDCM	GSFC	GSFC	USGS - provides data processing/distribution and on-orbit operations for LDCM.
SMAP	JPL	JPL/GSFC	TBD
ICESat-2	GSFC	GSFC	TBD
OSTM	JPL	JPL	CNES - provides spacecraft, 2 core instruments, and data processing for OSTM. NOAA provides data processing/distribution, ground stations, and on-orbit operations. EUMETSAT provides a ground station and data processing/distribution.
NPP	GSFC	GSFC	NOAA/IPO - provides 3 of 4 instruments and ground system for NPP.
Terra	GSFC	GSFC	Japan's Ministry of Economy, Trade and Industry (METI) provided the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The Canadian Space Agency provided the Measurements of Pollution in The Troposphere (MOPITT) instrument.
Aqua	GSFC	GSFC	The National Space Development Agency (NASDA, now part of the Japan Aerospace Exploration Agency, or JAXA) provided the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) instrument. Brazil's Instituto Nacional de Pesquisas Espaciais (INPE, the Brazilian Institute for Space Research) provided the Humidity Sounder for Brazil (HSB) instrument.

Mission Directorate:	Science
Theme:	Earth Science
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Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aura	GSFC	GSFC	The National Environmental Research Council of the United Kingdom funded the High Resolution Dynamics Limb Sounder (HIRDLS); the instrument was designed by universities and laboratories in the U.K. and the U.S., including the University of Colorado, Oxford University, the National Center for Atmospheric Research (U.S.), and the Rutherford Appleton Laboratory (U.K.). The University of Edinburgh (U.K.) contributed to data processing algorithms and validation for the Microwave Limb Sounder (MLS). The Ozone Monitoring Instrument (OMI) was built by Dutch Space and TNO TPD in the Netherlands in cooperation with Finnish VTT and Patria Advanced Solutions Ltd. KNMI (Royal Netherlands Meteorological Institute) is the Principal Investigator Institute. Overall responsibility for OMI lies with the Netherlands Agency for Aerospace Programmes (NIVR), with the participation of the Finnish Meteorological Institute (FMI).
TRMM	GSFC	GSFC	The Japan Aerospace Exploration Agency (JAXA) provided the Precipitation Radar (PR) instrument and the launch vehicle (an H-II F6).
ACRIMSat	JPL	JPL	None.
QuikSCAT	JPL	JPL	None.
EO-1	GSFC	GSFC	None.
Jason	JPL	JPL	The French Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) is responsible for the Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instrument; THALES built the instrument, and SMP provided the ground beacons. The CNES is also responsible for the Poseidon-2 nadir-viewing radar altimeter; Alcatel Space Industries was prime contractor for the instrument.
ICESat	GSFC	GSFC	None.
SORCE	GSFC	GSFC	None.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Acquisition Strategy

The LDCM instrument was selected through open competition in FY 2007. The Ball Aerospace and Technologies Corporation will build the Operational Land Imaging (OLI) instrument for LDCM. LDCM spacecraft used Rapid Spacecraft Development Office selection, and selected General Dynamics. The Thermal Infrared Sensor (TIRS) instrument was a directed development, assigned to the GSFC and being built in-house at GSFC.

NPOESS Preparatory Project (NPP): Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office. The procurement award for each element was as follows:
- Ball Aerospace: Spacecraft and Ozone Mapping Profile Suite Development
- NG Electronic Systems: Advanced Technology Microwave Sounder Development
- ITT Aerospace: Cross-track Infrared Sounder Development
- Raytheon: Visible Infrared Imaging Radiometer Development
- NG Space Technology: Clouds and the Earth's Radiant Energy System Development
- Raytheon: Ground systems and operations.

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation will build the GPM Microwave Imager (GMI) instrument for GPM. The GPM Core Spacecraft will be an in-house development at GSFC. The Dual-frequency Precipitation Radar (DPR) instrument and launch vehicle for the Core Spacecraft will be provided by a foreign partner, Japan Aerospace Exploration Agency (JAXA). The ground system will be selected through open competition.

Senior Reviews are held every two years to assess the continued science value of missions in operation past their prime mission phase. In FY 2009, all operating Earth Systematic Missions other than OSTM went through the competitive Senior Review process to determine whether they should enter or continue in an extended mission phase. Preparations are underway for the 2011 Senior Reviews in which all missions then in operation (currently 13) will be evaluated.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	5/2009	All missions were extended with modifications to their mission budgets.	04/2011

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**300.4**	**61.0**	**27.1**	**21.9**	**5.5**	**7.7**	**8.3**	**8.6**	**0.0**	**440.6**
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8
Development / Implementation	229.6	61.0	27.1	21.5	0.0	0.0	0.0	0.0	0.0	339.2
Operations / Close-out	0.0	0.0	0.0	0.4	5.5	7.7	8.3	8.6	0.0	30.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
FY 2010 President's Budget Request	**300.8**	**50.7**	**27.1**	**10.1**	**4.4**	**1.9**	**0.0**	**--**	**0.0**	**395.0**
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	70.8
Development / Implementation	230.0	50.7	15.4	0.0	0.0	0.0	0.0	--	0.0	296.1
Operations / Close-out	0.0	0.0	11.7	10.1	4.4	1.9	0.0	--	0.0	28.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**-0.4**	**10.4**	**0.0**	**11.8**	**1.1**	**5.8**	**8.3**	**--**	**0.0**	**45.6**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-0.4	10.3	11.7	21.5	0.0	0.0	0.0	--	0.0	43.1
Operations / Close-out	0.0	0.0	-11.7	-9.7	1.1	5.8	8.3	--	0.0	2.4
Other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Explanation of Project Changes

Cost growth since the FY 2009 Budget is related to the launch delay from January 2010 to November 2010. The reasons for the launch delay, and associated cost growth, were addressed in NASA's Glory Project Cost and Schedule Analysis Report (CSAR) to Congress, as required by Section 103(d)(2) of the NASA Authorization Act of 2005.

In spring 2009, an issue with the Maxwell-supplied, spacecraft computer emerged. Late in testing, NASA identified a series of intermittent computer anomalies. Further investigation identified the root cause of the anomalies to be intermittent printed wiring board open circuits. The printed wiring board manufacturer made several unsuccessful attempts to improve the manufacturing process but was unable to develop a reliable, flight quality board. On July 1, 2009, NASA changed the baseline Spacecraft Payload Computer from the Maxwell SCS750 Single Board Computer to the BAE Rad750 Single Board Computer delaying the Glory launch readiness date to November 2010. The key remaining risk to Glory cost and schedule is the readiness of the Taurus XL launch vehicle. On February 24, 2009, NASA's Orbiting Carbon Observatory failed to reach orbit after liftoff from Vandenberg Air Force Base in California, due to a failure of the Taurus XL launch vehicle. NASA convened a Mishap Investigation Board to investigate this incident, and because the Taurus XL is the same launch vehicle that NASA plans to use for Glory, the implementation schedule for corrective actions that addresses the results of this investigation could influence Glory schedule.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Purpose

The Glory mission will contribute to NASA's research regarding the atmospheric conditions that influence climate and improve understanding of the natural and man-made factors that contribute to climate change. It will also enable a greater understanding of the seasonal variability of aerosol properties. Both advances are essential components of predicting climate change. Solar radiation is the dominant, direct energy input into the terrestrial ecosystem, affecting all physical, chemical, and biological processes. Aerosols interact with atmospheric conditions in complex ways that can have large effects on climate.

Glory's science objectives are to:
1) Determine the global distribution, microphysical properties, and chemical composition of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate.
2) Continue measurement of the total solar irradiance to determine the Sun's direct and indirect effect on Earth's climate.

For more on the scientific questions addressed by Glory, visit http://glory.gsfc.nasa.gov/.

Project Parameters

The Glory mission will operate two scientific instruments aboard a preexisting NASA spacecraft asset requiring modification. The Glory satellite will fly in NASA's low Earth orbit Afternoon, or A-Train, constellation to enhance the utility of the mission data through synergistic observations and measurements from the other satellites. The A-Train constellation currently includes five spacecraft flying in close temporal proximity to each other, providing detailed observations of the Earth system. The Glory spacecraft will be the sixth satellite in the A-Train when it joins the constellation in FY 2011.

The Aerosol Polarimetry Sensor is an advanced polarimeter, which will provide measurements that increase our understanding of black carbon soot and other aerosols as causes of climate change. The APS will provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate. The APS is being developed by Raytheon Space and Airborne Systems in El Segundo, California.

The Total Irradiance Monitor (TIM) instrument provides measurement continuity for the 30-year solar irradiance data record by extending the measurement currently provided by NASA's Solar Radiation and Climate Experiment (SORCE). University of Colorado's Laboratory for Atmospheric and Space Physics is developing the TIM sensor, the instrument's Sun pointing platform, and the TIM science operations center.

Orbital Science Corporation, Dulles, Virginia, is developing the spacecraft and the ground system/mission operations center, and will integrate the instruments. Orbital also provides mission systems engineering support and performs mission operations.

Kennedy Space Center is responsible for Glory launch services. The mission will launch on a Taurus XL from Vandenberg Air Force Base, California.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Commitments

Glory will launch in November 2010 to begin a three-year prime mission (with a five-year goal) to gather scientific measurements of atmospheric aerosols and solar irradiance.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Aerosol Polarimetry Sensor (APS)	Raytheon	Provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols	Same	Same
Total Irradiance Monitor (TIM)	U of Colorado LASP	Maintain an uninterrupted solar irradiance data record	Same	Same
Spacecraft	Orbital	Refurbishment of the Vegetation Canopy Lidar (VCL) mission bus	Same	Same
Launch vehicle	Orbital	Taurus XL	Same	Same
Ground System Ops, TIM Science Ops, APS Science Ops	Orbital / Colorado University-Boulder LASP /GSFC Institute for Space Studies	Combination of the commercial ground stations and the networks that connect them	Same	APS: full data processing for 1 yr w/ 2 addt'l yrs of archiving. TIM: full data processing for 3 yrs
Mission Ops	Orbital	Operations of the spacecraft and the generation of command uplink	Same	Same
Data Archive	GSFC Earth Science Distributed Active Archive Center (GES DAAC)	Archival and distribution of mission data	Same	Same

Schedule Commitments

Glory was confirmed for development on December 13, 2005.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Mission Confirmation Review	11/2005	12/2005	12/2005
Mission Pre-ship review	8/2008	1/2009	7/2010
Launch	12/2008	1/2010	11/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Glory Mission	2008	259.1	2010	339.2	31	Launch Readiness	06/2009	11/2010	17

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**259.1**	**339.2**	**80.1**
Aircraft/Spacecraft	31.7	54.8	23.1
Payloads	117.4	126.6	9.2
Systems I&T	3.2	4.0	0.8
Launch Vehicle/Services	55.4	72.1	16.7
Ground Systems	0.9	1.1	0.2
Science/Technology	10.3	14.0	3.7
Other Direct Project Cost	40.2	66.6	26.4

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Management

Goddard Space Flight Center has Project Management responsibility. The Science Mission Directorate Program Management Council has program oversight responsibility.

The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
APS	GSFC	GSFC	None
TIM	GSFC	GSFC	None

Acquisition Strategy

All major procurements for the directed Glory Mission were sole-source awarded to meet the objective for an accelerated mission.

Aerosol Polarimetry Sensor: Raytheon Space and Airborne Systems.
Total Irradiance Monitor: University of Colorado Laboratory for Atmospheric and Space Physics.
Spacecraft/spacecraft support: Orbital Science Corporation.

There are no remaining major procurements, as all instrument and spacecraft contracts are in place.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NASA HQ	04/2008	DPMC Mission Continuation Review - Directorate review of Project replan (incl. corrective actions, risk mitigations, revised cost estimates). Replan planned for January 2010, changing LRD from 6/2009 to November 2010.	01/2010
Performance	NASA HQ	N/A	Flight Operations Review (FOR). This is the 2nd ground system review to examine mission operations requirements, design, testing, and planning is complete	3/2010
Performance	NASA HQ	N/A	Pre-Ship Review (scheduled prior to reserves) - Final review of the satellite readiness prior to shipment to the launch site	07/2010
Performance	NASA HQ	N/A	Mission Readiness Review (MRR) - Final pre-flight review of the operational readiness of the mission	10/2010
Performance	NASA HQ	N/A	Launch Readiness Review (LRR) - Final pre-launch review of the launch vehicle readiness	11/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Services Impact of Taurus XL Launch Failure on Glory	If Taurus T-8 (used on Orbiting Carbon Observatory, (OCO) mission) launch failure findings and / or corrective actions impact T-9 (Glory) schedule, then the Glory Launch Readiness Date (LRD) will be impacted	Continue to work with KSC as Taurus Return to Flight plans mature
Spacecraft - Implement Alternate BAE Processor Design in PIP	If Orbital can not execute the late changes to implement the alternate BAE processor design impacts schedule, then the Glory Launch Readiness Date (LRD) will be impacted	Project working closely with Orbital to insure the new spacecraft payload processor is ready on time and within the current reserves posture

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**589.0**	**42.2**	**104.6**	**64.4**	**5.2**	**5.1**	**5.1**	**5.4**	**0.4**	**821.4**
Formulation	47.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.1
Development / Implementation	541.9	42.2	104.6	58.5	0.0	0.0	0.0	0.0	0.0	747.2
Operations / Close-out	0.0	0.0	0.0	5.9	5.2	5.1	5.1	5.4	0.4	27.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**589.0**	**57.1**	**112.8**	**33.8**	**5.3**	**5.2**	**5.1**	**--**	**6.0**	**814.3**
Formulation	47.7	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	47.7
Development / Implementation	541.3	57.1	112.8	28.8	0.0	0.0	0.0	--	0.0	740.0
Operations / Close-out	0.0	0.0	0.0	5.0	5.3	5.2	5.1	--	6.0	26.6
Other	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.0**	**-14.9**	**-8.3**	**30.6**	**0.0**	**0.0**	**0.0**	**--**	**-5.6**	**7.1**
Formulation	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.6
Development / Implementation	0.6	-14.9	-8.2	29.7	0.0	0.0	0.0	--	0.0	7.2
Operations / Close-out	0.0	0.0	0.0	0.9	-0.1	-0.1	0.0	--	-5.6	0.5
Other	0.0	0.0	-0.1	0.0	0.1	0.1	0.0	--	0.0	0.0

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The changes to the NPP budget are due to the launch delay from January 2011 until September 2011 caused by late delivery to NASA of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument and the Cross-track Infrared Sounder (CrIS) by the NPOESS Integrated Program Office.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Purpose

The NPOESS Preparatory Project (NPP) is a joint mission with the National Oceanic and Atmospheric Administration and the U.S. Air Force to extend key environmental measurements for weather prediction and research. The satellite will measure atmospheric and sea surface temperatures, humidity profiles, land and ocean biological productivity, cloud and aerosol properties, and earth radiation budget quanities.

The NPP mission has two objectives: Provide a continuation of select global change observations following the Earth Observing System missions Terra and Aqua, and provide the nation's operational meteorological satellite system with risk-reduction demonstration and validation for critical sensors, algorithms, and ground processing. Due to delays in the development of the NPOESS system, the NPP data will be used operationally to avoid gaps in operational weather data.

For more information, visit the following website: http://jointmission.gsfc.nasa.gov

Project Parameters

The NPP spacecraft is based on a modified Ball Commercial Platform 2000 bus with a five-year design life. The NPP orbit is a polar, Sun-synchronous orbit at a nominal altitude of 824 kilometers. Four of the instruments are newly developed sensors based on heritage NASA sensors. The Advanced Technology Microwave Sounder (ATMS) has been developed by NASA, and three of the instruments (Visible/Infrared Imaging Radiometer Suite (VIIRS), Cross-track Infrared Sounder (CrIS), and Ozone Mapping and Profiling Suite (OMPS)) are being developed by the NPOESS Integrated Program Office (IPO). A fifth sensor, the Clouds and the Earth's Radiant Energy System (CERES) was a spare sensor developed by NASA for the Earth Observing System (EOS) program.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Commitments

NPP will launch in September 2011 and undertake the following scientific measurements over its five-year operating life: atmospheric and sea surface temperatures, humidity soundings, land and ocean biological productivity, cloud and aerosol properties, and Earth radiation budget measurements.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Visible Infrared Imaging Radiometer Suite (VIIRS)	Raytheon SBRS	Provide global imagery in visible and infrared frequency bands: 0.3 to 14 microns / 400 m resolution.	Same	Same
Ozone Mapping and Profiler Suite (OMPS)	Ball Aerospace	Collection of total column and vertical profile ozone data with 300-380 nm / LIMB 290-1000 nm .	Same	Same
Cross-Track Infrared Sounder (CrIS)	ITT Aerospace	Temperature and moisture profiles at 3.9-15.4 microns.	Same	Same
Advanced Technology Microwave Sounder (ATMS)	NG Electronic Systems	Temperature and moisture profiles at 22 channels / 23-183 ghz.	Same	Same
Clouds and the Earth's Radiant Energy System (CERES)	NG Space Technology	Provide Earth radiation budget measurements in shortwave (0.3-5micron) and longwave (8-12 micron) bands	Same	Same
Spacecraft	Ball Aerospace	5-year design life, mass is 2228 kg, Power 1400 watts.	Same	Same
Launch vehicle	Boeing	Delta II 7920.	Same	Same
Ground system	Raytheon	Command, Control, and Communication Segment (C3S) and Interface Data Processing Segment (IDPS).	Same	Same

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Schedule Commitments

The NPP mission completed Mission Confirmation Review (MCR) in November 2003.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
CrIS Flight Model Delivery	Oct 2005	May 2008	June 2010
ATMS Flight Model Delivery	Apr 2005	Oct 2005	Oct 2005
OMPS Flight Model Delivery	Sep 2005	Aug 2008	Aug 2008
VIIRS Flight Model Delivery	Nov 2005	Nov 2009	Dec 2009
CERES Flight Model Delivery	N/A	N/A	Oct 2008
Operations Readiness Review	Jun 2006	Dec 2009	Apr 2011
Launch	Oct 2006	Jan 2011	Sep 2011

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
NPOESS Preparatory Project (NPP)	2006	592.9	2010	725.2	22	Launch Readiness	04/2008	09/2011	41

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**592.9**	**725.2**	**132.3**
Aircraft/Spacecraft	160.0	180.0	20.0
Payloads	194.2	218.2	24.0
Launch Vehicle/Services	72.9	91.4	18.5
Ground Systems	48.2	65.7	17.5
Other Direct Project Cost	117.6	150.0	32.4
Science/Technology	0.0	19.9	19.9

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Management

GSFC is responsible for NPP project management. Agency PMC has program oversight responsibility. NOAA/DOD IPO is responsible for managing development of OMPS, CrIS and VIIRS instruments. Responsible official is the Earth Science Division Director.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	None	None
ATMS Development	GSFC	None	None
OMPS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CrIS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
VIIRS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CERES Refurbishment	GSFC	LaRC	NOAA
Data archive and storage	GSFC	None	NOAA
Ground Systems and Ops	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)

Acquisition Strategy

Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office.

The procurement award for each element was as follows:
Ball Aerospace: Spacecraft and OMPS Development;
NG Electronic Systems: ATMS Development;
ITT Aerospace: CrIs Development;
Raytheon: VIIRS Development;
NG Space Technology: CERES; and
Raytheon: Ground systems and operations.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NPP IRT	N/A	Operations Readiness Review	4/2011

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Instrument Delivery Delay	If IPO instrument deliveries continue to slip then the NPP LRD will continue to slip; causing increased cost to NPP.	Government program manager worked to successfully execute planned schedule during last year to deliver VIIRS to the NPP project. CrIS instrument repairs in process. Government will work closely with IPO management team to delivery CrIS on plan.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**205.4**	**143.8**	**155.6**	**128.8**	**125.7**	**90.0**	**52.8**	**35.7**	**38.2**	**975.9**
Formulation	205.4	143.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	349.2
Development / Implementation	0.0	0.0	155.6	128.8	125.7	86.9	36.9	15.6	5.7	555.2
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	3.1	15.9	20.1	32.5	71.6
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
FY 2010 President's Budget Request	**205.4**	**157.8**	**159.5**	**127.6**	**137.5**	**111.2**	**80.4**	**--**	**202.7**	**1,182.1**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	205.4	157.8	159.5	127.6	137.5	111.2	80.4	--	202.7	1,182.1
Changes from FY 2010 Request	**0.0**	**-14.0**	**-3.9**	**1.2**	**-11.8**	**-21.2**	**-27.7**	**--**	**-164.5**	**-206.3**
Formulation	205.4	143.8	0.0	0.0	0.0	0.0	0.0	--	0.0	349.2
Development / Implementation	0.0	0.0	155.6	128.8	125.7	86.9	36.9	--	5.7	555.2
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	3.1	15.9	--	32.5	71.6
Other	-205.4	-157.8	-159.5	-127.6	-137.5	-111.2	-80.5	--	-202.7	-1,182.3

Explanation of Project Changes

The changes to the GPM budget are due to the fact that the Low-Inclination Observatory (LIO) implementation approach was changed to an international or domestic partnership for its spacecraft bus and launch vehicle to ensure planned budget/schedule confidence.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

Project Purpose

The Global Precipitation Measurement (GPM) mission will advance the measurement of global precipitation, making possible high spatial resolution precipitation measurements available at a three-hour or less refresh rate over much of the globe. A joint mission with the Japan Aerospace Exploration Agency (JAXA), GPM will provide the first opportunity to calibrate measurements of global precipitation (including the distribution, amount, rate, and associated heat released) across tropic, mid-latitude, and polar regions.

The GPM mission has the following scientific objectives:

(1) Advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques. These advanced measurements will be used to calibrate dedicated and operational passive microwave sensors with the goal of achieving global sampling.

(2) Advance understanding of global water/energy cycle variability and fresh water availability. Improved measurements of the space-time variability of global precipitation will substantially close the water/energy budget and elucidate the interactions between precipitation and other climate parameters.

(3) 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 the Earth's atmosphere.

(4) Advance Numerical Weather Prediction (NWP) skills through more accurate and frequent measurements of instantaneous rain rates with better error characterizations, and the development of improved assimilation methods.

(5) Improve flood-hazard and fresh-water-resource prediction capabilities through better temporal sampling and wider spatial coverage of high-resolution precipitation measurements, and innovative designs in hydro-meteorological modeling.

For more information see http://gpm.gsfc.nasa.gov/.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

Project Parameters

The GPM Project includes a Core Observatory Spacecraft and a GPM Microwave Imager (GMI). A second GMI along with a Tracking Data and Relay Satellite System (TDRSS) communication subsystem for near real time data access is planned to be flown on an as yet to be determined (TBD) partner-provided Low-Inclination Observatory (LIO). The Core Observatory will leverage passive microwave measurements from other operating and planned "satellites of opportunity" by calibrating their measurements to its own. The exact sampling rate over different areas of the globe will depend on the number and orbits of the satellites of opportunity, but given the prevalence of passive microwave instruments on operational satellite systems, the global sampling will be robust.

The NASA Core Observatory will fly in a 65 degree inclined orbit at an altitude of 407 kilometers; the 65 degree orbit provides improved latitude coverage over TRMM (which is 35 degrees). The Core Observatory includes two scientific instruments which will provide active and passive microwave measurements of precipitation.

The JAXA-supplied Dual-frequency Precipitation Radar (DPR) instrument has cross-track swath widths of 245 km and 120 km, in Ku-band Ka-band, providing three-dimensional observation of rain and an accurate estimation of rainfall rate. The KuPR (13.6 GHz) subsystem of the DPR is an updated version of the highly successful radar flown on TRMM.

The GPM Microwave Imager (GMI) instrument is a conically-scanning radiometer which will provide significantly improved spatial resolution over the TRMM Microwave Imager (TMI).

The as yet TBD partner-provided Low-Inclination Observatory is planned to fly in a 40 degree inclined orbit to improve real-time monitoring and prediction of hurricanes/typhoons; the satellites of opportunity will fly at multiple altitudes and inclinations.

The Core Observatory Spacecraft will be launched from Tanegashima Space Center, Japan on an H-IIA launch vehicle. The DPR and GMI data will be relayed using the TDRSS multiple access (MA) and single access (SA) service.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

Project Commitments

The GPM Core Observatory is planned for a launch in July 2013 to begin a three-year prime mission (five-year goal). The LIO spacecraft, launch vehicle and spacecraft mission operations are planned to be contributed by an as yet to be determined (TBD) partner. The second GMI, flown on the partner-provided LIO, will be available for integration or storage in May 2013. When calibrated with existing and planned passive microwave measurements, GPM will provide global measurements of precipitation with a sampling frequency of three hours or less over much of the globe.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Core Observatory	GSFC	Provides platform for the GMI and JAXA-supplied DPR instruments	Same	Same
Low-Inclination Observatory	TBD	Provides platform for the second GMI instrument	Same	Changed to be partner-provided
Dual-frequency Precipitation Radar (DPR)	JAXA	Provides cross-track swath widths of 245 km and 120 km, for the Ku precipitation radar (KuPR) and Ka-band precipitation radar (KaPR).	Same	Same
GPM Microwave Imager (GMI)	GSFC	Provides 13 microwave channels ranging in frequency from 10 GHz to 183 GHz; four high frequency, millimeter-wave, channels about 166 GHz and 183 GHz. 1.2 m diameter antenna	Same	Same
Launch Vehicle	JAXA	H-IIA	Same	Same

Schedule Commitments

GPM entered formulation in July 2002. The below milestone dates reflect the December 2009 KDP-C commitments.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
KDP-C	Dec 2009	May 2009	Dec 2009
Core Observatory launch readiness date (LRD)	Jul 2013	Jun 2013	Jul 2013

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Global Precipitation Measurement (GPM)	2010	555.2	2010	555.2	0	Launch Readiness	07/2013	07/2013	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**555.2**	**555.2**	**0.0**
Aircraft/Spacecraft	151.2	151.2	0.0
Payloads	91.2	91.2	0.0
Systems I&T	6.8	6.8	0.0
Launch Vehicles/Services	1.5	1.5	0.0
Ground Systems	30.5	30.5	0.0
Science/Technology	28.4	28.4	0.0
Other direct project cost	245.6	245.6	0.0

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Global Precipitation Measurement (GPM)

Project Management

Goddard Space Flight Center (GSFC) has project management responsibility. The Agency Program Management Council has program oversight responsibility.

The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Core Observatory	GSFC	GSFC	None
Core Observatory: GMI	GSFC	GSFC	None
Core Observatory: DPR	GSFC	GSFC	JAXA
Low-Inclination Observatory: GMI	GSFC	GSFC	None
Launch vehicle and services: Core Observatory	GSFC	None	JAXA
Launch vehicle and services: Low-Inclination Observatory	TBD	TBD	TBD
Ground Systems	GSFC	GSFC	None

Acquisition Strategy

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation (BATC) will build the GPM Microwave Imager (GMI) instruments for GPM. The GPM core spacecraft will be an in-house development at GSFC. The DPR instrument and launch vehicle for the Core Observatory will be provided by a foreign partner (JAXA). The Low-Inclination Observatory's (LIO) Tracking Data and Relay Satellite System (TDRSS) communication subsystem will be acquired by open competition. The LIO spacecraft and launch vehicle are planned to be contributed by ans as yet to be determined partner. The ground systems for both the core spacecraft and the second GMI to be flown on the TBD partner-provided LIO will be selected through open competition.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	12/2009	Mission Critical Design Review (CDR) successfully completed	n/a

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Non-NASA Constellation elements	Exact global sampling depends on operations of "spacecraft of opportunity" that are not part of this project.	NASA is developing data algorithms that allow GPM to make the broadest possible use of microwave instruments on other spacecraft; NASA participates in inter-agency and international planning processes for operational Earth observation measurements to maximize the leverage opportunities for GPM.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Landsat Data Continuity Mission (LDCM)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**221.9**	**200.9**	**120.6**	**156.8**	**157.9**	**69.5**	**3.1**	**3.1**	**10.1**	**943.9**
Formulation	221.9	119.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	341.5
Development / Implementation	0.0	81.3	120.6	156.8	157.9	69.0	0.0	0.0	0.0	585.6
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.5	3.1	3.1	10.1	16.8
Other	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**222.0**	**200.9**	**120.6**	**137.4**	**165.0**	**90.0**	**15.0**	**--**	**7.1**	**958.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	222.0	200.9	120.6	137.4	165.0	90.0	15.0	--	7.1	958.0
Changes from FY 2010 Request	**-0.1**	**0.0**	**0.0**	**19.4**	**-7.1**	**-20.5**	**-11.9**	**--**	**3.0**	**-14.1**
Formulation	221.9	119.6	0.0	0.0	0.0	0.0	0.0	--	0.0	341.5
Development / Implementation	0.0	81.3	120.6	156.8	157.9	69.0	0.0	--	0.0	585.6
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.5	3.1	--	10.1	16.8
Other	-222.0	-200.9	-120.6	-137.4	-165.0	-90.0	-15.0	--	-7.1	-958.0

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The LDCM Project, which was approved to proceed with development in December 2009, now has a fully integrated budget including the development and accommodation of the Thermal Infrared Sensor (TIRS). All previous life cycle costs were preliminary estimates.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Landsat Data Continuity Mission (LDCM)

Project Purpose

Unprecedented changes in land cover and use are having profound consequences for weather and climate change, ecosystem function and services, carbon cycling and sequestration, resource management, the national and global economy, human health, and society. The Landsat data series, begun in 1972, is the longest continuous record of changes in Earth's surface as seen from space and the only satellite system designed and operated to repeatedly observe the global land surface at moderate resolution. Landsat data are available at an affordable cost, providing a unique resource for people who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research.

The purpose of the Landsat Data Continuity Mission (LDCM) is to extend the record of multi-spectral, moderate resolution Landsat-quality data, and to meet U.S. Government operational and scientific requirements for observing land use and land change.

For additional information, visit the LDCM Mission Home Page: http://ldcm.nasa.gov/

Project Parameters

LDCM is being developed for a Launch Readiness Date (LRD) that will minimize a potential data gap in the archive due to the fuel-limited life of Landsat-7. Recent analyses by the USGS and NASA have estimated the Landsat-7 mission should continue to operate through at least the end of 2012. The LDCM mission completed its Confirmation Review on November 30, 2009, and its KDP-C transition review, on December 16, 2009. Due to the high national importance of the mission and the need to maintain the continuity of the Landsat data record, NASA and USGS will implement the LDCM mission for a December 2012 launch at the 50% schedule confidence level, providing necessary budget and other resources to ensure all mission elements are ready for this launch date. A Joint Confidence Level (JCL) assessment was conducted determining the 70%-confident launch date to be June 2013, driven by the late addition of the TIRS instrument. Specifically, the LDCM Project has been directed to execute all necessary contracts and actions to accomplish the June 2013 Launch Readiness Date, including securing a launch vehicle for a launch in June 2013.

LDCM consists of a two science instruments (the Operational Land Imager and the Thermal Infrared Sensor), a spacecraft, and a mission operations element. The LDCM is in implementation and system level requirements are baselined to provide the following system-level performance parameters:

- Earth Spatial-Temporal Coverage: 16-day repeat coverage of the global land mass.

- Spatial Resolution: 30 meters (visible, NIR, SWIR), 120 meters (thermal); 15 meters (panchromatic).

- Radiometric Performance: accuracy, dynamic range, and precision sufficient to detect land cover change using historic Landsat data.

- Data: 185-km-cross-track-by-180-km-along-track multi-spectral image of Earth surface.

- Mission Life: five years.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Landsat Data Continuity Mission (LDCM)

Project Commitments

After launch, the spacecraft and OLI instrument will operate for a minimum of five years. The TIRS instrument will operate for a minimum of three years.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Operational Land Imager (OLI)	Ball Aerospace and Technology Corporation	Provide Landsat-equivalent data to extend the Landsat data of Earth's land surface for five years.	Same	Same
Thermal Infrared Sensor (TIRS)	GSFC	Provide Landsat-equivalent thermal data to extend the Landsat data of Earth's land surface for three years.	N/A	New
Spacecraft	General Dynamics	Provide performance and reliability commensurate with OLI and TIRS data requirements.	Same	Same
Launch Vehicle	ULA	Provide launch service access to space.	Same	Same
Mission Operations Element	Hammers Corporation	Provide capability for command and control, mission scheduling, long-term trending and analysis, and flight dynamics analysis.	Same	Same

Schedule Commitments

LDCM will complete its spacecraft Critical Design Review (CDR) and mission CDR in FY 2010. Due to the high national importance of the mission and the need to maintain the continuity of the Landsat data record, NASA and USGS will strive to launch LDCM in December 2012. The LDCM Project has been directed to execute all necessary contracts and actions to accomplish the December 2012 launch. Consistent with NASA policies regarding commitments to cost and schedule, the LDCM launch shall be no later than June 2013.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Formulation			
Award OLI contract	July 2007	July 2007	July 2007
Confirmation Review	Dec 2009	Dec 2009	Dec 2009
Critical Design Review (CDR)	Apr 2010	Apr 2010	Apr 2010
PSR	Sep 2012	June 2012	Sep 2012
Launch	Jun 2013	Dec 2012	Jun 2013
Handover of Operations to USGS	Sep 2013	n/a	Sep 2013

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Landsat Data Continuity Mission (LDCM)

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Landsat Data Continuity Mission (LDCM)	2010	583.4	2010	583.4	0	Launch Readiness	6/2013	6/2013	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**583.4**	**583.4**	**0.0**
Aircraft/Spacecraft	116.7	116.7	0.0
Payloads	131.3	131.3	0.0
Systems I&T	1.7	1.7	0.0
Launch Vehicle	126.4	126.4	0.0
Ground Systems	10.7	10.7	0.0
Science/Technology	13.3	13.3	0.0
Other Direct Project Costs	183.3	183.3	0.0

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Landsat Data Continuity Mission (LDCM)

Project Management

LDCM is under the Earth Systematic Missions Program within the Earth Science Division (ESD) of SMD. The NASA AA is the Decision Authority; the ESD Director is the Responsible Official; and GSFC is the Lead Management Organization.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Operational Land Imager	GSFC	GSFC	None
Thermal Infrared Sensor	GSFC	GSFC	None
Spacecraft	GSFC	GSFC	None
Ground System	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey
Mission Operations	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey

Acquisition Strategy

NASA's acquisition plan includes acquiring separate elements of the LDCM mission through open competition, with GSFC acting as the mission integrator and leading the element source selections. NASA has issued competitively selected contracts for the following major elements: to the Ball Aerospace and Technology Corporation for the development of the Operational Land Imager in July 2007, to the General Dynamics Corporation for the development of the spacecraft in April 2008, and to the Hammers Corporation for the development of the MOE in September 2008. The Thermal Infrared Sensor will be designed and built in-house at GSFC utilizing civil servants and support contractor personnel.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	9/2008	Systems Requirement Review (SRR) - Successful	N/A
Performance	HQ and GSFC	7/2009	Mission Preliminary Design Review - Successful	N/A
Performance	HQ and GSFC	N/A	Mission Critical Design Review	4/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Thermal Infrared Sensor (TIRS) development risk	The TIRS instrument has an aggressive development schedule due to late addition to the instrument complement and there is a risk that TIRS will not be delivered on schedule to meet the LDCM launch readiness date.	The TIRS Project will continuously examine use of parallel paths for instrument development to mitigate risk where appropriate. LDCM Project will develop alternative Observatory I&T scenarios to allow for late arrival of TIRS. In the event that TIRS cannot be delivered in time to meet the LDCM launch date, a flyable mass model will be developed.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Ice, Cloud, and land Elevation Satellite

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	38.8	39.2	68.5	116.0	178.6	153.9	94.9
FY 2010 President's Budget Request	38.8	39.2	74.6	99.1	126.9	161.7	--
Total Change from 2010 President's Budget Request	0.0	0.0	-6.1	17.0	51.7	-7.8	--

Project Purpose

The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) will continue the measurements begun with the ICESat mission, measuring elements of ice-sheet mass balance, sea ice freeboard and large-scale biomass to quantify polar ice sheet contributions to current and recent sea level change and linkages to the climate state. In addition ICESat-2 will quantify regional signatures of ice sheet changes to assess mechanisms driving that change and improve predictive ice sheet models. The science focus areas served by ICESat-2 include climate variability and change, Earth surface and interior, and water and energy cycles. The ICESat-2 mission is one of four first-tier missions recommended by the National Research Council (NRC) report entitled, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". The ICESat-2 mission will draw from the original ICESat satellite launched in FY 2003 and operated through CY 2009.

For more information see http://nasascience.nasa.gov/missions/icesat-ii

Project Preliminary Parameters

The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation lidar. It will be launched into a 600 km, 94-degree, 91-day repeat orbit.

Pursuant to Senate Report 111-34, incorporated by reference into the Statement Accompanying the Consolidated Appropriations Act, 2010 (PL 111-117) and as required by NASA standard project formulation processes, the ICESat-2 Project is working toward a mature [Technology Readiness Level - 6] baseline instrument concept in preparation for formal Mission Confirmation at the end of FY 2012. This includes the photon-counting approach to provide cross-track measurement capabilities identified in Senate Report 111-34. As part of this engineering process, the project will use an airborne instrument to simulate the space-based measurements to optimize the final instrument design and to develop algorithms to meet all Level 1 Requirements. Based on cost and schedule analysis of the ICESat-2 preliminary design, a baseline budget and launch readiness date will be established at Mission Confirmation.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Ice, Cloud, and land Elevation Satellite

Estimated Project Deliverables

ICESat-2 is still in pre-formulation and does not yet have an official launch date; however, the pre-Phase A target launch date is late 2015 with a notional 5 year prime mission.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	TBD	Competitively selected	New	Same
Lidar Instrument	TBD	Multi-beam micro-pulse laser with photon-counting detector	N/A	New
Launch Vehicle	TBD	Competitively selected	New	Same

Estimated Project Schedule

ICESat-2 is still in pre-formulation. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
Formulation			
KDP-A	N/A	September 2009	December 2009
Launch readiness date (LRD)	N/A	Late 2014/Early 2015	Late 2015

Project Management

The Goddard Space Flight Center (GSFC) has project management responsibility. The Science Mission Directorate Program Management Council has programmatic oversight. The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	TBD	TBD
Lidar	GSFC	GSFC	None
Mission Operations	GSFC	TBD	TBD
Launch Vehicle	GSFC	TBD	TBD

Acquisition Strategy

The ICESat-2 lidar instrument will be designed and tested at GSFC using component procurements from industry. The spacecraft vendor will be competitively selected. The approach for the mission operations element has not yet been determined. The source and selection method for launch services will be determined during formulation.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Ice, Cloud, and land Elevation Satellite

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	ICESat-2 Independent Review Team	02/2009	Mission Concept Review/Requires Delta Review	11/2009
Performance	ICESat-2 Independent Review Team	11/2009	Mission Concept Review /Successfully completed	12/2009
Performance	Standing Review Board	n/a	System Requirements Review (SRR) and Mission Definition Review (MDR)	09/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**103.3**	**70.0**	**82.5**	**139.0**	**163.8**	**80.0**	**10.0**
FY 2010 President's Budget Request	**104.3**	**70.0**	**132.2**	**180.4**	**135.0**	**40.0**	**--**
Total Change from 2010 President's Budget Request	**-1.0**	**0.0**	**-49.7**	**-41.4**	**28.8**	**40.0**	**--**

Project Purpose

The Soil Moisture Active and Passive (SMAP) mission will provide unique information on global soil moisture and its freeze/thaw states enabling new advances in hydrospheric science/applications and climate research. Direct measurements of soil moisture and freeze/thaw states are needed to improve our understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Obtaining global soil moisture measurements every three days, SMAP's data will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. Soil moisture and freeze/thaw information is useful for many purposes, and thus the SMAP mission will contribute to the goals of other Earth Science Focus Areas (Carbon Cycle, Ecosystem, Weather, and Climate). The SMAP mission is one of the four Tier-1 NASA missions recommended by the Earth science and applications Decadal Survey. SMAP is based on the soil moisture and freeze/thaw mission concept developed under the NASA Earth System Science Pathfinder (ESSP) Program Hydrosphere State (Hydros) project and builds on the Hydros formulation and technology risk mitigation studies conducted in 2003 - 2005. Climate Initiative funding has been used to advance the SMAP launch date by 7 months to late CY 2014.

For more information see http://nasascience.nasa.gov/missions/smap

Project Preliminary Parameters

The SMAP observatory employs a dedicated spacecraft with an instrument suite that will be launched into a near-polar, sun-synchronous orbit on an expendable launch vehicle. The baseline SMAP instrument suite includes a radiometer and a synthetic aperture radar operating in the L-band range (1.20-1.41 GHz) designed to make coincident measurements of soil emission and backscatter and sense the top 5 cm of soil through moderate vegetation cover. These measurements will be analyzed to yield estimates of soil moisture and freeze/thaw state. The measurements 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.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

Estimated Project Deliverables

SMAP is planned for a launch in late CY 2014, to begin a three-year prime mission. SMAP will make soil moisture measurements around the entire Earth every 3 days.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	JPL	Provides platform for the instrument	New	Same
L-Band Synthetic Aperture Radar (SAR)	JPL	Combined with Radiometer provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	New	Same
L-Band Radiometer	GSFC	Combined with SAR provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	New	Same
Launch Vehicle	TBD	TBD	New	Same

Estimated Project Schedule

With the Climate Initiative provided in the President's FY2011 budget, SMAP launch has been accelerated at least 7 months, from mid CY 2015 to late CY 2014. This launch date cannot be further accelerated by additional funding augmentations; it is dictated by launch vehicle selection and implementation process times, and by the minimum SMAP Phase C-D durations recommended by the Project's Independent Standing Review Board. SMAP will conduct a three-year prime mission.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
Formulation			
KDP-C	April 2010	December 2010	December 2010
Launch readiness date (LRD)	Mid CY 2015		late CY 2014

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

Project Management

The Jet Propulsion Laboratory (JPL) has project management responsibility for SMAP. The Science Mission Directorate Program Management Council has program oversight responsibility.
The Earth Sciences Division Director is the responsible official.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	JPL	None
L-Band Synthetic Aperture Radar (SAR)	JPL	JPL	None
L-Band Radiometer	JPL	GSFC	None
Launch Vehicle	JPL	To be determined	To be determined

Acquisition Strategy

The SMAP Spacecraft will be built in-house at JPL. The SMAP instrument, combining the Synthetic Aperture Radar (SAR) and radiometer, will be integrated by JPL. The SAR will be built by JPL. The radiometer will be built by GSFC. The Deployable Antenna/Boom and instrument spin assemblies will be procured through an open competition. The source and selection method for launch services will be determined later in formulation.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SMAP Standing Review Board SRB	02/2009	Mission Design Review-successfully completed.	05/2009

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	122.1	80.0	303.8	204.3	196.4	190.1	228.9
Aquarius	46.9	18.3	17.0	5.4	5.2	2.4	4.6
OCO-2	0.0	25.0	171.0	91.0	51.0	13.0	4.0
Venture Class Missions	21.0	12.9	79.5	75.1	106.9	140.5	185.3
Other Missions and Data Analysis	54.3	23.8	36.2	32.7	33.4	34.2	35.0
FY 2010 President's Budget Request	118.3	63.9	128.8	114.2	121.4	119.1	--
Aquarius	44.7	18.3	6.3	4.2	2.8	0.0	--
Venture Class Missions	21.0	12.9	79.2	66.5	75.1	75.7	--
Other Missions and Data Analysis	52.6	32.8	43.3	43.5	43.5	43.4	--
Changes from FY 2010 Request	3.9	16.1	175.0	90.0	75.0	71.0	--

Program Overview

ESSP includes a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, Principal Investigator-led missions. These missions, complement the larger and more broadly capable Earth Systematic Missions (ESM). ESSP missions each have focused scientific objectives to support a selected subset of studies of the atmosphere, oceans, land surface, polar ice regions, or solid Earth. Investigations include development and operation of remote-sensing instruments and the conduct of investigations using data from these instruments. In FY 2011, NASA will initiate the accelerated development of an Orbiting Carbon Observatory Reflight mission (OCO-2) with the objective to launch in Feb 2013. In mid-FY 2010, the awards will be made for the initial Venture Class solicitation (EV-1). The selectees will commence their airborne campaign study activities in FY 2011. The ESSP will complete the development two solicitations: (1) the second Earth Venture AO call, EV-2, to be released in FY 2012 for small complete satellite missions, and (2) the initial annual call (EV-Instrument) for instruments of opportunity in support of the Climate Initiative. The initial EV-Instrument call will be released at the start of FY 2012 for an anticipated instrument delivery in FY 2015; annual EV-Instrument calls are an integral part of the Climate Initiative and are supported in the President's budget. ESSP currently has one mission in formulation (OCO-2), one mission in development (Aquarius), and three operating missions: Gravity Recovery and Climate Experiment (GRACE), CloudSat, and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO).

For more information see http://earth.nasa.gov

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Plans For FY 2011

The Earth System Science Pathfinder (ESSP) Program plans for FY 2011 include:

1) Completion of Aquarius/SAC-D observatory environmental testing, delivery to the launch site, launch and on-orbit checkout of the Aquarius/SAC-D mission;

2) Completion of the OCO-2 KDP-C and transition of this mission into development;

3) Initial science data acquisitions from the selected EV-1 investigations;

4) Preparation and release of the EV-2 small-mission AO, with selections to take place in FY 2012;

5) Preparation (for an early 2012 release) of the first annual EV-Instrument AO, soliciting significant Earth-observing instruments for flights of opportunity;

6) Continued operations of GRACE, CloudSat, and CALIPSO will continue operations as determined by the 2009 Senior Review; and,

7) Conduct and completion of the 2011 biannual Senior Review for GRACE, Cloudsat, and CALIPSO.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Project Descriptions and Explanation of Changes

Aquarius

Aquarius will observe and model 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 science focus areas served by Aquarius will include: climate variability and change; and water and energy cycles. Aquarius is currently in Phase C-D with a manifested launch date of January 2011 and 3 years of prime mission life. Additional detail can be found in the Aquarius development section of this document.

Orbiting Carbon Observatory - 2

OCO-2 is a replacement for the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's implementation approach to the greatest degree practical to reduce mission development risk. The OCO-2 mission objectives are identical to those for OCO. The OCO-2 employs a dedicated spacecraft with a single instrument, designed to measure CO2 and O2 near-infrared absorptions from reflected sunlight. Additional detail can be found in the OCO-2 section of this document.

Venture Class Missions

"Venture-class" Earth System Science Pathfinder missions have been established in response to the National Research Council's Earth Science Decadal Survey. Venture-class missions will be small, competed science investigations, and may include suborbital payloads; instruments to be flown on non-NASA spacecraft; and small, focused satellites.

Other Missions and Data Analysis

Included in this line item are three operating spacecraft:
- The Gravity Recovery and Climate Experiment (GRACE), launched in FY 2002, measures Earth's gravity field and its variations with time.
- CloudSat, launched in FY 2006, measures cloud characteristics to increase understanding of the role of optically thick clouds in Earth's radiation budget.
- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission, launched in FY 2006, measures the vertical distribution of clouds and aerosols in the atmosphere.

In addition, this line includes the ESSP research project providing funds for the science teams for the ESSP missions. The science teams are comprised of competitively selected individual investigators who analyze data from the missions to address the related science questions.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Senior Review (SR) to make Senior recommendations on mission extensions	GRACE, CloudSat, and CALIPSO	Same

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Implementation Schedule

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

Project	Phase	Beg	End
Aquarius	Tech		
	Form	Oct-03	Sep-05
	Dev	Oct-05	Jan-11
	Ops	Jan-11	Apr-14
	Res		
Orbiting Carbon Observatory - 2	Tech		
	Form	Feb-10	Sep-10
	Dev	Oct-10	Jan-13
	Ops	Feb-13	Feb-15
	Res		
Gravity Recovery and Climate Experiment (GRACE)	Tech		
	Form		
	Dev		
	Ops	Mar-02	Sep-11
	Res		
CloudSat	Tech		
	Form		
	Dev		
	Ops	Apr-06	Sep-11
	Res		
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (CALIPSO)	Tech		
	Form		
	Dev		
	Ops	Apr-06	Sep-11
	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Program Management

The Agency Program Management Council has program oversight responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aquarius	JPL	JPL	Argentina's Comision Nacional De Actividades Espaciales (CONAE), National Oceanic and Atmospheric Administration, Naval Research Laboratory, National Center for Atmospheric Research.
Orbiting Carbon Observatory - 2	JPL	JPL	N/A
Gravity Recovery and Climate Experiment (GRACE)	Earth Science Division	JPL	Deutches Zentrum fur Luft- und Raumfahrt (DLR, the German Aerospace Center); Office National d'Etudes et de Recherches Aerospatiale (ONERA) of France; GeoForschungsZentrum (German National Research Centre for Geosciences); National Oceanic and Atmospheric Administration; National Geospatial-Intelligence Agency.
CloudSat	Earth Science Division	JPL	Canadian Space Agency; U.S. Air Force; Department of Energy.
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)	Earth Science Division	LaRC	France's Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) and Alcatel; SODERN; Institut Pierre Simon Laplace, France.

Acquisition Strategy

ESSP program missions are selected competitively via Announcements of Opportunity (AO). The AO process uses peer review for the science content of the proposed missions, as well as thorough independent review of their technical, management, and cost elements. In FY 2011 winners of the first Venture Call, EV-1, will begin their airborne campaign mission development activities. Preparations will be completed for the second Venture Class call, EV-2, and for the first release of the instrument only AO, EV-I1, with the AOs for each to be released in FY 2012. OCO-2 is a NASA directed mission, but remains under the ESSP Program, as the original OCO was selected under an AO. NASA will seek to duplicate the OCO acquisition strategy to the greatest degree practical.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	05/2009	CALIPSO, GRACE and CloudSat were reviewed as part of the Earth Science biennial Senior Review process. All three missions were approved for extended operatons through the end of FY11.	04/2011
Performance	SRB	N/A	OCO-2 will be subject to a KDP-C Confirmation Review to establish the mission development baseline	11/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**181.6**	**46.9**	**18.3**	**17.0**	**5.4**	**5.2**	**2.4**	**4.6**	**4.8**	**286.2**
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.6
Development / Implementation	146.0	46.9	18.3	13.7	0.0	0.0	0.0	0.0	0.0	224.9
Operations / Close-out	0.0	0.0	0.0	3.3	5.4	5.2	2.4	4.6	4.8	25.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**181.5**	**44.7**	**18.3**	**6.3**	**4.2**	**2.8**	**0.0**	**--**	**0.0**	**257.8**
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	35.6
Development / Implementation	145.9	44.7	15.8	0.0	0.0	0.0	0.0	--	0.0	206.4
Operations / Close-out	0.0	0.0	2.5	6.3	4.2	2.8	0.0	--	0.0	15.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.1**	**2.2**	**0.0**	**10.7**	**1.2**	**2.4**	**2.4**	**--**	**4.8**	**28.4**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.1	2.2	2.5	13.7	0.0	0.0	0.0	--	0.0	18.5
Operations / Close-out	0.0	0.0	-2.5	-3.0	1.2	2.4	2.4	--	4.8	9.9
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The FY 2010 Budget for Aquarius reflected the cost for a launch in May 2010. Spacecraft development delays at NASA's foreign partner, Argentina's National Committee of Space Activities (CONAE) spacecraft have delayed the launch to no earlier than December 2010, with a current manifest date of January 2011. The current budget reflects this change.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Project Purpose

The Aquarius mission will investigate the links between the global water cycle, ocean circulation, and climate. It will observe and model variations of sea surface salinity, and how these relate to changes in the water cycle and ocean circulation. This will yield an unprecedented view of the oceans' role in climate and weather.   For more information visit: http://aquarius.gsfc.nasa.gov/

Project Parameters

Aquarius is an instrument on Argentina's CONAE spacecraft, Satellite de Aplicaciones Cientificas-D (SAC-D). The combined NASA and CONAE instruments and spacecraft form the Aquarius/SAC-D observatory. This observatory will be launched into a polar, Sun-synchronous orbit that allows global coverage of ice-free ocean surfaces consistent with Aquarius/SAC-D science observational targets. The Aquarius instrument includes an L-band microwave radiometer (1.413 GHz) and scatterometer (1.26 GHz). The radiometer will measure the surface brightness temperature, which is related to the surface emissivity and physical temperature of the seawater. The surface emissivity is determined by the dielectric constant of seawater, which is related to salinity. The scatterometer is required to provide coincident information of sea surface roughness, a critical correction term for retrieval of sea surface salinity.

Project Commitments

Aquarius is manifested to launch in January 2011 to begin a three-year prime mission to measure sea surface salinity (SSS) with the precision, resolution, and coverage needed to characterize salinity variations and investigate the linkage between ocean circulation, Earth's water cycle, and climate variability.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Aquarius Instrument (integrated radiometer/ scatterometer)	JPL	L-band microwave radiometer at 1.413 GHz; scatterometer at 1.26 GHz; SSS measurements with root-mean-sq random errors and systematic biases <= 0.2 psu on 150 km sq scales over ice-free oceans.	Same	Same
Spacecraft	CONAE	SAC-D	Same	Same
Launch Vehicle	Boeing	Delta II	Same	Same
Data Management	GSFC	N/A	Same	Same
Operations	CONAE	Command and telemetry	Same	Same

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Schedule Commitments

The Aquarius mission entered a Risk Mitigation Phase (RMP) in July 2002. Following the RMP, the project was authorized to proceed to a formulation phase in December 2003. The Aquarius mission was authorized by the NASA Science Mission Directorate to proceed to Development on October 12, 2005. In November 2007, the NASA Science Mission Directorate Program Management Council approved a rebaseline of Aquarius, including a launch delay to May 2010. In December 2009, the NASA Science Mission Directorate Program Management Council approved another rebaseline of Aquarius, including a launch delay manifesting the Aquarius/SAC-D mission for a January 2011 launch.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Mission Confirmation Review	September 2005	September 2005	September 2005
Mission CDR	August 2007	July 2008	July 2008
Aquarius Instrument Pre-ship Review [FY 2008 APG]	May 2008	May 2009	May 2009
Launch	March 2009	May 2010	January 2011

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Aquarius	2007	192.6	2010	222.6	16	Launch Readiness	07/2009	01/2011	18

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**192.6**	**222.6**	**30.0**
Payloads	55.4	96.1	40.7
Launch Vehicle/Services	78.9	79.4	0.5
Ground Systems	5.5	5.5	0.0
Science/Technology	10.9	11.8	0.9
Other Direct Project Cost	41.9	29.8	-12.1

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Project Management

The Jet Propulsion Laboratory is responsible for project management. The Science Mission Directorate Program Management Council is responsible for program oversight.

The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Launch Vehicle	KSC	KSC	None
Ground System	JPL	GSFC	None
Aquarius Instrument	JPL	JPL	None
Spacecraft	CONAE	None	CONAE
Radiometer	JPL	GSFC	None
Data management	GSFC	GSFC/JPL	None
Mission operations	CONAE	None	CONAE

Acquisition Strategy

Aquarius was competitively selected from proposals submitted in response to Earth System Science Pathfinder (ESSP) Announcement of Opportunity 3. All elements of the project were included in that selection, and there are no other planned major procurements.

The launch vehicle procurement was awarded to Boeing. Goddard Space Flight Center and the Jet Propulsion Laboratory were selected for the remaining project elements not provided by CONAE.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Aquarius Standing Review Board	4/2009	Aquarius/SAC-D Systems Integration Review -- Determined readiness of Aquarius instrument integration with the SAC-D Observatory (Phase D). Recommendation to proceed to Phase D.	7/2010
Performance	Aquarius Standing Review Board	11/2009	Aquarius Rebaseline Review -- Determined readiness of Aquarius instrument integration with the SAC-D Observatory (Phase D). Recommendation to proceed to Phase D.	7/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Spacecraft Development Delays	Further delays could impact launch date.	Monitor COMISION NACIONAL DE ACTIVIDADES ESPACIALES (CONAE) Progress and confirm commitments; reassess available schedule reserves.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Formulation:	OCO - 2

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**25.0**	**171.0**	**91.0**	**51.0**	**13.0**	**4.0**
Total Change from 2010 President's Budget Request	**0.0**	**25.0**	**171.0**	**91.0**	**51.0**	**13.0**	**--**

Project Purpose

The data received from the Orbiting Carbon Observatory-2 (OCO-2) will support climate research by providing an improved understanding of natural, distributed CO2 sources and sinks and ocean/atmosphere and land/atmosphere CO2 exchange processes. OCO-2 measurements will initiate a global time series of atmospheric CO2 for direct support of policy development and verification of regulations and environmental treaties. Rapid development and launch of OCO-2 is a key element of the President's budget.

OCO-2 replaces the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's detailed design and implementation approach to the greatest possible degree to reduce risk. The mission objectives of OCO and OCO-2 are identical.

Project Preliminary Parameters

The OCO-2 mission consists of a dedicated spacecraft with a single instrument, flying in a near-polar, sun synchronous orbit launched by an expendable launch vehicle. The orbit's early afternoon equator crossing time maximizes the available signal and minimizes diurnal biases in CO2 measurements associated with photosynthesis. The OCO-2 flight system uses hardware components, software and processes with spaceflight heritage. OCO-2's three-axis stabilized bus design is derived from the LEOStar-2 spacecraft class currently in production at Orbital Science Corporation. The design and architecture of the OCO-2 spacecraft bus is based on the successful Solar Radiation and Climate Experiment (SORCE) and Galaxy Explorer (GALEX) missions. The spacecraft structure is made of honeycomb panels that form a hexagonal shape. This structure houses the instrument and the spacecraft bus components. Panels with solar cells are attached and stowed such that the whole structure fits inside the small fairing of the Taurus XL launch vehicle. For the OCO-2 mission, the spacecraft has been elongated to accommodate the instrument and the instrument has been embedded into the structure of the spacecraft. The instrument consists of a single telescope feeding three high-resolution grating spectrometers. The optics will be cooled to approximately 270 Kelvin and the Focal Plane Arrays (FPAs) to approximately 120 Kelvin. The instrument is designed to measure CO2 and O2 near-infrared absorptions from reflected sunlight. Remote sensing retrieval algorithms will process these data to yield estimates of the column-averaged CO2 dry air mole fraction, XCO2. The total weight of the observatory is about 530 kilograms (1170 pounds). The original OCO successfully completed qualification of this configuration prior to launch.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Formulation:	OCO - 2

Estimated Project Deliverables

The OCO-2 is planned to launch in February 2013 to begin a two-year mission. OCO-2 will provide atmospheric CO2 measurements with near global coverage of the sunlit portion of the Earth with a 16-day repeat cycle.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	Orbital Sciences Corp	Provides platform for the instrument	N/A	New
OCO-2 Instrument	JPL	Three channel, high-resolution grating spectrometer measuring CO2 and O2 near-infrared absorptions from reflected sunlight	N/A	New
Launch Vehicle	Orbital Sciences Corp	Taurus XL	N/A	New

Estimated Project Schedule

Based on the design maturity,(due to the heritage of OCO), OCO-2 will be placed in Formulation in February 2010. Completion of KDP-C and transition to Development is expected in late CY2010. Further milestone dates are preliminary estimates pending completion of Formulation and KDP-C.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
KDP-C	N/A	N/A	December 2010
Launch readiness date (LRD)	N/A	N/A	February 2013

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Formulation:	OCO - 2

Project Management

The Jet Propulsion Laboratory (JPL) has project management responsibility for OCO-2. The Science Mission Directorate Program Management Council has program oversight responsibility. The Earth Sciences Division Director is the responsible official.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	None	None
Instrument	JPL	JPL	None
Ground System	JPL	JPL	None
Launch Vehicle	JPL	KSC	None

Acquisition Strategy

The OCO-2 Spacecraft will be built by Orbital Sciences Corporation. A sole source procurement is being pursued to maintain the same configuration as OCO. The OCO-2 instrument will be built in-house at JPL.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	OCO-2 SRB	N/A	OCO-2 will complete a KDP-C Confirmation Review, to establish the mission development baseline.	11/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	146.0	149.9	161.2	164.5	160.5	165.8	169.8
Earth Science Multi-Mission Operations	146.0	149.9	161.2	164.5	160.5	165.8	169.8
FY 2010 President's Budget Request	148.1	149.9	160.3	165.4	161.3	165.5	--
Earth Science Multi-Mission Operations	148.1	149.9	160.3	165.4	161.3	165.5	--
Changes from FY 2010 Request	-2.1	0.0	0.9	-0.9	-0.8	0.3	--

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Program Overview

The Earth Science Multi-Mission Operations Program acquires, preserves, and distributes observational data to support Earth Science focus areas in conformance with national science objectives. The Earth Science focus areas are as follows: (1) Climate variability and change; (2) Atmospheric composition; (3) Carbon cycle, ecosystems, and biogeochemistry; (4) Water and energy cycles; (5) Weather; and (6) Earth surface and interior. Facilities involved in this undertaking include data-handling, data processing, and archiving systems.

NASA's principal Earth Science information system is the Earth Observing System Data and Information System (EOSDIS), which has been operational since August 1994. EOSDIS acquires, processes, archives, and distributes Earth Science data and information products created from satellite data, which arrive at the rate of more than four trillion bytes (4 terabytes) per day. Having successfully created this system, NASA is using advances in information technology to expand its capabilities while providing continuous service to the user community.user community. The successful completion of the Evolution of EOSDIS Elements (EEE) effort has increased efficiency and operability; increased data usability by the research, application, and modeling communities. EOSDIS is now; providing services and tools needed to enable use of NASA's Earth Science data in next-decadal models, research results, and decision support system benchmarking; and improving support for end users. The budget request for FY 2011 incorporates cost savings that result from this effort. A system plan for 2015 and beyond will guide further improvements and will take into account evolution needs for new missions being developed in response to the decadal survey Earth Science and Applications from Space (National Research Council). Very modest investments will enable the system to keep technologically current, and incorporate new research data and services.

NASA Earth Science information is archived at eight Distributed Active Archive Centers (DAACs) located across the United States. The DAACs specialize by topic area, and make their data available to researchers around the world. For more information, please see http://eos.nasa.gov/eosdis. Research opportunities related to EOSDIS are available through the Advanced Collaborative Connections for Earth System Science (ACCESS) at http://access-projects.gsfc.nasa.gov/ and Making Earth System data records for Use in Research Environments (MEaSUREs) at http://measures-projects.gsfc.nasa.gov/ programs. Participants in these programs are solicited through the Research Opportunities in Space and Earth Sciences (ROSES), the NASA Research Announcement soliciting basic and applied research proposals.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Plans For FY 2011

The Earth Science Multi-Mission Operations Program will continue operation of EOSDIS, the DAACs and their accompanying functions, as well as Core System Science Data Processing Systems. The maintenance of these systems is important to the collection of data from Earth Science satellites in orbit, as well as to the continuity of Earth Science research efforts.

NASA plans to continue the support of the Evolution of EOSDIS Elements effort to enable a service oriented architecture between now and 2015.

Five-year MEaSUREs Projects began work in FY 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. An Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation was released in NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009) and selections were made for new ACCESS Projects beginning in FY 2010. A third program solicitation, Earth System Data Records Uncertainty, is being readied for ROSES-2010. These Cooperative Agreements are proving very valuable for keeping research and modeling communities actively involved with the EOSDIS architecture, and informing core infrastructure evolution decisions.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Project Descriptions and Explanation of Changes

EOSDIS

EOSDIS is the central data handling system for NASA's Earth Science efforts. EOSDIS components funded in the project include:

Production of standard science data products, using algorithms and software developed by EOS investigators;

Active archive of data, as well as ordering, distribution, and data management. Also ensures the preservation of data, products, related algorithms, and system-configuration history;

Information Management, enabling researchers to rapidly locate and retrieve data critical to their work; and

User Support for research scientists, educators, students, and users in public agencies responsible for operational applications of the data, as well as for the general public.

The Precipitation Processing System (PPS) is a measurement-based data and information system at GSFC that evolved from the TRMM Science Data and Information System (TSDIS). PPS continues to support the TRMM Science Team with analyzed rainfall data from TRMM as well as data from other precipitation instruments, and is also developing further to support the upcoming Global Precipitation Mission (GPM) to be launched in FY 2013.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

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, and the Distributed Active Archive Centers, which collect, disseminate, and archive Earth Science data at eight centers across the Nation:

-The Alaska SAR Facility, which collects Synthetic Aperture Radar data, and information on sea ice, polar processes, and geophysics;

-The GSFC 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.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Provide services and tools needed to enable use of NASA's Earth Science data in next-decadal models, research results, and decision support system benchmarking.	EOSDIS and DAACs	None

Implementation Schedule

Project	Schedule by Fiscal Year	Phase	Beg	End
EOSDIS and Multi-Mission Operations (including DAACs)	Prior – 15	Tech		
		Form		
		Dev		
		Ops	Aug-94	Dec-15
		Res		
Elements of EOSDIS Evolution (phased start-up beginning in FY 2008)	Prior – 20	Tech		
		Form	Nov-04	Nov-05
		Dev	Dec-05	Mar-08
		Ops	Apr-08	Dec-20
		Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The Science Mission Directorate and the Program Management Council have oversight responsibility for this program. The Earth Science Data and Information System Project Office at GSFC has primary responsibility for the program.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Precipitation Processing System (PPS)	GSFC	GSFC	NASA operates and is further developing the PPS to provide analyzed data from the TRMM and GPM missions. Both TRMM and GPM are joint missions of NASA and JAXA, a key stakeholder
ACCESS, MEaSUREs, Earth System Data Records Uncertainty Analysis (peer-reviewed data research	SMD	NASA Headquarters	None.
Multi-Mission Operations (operations and maint of Core EOSDIS systems; DAACs, Evolution of EOSDIS	GSFC	Earth Science Data and Information Systems Office, Goddard Space Flight Center	Key participants in the Multi-Mission Operations project include the space agencies of Europe, Canada, Germany, France, and Japan. Other U.S. agency partners include the National Oceanic and Atmospheric Administration (Department of Commerce), U.S. Geological Survey (Department of the Interior), and the Department of Defense.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Acquisition Strategy

The EOSDIS Core System is a high-performance software system that provides science data ingest, archive and distribution capabilities for a multitude of Earth science instruments. Maintenance and operations for this system, utilized by three DAAC's post-Step 1 Evolution of EOSDIS Elements, is performed under contract procured by GSFC. The contract, managed by the ESDIS Project at GSFC, is being recompeted to be completed in 2010.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	Earth Science Subcommittee	10/2009	The Earth Science Subcommittee reported that they were impressed by the success and clear sense of direction of this program.	TBD
Quality	DAAC Data Priority Workshops	ongoing	DAAC archive holdings peer reviewed for scientific merit. Multiple reviews related to individual research areas, all successful, several recommendations in work.	annual

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Technology

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	55.3	45.9	52.8	53.9	57.1	64.7	68.0
Earth Science Technology	55.3	45.9	52.8	53.9	57.1	64.7	68.0
FY 2010 President's Budget Request	54.1	45.9	47.2	48.2	49.5	52.7	--
Earth Science Technology	54.1	45.9	47.2	48.2	49.5	52.7	--
Changes from FY 2010 Request	1.2	0.0	5.6	5.7	7.7	11.9	--

Program Overview

Advanced technology plays a major role in enabling Earth research and applications programs by providing an improved understanding of the total Earth system and its effects of natural and human-induced changes on the global environment. The Earth Science Technology Program (ESTP) provides the Earth Science Division with new capabilities, enabling previously unforeseen and infeasible science investigations, enhancing existing measurement capabilities, and reducing the cost, risk, and development times of Earth science measurements.

The Earth Science Technology Office (ESTO) provides strategic, science-driven technology assessments and requirements development. The program implements a science focused technology program by pursuing promising scientific and engineering concepts through open competition solicitations.

For more information, please see: http://esto.nasa.gov

Plans For FY 2011

ESTP will plan and implement development of new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements and data system capabilities. Planning will start with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess measurement options for meeting technology performance requirements. Implementation will be performed through managing awarded tasks from competed solicitations in the three project areas: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives. Ongoing activities in these areas are described in more detail in the project description section below.

For FY 2011 new work will be solicited in the Advanced Information Systems Technology and Advanced Component Technology areas. This FY 2011 solicitation will be part of the ROSES-2011 NASA Research Announcement. Both calls will support the expanded and accelerated mission set enabled by the President's budget including the Climate Initiative.

Project Descriptions and Explanation of Changes

Instrument Incubator

This project develops new and innovative instruments and measurement techniques at the system level, including laboratory development and airborne validation.

A solicitation for new instrument technologies was released in FY 2007 and 21 new awards were made for sensors measuring atmospheric trace gases, aerosols, clouds, gravity fields, ocean topography, tropospheric winds, thermal land imaging, Earth radiation balance, precipitation, ocean color, snow, and vegetation. Instrument technologies include imagers, spectrometers, lidars, microwave sounders, and radars. These projects started in FY 2008 and will continue through FY 2011. The next solicitation was released in FY 2010 with selections expected to be made in the first quarter of FY 2011.

Some notable recent Instrument Incubator demonstrations include airborne radar measurements of Greenland ice sheet basal topography from high altitude and in two dimensions, the first simultaneous lidar measurements of tropospheric water vapor and aerosols from an aircraft, a ground-based demonstration of the hybrid Doppler wind lidar with simultaneous coherent and direct detection measurements, and airborne Ka-band interferometric synthetic aperture radar (SAR) topography measurements.

Advanced Information Systems Technology

This project develops end-to-end information technologies that enable new Earth-observation measurements and information products. The technologies are used to process, archive, access, visualize, communicate, and understand science data. The next solicitatoin is in the ROSES-11 with selections expected to be made in the first quarter of FY 2012.

The last solicitation released in June 2008 awarded 20 additional projects in early FY 2009, focused on three areas needed to support future Earth science measurements: Sensor System Support (to incorporate autonomy and rapid response in the sensing process and improve the science value of data); Advanced Data Processing (to improve or enhance the information extracted from the data stream); and Data Services Management (to better manage the growing body of Earth science data and allow for efficient exchange).

As examples, one project team deployed a fleet of SnoMote robots to test their mobile sensor network on Mendenhall Glacier in Alaska; the autonomous SnoMotes are designed to gather in-situ science data in dangerous, volatile ice environments to augment remote sensing data with accurate ground-truth measurements. Another task develops an inter-operable sensor architecture system that integrates four satellites, a UAV, and multiple ground sensors, data algorithms, and models, and has been demonstrated as a tool to help manage wildfires.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Technology

Advanced Technology Initiatives

The Advanced Technology Initiatives element provides for the development of critical component and subsystem technologies for the instruments and platforms which support the Earth Science Decadal Survey. The next solicitation is in ROSES-11 with selections expected to be made in the first quarter of FY 2012.

The last solicitation for Advanced Component Technology was in ROSES-08 for technologies such as: space-qualifiable laser transmitters, passive optical technologies, microwave and calibration technologies. Sixteen awards were made, supporting 14 of the 15 NASA Earth Science Decadal Survey missions. Some examples of these awards follow. A corrugated mirror telescope array for lidar will support seven of the Decadal Survey missions and help to enable the measurement of ice, crustal deformation, carbon dioxide and even 3D winds. Another notable technology is a large aperture deployable reflector which will support: soil moisture, ocean and river water dynamics, temperature and humidity soundings and snow accumulation for fresh water assessments. Other awards support measurements of: solar radiance, ozone, aerosols, atmospheric gas columns for air quality and ocean color for coastal ecosystem health and climate emissions.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Annually advance a portion of funded technology developments by one technology readiness level.	ESTP	Same
Annually mature several technologies to the point of readiness for demonstration.	ESTP	Same
Annually enable or improve one new science measurement capability.	ESTP	Same

Program Management

The Earth Science Division within the Science Mission Directorate has oversight responsibility of the technology program office.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Instrument Incubator	ESTO	GSFC, JPL, LaRC, ARC, GRC	None.
Advanced Info Systems	ESTO	GSFC, JPL, LaRC, ARC, GRC, MSFC	None.
Advanced Tech Initiatives	ESTO	GSFC, JPL, LaRC, ARC, GRC	None.

Acquisition Strategy

Tasks are procured primarily through full and open competition, such as the Research Opportunities in Space and Earth Sciences (ROSES)announcements.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Technology

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC - Earth Science Sub Committee	10/2009	The Earth Science Subcommittee reviewed the Earth Science Technology Program for infusion of new technologies and participation of universities in developing the new generation of technologists. The committee was overall pleased with the technology program; it wanted to ensure that tasks focus on being able to reduce cost in missions and are directed towards enabling/enhancing specific measurements.	10/2011

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**47.8**	**32.2**	**36.6**	**38.3**	**41.1**	**45.9**	**48.7**
Pathways	47.8	32.2	36.6	38.3	41.1	45.9	48.7
FY 2010 President's Budget Request	**47.8**	**32.2**	**30.7**	**31.5**	**32.2**	**33.1**	**--**
Pathways	47.8	32.2	30.7	31.5	32.2	33.1	--
Changes from FY 2010 Request	**0.0**	**0.0**	**5.9**	**6.9**	**8.9**	**12.8**	**--**

Program Overview

The Applied Sciences Program (http://nasascience.nasa.gov/earth-science/applied-sciences) leverages NASA Earth Science research and observations to enable innovative and practical uses in management, business, and policy decisions. NASA Applied Sciences projects address applied research needs in the user community, discover and demonstrate new applications of Earth science data, and facilitate adoption of applications by non-NASA stakeholder organizations. The projects are designed to improve decision-making activities through which the nation can 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 include improved public health tracking systems for infectious diseases with the Centers for Disease Control; advances in prediction of weather conditions for airplane pilots through the National Weather Service and the Federal Aviation Administration; improved tracking of air pollutants with the Environmental Protection Agency for air quality management; improving the Department of Agriculture's Global Economic Forecasting; and international disaster management support with the U.S. Agency for International Development. The Program's primary outcomes are the routine, sustained uses of NASA Earth science products in user organizations' policy, business, and management decisions to serve society; the impacts are the resulting socioeconomic benefits from the improved decisions.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

Plans For FY 2011

In FY 2011, the Applied Sciences Program will continue or initiate projects across a range of application areas, including agriculture, air quality, climate, ecological forecasting, public health, natural disasters, water resources, and weather. These projects are competitively selected through NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2007, 2008, 2009, and 2010. In FY 2011, the Program will feature increased joint solicitations with research and end-user organizations, expanded contributions to mission science teams to ensure consideration and incorporation of applications requirements throughout the mission design process, and continuation of efforts to build skills and capabilities on how to access and apply Earth observations data to benefit society. The FY 2011 President's Budget enables the Program to introduce a new solicitation, increase the number of project selections, increase end-user involvement in early phase mission planning, and expand the products and services provided by the highly successful NASA/USAID joint-funded SERVIR network.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

Project Descriptions and Explanation of Changes

Applied Sciences

In FY 2011, the Applied Sciences Program will sponsor several solicitations and competitively-selected projects across the range of applications themes described above, including topics that cross-cut these themes:

1. Decision Support projects: These are 3-4 year projects that are carried out collaboratively with end user organizations to integrate Earth observations data into their decision-making activities and enable the transition for the organizations' sustained use of the Earth observations data.

2. Applications Feasibility projects; These are short-term, proof-of-concept projects to generate and test preliminary ideas for applications of Earth science products to determine their potential value and readiness for a more in-depth project.

3. Applications Knowledge projects: These are multiple-year projects focused on applied research to generate fundamental understanding of how Earth science can be scaled and applied to serve society and methods to enable institutions to apply new types of information in traditional decision making activities.

4. Applied Sciences Teams: These are multiple-year teams of applications-specialists and scientists to address key applications-oriented challenges and critical data products needed by the applied community and end users.

The program supports joint solicitations with the Earth Science Research Program and supports some applications-oriented projects that are identified in solicitations managed by the Research Program's science focus areas.

The projects also include a small number of activities that crosscut and support the tasks, including capacity building projects, workshops, and outreach activities.

In FY11, the Applied Sciences Program will expand the SERVIR network and enhance its scientific capabilities across a broader set of NASA Earth science products and its service as a testbed for innovative applications.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

Performance Evaluation

As part of the Administration's government-wide initiative to strengthen program evaluation, the request includes funds for a study of the NASA Earth Science's Applied Sciences Program (hereafter, the Program). NASA's current evaluation efforts are focused primarily on large engineering projects. NASA seeks to develop capacity to perform appropriate impact evaluations for small, science-based projects that have the potential to provide direct societal benefits stemming from NASA research investments. The Program works with numerous partner organizations (e.g., FAA, EPA, CDC, USFS, USAID) which have different types of management and decision activities (e.g., resource allocation, early warning, forecasting, planning, response and recovery), with their organization's corresponding outcome and impact measures. The Program develops applications and facilitates their transition and adoption by the partner organizations. As such, the Program would also benefit from factors within the impact evaluations that can help to highlight key success criteria across the decision types.

This study will select 2 projects completed in the 2009-10 timeframe, addressing two different application topics, in order to pilot evaluation approaches for different types of decision making. The study will likely use a pre-post comparison to assess utility, efficiency, and/or effectiveness gains in the partners' decision making. The evaluation will compare the improved decision-making performance (with NASA data) compared to baseline conditions (without NASA data). The evaluations will pilot an approach to conduct a value-of-information or cost-benefit analysis on the completed projects. The information and capabilities from this pilot effort can help NASA in further studies to identify critical factors in the design and execution of applications projects, and to scope larger-scale activities in determining and articulating impacts of its science and other research-based programs.

This study is one of 23 evaluation proposals specifically approved by the Office of Management and Budget for 2011 to strengthen the quality and rigor of Federal program evaluation. To ensure the study is well designed and implemented, NASA will work with evaluation experts at OMB and the Council of Economic Advisers during the planning, design, and implementation of the study. NASA is committed to promoting strong, independent evaluation that can inform policy and program management decisions and will post the status and findings of this and other important evaluations publicly available online.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Issue competed peer reviewed research awards.	Applied Sciences	Same
Maximize resource utilization through streamlining processes and operations across the program.	Applied Sciences	Same
Conduct impact evaluation on mature projects.	Applied Sciences	New

Program Management

Applied Sciences Program responsibility resides within the Earth Science Division of the Science Mission Directorate.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Earth Science Applications	NASA HQ	GSFC, LaRC, SSC, JPL, MSFC, and ARC	EPA, NOAA, USDA, FAA, DOE, DOI, CDC, USAID ; state agencies, and regional organizations such as the Western Governors Association, American Water Resources Association, Gulf of Mexcio Alliance. Private sector and universities. Non-Profit and intergovernment organizations, such as United Nations Food and Agriculture Organization.

Acquisition Strategy

The Earth Science Applications Program is based on full and open competition. Grants are peer reviewed and selected based on NASA Research Announcements and other related announcements. The program emphasizes cost-sharing in projects, especially Decision Support projects.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Research Council	10/2007	The Applied Sciences Program strategy and implementation.	2013
Relevance	Applied Sciences Analysis Group	N/A	Applied Sciences program strategy and implementation.	12/2010

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Mission Directorate:	Science
Theme:	Planetary Science

Theme Overview

Planetary Science is a grand human enterprise that seeks to discover the nature and origin of the celestial bodies among which we live, and to explore whether life exists beyond Earth. The scientific imperative for Planetary Science, the quest to understand our origins, is universal. How did we get here? Are we alone? What does the future hold? These overarching questions lead to more focused, fundamental science questions about our solar system: How did the Sun's family of planets, satellites, and minor bodies originate and evolve? What are the characteristics of the solar system that lead to habitable environments? How and where could life begin and evolve in the solar system? What are the characteristics of small bodies and planetary environments and what potential hazards or resources do they hold?

To address these science questions, NASA relies on various flight missions, research and analysis (R&A) and technology development. There are seven programs within the Planetary Science Theme: R&A, Lunar Quest, Discovery, New Frontiers, Mars Exploration, Outer Planets, and Technology. R&A supports two operating missions with international partners (Rosetta and Hayabusa), as well as sample curation, data archiving, dissemination and analysis, and Near Earth Object Observations. The Lunar Quest Program consists of small robotic spacecraft missions, Missions of Opportunity, Lunar Science Institute, and R&A. Discovery has two spacecraft in prime mission operations (MESSENGER and Dawn), an instrument operating on an ESA Mars Express mission (ASPERA-3), a mission in its development phase (GRAIL), three Missions of Opportunities (M3, Strofio, and LaRa), and three investigations using re-purposed spacecraft: EPOCh and DIXI hosted on the Deep Impact spacecraft and NExT hosted on the Stardust spacecraft. New Frontiers has one operating spacecraft (New Horizons) and one mission (Juno) currently in its development phase. The Mars Exploration Program has two orbiting spacecraft (Odyssey and MRO) and two rovers (Spirit and Opportunity) in operation, one mission in development (MSL), one scout class mission in formulation (MAVEN) and a science instrument to be included in the ESA ExoMars mission, and project activities for technology, next decade mission design/development, and research. The Outer Planets Program includes research, one operating mission (Cassini) and an Outer Planets Flagship mission under study. The Technology Program includes in-space propulsion systems, advanced power generation, and the Advanced Multi-Mission Operations System (AMMOS).

Mission Directorate: Science
Theme: Planetary Science

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**1,288.1**	**1,341.3**	**1,485.7**	**1,547.2**	**1,591.2**	**1,630.1**	**1,649.4**
Planetary Science Research	166.2	160.7	180.4	190.8	195.2	214.2	240.9
Lunar Quest Program	69.1	103.6	136.6	136.4	131.7	109.7	110.5
Discovery	234.8	209.2	202.0	216.8	235.9	263.0	312.9
New Frontiers	279.0	264.1	223.8	229.5	237.9	247.7	258.5
Mars Exploration	361.7	416.1	532.8	514.8	549.9	569.6	485.8
Outer Planets	104.8	98.6	103.5	157.9	152.0	144.0	155.8
Technology	72.4	89.0	106.5	101.1	88.7	82.0	85.1
FY 2010 President's Budget Request	**1,325.6**	**1,346.2**	**1,500.6**	**1,577.7**	**1,600.0**	**1,633.2**	**--**
Planetary Science Research	162.1	161.7	193.5	240.2	232.6	254.2	--
Lunar Quest Program	105.0	103.6	142.6	138.6	145.5	118.7	--
Discovery	247.0	213.2	234.6	256.8	256.5	264.3	--
New Frontiers	263.9	264.1	239.9	294.2	239.8	249.6	--
Mars Exploration	381.6	416.1	494.5	405.5	514.3	536.7	--
Outer Planets	101.1	98.6	97.1	140.3	117.7	118.5	--
Technology	64.9	89.0	98.4	102.1	93.5	91.4	--
Total Change from FY 2010 Request	**-37.6**	**-4.9**	**-15.0**	**-30.5**	**-8.7**	**-3.1**	**--**

Note: Zero-sum funds transfer within NASA to consolidate CM&O, institutional facilities, and SBIR. Funds were included for additional NEO activities and carved out within Planetary Science Theme to co-fund Plutonium restart effort with DOE.

Plans for FY 2011

Planetary Science Research

The Research and Analysis (R&A) program will continue to release research announcements and make research project and grant selections. The Planetary Data System (PDS) will continue to archive and release planetary science data to the science community in a timely manner for further scientific analysis. The Astromaterial Curation project will continue its efforts on curation and distribution of solar system samples (Astromaterials) returned by NASA planetary missions such as Stardust and Genesis. The Rosetta project will continue toward its arrival at comet Churyumov-Gerasimenko (January 2014). Having successfully supported JAXA asteroid mission Earth Return in June 2010, the Hayabusa (MUSES-C) project will start to perform the science and sample analysis phase through September 2011. The expanded NEOO program will improve and increase its efforts to detect Earth approaching asteroids and comets which may provide resources for our exploration of the inner solar system or could become potential impact hazards to the Earth. It will also expand efforts to characterize their nature, both to better understand their composition and provide information for study of potential hazard mitigation techniques.

Lunar Quest Program

Project elements under LQP include the Lunar Atmosphere and Dust Environment Explorer (LADEE), the International Lunar Network (ILN)/ Lunar Surface Science missions, Plutonium, and Lunar Science Research. LADEE completed its preliminary design review in FY 2009 and will enter Implementation Phase (KDP-C) in late FY 2010. The ILN/Lunar Surface Science mission will continue with its the risk reduction efforts during FY 2011. NASA will negotiate and work the Plutonium restart capability with DOE throughout FY 2011. Research Announcement for Lunar Research & Analysis will be released annually, followed by selections and awards.

Discovery

Having completed its third fly-by of Mercury, MESSENGER will prepare for Mercury orbit insertion (planned for March 2011) while it continues its operations and analyses of valuable data from the three flybys. The Dawn spacecraft completed its cruise from a Mars gravity assist in February 2009 to begin its Vesta encounter in May 2011. ASPERA-3 will complete collection of data on its extended mission of Mars Express. Though the M3 instrument will not continue to collect science measurements due to the loss of ISRO's Chandrayaan-1 mission, NASA will continue to perform analysis on the data received. The DIXI mission draws to a close in FY 2011 and NASA will be performing analysis on data collected during its encounter with the comet Hartley 2 in November 2010. Stardust NExT will be the Discovery Program's return to the comet Tempel 1 in February 2011 to see how it has evolved since the Deep Impact encounter in FY 2005. GRAIL will be in Assembly, Test, and Launch Operations (ATLO) by the end of FY 2010 and will prepare for its launch in September 2011. Two new Missions of Opportunity have been selected for the Discovery Program, the Strofio: Exospheric Sample of Mercury's Surface Composition on BepiColombo for a launch in 2014, and LaRa: Lander Radio-science will likely be accommodated as part of joint NASA-ESA Mars program which is currently under negotiation. A new Discovery 12 AO selection will be made by the end of FY 2011 following the AO release in early CY 2010.

New Frontiers

Juno will have successfully completed ATLO during FY 2010, and will deliver all instruments and hardware in preparation for a launch in August 2011. The New Horizons mission will continue on its course toward Pluto and its moons, with periodic spacecraft and instrument checkouts as it cruises. Having recently chosen three concept studies to pursue in 2010, NASA expects to select one New Frontiers 3 mission to proceed into Phase B (or an extended Phase A) by third quarter to late FY 2011.

Mission Directorate:	Science
Theme:	Planetary Science

Plans for FY 2011

Mars Exploration

MSL will complete ATLO and deliver all hardware in preparation for a launch either October or November 2011. The Mars Atmosphere and Volatile EvolutioN (MAVEN), Mars Scout mission, will start implementation phase in the 3rd quarter of FY 2010, leading to a successful completion of PDR and CDR by the end of FY 2011. The U.S. ExoMars instrument will remain in an extended Phase B throughout FY 2011. Odyssey will be in a new orbit with an expected improved sensitivity to detect minerals on the surface. The Mars Reconnaissance Orbiter (MRO) and (if technically possible) both Spirit and Opportunity rovers (MER) will continue to explore and perform data analysis throughout FY 2011. Concept studies with the ESA-NASA 2016/2018 partnership missions will finalize and the Mars 16 mission will enter into formulation phase by the end of FY 2011.

Outer Planets

NASA Cassini will continue its historic operations and data analysis. In FY 2010 and FY 2011 NASA will continue to provide funding for further definition study and technology development efforts for the Outer Planets Future mission while awaiting the results of the Decadal Survey establishing the science community's highest joint priorities. NASA will also continue to negotiate the details of potential partnerships with the European Space Agency (ESA) and other international partners.

Technology

The In-Space Propulsion Program (ISP) will continue toward a completion of the NASA's Evolutionary Xenon Thruster (NEXT) electric propulsion life validation. The Radioisotope Power Systems (RPS) Program, working with the Department of Energy, will start the flight development of the Advanced Stirling Radioisotope Generator (ARSG) that would support a flight in the 2014-2015 timeframe. Furthermore, the RPS Program continues to develop technologies and processes to support current and future NASA missions. The Advanced Multi-Mission Operation System (AMMOS) project will continue to develop the multi-mission software tools for spacecraft navigation and mission planning throughout FY 2011.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The Planetary Science Program is guided by the Space Act and subsequent legislation, and by U.S. National Space Policy and related policies, which call on NASA to conduct robotic missions throughout the solar system. The Program follows NASA's tradition of establishing its science priorities through consultation with world-class experts via the National Research Council's decadal survey process. The most recent decadal survey was published in 2002, and the next one is under development for release in 2011. Planetary Science also receives tactical-level advice from the external science community via the Planetary Science Subcommittee of the NASA Advisory Council.

Planetary Science seeks to achieve both near and long-term science goals by studying solar system objects and phenomena primarily in situ, but also by returning samples for study in laboratories on Earth. Planets and satellites of the solar system and the ancient icy bodies far from the Sun are "Rosetta stones" that can tell unique stories about the evolution of the solar system. As researchers learn more about the origins of living organisms on Earth and about the solar system's planets and moons, they may learn that life has arisen in places beyond Earth.

Robotic explorers gather data to help scientists understand how the planets formed, what triggered different evolutionary paths among planets, and how Earth formed, evolved, and became habitable. To search for evidence of life beyond Earth, scientists use this data to map zones of habitability, study the chemistry of alien worlds, and unveil the processes that lead to conditions necessary for life. Robotic exploration will generate knowledge about our solar system needed to identify the most promising human exploration missions. This knowledge will also help enable safe human space exploration in the forbidding environments they will encounter and may aid in the mitigation of hazards to life here on Earth.

Relevance to education and public benefits:

Planetary Science uses its missions, research programs, and the human resources of the space science community to enhance the quality of American science, technology, engineering and mathematics (STEM) education. The innovative nature of planetary science projects creates an impetus for new techniques and technologies that later benefit the public. Many of our missions are using mission data to create authentic education experiences and engaging students from secondary school through graduate school. The Robotics Alliance Program (RAP) is a concrete example of the Planetary Science program's contribution to education. NASA's Planetary Science is dedicated to sharing the excitement of discoveries and knowledge generated by space science missions and research, with the public, and thus contributing to educating and inspiring the next generation of STEM employees needed for the 21st century.

Public benefits from Planetary Science include a growing understanding of the solar system and Earth's significance within it. NASA's robotic science missions are paving the way for understanding the origin and evolution of the solar system and working to identify past and present habitable locations. These missions also enable human space exploration by studying and characterizing alien environments and identifying possible resources that will enable safe and effective human missions to the Moon and beyond.

Mission Directorate:	Science
Theme:	Planetary Science

Performance Achievement Highlights:

NASA scientists discovered the sample from Wild 2 comet (from the Stardust mission) contained crystalline silicates, a rock forming mineral typically found in asteroids. Most asteroids in the solar system are concentrated in a belt between Mars and Jupiter. Wild 2 originated in the Kuiper Belt beyond Neptune, and as a result, the mineral must have been transported from the asteroid belt to the cold, icy reaches of the Solar System to be incorporated into a comet. These findings show that the dust-gas cloud surrounding the primitive Sun before comets, asteroids, and planets began forming was a dynamic system.

A discovery made by the CRISM (Compact Reconnaissance Imaging Spectrometers for Mars) instrument on the MRO offers a better understanding of habitability on Mars. Data from the instrument showed the presence of magnesite, a magnesium-rich carbonate, on the surface of Mars. Scientists had expected to find carbonate on Mars because of its carbon dioxide rich atmosphere and the evidence of water. However, carbonate in bedrock outcrops clearly identifies the geologic environment where it formed and whether the environment could support life. NASA scientists achieved definitive detection of methane and its global variation in the atmosphere of Mars. The discovery indicated the planet is either biologically or geologically active or both. The team found methane in the Martian atmosphere by carefully observing the planet during several Mars years with NASA's Infrared and Keck telescopes. If microscopic Martian life is producing the methane, it likely resides far below the surface where it is warm enough for liquid water to exist. It is possible a geologic process produced the Martian methane, either now or eons ago. On Earth, the conversion of certain iron oxide minerals into a group of more oxidized minerals creates methane. On Mars, this process could occur using water, carbon dioxide and the planet's internal heat.

In FY 2009, asteroid search teams funded by NASA's NEO project found 22 asteroids larger than one kilometer (km) (0.62 miles) in size and two comets with orbits coming within Earth's vicinity. The teams also found 804 smaller asteroids of less than one km in mean diameter, bringing the total number of known near Earth asteroids of all sizes to 6,399. However, 1,066 are in orbits that could become a hazard in the more distant future and warrant monitoring, of which 145 are larger than one kilometer in diameter. Of all these potential hazards, 91 were found this year alone, 4 larger than one km in diameter. A unique event occurred for the first time allowing scientists to collect remnants of a meteorite fall from a parent asteroid whose origin was known. A very small 3 meter sized asteroid on collision course with Earth was spotted before it impacted allowing science teams to collect measurements via remote sensors of the object while it was still in space, and then to search for remnants of the object on the ground. Designated object 2008 TC3, the NEO observer network was quickly alerted and over 570 observations were collected by 27 different observers worldwide, including spectrometric data, within the 19 hours before it impacted the Earth's atmosphere. As a result, fresh and practically uncontaminated fragments have been collected. This is the next best thing to an asteroid sample return mission.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council	02/2007	Reviews science and program implementation strategies and relevancies to the NASA strategies and goals. Findings from the 2007 review included, NASA has made significant progress toward implementing the recommendations of the NRC's decadal survey and Mars Architecture report. NASA's current planetary exploration program is highly productive, carrying out exciting missions and making fundamental discoveries.	12/2010
Relevance	National Research Council	12/2003	Decadal Survey of Planetary Science priorities/Published Decadal Report entitled "New Frontiers and the Solar System: An Integrated Exploration Strategy". Decadal Survey noted that Planetary Science funding reductions overtime have prevent NASA from being able to achieve all of the goals originally envisioned by the Nation's science community in the 2003 Decadal Survey. The next/current Decadal Survey began in 2009.	04/2011

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Planetary Science Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**166.2**	**160.7**	**180.4**	**190.8**	**195.2**	**214.2**	**240.9**
Planetary Science Research and Analysis	135.6	132.1	131.0	139.0	142.4	147.4	150.4
Other Missions and Data Analysis	19.5	21.4	23.9	23.7	23.4	30.2	29.0
Education and Directorate Management	7.4	1.4	5.1	7.7	8.9	16.0	40.8
Near Earth Object Observations	3.7	5.8	20.3	20.4	20.5	20.6	20.7
FY 2010 President's Budget Request	**162.1**	**161.7**	**193.5**	**240.2**	**232.6**	**254.2**	**--**
Planetary Science Research and Analysis	135.0	135.1	144.4	153.2	156.9	160.7	--
Other Missions and Data Analysis	19.5	21.4	22.2	22.3	22.7	29.3	--
Education and Directorate Management	3.9	1.4	23.1	60.7	49.0	60.1	--
Near Earth Object Observations	3.7	3.8	3.8	3.9	4.0	4.1	--
Changes from FY 2010 Request	**4.0**	**-1.0**	**-13.1**	**-49.3**	**-37.5**	**-40.0**	**--**

Program Overview

The Planetary Science Research Program supports the development of theoretical tools and laboratory data needed to analyze flight data, makes possible new and better instruments to fly on future missions, and analyzes the data returned. These capabilities allow Planetary Science to answer specific questions and develop an increased understanding of the origin and evolution of the solar system. This program represents an essential complement to flight missions, providing the scientific research and the theoretical foundation to allow the nation to plan and fully utilize the unique data sets returned from the missions exploring the solar system. It is also NASA's primary interface with university faculty and graduate students in this field as well as the research community in general. The Research Program achieves this goal by supporting research grants which are solicited annually and subjected to a careful peer review before being awarded.

For further information see http://nasascience.nasa.gov/planetary-science

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Planetary Science Research

Plans For FY 2011

Release Research Announcements soliciting Research and Analysis proposals and make selections.

Continue planetary science data archiving and distribution of this data to the science community in a timely manner for further scientific analysis.

Continue curation and distribution of solar system samples (Astromaterials) returned by NASA planetary missions such as Stardust and Genesis.

Support the Rosetta mission toward its arrival at comet Churyumov-Gerasimenko (January 2014),

Complete support to Hayabusa (MUSES-C) for navigation and Deep Space Network Tracking and coordinate Sample Analysis from Earth Return in June 2010 and finish archiving the data in the PDS through 2011.

The budget for Near Earth Objects Observations (NEOO) will significantly expand our efforts to find and characterize asteroids and comets approaching Earth which may be destinations and resources for our exploration of the solar system, or could become potential impact hazards to the Earth.

Project Descriptions and Explanation of Changes

Planetary Science Research and Analysis

The scope of Research and Analysis (R&A) is wide because the effort must provide new theories and instrumentation that enable the next generation of flight missions. R&A also provides the foundation for the formulation of new scientific questions and strategies. Discoveries and concepts developed in the R&A Project are the genesis of scientific priorities, missions, instrumentation, and investigations. 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). R&A provides for instrument and measurement concepts, and supports the initial definition of mission concepts and development of instruments for future Discovery, New Frontiers, or Mars missions.

Other Missions and Data Analysis

Rosetta, a European Space Agency/NASA comet rendezvous mission in operations phase, launched in March 2004 and will arrive at comet Churyumov-Gerasimenko in FY 2014. The prime scientific objective of the Rosetta mission is to study 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 the long-term exploration of a comet at close quarters. It comprises a large orbiter, which is designed to operate for a decade at large distances from the Sun, and a small lander. Each of these carries a large complement of scientific experiments designed to complete the most detailed study of a comet ever attempted. Rosetta will allow scientists to look back 4600 million years to an epoch when no planets existed and only a vast swarm of asteroids and comets surrounded the Sun.

Hayabusa (MUSES-C), in its operations phase, is a near-Earth asteroid rendezvous mission that will return samples to Earth. The spacecraft launched in May of 2003 and landed on the Asteroid Itokawa in November 2005. In April 2007, the spacecraft began its return to Earth to bring with it an asteroid sample. Hayabusa will arrive at Earth in June 2010. Hayabusa observed Itokawa's shape, geographical features, reflectance, mineral composite, and gravity from an altitude of 3 to 20 km, and clarified the Itokawa's structure as a "pile of rubble." Science published seven Hayabusa related essays, the first time for the magazine to feature a Japanese asteroid probe project. The Hayabusa project also received a "Space Pioneer Award" from the National Space Society of the United States at the International Space Development conference held in Los Angeles in May 2006.

The Planetary Data Systems (PDS) and Astromaterials Curation Projects provide funds for data archives, sample processing and storage facilities, and analysis tools needed to perform research. PDS is the active data archive for NASA's Planetary Science Theme. The Astromaterials Curation Facility, at Johnson Space Center, provides services for all returned planetary materials that do not require planetary protection laboratories.

Education and Directorate Management

The Education and Directorate Management projects include Science Mission Directorate-wide management reserve. It is used to support unforeseen administrative and programmatic requirements that cannot and/or should not be funded by other programs and projects.
Robotics Alliance Program (RAP) is a non-profit organization dedicated to increasing interest in science, technology, engineering and mathematics among youth in the United States. There are annual activities and events to expose students to challenging applications of engineering and science. The RAP competition consists of national contests in which high school students team with engineers from government, industry, and universities to get hands-on experience and mentoring from engineering and technical professionals.

Near Earth Object Observations

The Near Earth Object Observations (NEOO) program objective is to detect and track at least 90 percent of the Near Earth Objects, asteroids, and comets that come within 1.3 Astronomical Units of the Sun, and to find those to at least 140 meters in size which have any potential to collide with Earth and do significant damage at the surface. In the course of this effort many objects which present viable targets for both robotic and crewed exploration will be found and initially characterized. A significant increase in effort is planned for this program, in accordance with the findings and recommendations of the recent National Research Council study on the NEO hazard, issued January 2010. While it continues to fund the existing network of 1-meter class ground-based telescopes and supporting data processing and analysis infrastructure at the Minor Planet Center and JPL, it will seek to improve the current capability with upgrades and modifications to existing and planned ground and space-based observatory missions. With the additional funding of $16M, it will:
- Extend the collection, archive and analysis of small body data collected by NASA's WISE mission, and support increased follow-up and analysis of this data,
- Enable collection of NEO detection and characterization data by the USAF's Panoramic Survey Telescope and Rapid Reporting System (Pan-STARRS) and investigate the use of other USAF space surveillance assets for this mission,
- Support the continued operation of planetary radar capabilities at the NSF's Arecibo and NASA's Goldstone facilities,
- Begin the investigation of both ground and space-based concepts for increasing capacity to detect, track and characterize Potentially Hazardous Objects (PHOs) down to sizes 140 meters and below, and
- Determine the parameters necessary to understand the characteristics of PHO's important for determination of possible mitigation actions against a detected impact threat.

More information on NASA's NEO program is available at http://neo.jpl.nasa.gov/.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Release of Research Announcements soliciting R&A proposals (annual selections)	Research & Analysis (R&A)	Same
Meeting commitments to the International Partners as agreed to in the MOU.	Rosetta and Hayabusa	Same
Archive and release mission data to the science community within 6 months of downlink.	Planetary Data System (PDS)	Same
Store new samples of Astromaterials and distribute them as requests are approved by CAPTEM.	Astromaterials Curations	Same
Improve the search for hazardous NEOs, asteroids, and comets down to 140 meters in size that may pose an impact threat.	NEOO	Added elements for upgrading search and characterization of NEOs on NASA, NSF & AF assets.

Implementation Schedule

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

Project	Phase	Beg	End
R&A, PDS, Curation	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-68	Sep-23
Rosetta	Tech		
	Form		
	Dev		Mar-04
	Ops	Mar-04	Sep-17
	Res	Sep-08	Sep-17
Hayabusa	Tech		
	Form		
	Dev		May-03
	Ops	May-03	Sep-11
	Res	Jun-10	Sep-11
NEOO	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-07	Sep-23

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Planetary Science Research

Program Management

NASA HQ is responsible for R&A and Astromaterials Curation; JPL is responsible for Rosetta and Hayabusa operations and the NEOO Program Office; GSFC is responsible for PDS project management.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Research & Analysis	HQ	Multiple (NASA Centers, Universities, industries, etc.)	None
Rosetta	JPL	JPL	The European Space Agency (ESA) built the spacecraft, provided the launch vehicle, and operates the spacecraft.
Hayabusa (Muses -C)	JPL	JPL	Japan Aerospace Exploration Agency (JAXA) responsibilities include the spacecraft, launch vehicle, and operations.
Planetary Data System (PDS)	GSFC	JPL and other Discipline Nodes	None
Astromaterials Curation	HQs	JSC	NSF and Smithsonian Institution for Antarctic meteorites.
NEOO	HQs	JPL	None

Acquisition Strategy

The R&A FY 2011 budget will fund competitively selected activities from the ROSES-10 (Research Opportunities in Space and Earth Science) Omnibus NRA. All major acquisitions for Rosetta, Hayabusa, Planetary Data System (PDS), and Astromaterials Curation are in place. The following institutions operate the PDS nodes: Atmospheres Node (NMSU); Engineering Node (JPL); Geosciences Node (Wash U St. Louis); HiRISE Data Node (UAZ); Human Interface Design (ARC); Imaging Node (USGS Flagstaff); Navigation Ancillary Information Facility (NAIF at JPL); Planetary Plasma Interactions Node (UCLA); Radio Science (SETI); Rings Node (SETI); Small Bodies Node (U of MD); JPL, and ARC. NEOO data processing nodes are located at the Minor Planet Center (Cambridge, MA) and the Sentry high precision orbit determination node at JPL.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Panel of scientists	10/2009	Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) reviews ongoing curation activities and future plans. Curation of Genesis, Stardust, and Apollo lunar samples are on track and meeting distribution requests. The Curation Project is performing well overall. They reviewed and approved numerous samples for distribution to scientists and reviewed plans for the upgrade of JSC curation facilities and efforts to work with Constellation on curation of samples on the Moon.	03/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	69.1	103.6	136.6	136.4	131.7	109.7	110.5
Lunar Science	28.9	33.3	74.7	77.6	108.7	105.4	103.9
Lunar Atmosphere and Dust Environment Explorer	30.2	55.3	57.9	54.7	18.7	0.0	0.0
International Lunar Network	10.0	15.0	4.0	4.1	4.2	4.3	6.6
FY 2010 President's Budget Request	105.0	103.6	142.6	138.6	145.5	118.7	--
Lunar Science	64.8	33.3	52.4	58.5	64.3	39.4	--
Lunar Atmosphere and Dust Environment Explorer	30.2	66.5	73.9	31.1	0.0	0.0	--
International Lunar Network	10.0	3.7	16.3	48.9	81.2	79.3	--
Changes from FY 2010 Request	-35.9	0.1	-6.0	-2.1	-13.8	-8.9	--

Note: Concept studies and independent analysis of the ILN mulit-lander network mission demonstrated that costs greatly exceeded the budget originally envisioned for this effort. NASA will continue to fund concept studies led be the Marshall Space Flight Center to identify and mature technologies associated with small lunar landers. The science priorities specified in the upcoming Planetary Science Decadal Survey will determine whether the Lunar Quest Program should include a lunar lander mission. This will in turn determine whether these technology development efforts should continue.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

Program Overview

The Lunar Quest Program's (LQP) goal is to conduct science exploration of the Moon through research and analysis, and through the development of a series of small-medium satellite and possibly surface missions. The LQP answers the National Research Council report, "The Scientific Context for Exploration of the Moon" (SCEM) and fits within NASA's Space Exploration Policy to scientifically explore our Solar System. The LQP complements other lunar missions sponsored by NASA and international agencies. The goal of the LQP is to provide small robotic lunar science investigations and lunar research and analysis addressing prioritized science objectives. LQP objectives include:

-Provide opportunities to conduct lunar-focused science missions and research;
-Re-establish lunar science and a lunar science community;
-Facilitate the application of enhancing or enabling technologies to support flight missions; and
-Enhance science opportunities in the implementation of NASA's lunar exploration goals.

LQP is a loosely coupled and a multi-element science program which includes flight missions and research opportunities. Because of identified needs for future missions, it also is a cost-sharing partner with DOE for Plutonium restart infrastructure. Each LQP project will be independent, but they will also have interrelated objectives and a common management and funding structure. The LQP flight opportunities consist of small-medium robotic science spacecraft or landers. The Lunar Atmosphere and Dust Environment Explorer (LADEE), potentially an International Lander Network (ILN), if it is included in the Planetary Decadal Survey, and the Lunar Reconnaissance Orbiter (LRO) science mission are three LQP flight missions. LADEE is currently in formulation phase, with current planned launch date of January 2013. The ILN risk reduction activities are underway, while LRO is in the Exploration Mission operations phase (to be transferred to the LQP in September, 2010). The LQP also includes a Lunar Science Research and Analysis (R&A) element that will enhance participation and collaboration within the lunar science community. This science participation will provide near-term activity stimulating and reinvigorating the broad scientific community, and enticing international collaboration for mutual leverage in accomplishing lunar goals and objectives. Included in the FY 2011 budget request is funding to restart plutonium-238 (Pu-238) production which is an important requirement for future NASA missions.

Plans For FY 2011

Following a LADEE confirmation for Implementation Phase (KDP-C), the project will successfully complete CDR by the end of FY 2011.

Once successfully transferred from ESMD, the LRO Science Mission will operate and perform data analysis throughout FY 2011.

Release Research Announcement soliciting Research & Analysis proposals and make selections.

NASA will work with the Department of Energy (DOE) to define the roles and contributions of major users of Pu-238 in response to Congressional direction.

Project Descriptions and Explanation of Changes

Lunar Science

Lunar Research & Analysis (R&A) will enhance participation and collaboration within the lunar science community. It is composed of competed research and analysis opportunities such as: National Lunar Science Institute (NLSI) a virtual institute of geographically dispersed researchers and institutions, directed by the Ames Research Center for management and implementation; Lunar Advanced Science and Exploration Research (LASER) a lunar-only element in the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA) and; Lunar Data Competed Studies which analyze new and existing lunar science data procured under other ROSES elements.

In September 2010, ESMD will transfer Lunar Reconnaissance Orbiter (LRO) operational control and funding responsibility to SMD for a two year science mission. The LRO Science Mission will give the scientific community a unique opportunity to concentrate the capabilities of selected LRO instruments on focused lunar science investigations identified from the data obtained during the mapping phase of the mission. The focused investigations will allow us to further improve our understanding of the origin and evolution of the Moon.

The Lunar Science element of the Lunar Quest Program includes funds set aside for future priority decadal mission. These funds could be applied to the International Lunar Network (ILN), pending the recommendations from the Planetary Decadal, the results of which are expected in spring 2011.

Plutonium production is critical to maintaining NASA's ability to explore the solar system, and is an Administration priority. Therefore SMD will begin a jointly funded DOE-NASA effort to restart production capability. NASA will negotiate and work the Plutonium restart capability with DOE starting in FY 2011 until the capability is established.

Lunar Program Management provides management and oversight of the Lunar Quest selected flight missions. This line also provides for independent panel reviews and selection process efforts.

Lunar Atmosphere and Dust Environment Explorer (LADEE)

Currently in Phase B, LADEE, the first LQP mission, is a cooperative effort between Ames Research Center (ARC) and Goddard Space Flight Center (GSFC). The LADEE mission objective is to address high priority science goals as identified by the "The Scientific Context for Exploration of the Moon" (SCEM): to determine the global density, composition, and time variability of the fragile lunar atmosphere. LADEE's measurements will also determine the size, charge, and spatial distribution of electrostatically transported dust grains and assess their likely effects on lunar exploration and lunar-based astronomy. Additionally, LADEE will carry the optical laser communications package to be provided by the Space Operations Mission Directorate (SOMD). The optical laser will technically demonstrate high bandwidth communication from the Moon. NASA plans to launch LADEE in January 2013. The nominal science mission is 100 days in length. Additional detail can be found in the LADEE project formulation section of this document.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

International Lunar Network (ILN)

Concept studies and independent analysis of the ILN mulit-lander network mission demonstrated that costs greatly exceeded the budget originally envisioned for this effort. NASA will continue to fund concept studies led by the Marshall Space Flight Center to identify and mature technologies associated with small lunar landers. The science priorities specified in the upcoming Planetary Science Decadal Survey will determine whether the Lunar Quest Program should include a lunar lander mission. This will in turn determine whether these technology development efforts should continue.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Conduct scientific investigations to achieve SMD lunar science goals and objectives in the "Scientific Context for Exploration of the Moon" (SCEM, 2007).	Lunar Quest Program	Same

Implementation Schedule

Project	Schedule by Fiscal Year (Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23)	Phase	Beg	End
Research		Tech		
		Form		
		Dev		
		Ops		
		Res	Oct-08	Sep-23
Lunar Reconnaissance Orbiter (LRO) Science Mission		Tech		
		Form		
		Dev		
		Ops	Sep-10	Sep-12
		Res	Sep-10	Sep-13
Lunar Atmosphere and Dust Environment Explorer (LADEE)		Tech		
		Form	Mar-08	Sep-10
		Dev	Sep-10	Jan-13
		Ops	Feb-13	Sep-13
		Res		
Plutonium		Tech	Oct-10	Sep-23
		Form		
		Dev		
		Ops		
		Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

Program Management

Scientific mission priorities and assignment responsibilities reside with SMD. MSFC has Lunar Quest Program management responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Research & Analysis	HQ	ARC, GSFC, MSFC, JPL, JSC	N/A
LRO Science Mission	GSFC	GSFC	N/A
LADEE	ARC	ARC, GSFC, HQ/USAF	N/A
Future Decadal Priority	MSFC	TBD	TBD
Plutonium	HQ		DOE

Acquisition Strategy

The LQP acquisition strategy is to direct development of flight projects including the spacecraft bus to NASA centers, competitively select instruments and science team participation through the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA) and the Stand Alone Missions of Opportunity (SALMON) AO processes.

Major acquisitions for the LADEE, the Lunar Surface Science Mission and the LRO science missions are in place. NASA has selected ARC and GSFC to provide the spacecraft for LADEE. Three science instruments have been selected for LADEE: Neutral Mass Spectrometer (NMS), UV Spectrometer (UVS), and Lunar Dust EXperiment (LDEX). The NMS instrument will be provided by GSFC; ARC will provide UVS; and the University of Colorado/LASP will provide LDEX. MIT/LL and GSFC to provide the SOMD LLCD contribution.

GSFC will continue to operate the LRO science mission.

Science instruments and research and analysis of existing and new lunar science data are to be procured under the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA). Missions of opportunity (MO) are to be selected via the Stand Alone Missions of Opportunity (SALMON) AO.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	12/2009	Standing Review Board (SRB) will be assigned to first perform a Program Acceptance Review (PAR) assessing the Program's readiness to enter implementation. Following approval to enter implementation, the SRB will thereafter conduct biannual Program Implementation Reviews (PIRs) throughout implementation to assure the program is operating according to the program plan and that it is successfully meeting program objectives.	02/2012

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**30.2**	**55.3**	**57.9**	**54.7**	**18.7**	**0.0**	**0.0**
Total Change from 2010 President's Budget Request	**30.2**	**55.3**	**57.9**	**54.7**	**18.7**	**0.0**	**--**

Note: The cost estimate does not include Lunar Laser Communication Demonstration (LLCD), which is a payload of opportunity funded by the Space Operations Mission Directorate, but not part of the baseline LADEE science mission.

Project Purpose

LADEE, the first mission developed within the Lunar Quest Program, is a cooperative effort between Ames Research Center and Goddard Space Flight Center. The LADEE mission objective is to address high-priority science goals, as identified by the NRC, to determine the global density, composition, and time variability of the fragile lunar atmosphere. LADEE's measurements also will determine the size, charge, and spatial distribution of electrostatically transported dust grains. Additionally, LADEE will carry an optical laser communications demonstrator to be provided by SOMD. The optical laser will technically demonstrate high-bandwidth communication from Lunar orbit.

Project Preliminary Parameters

LADEE spacecraft design is based on a reusable common bus concept, and will be the first space craft based on this bus design. The space craft is a small Class III, Enhanced Class D Orbiter.

Estimated Project Deliverables

The spacecraft is planned for launch in January 2013, into a near circular, lunar equatorial orbit at approximately 50 km. Science operations are planned for 100 days. An extended mission will not be possible under the current plans. In order to maintain orbit, all delta V will be utilized for science data collection, and the mission will be terminated into the lunar surface within three days of completing operations.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	NASA ARC	Small S/C based on reusable design	N/A	New
Integrated Payload	NASA GSFC	3 science Instruments (UVS, NMS, LDEX)	N/A	New
Launch Vehicle	USAF	Medium Class ELV	N/A	New

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

Estimated Project Schedule

The Science Mission Directorate announced the LADEE project in April 2008 and assigned leadership of the mission to the Ames Research Center (ARC). Project confirmation to proceed into development phase is currently planned for Oct-Nov 2010.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
KDP-C	TBD	n/a	November 2010
LRD	TBD	n/a	January 2013

Project Management

LADEE is part of the Lunar Quest Program (LQP) managed by Marshall Space Flight Center. Space Operations Mission Directorate (SOMD) is providing LLCD, a payload of opportunity, and the funding for this payload.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Project Management	Overall, day-to-day mgt	ARC	N/A
Spacecraft	Design, build and deliver the spacecraft	ARC	N/A
Neutral Mass Spectrometer (NMS) Instrument	Design, build and deliver the NMS instrument. Also responsible for integrating of LDEX and UVS.	GSFC	N/A
UV Spectrometer (UVS) Instrument	Design, build, and deliver	ARC	N/A
Lunar Dust EXperiment (LDEX) Instrument	Design, build, and deliver	University of Colorado, LASP	N/A
Launch Vehicle	Integrate vehicle and provide launch service	TBD	N/A

Acquisition Strategy

Except for launch vehcile, all major acquisitions are in place. The Spacecraft bus was directed to Ames Research Center (ARC) in partnership with Goddard Space Flight Center (GSFC). The Neutral Mass Spectrometer (NMS) was assigned to GSFC and the UV Spectrometer (UVS) was assigned to ARC. The Lunar Dust Experiment (LDEX) was competitively selected through Stand Alone Missions of Opportunity Notice (SALMON) and awarded to the University of Colorado/LASP.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	07/2009	Passed Systems Requirements Review, Mission Definition Review, and Preliminary Non-advocate Review.	04/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
S/C design outgrows mass margin allocation	If: additional structural enhancements, power or alternative propulsion options are baselined, Then: the S/C design may outgrow launch vehicle performance.	Mitigate through spacecraft design planning, including management of margins and contingencies per LADEE System Engineering Master Plan, carefully watch launch vehicle performance margins.
Component Vendors Acceptance Testing	If: the as-delivered spacecraft components have gaps in their acceptance level test programs compared to Ames Procedural Requirement 8070.2 requirements, Then: there is a possibility of cost and schedule impacts in order to fully meet components-level acceptance test requirements.	Scope the acceptance test gaps and plan whether to add to existing contracts, test in-house or at a third-party facility. Possibly perform tests at subsystem level. Bring a dedicated procurement officer onto LADEE.
Qualification of Propulsion System	If: the propulsion system for LADEE was qualified for different operating conditions Then: there is the possibility that re-qualification will incur substantial cost and schedule impacts.	Mitigate by early proactive costs control associated with qual testing, facilities, and seeking partners to share the facilities and other cost burden.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	234.8	209.2	202.0	216.8	235.9	263.0	312.9
Gravity Recovery and Interior Laboratory (GRAIL)	152.9	124.1	104.8	41.4	4.7	0.0	0.0
Other Missions and Data Analysis	81.9	85.1	97.2	175.4	231.2	263.0	312.9
FY 2010 President's Budget Request	247.0	213.2	234.6	256.8	256.5	264.3	--
Gravity Recovery and Interior Laboratory (GRAIL)	122.4	124.1	104.8	41.4	4.7	0.0	--
Other Missions and Data Analysis	124.6	89.1	129.9	215.4	251.8	264.3	--
Changes from FY 2010 Request	-12.2	-4.0	-32.7	-40.1	-20.6	-1.2	--

Program Overview

Robotic space exploration holds tremendous opportunity for exploration and discovery. Even with the vast amount of knowledge gained since exploration of the solar system began, there are many unanswered questions about the origin and evolution of our own solar system. NASA's Discovery Program provides relatively frequent opportunities to utilize innovative missions to uncover the mysteries of the solar system. It provides highly-focused planetary science investigations designed to increase our understanding of the solar system and its evolution. The Discovery Program offers the scientific community the opportunity to assemble and lead cross-functional teams to design and implement exciting science investigations that complement NASA's larger planetary science missions.

All completed Discovery missions (NEAR, Mars Pathfinder, Lunar Prospector, Deep Impact, Stardust, Genesis, and Moon Mineralogy Mapper) have achieved groundbreaking science, with each taking a unique approach to space exploration. Current Discovery missions include: MESSENGER, Dawn, ASPERA-3, Extrasolar Planet Observations and Characterization (EPOCh), Deep Impact eXtended Investigation (DIXI), StardustNExT, Exospheric Sampling of Mercury's Surface Composition (Strofio), Lander Radio-science on ExoMars (LaRa), and the Gravity Recovery and Interior Laboratory (GRAIL). Additional details on the GRAIL mission are contained in the GRAIL "Project in Development" pages.

For more information regarding the Discovery Program, see http:/discovery.nasa.gov.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Plans For FY 2011

The MESSENGER spacecraft completed its third flyby of Mercury September 2009 and has made preparations for its Mercury orbit insertion in March 2011.

The Dawn spacecraft will encounter and orbit Vesta for about ten months starting in May 2011.

ASPERA-3 continues to collect data on its extended mission of Mars Express.

The DIXI mission will approach and accomplish the encounter of its target, comet Hartley 2, in November 2010.

The repurposed Stardust NExT mission will approach and accomplish the re-encounter with comet Tempel 1 in February 2011 to detect any changes since the July 2005 Deep Impact mission.

GRAIL has completed its Critical Design Review and begun Assembly, Test, and Launch Operations (ATLO) in preparation for launch scheduled in September 2011.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Project Descriptions and Explanation of Changes

GRAIL

GRAIL continues its development phase. GRAIL will perform high-quality gravity field mapping of the Moon to determine its interior structure. GRAIL will provide the most accurate global gravity field to date for any planet, including Earth. GRAIL will enable the public to directly interact with observations through cameras on each satellite dedicated to public outreach and education. GRAIL was selected in December 2007 and given approval to proceed into its Development Phase (Phase C) in January 28, 2009. GRAIL is currently scheduled to launch in September 2011. Additional detail can be found in the GRAIL development section of this document.

Other Missions and Data Analysis

The Dawn mission, now in its cruise operation phase, has begun a journey to the two largest and most massive asteroids in our solar system, Vesta and Ceres. Vesta's physical characteristics reflect those of the inner planets, whereas Ceres' are more like the icy moons of the outer planets. By studying these contrasts and comparing these two minor planets, scientists will develop an understanding of the transition from the rocky inner regions to the icy outer regions of the Solar System. The Dawn mission marks the first time a spacecraft will orbit a body in the main asteroid belt and the first time a spacecraft will orbit two sequential targets, enabling a detailed and intensive study of both. Dawn launched in September 2007. The Dawn spacecraft will encounter and orbit Vesta for about ten months starting in FY 2011, then travel an additional three years to reach and orbit Ceres.

MESSENGER, a mission to orbit Mercury, launched on August 3, 2004 and is in its cruise operations phase. During the three Mercury flybys that prepare the spacecraft for orbit insertion, it has collected images that provide coverage of all but 2% of the planet and collected detailed information on its geologic history, the nature of its thin atmosphere and very active magnetosphere. MESSENGER carries seven scientific instruments and a radio science experiment to accomplish an ambitious objective: return for the first time comprehensive data from Mercury orbit. The miniaturized payload, designed to work in the extreme environment near the Sun, will image all of Mercury for the first time, as well as gather data on the composition and structure of Mercury's crust, its geologic history, the nature of its active magnetosphere and thin atmosphere, and the makeup of its core and the materials near its poles.

As a result of three 2006 Discovery missions of opportunity selected on June 19, 2007, Deep Impact and Stardust spacecraft, both in extended operations phase, have been repurposed for new science missions. The EPOCh mission has used the high-resolution imager on the Deep Impact spacecraft to search for Earth-sized planets around other stars. The DIXI mission will investigate comets using the existing Deep Impact spacecraft for an extended flyby mission to a second comet, Hartley 2, to take pictures of its nucleus and increase understanding of the diversity of comets. These two missions were combined in a joint mission called EPOXI. The Stardust NExT will use the existing Stardust spacecraft for another flyby of comet Tempel 1 to evaluate possible surface erosion since the last flyby in FY 2005.

ASPERA-3, a Mission of Opportunity, is in a second extension of its operational phase. It is one of seven instruments aboard the European Space Agency's Mars Express spacecraft in orbit around Mars, with a goal to study the interaction of the solar wind and Martian atmosphere. The measurements taken by this instrument will help answer the question of how strongly the interplanetary plasma and electromagnetic fields affect the Martian atmosphere.

The M3 Project was part of the scientific payload for ISRO's Chandrayaan-1 mission which launched October 2008 from India, whose operations were terminated in Aug 2009. Primary objectives of M3 are to assess the mineral resources of the Moon, and characterize and map the composition of the surface at high spatial resolution. The M3 science team will be processing the data collected during the shortened mission through CY 2011.

Other Missions & Data Analysis (Continued)

Two new Missions of Opportunity have been selected for the Discovery Program, Strofio: Exospheric Sample of Mercury's Surface Composition, and LaRa: Lander Radio-science on ExoMars. Strofio, in its development phase, will be part of the ESA mission BepiColombo. Strofio will provide valuable information about Mercury's exosphere and its interaction with the magnetosphere and surface. LaRa, currently in a formulation phase, is an instrument that will provide quantitative improvement of several constraints on the structure and state of the interior of Mars. Negotiation is underway where LaRa is to be included as a science instrument in one of the joint NASA/ESA Mars missions.

The Discovery Research line provides funding for: Planetary Mission Data Analysis Program (PMDAP) on archived data collected on Discovery missions; Laboratory Analysis of Returned Samples (LARS) which supports development of new instruments for use in terrestrial laboratories to analyze samples returned from NASA Planetary Science missions; and participating scientists for the MESSENGER and Dawn missions. As stated in the ROSES NRA, the PMDAP is "...to enhance the scientific return of the completed Discovery missions by broadening the science participation in the analysis of data collected and samples returned ...." Specifically, the PMDAP allows scientists not previously associated with Discovery missions an opportunity to perform data analysis of the data archived in the Planetary Data System. Data access through Discovery Research allows a much broader, and perhaps more objective analysis of the data and samples, and also allows research to continue for many years after the mission has been completed. Areas for additional data analyses are proposed by scientists throughout the U.S. planetary community and are competitively selected with major input from science community peer review.

The Discovery Future line provides funds for future Discovery flight missions to be selected via a competitive Announcement of Opportunity (AO) process. The Discovery 2010 AO process will likely result in selection of a new mission by the end of 2011. The Planetary Science Division will continue to work with the Exploration Mission Directorate as their new Exploration Precursor Robotic Program is defined to coordinate and optimize the science return as appropriate.

Discovery Program Management provides for the management of the Discovery selected flight missions. This line also provides for the development of Announcements of Opportunity (AOs), supports independent panel reviews, and the mission selection process.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Launch an average of one mission per 24 months .	Discovery Program	Same
Complete current prime and funded extended operating missions.	Dawn, MESSENGER, ASPERA-3, EPOXI, M3, and StardustNExT	Same
Complete design and begin spacecraft or instrument development and assembly	GRAIL, Strofio, LaRA	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Implementation Schedule

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

Project	Phase	Beg	End
MESSENGER	Tech		
	Form	Jul-99	Jun-01
	Dev	Jun-01	Aug-04
	Ops	Aug-04	Mar-13
	Res		
ASPERA-3	Tech		
	Form		
	Dev	Sep-00	Jun-03
	Ops	Jun-03	May-11
	Res		
Dawn	Tech		
	Form	Dec-01	
	Dev	Feb-04	Sep-07
	Ops	Sep-07	Nov-15
	Res		
Moon Mineralogy Mapper (M3)	Tech		
	Form	Mar-05	Feb-06
	Dev	Mar-06	Mar-08
	Ops	Mar-08	Aug-09
	Res	Aug-09	Dec-11
EPOXI	Tech		
	Form		
	Dev		
	Ops	Jun-07	Oct-11
	Res		
Stardust NExT	Tech		
	Form		
	Dev		
	Ops	Jun-07	Feb-11
	Res		
GRAIL	Tech		
	Form	Oct-07	Mar-09
	Dev	Mar-09	Sep-11
	Ops	Oct-11	Jul-12
	Res		
Strofio	Tech		
	Form	May-09	Jul-10
	Dev	Jul-10	Sep-14
	Ops	Sep-14	Aug-20
	Res		
LaRa	Tech		
	Form	Oct-09	Oct-13
	Dev	Oct-13	Mar-16
	Ops	Mar-16	Oct-19
	Res		
Discovery Management	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-99	Sep-23
Discovery Research	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-99	Sep-23

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Program Management

MSFC is responsible for Discovery program management. Scientific mission priorities and assignment of responsibilities reside with the Science Mission Directorate.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
MESSENGER	Applied Physics Laboratory (APL)	GSFC, JPL	None
ASPERA-3	South West Research (SwRI)	MSFC	Sweden; European Space Agency (ESA).
Dawn	JPL	JPL	German Aerospace Center (DLR); Los Alamos National Labs (LANL); Italian Space Agency; and Max-Planck.
M3	JPL	JPL	ISRO Chandrayan spacecraft. USGS.
EPOXI	JPL	JPL	Max-Planck-Institute in Garsching, Germany
Stardust-NExT (Stardust-New Exploration of Tempel)	JPL	JPL	None
GRAIL	JPL	GSFC, JPL, KSC	None
Strofio	SwRI	GSFC	European Space Agency (ESA) BepiColombo Spacecraft.
LaRa	JPL	JPL	European Space Agency (ESA)

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Acquisition Strategy

The Discovery Program solicits proposals for full planetary missions and missions of opportunity. The proposals are put together by teams led by a PI which may include firms, small businesses, government and universities. The initial phase of each competitive selection is a concept study, and several missions and missions of opportunity are generally selected for this phase. At the completion of the study phase, one or more concepts may be selected for development, based on their continued scientific merit, technical, management and cost viability, and the availability of funding.

With the exception of future NASA Announcements of Opportunity, all major acquisitions are in place.

Southwest Research Institute employs the Principal Investigator and Lead Scientist for ASPERA-3 and Strofio.

The University of California at Los Angeles sponsors the Principal Investigator and Lead Scientist for the Dawn mission.
Brown University sponsors the Principal Investigator and Lead Scientist for M3. SAIC, University of Hawaii, and University of Tennessee are also participants.

The Department of Terrestrial Magnetism at the Carnegie Institution of Washington employs the Principal Investigator and Lead Scientist for MESSENGER.

The University of Maryland employs the Principal Investigator for the EPOXI Mission of Opportunity, the combined EPOCh and DIXI missions.
Cornell University employs the Principal Investigator for the Stardust New Exploration of Tempel 1 (NExT) Mission of Opportunity.
The Massachusetts Institute of Technology (MIT) employs the Principal Investigator and leads the GRAIL mission.

Jet Propulsion Laboratory, California Institute of Technology employs the Principal Investigator for the LaRA Mission of Opportunity.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2008	Verified compliance with Agency requirements for program implementation and alignment with Agency strategic goals and objectives. The Discovery Program provides effective technical and schedule analysis support to the projects and continues to actively use risk-based insight as part of its oversight of the projects. The AO process has proven to be a well-defined, disciplined process that is viewed by the science community as fair and effective.	10/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**68.3**	**152.9**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**0.0**	**0.0**	**496.2**
Formulation	28.2	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.5
Development / Implementation	40.1	130.6	124.1	104.5	27.7	0.0	0.0	0.0	0.0	427.0
Operations / Close-out	0.0	0.0	0.0	0.3	13.7	4.7	0.0	0.0	0.0	18.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
FY 2010 President's Budget Request	**68.3**	**122.4**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**--**	**0.0**	**465.6**
Formulation	28.2	22.3	0.0	0.0	0.0	0.0	0.0	--	0.0	50.5
Development / Implementation	40.1	100.1	124.1	104.5	27.7	0.0	0.0	--	0.0	396.5
Operations / Close-out	0.0	0.0	0.0	0.3	13.7	4.7	0.0	--	0.0	18.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1
Changes from FY 2010 Request	**0.0**	**30.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**--**	**0.0**	**30.6**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	30.5	0.0	0.0	0.0	0.0	0.0	--	0.0	30.5
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1

Explanation of Project Changes

NASA confirmed GRAIL to proceed into implementation phase (KDP-C or Phase C/D) on January 28, 2009. GRAIL approved baseline development ($427M) and the LCC ($496.2M) numbers remain unchanged since KDP-C.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Project Purpose

GRAIL was selected in December 2007 under the 2006 Discovery Announcement of Opportunity. The overarching scientific goal of the GRAIL mission is to determine the structure of the lunar interior from crust to core. The GRAIL mission will also advance our understanding of the thermal evolution of the Moon and extend our knowledge gained from the Moon to the other terrestrial-type planets.

GRAIL has six lunar science objectives: map the structure of the crust and lithosphere; study the moon's asymmetric thermal evolution; determine the subsurface structure of impact basins and the origin and of masons (i.e., high-gravity areas); study the temporal evolution of crustal brecciation and magmatism; study affect on the structure of the deep lunar interior from lunar tides; and understand the size of the possible lunar inner core.

Project Parameters

GRAIL will achieve its science objectives by placing twin spacecraft in a nearly circular low altitude (50 km) polar orbit. The two spacecraft will perform high-precision range-rate measurements between them. Analysis of changes in the spacecraft-to-spacecraft range-rate data caused by gravitational differences will provide direct and high-precision measurements of the lunar gravity. GRAIL will ultimately provide a global, high-accuracy (<10 mGal), high-resolution (30 km) gravity map of the moon. The instrument is based on the successful Earth orbiting Gravity Recovery and Climate Experiment (GRACE) mission.

Project Commitments

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Flight System	Lockheed Martin	2 spacecraft with s/c separation of 175-225 km, conducting 90-day science phase	Same	Same
Lunar Gravity Ranging System	JPL	Ka-band ranging system determines the precise instantaneous relative range-rate of the two s/c	Same	Same
E/PO MoonKam	Sally Ride Science (SRS)	Taking images of the moon, the data will enrich the middle school space science curriculum	Same	Same
Launch Vehicle	ULA	CLIN23 - Delta II Heavy	Same	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Schedule Commitments

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Development (Phase C/D or KDP-C)	January 28, 2009	Same	Same
Critical Design Review (CDR)	November 2009	Same	Same
System Integration Review (formerly ATLO)	July 2010	Same	June 2010
Launch Readiness Review	September 2011	Same	Same
End of Prime Mission	June 2012	same	same

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Gravity Recovery and Interior Laboratory	2009	427.0	2010	427.0	0	Launch Readiness	09/2011	09/2011	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**427.0**	**427.0**	**0.0**
Payload	18.1	19.8	1.7
Spacecraft	133.3	141.5	8.2
Ground System	12.3	12.3	0.0
Science	10.8	10.8	0.0
Launch Vehicle	152.8	152.8	0.0
Other	99.7	89.8	-9.9

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Project Management

The Gravity Recovery and Interior Laboratory Project is part of the Discovery Program managed by Marshall Space Flight Center. The Principal Investigator from Massachusetts Institute of Technology has delegated day-to-day project management to JPL.

Acquisition Strategy

GRAIL was selected competitively in December 13, 2007 under a Discovery Program Announcement of Opportunity (AO-NNH06ZDA001O).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2008	Assess cost, schedule, and risk status of project. Findings for the review showed that cost and schedule for the 2011 launch are consistent with the project's plans.	10/2010
Performance	SRB	11/2009	The Critical Design Review was held to assess cost, schedule, and risk status of the project. The findings for the review showed that cost and schedule for the 2011 launch are consistent with the project's plans.	05/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Vehicle	Delta II launch rate is very low in CY 2010 and 2011. The USAF has stopped flying Delta II, and the last launch of the Delta II is currently planned for GRAIL, late in 2011.	ULA is committed to ensuring that the Delta II will be ready and continued insight/oversight with KSC.
Single String Spacecraft	Both GRAIL spacecraft are largely single string.	The single string risks are mitigated by use of proven designs, high reliability parts, and additional testing of critical systems, consistent with the cost and schedule constraints of the project.
Reaction Wheel	Light weight Reaction Wheel (RW) is a new development.	If the light weight reaction wheel development falls behind schedule, the project will revert back to an existing RW. The reaction wheel is currently scheduled for a delivery date of June 2010, 2 months before the need date for the start of ATLO.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	279.0	264.1	223.8	229.5	237.9	247.7	258.5
Juno	260.1	237.2	184.2	46.4	17.8	18.1	16.8
Other Missions and Data Analysis	19.0	26.9	39.6	183.1	220.1	229.6	241.6
FY 2010 President's Budget Request	263.9	264.1	239.9	294.2	239.8	249.6	--
Juno	245.0	237.2	174.2	71.4	17.8	18.1	--
Other Missions and Data Analysis	19.0	26.9	65.7	222.8	222.0	231.5	--
Changes from FY 2010 Request	15.1	0.0	-16.0	-64.7	-1.8	-1.9	--

Program Overview

The New Frontiers Program, comprised of medium to large-sized missions, constitutes a critical element of NASA's solar system exploration capability. NRC-recommended science targets for the New Frontiers Program include Pluto and the Kuiper Belt, Jupiter, Venus, Network Science, Io, Ganymede, Trojan/Centaurs, and sample returns from Earth's Moon, an asteroid, and a comet nucleus. The program accomplishes high-quality planetary science investigations using efficient management approaches. The program's prime objectives are to enhance our understanding of the solar system as it is today and of the solar system's formation and evolution.

The New Horizons mission to Pluto is the first peer-review selected mission of the New Frontiers Program. It will conduct reconnaissance of Pluto and its moons Charon, Nixa, and Hydra. New Horizons is currently on its way to its primary target, Pluto. The second New Frontiers mission currently under development is Juno with the overarching scientific goal to understand the origin and evolution of Jupiter and planetary formation. The third New Frontiers AO was released in April 2009. Three mission concept studies were awarded on December 29, 2009. Selection of the final mission is expected by the end of FY 2011, allowing the New Frontiers 3 mission to proceed into Phase B or an extended Phase A.

For more information on the New Frontiers Program, see http://newfrontiers.nasa.gov/index.html.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Plans For FY 2011

The Juno Mission continues its development phase. All Juno mission hardware will be fully tested and be delivered to Cape Canaveral in preparation for a launch in August 2011.

The New Horizons spacecraft remains on track for a July 2015 arrival. The project will continue its cruise period throughout FY 2011; work during the cruise period will include annual spacecraft and instrument checkouts and dress rehearsals for the Pluto fly-by.

The third New Frontiers AO was released in April 2009. Selection of New Frontiers 3 proposals for funded mission Phase A concept studies occurred on December 29, 2009.   Down-selection of one mission to proceed to the subsequent phases is expected in third quarter to late FY 2011.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Project Descriptions and Explanation of Changes

Juno

Juno, now in its development phase, is a mission to Jupiter scheduled to launch in August 2011.The Juno science goals are to: determine the oxygen to hydrogen ratio to determine water abundance and estimate core mass in order to decide among alternative theories of planetary origin; understand Jupiter's interior structure and dynamic properties, including internal convection and the size and mass of its core, through mapping of its gravitational and magnetic fields with unprecedented accuracy; map variations in atmospheric composition, temperature, cloud opacity and dynamics to depths greater than 100 bars at all latitudes; and characterize and explore the three-dimensional structure of Jupiter's polar magnetosphere and auroras. Juno uses a simple, spin-stabilized spacecraft in an elliptical polar orbit that minimizes radiation exposure by flying under Jupiter's radiation belts at perijove and outside them at apojove. Juno's baseline orbit remains continuously in sunlight, resulting in benign and stable thermal conditions. Spin stability eliminates complex, power-hungry attitude control components such as reaction wheels. Additional detail can be found in the Juno Project development section of this document and at http://newfrontiers.nasa.gov/missions_juno.html.

Other Missions and Data Analysis

The New Frontiers Future Project provides funds for future New Frontiers space missions to be selected via a competitive Announcement of Opportunity process. The Third Announcement of Opportunity (NF-3) was released for competition in April 2009. The science targets for this NF-3 AO are those identified in the NRC report Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity (NRC, 2008). Three mission concept studies were awarded on December 29, 2009. These concept missions would probe the atmosphere and crust of Venus; return a piece of a near-Earth asteroid for analysis; or drop a robotic lander into a basin at the moon's south pole to return lunar rocks back to Earth for study. The studies begin during 2010 for 12 months, and the selected mission must be ready for launch no later than Dec. 30, 2018. Mission cost, excluding the launch vehicle, is limited to $650M FY 2009 fixed year dollars. Downselection, to one mission, is currently planned for third quarter to late FY 2011.

The New Frontiers Research line provides for the Jupiter Data Analysis Project (JDAP), which broadens the science community participation in the analysis of mission data, and allows scientists outside the selected flight team to analyze the data from the mission, do research, and publish their findings. Data access through the New Frontiers Research project allows a much broader, and perhaps more objective analysis of data and samples. JDAP also facilitates new ideas and approaches, getting young people started in science, and broadening participation to get a critical mass of scientific talent working on mission data at the critical time.

On January 19, 2006, the New Horizons mission successfully launched on an Atlas V launch vehicle. New Horizons will reach Pluto and its moon, Charon, in July 2015. New Horizons will conduct a reconnaissance of the Pluto-Charon system, mapping their surface composition and surface temperatures, characterizing their geology, characterizing the atmosphere of Pluto, searching for any atmosphere around Charon, and searching for rings and additional satellites around Pluto, including the recently discovered Nixa and Hydra.

New Frontiers Program Management supports the development of Announcements of Opportunity (AOs), assessments for new missions, and independent management reviews.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Launch an average of one mission per 52 months	New Frontiers Program	Same

Implementation Schedule

Project	Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	Phase	Beg	End
New Horizons		Tech		
		Form	Nov-01	Mar-03
		Dev	Mar-03	Jan-06
		Ops	Jan-06	Sep-17
		Res		
Juno		Tech		
		Form	Jul-04	Aug-08
		Dev	Aug-08	Aug-11
		Ops	Aug-11	Aug-18
		Res		
New Frontiers Research		Tech		
		Form		
		Dev		
		Ops		
		Res	Oct-08	Sep-23

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The Science Mission Directorate assigns scientific mission priorities and program responsibilities. MSFC has New Frontiers program management responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
New Horizons	MSFC	GSFC, JPL	None
Juno	MSFC	JPL, KSC, GSFC	Italian Space Agency (ASI)
New Frontiers Research	HQ	Multi-Center	None

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Acquisition Strategy

Future acquisitions of New Frontiers missions occur under open Announcement of Opportunity (AO) competitions. The New Frontiers Program solicits proposals for an entire mission (including instruments), put together by teams led by a Principal Investigator and comprised of people from industry, small businesses, government, and academia.

Major acquisitions for the New Horizons (APL) and Juno (JPL) projects are in place. The Principal Investigator for New Horizons is at SouthWest Research Institute, Boulder, CO. Johns Hopkins University/Applied Physics Laboratory has project management responsibility.

The Juno Principal Investigator is from the SouthWest Research Institute, San Antonio. Jet Propulsion Laboratory provides mission project management and Lockheed Martin Space Systems is building the spacecraft. The Italian Space Agency, ASI, is contributing the Ka-band Translator and Infrared Spectrometer instrument.

New Frontiers Research will be competitively selected from proposals received in response to the ROSES NRA.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2007	Verified compliance with Agency requirements for program implementation and alignment with Agency strategic goals and objectives. The New Frontiers Program provides effective technical and schedule analysis support to the projects and continues to actively use risk-based insight as part of its oversight of the projects. The AO process has proven to be a well-defined, disciplined process that is viewed by the science community as fair and effective.	06/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**225.9**	**260.1**	**237.2**	**184.2**	**46.4**	**17.8**	**18.1**	**16.8**	**85.6**	**1,092.0**
Formulation	186.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	186.3
Development / Implementation	39.6	260.1	237.2	168.5	22.0	0.0	0.0	0.0	0.0	727.4
Operations / Close-out	0.0	0.0	0.0	15.7	24.4	17.8	18.1	16.8	85.6	178.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
FY 2010 President's Budget Request	**225.9**	**245.0**	**237.2**	**174.2**	**71.4**	**17.8**	**18.1**	**--**	**102.4**	**1,091.9**
Formulation	186.3	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	186.3
Development / Implementation	39.6	245.0	237.2	158.5	46.9	0.0	0.0	--	0.0	727.2
Operations / Close-out	0.0	0.0	0.0	15.7	24.5	17.8	18.1	--	102.4	178.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1
Changes from FY 2010 Request	**0.0**	**15.1**	**0.0**	**10.0**	**-25.0**	**0.0**	**0.0**	**--**	**-16.8**	**0.1**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	15.1	0.0	10.0	-24.9	0.0	0.0	--	0.0	0.2
Operations / Close-out	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	--	-16.8	-0.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--

Note: The FY 2011 LCC number in the table above is understated by $15M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, both the lifecycle and development cost estimates will remain unchanged; the lifecycle cost will remain at $1107M, and the development cost will remain at $742.3M.

Explanation of Project Changes

The funding profile has been modified consistent with NASA risk management plan and strategy. There are no changes to the Juno approved development ($742.3M) nor the LCC ($1107M) baselines since KDP-C.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Purpose

NASA selected Juno on July 15, 2005, under the New Frontiers Announcement of Opportunity. The overarching scientific goal of the Juno mission is to improve our understanding of the origin and evolution of Jupiter. However, as the archetype of giant planets, Jupiter can also provide knowledge that will improve our understanding of both the origin of our solar system and of planetary systems being discovered around other stars. The investigation focuses on the four science objectives:

Origin: Determine the oxygen-to-hydrogen ratio to determine water abundance and estimate core mass to decide among alternative theories of planetary origin.

Interior: Understand Jupiter's interior structure and dynamic properties through mapping of its gravitational and magnetic fields with unprecedented accuracy, leading to observations of internal convection and the size and mass of its core.

Atmosphere: Map variations in atmospheric composition, temperature, and cloud opacity and dynamics, to depths greater than 100 bars, at all latitudes.

Magnetosphere: Characterize and explore the three-dimensional structure of Jupiter's polar magnetosphere and auroras.

These objectives have been rated very highly in the National Academy of Sciences' Solar System Exploration Decadal Survey and Sun-Earth Connections Decadal Survey. The Astrophysics Decadal Survey identified the study of star formation, their planetary systems, as well as giant and terrestrial planet birth and evolution as high priority. Juno fulfills key goals outlined in recent NASA and NRC studies.

Project Parameters

Juno achieves the science objectives by using a simple spinning, solar-powered spacecraft to make global maps of the gravity, magnetic fields, and atmospheric composition of Jupiter from a unique elliptical polar orbit with a close perijove. The spacecraft carries precise, high-sensitivity radiometers, magnetometers, and gravity science systems. Juno's 32 orbits extensively sample Jupiter's full range of latitudes and longitudes. From its polar perspective Juno combines in-situ and remote sensing observations to explore the polar magnetosphere and determine what drives Jupiter's remarkable auroras.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Commitments

The Juno launch date is August 2011. After a five-year cruise to Jupiter, Juno will enter Jupiter Orbit Insertion (JOI) during October 2016. Juno will perform one year of science operations.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Waves	University of Iowa	Measures radio and plasma emissions; 4 m elec. dipole and search coil	Same	Same
Jupiter Energetic particle Detector Instrument (JEDI)	John Hopkins Applied Physics Lab (APL)	Measures auroral distributions of electrons and ions; TOF vs. energy, ion & electron sensors	Same	Same
Gravity Science	Jet Propulsion Lab (JPL)	Maps Jupiter's gravitational field to determine structure of core; X & Ka-band precision Doppler	Same	Same
Flux-Gate Magnetometer (FGM)	GSFC	Maps Jupiter's Magnetic Field (Vector)	Same	Same
Launch Vehicle	KSC	C3 = 32.0 km2/s2, Capability=3545 kg	Same	Same
UV Spectrometer (UVS)	Southwest Research Institute (SwRI)	FUV spectral imager for auroral emissions	Same	Same
Microwave Radiometer (MWR)	Jet Propulsion Lab (JPL)	6 wavelengths (1.3-50 cm); sounds atmosphere to determine water and ammonia abundances	Same	Same
Spacecraft	Lockheed Martin	Solar-powered, spin-stabilized spacecraft in an elliptical polar orbit that minimizes radiation exposure	Same	Same
Jovian Auroral Distributions Experiment (JADE)	Southwest Research Institute (SwRI)	Ion mass spectrometer & electron analyzers; measures auroral distributions of electrons and ions	Same	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Schedule Commitments

Formulation started at project selection in July 2005. Juno proceeded into the implementation phase on August 5, 2008.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Formulation			
PDR	5/2008	same	same
ATLO Readiness	3/2010	same	same
Launch	8/2011	same	same
Development			
CDR	3/2009	same	4/2009

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Juno	2009	742.3	2010	742.3	0	Launch Readiness	08/2011	08/2011	0

Development Cost Details

Consistent with 1QTR FY 2010 MPAR, below is detailed development estimate supporting August 2011 launch readiness date (LRD).

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**742.3**	**742.3**	**0.0**
Spacecraft	236.5	282.6	46.1
Payloads	63.9	84.9	21.0
Launch Vehicle	190.4	190.4	0.0
Ground Systems	8.8	11.4	2.6
Science/Technology	22.1	20.8	-1.3
Other Direct Project Costs	220.6	152.2	-68.4

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Management

Juno is part of the New Frontiers Program, with program management at Marshall Space Flight Center. The Principal Investigator, from Southwest Research Institute, has delegated day-to-day Juno project management to the Jet Propulsion Laboratory.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Project Management	Project Management & Oversight	JPL	N/A
Jupiter energetic particle instrument (JEDI)	Jet Propulsion Lab (JPL)	None	None
Plasma Waves Experiment (WAVE)	Jet Propulsion Lab (JPL)	None	None
Management; Microwave radiometer, and Gravity Science Experiment	MSFC/New Frontiers Program Office		None
Vector Fluxgate Magnetometer (FGM)	Jet Propulsion Lab (JPL)	Goddard Space Flight Center (GSFC)	None
UVS and JADE instruments	MSFC/New Frontiers Program Office	None	None
Flight System, Integration and Test	Jet Propulsion Lab (JPL)	None	None
Overall responsibility for the development, implementation, operation, and success of the mission	MSFC/New Frontiers Program Office	None	None
JunoCam	Jet Propulsion Lab (JPL)	None	None
KaBand and IR science	Jet Propulsion Lab (JPL)	None	Italian Space Agency (ASI)

Acquisition Strategy

All major acquisitions are in place. Juno was selected competitively in July 15, 2005 under a New Frontiers Program Announcement of Opportunity (AO-03-OSS-03).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO /SRB	04/2009	Assess cost, schedule, and risk status of project/Findings for the review showed that cost and schedule for the August 2011 launch are consistent with the project's plans.	03/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Flight System Estimate at Complete underestimates Phase C/D cost	The July 2009 Comprehensive Estimate At Complete (CEAC) includes some items and excludes some others that may or may not come to pass. This risk addresses the possibility of large increases in the flight system cost due to the items not included in the July 2009 CEAC	Identify cost savings and Deferral options to reduce the likelihood of large increases in CEAC.
Power Margin at Jupiter	Large variations in solar intensity, solar array temperatures, solar off-point angle, radiation degradation, battery SOC, along with multiple string lengths, larger than normal uncertainties in power supply capabilities make it difficult to assure that all cases are handled with sufficient accuracy	Develop and use integrated system power model; conduct radiation test on larger sample of cells; conduct radiation test on ITO
Completeness of Magnetic Test Approach	If completeness of Juno magnetics verification approach does not adequately verify the effects of Jupiter's magnetic environment on Juno spacecraft (Magnetic susceptibility and residual or induced magnetic dipole effects on MAG measurements) then failure modes may result in loss of mission performance and/or mission success.	Perform material and design susceptibility review to prioritize test items and perform testing on Juno hardware to determine susceptibility
CMIC Design Changes	MRO has experienced 4 in-flight anomalies linked to the CMIC (C&DH Module Interface Card) -- 3 resets and one side-swap. The Juno C&DH also contains a CMIC based on the MRO design. Some design changes have already been made to the Juno CMIC design (re: radiation environment, response to earlier MRO CMIC anomaly) but the root cause of the MRO anomalies is unknown and residual risk exists for Juno.	Add ultimate safe mode within existing architecture; add ability to power off inactive CMIC; evaluate 2 box testing for EMI-EMC and Magnetics

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Solar Array Issues	Development issues with the solar arrays, specifically the qualification panel disbonding, moly tab pull test failures, and qualification coupon TVAC test diode failure, may affect readiness of the flight system for environmental testing.	Established Failure Review Board; investigate Moly tab failures; review panel processing and disbanding; inspect Diode tab welds; utilize outside vendor for panel fabrication; investigate ATLO options

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**361.7**	**416.1**	**532.8**	**514.8**	**549.9**	**569.6**	**485.8**
2009 Mars Science Lab	229.3	204.0	231.6	91.8	42.0	38.5	0.0
MAVEN	6.7	53.4	161.2	210.9	170.5	25.8	18.4
Other Missions and Data Analysis	125.7	158.7	140.0	212.1	337.4	505.3	467.3
FY 2010 President's Budget Request	**381.6**	**416.1**	**494.5**	**405.5**	**514.3**	**536.7**	**--**
2009 Mars Science Lab	223.3	204.0	194.6	67.3	65.0	30.0	--
MAVEN	6.7	53.4	168.7	182.6	138.4	30.6	--
Other Missions and Data Analysis	151.6	158.7	131.2	155.7	310.9	476.1	--
Changes from FY 2010 Request	**-19.9**	**0.0**	**38.3**	**109.3**	**35.6**	**32.9**	**--**

Program Overview

Mars is the most Earth-like planet in our solar system, with land mass approximately equivalent to the Earth's, and having familiar features such as riverbeds, past river deltas, and volcanoes. Mars has the best planetary record of the first billion years of our solar system and holds scientific clues to the development of the solar system, planets, and maybe life itself. The Mars Exploration Program has been developed to conduct a rigorous, incremental, discovery-driven exploration of Mars to determine the planet's physical, dynamic, and geological characteristics.

Spirit and Opportunity are six years into their surface exploration of Mars, and they continue to return a wealth of new results. Opportunity has been moving south to Endurance Crater, twenty times larger than Victoria Crater. Spirit has been conducting further studies in the area of what remains of an ancient hydrothermal system. However, Spirit is currently stuck and NASA is assessing the science it can accomplish in situ should extraction prove impossible. The Mars Reconnaissance Orbiter (MRO) is in its extended mission operations phase and is continuing to return results highlighting areas showing morphological, and mineralogical evidence of interaction with liquid water. Mars Odyssey's gamma ray spectrometer has lent support to the idea of ancient oceans, and its Thermal Emission Imaging System (THEMIS) has found new evidence of salt deposits. Meanwhile, the Mars Science Laboratory (MSL) mission continues to achieve technical and schedule progress toward the CY 2011 launch opportunity. MAVEN is the second Mars Scout mission and will study atmospheric processes that will lead to understanding the evolution of the Martian atmosphere. The Program has engaged ESA in investigating the options for a joint 2016 and 2018 mission encompassing their ExoMars rover mission, recently signing an agency to agency agreement for joint missions.

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

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Plans For FY 2011

Having completed all of its hardware builds and successfully completed the rover environmental test program and ATLO, Mars Science Laboratory (MSL) project will deliver the cruise stage and the rover to the Kennedy Space Center for final assembly in preparation for launch in October-November 2011.

Having successfully completed Preliminary Design Review (PDR) in FY 2010, the MAVEN project plans to successfully complete CDR by the end of FY 2011.

MER, MRO, Odyssey, and ESA's Mars Express will continue to operate, return science data and perform telecom and relay support throughout FY 2011.

NASA and ESA will take their first steps in implementing a joint program of Mars Exploration by soliciting instruments to compete for the opportunity to fly on a Mars 2016 orbiter mission to measure trace gases including methane. Furthermore, collaborative studies will be conducted defining the joint NASA-ESA Mars 2018 mission, which could include rovers from both agencies.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Project Descriptions and Explanation of Changes

Mars Science Laboratory (MSL)

Currently in its implementation phase, MSL takes a major step forward in Mars exploration, both technically and scientifically, utilizing a new entry, descent, and landing system, a long-duration rover, and ten payload elements for definitive mineralogical and organics measurements. The primary scientific objective is to explore and quantitatively assess a local region on Mars as a potential habitat for past or present life. MSL will lay the ground work for future scientific missions, including Mars Sample Return, and will provide key information for human exploration. Additional detail can be found in the MSL Project development section of this document.

Mars Atmosphere and Volatile EvolutioN (MAVEN)

NASA selected the second Mars Scout mission, MAVEN, for formulation phase on September 15, 2008. Currently in its formulation phase, MAVEN, a robotic orbiter mission, will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses. It will deliver key measurements addressing longstanding questions about the climate history and habitability of Mars. NASA's Goddard Space Flight Center in Greenbelt, MD., will manage the project. Lockheed Martin of Littleton, Colorado, will build the spacecraft based on designs from NASA's Mars Reconnaissance Orbiter and 2001 Mars Odyssey missions. Additional detail can be found in the MAVEN Project section of this document.

Other Missions & Data Analysis

In its third extended mission operation phase, the primary scientific objectives of Odyssey include more sensitive measurement of the mineralogy of the surface, monitoring of inter-annual variations of Mars climate and surface processes, acquiring future mission landing site data, and continuing as a key telecommunications relay at Mars. Currently in their sixth extended operation phase, both the Spirit and Opportunity rovers continue to explore geological settings on the surface of Mars using a suite of remote sensing and in-situ instruments. Their objective is to expand our understanding of the history and the geological processes that shaped Mars, particularly those involving water.

Currently in its second extended mission operation phase, the objective of Mars Express, a European Space Agency and Italian Space Agency mission, is to search for sub-surface water from orbit. NASA participates in the scientific analysis of mission data, including the recent investigations into the mysterious deposits of the Medusae Fossae Formation.

Currently in its first extended operation phase, MRO's science objectives include: providing high resolution spectral maps and images for interpretation of the geology of the Martian crust; using ground-penetrating radar to map compositional discontinuities and layering under the surface; and creating planetary-scale maps of critical atmospheric properties. MRO is also the key telecommunications relay for the first half of the next decade at Mars.

Mars Mission Operations (MMO) provides management and leadership for the development and execution of Mars multi-mission operations. MMO supports and provides operational capabilities at a lower cost and risk to all current Mars projects.

Once missions have concluded their primary mission phase, further funding for extended operations is allocated based on the findings of a senior review board. Their review of each mission enables them to make recommendations for the allocation of the extended operations budget based on scientific merit. Missions under consideration for extension in FY 2011 include MRO, Odyssey, Mars Express, and MER.

NASA invests in 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.

NASA selected the Urey and MOMA instrument proposals for technology development studies for potential inclusion in the European ExoMars mission. The ESA ExoMars launch has been delayed from the 2016 to the 2018 joint ESA-NASA launch opportunity, and only MOMA can be accommodated within the ESA mission mass allocation and constraint. MOMA is currently in Phase B and will continue to be in Phase B throughout FY 2011.

The Mars Exploration Program plans future missions to Mars that build on scientific discoveries from past missions and incorporate the lessons learned from previous mission successes and failures. Missions in planning include a Mars mission in 2016 and 2018, both in collaboration with ESA.

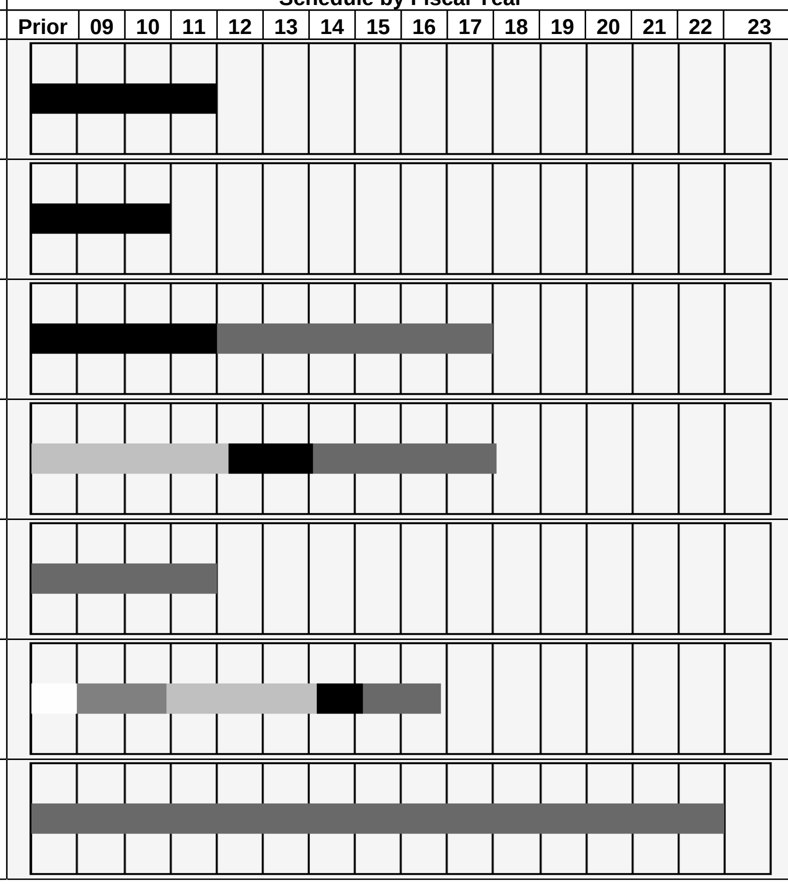
Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
MEP will provide continual operational presence on Mars	Mars Exploration	same
At least one Mars mission will be launched at every opportunity (every 26 months)	Mars Exploration	same

Implementation Schedule

Schedule by Fiscal Year



Project	Phase	Beg	End
Mars Odyssey	Tech		
	Form	Apr-97	Apr-99
	Dev	Apr-99	Apr-01
	Ops	Apr-01	Sep-11
	Res		
Mars Exploration Rovers (Spirit & Opportunity)	Tech		
	Form	May-00	Aug-01
	Dev	Aug-01	Jun-03
	Ops	Jun-03	Sep-10
	Res		
Mars Reconnaissance Orbiter (MRO)	Tech		
	Form	Jan-01	Jul-02
	Dev	Jul-02	Aug-05
	Ops	Aug-05	Sep-11
	Res	Oct-11	Sep-17
Mars Science Laboratory (MSL)	Tech		
	Form	Nov-03	Aug-06
	Dev	Aug-06	Dec-11
	Ops	Dec-11	Oct-13
	Res	Oct-13	Oct-17
Mars Express	Tech		
	Form	Jan-00	Sep-00
	Dev	Sep-00	Jun-03
	Ops	Jun-03	Dec-05
	Res	Dec-05	Sep-11
The Mars Atmosphere and Volatile EvolutioN (MAVEN)	Tech		
	Form	Sep-08	Sep-10
	Dev	Sep-10	Nov-13
	Ops	Nov-13	Dec-14
	Res	Dec-14	Jul-16
Mars R&A	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-00	Sep-22

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Program Management

The Jet Propulsion Laboratory has responsibility for implementation of the Mars Exploration Program. Mars Program science resides at Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Mars Exploration Rovers (MER)	JPL	JPL, ARC, GRC, JSC, GSFC	None
Mars Reconnaissance Orbiter (MRO)	JPL	JPL, ARC, GSFC, JSC, MSFC	Agenzia Spaziale Italiana (ASI)
Mars Science Laboratory (MSL)	JPL	JPL , ARC, GSFC, KSC, GRC, LaRC, JSC	Department of Energy; International partners include Canada, Spain, and Russia.
Mars Atmosphere and Volatile EvolutioN (MAVEN)	JPL	GSFC, KSC, JPL	Centre d'Etude Spatiale des Rayonnements (CESR)
Mars Odyssey	JPL	JPL, MSFC	None
Mars Express (MEX)	JPL	JPL, GSFC	European Space Agency (ESA)
ExoMars	JPL	JPL, ARC, LaRC, GSFC	European Space Agency (ESA)
Mars 2016 and 2018 Missions	JPL	Multiple Centers	European Space Agency (ESA)

Acquisition Strategy

The Mars Exploration Program (MEP) has set a goal of open competition for all missions.

All major acquisitions for MSL, ExoMars instruments, and MAVEN are in place. Malin Space Systems, Honeybee Robotics, Lockheed Martin, Aeroflex are providing support and hardware for the MSL mission. The principal investigator for the MAVEN mission is Dr. Bruce Jakosky of the Laboratory for Atmospheric and Space Physics at the University of Colorado at Boulder. NASA's Goddard Space Flight Center in Greenbelt, Md., will manage the project, and Lockheed Martin of Littleton, Colo., will build the spacecraft. All research and technology is procured through the ROSES announcement and a competitive, peer review selection process.

NASA and ESA are planning joint missions in the 2016 (trace gas orbiter) and the 2018 (two rovers) launch opportunity. The intention is to compete science and instruments for these missions, and JPL will implement the ESA/NASA contributions for both missions.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	11/2006	A Program Implementation Review was conducted in October 2006. Review determined the Mars program was functioning well and continuing to make important contributions to science and the Vision, but was short on reserve funding. It also found that MSL is critical for future mission science and technology.	11/2010
All	Senior Review Panel	03/2008	Comparative review of Mars operating missions. Missions are ranked in terms of science, engineering capability, and their programmatic roles as they relate to the Mars Exploration program. The findings lead to mission extension for Odyssey, MER, MEX, and MRO, with orbit time change for the Mars Odyssey mission.	03/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**1,515.1**	**229.3**	**204.0**	**231.6**	**91.8**	**42.0**	**38.5**	**0.0**	**0.0**	**2,352.3**
Formulation	515.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	515.5
Development / Implementation	999.6	229.3	204.0	231.6	13.5	0.0	0.0	0.0	0.0	1,678.0
Operations / Close-out	0.0	0.0	0.0	0.0	78.3	42.0	38.5	0.0	0.0	158.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**1,515.1**	**223.3**	**204.0**	**194.6**	**67.3**	**65.0**	**30.0**	**--**	**0.0**	**2,299.3**
Formulation	515.5	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	515.5
Development / Implementation	999.6	223.3	204.0	194.6	3.5	0.0	0.0	--	0.0	1,625.0
Operations / Close-out	0.0	0.0	0.0	0.0	63.8	65.0	30.0	--	0.0	158.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.0**	**6.0**	**0.0**	**37.0**	**24.5**	**-23.0**	**8.5**	**--**	**0.0**	**53.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	6.0	0.0	37.0	10.0	0.0	0.0	--	0.0	53.0
Operations / Close-out	0.0	0.0	0.0	0.0	14.5	-23.0	8.5	--	0.0	--
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0

Explanation of Project Changes

While the project continues to make technical, cost and schedule progress, the project still continues to experience technical problems with the actuators, avionics and the titanium. As a result, NASA has adopted a more conservative posture by providing additional funding consistent with NASA risk management plan and strategy. The current LCC is estimated at $2,394.3M, in comparison to the original baseline of $1,642M. SMD anticipates reprogramming additional funds to MSL in the initial FY 2010 operating plan to address the technical problems and related Life Cycle Cost increases.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Purpose

The Mars Science Laboratory (MSL) mission is the most technologically challenging interplanetary rover ever designed. It will use new technologies to adjust its flight while descending through the Martian atmosphere, and to set the rover on the surface by lowering it on a tether from a hovering descent stage. Advanced research instruments make up a science payload 10 times the mass of instruments on NASA's Spirit and Opportunity Mars rovers. The Mars Science Laboratory is engineered to drive longer distances over rougher terrain than previous rovers. It will employ a new surface propulsion system.

The MSL Project will make detailed measurements of element composition, elemental isotopes and abundance, mineralogy, and organic compounds to determine if Mars has, or ever had an environment capable of supporting life within the regions it will explore.

MSL has four science objectives: assess the biological potential of at least one selected site on Mars; characterize the geology and geochemistry of the landing region at all appropriate spatial scales; identify planetary processes relevant to past habitability; and characterize the broad spectrum of the Martian surface radiation environment.

For more information, see the MSL homepage at http://marsprogram.jpl.nasa.gov/missions/future/msl.html.

Project Parameters

The MSL is a surface rover that will collect Martian soil and rock samples and analyze them for organic compounds and environmental conditions that could have supported microbial life now or in the past. MSL will be a long-duration (two years) roving science laboratory that will be twice as long and three times as heavy (800-850 kilograms) as the Mars Exploration Rovers, Spirit and Opportunity.

Key technologies developed for MSL include: throttle-controlled, high-thrust engines, required during Martian entry, descent, and landing (EDL); sample acquisition and processing equipment used to acquire and distribute samples to the analytic instrument suite; and long-life, high-reliability, thermal-cycle-resistant electronics for use in the rover.

The EDL system will accommodate a wide range of possible latitude and altitude locations on Mars in order to be discovery-responsive and to have the capability to reach very promising, but difficult-to-reach scientific sites.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Commitments

The Mars Science Laboratory (MSL) will be ready to launch in late CY 2011 and will arrive at Mars after approximately 9 months of flight time. MSL will operate for two Earth years on the surface of Mars and will travel approximately 20 kilometers.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Rover	JPL	Travel 20 kilometers over the Martian surface.	Same	Same
Stereoscopic and microscopic cameras	Malin Space Systems	Acquire color, stereo images with resolutions up to 0.2 mm/pixel at 2 m range.	Deleted descent imager and camera zoom	Same
Robotic arm tools	Honeybee Robotics	Acquire, process and deliver 75 rock and soil samples to analytic instruments.	Changed the rock grinder to a brush, sample quantity unchanged	Same
Chemistry camera (ChemCam)	Department of Energy/Los Alamos National Laboratory; France	Remotely measure elemental composition of rocks and soil up to 9m from rover.	Same	Same
Alpha Particle X-ray Spectrometer	Canada (CSA)	Measure with high precision the elemental composition of in situ rocks and soil.	Same	Same
Rover Environmental Monitoring System (REMS)	Spain	Monitor key atmospheric measurements including temperature, pressure, wind speed/direction and humidity.	Same	Same
Dynamic Albedo of Neutrons (DAN)	Russia (IKI)	Measure hydrogen content in subsurface deposits.	Same	Same
Cruise stage and entry system	Lockheed Martin	Transport rover to Martian surface and land with impact speed below 1 m/s	Same	Same
Mission operations and data archive	JPL	Conduct one-year cruise and two-year rover primary mission with remotely located science team.	Same	Same
Sample Analysis at Mars (SAM)	NASA/GSFC	Analysis of elemental and isotopic composition of Mars samples	Same	Same
Chemistry & Mineralogy Instrument (CheMin)	NASA/ARC	Analysis of mineral and chemical content of Mars samples	Same	Same
Sample cache	ARC	Hockey puck-sized container will collect sample of Martian soil for possible later collection by a Mars Sample Return mission	Deleted	Same (deleted)

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Schedule Commitments

The Mars Science Laboratory Project entered formulation in November 2004, proceeded into the development phase in August 2006, with a launch currently scheduled for late November 2011.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Critical Design Review	June 2007	No change	Same
System Integration Review (formerly ATLO)	February 2008	February 2008	Same
Launch Readiness Review	September 2009	4QTR CY 2011	Same

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2009 Mars Science Lab	2010	1,719.9	2010	1,719.9	0	Launch Readiness	11/2011	11/2011	0

Development Cost Details

Development cost increased, $95M, to resolve technical problems associated with the actuators, avionics and titanium.

Base or initial estimate was estimate in 2006 at $1642M for LCC and $969M for development. The table below reflects the rebaselined numbers, as established in January 2010.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**1,719.9**	**1,719.9**	**0.0**
Spacecraft	930.9	975.9	45.0
Payloads	130.3	139.8	9.5
Systems I&T	89.9	96.1	6.2
Launch Vehicle/Services	232.8	232.8	0.0
Ground Systems	74.2	75.4	1.2
Science/Technology	15.9	15.9	0.0
Other direct project cost	245.9	184.0	-61.9

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Management

2009 Mars Science Laboratory is a JPL-managed in-house project. Instrument implementation has been assigned to JPL. The responsible NASA official is the Director for the Planetary Science Division.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Rover	JPL	JPL	None
Stereoscopic and microscopic cameras	JPL	None	None
Robotic arm tools	JPL	JPL	None
Chemistry camera (ChemCam)	JPL	None	Department of Energy and France
Alpha Particle X-ray Spectrometer	JPL	None	Canada
Rover Environmental Monitoring System (REMS)	JPL	None	Spain
Dynamic Albedo of Neutrons (DAN)	JPL	None	Russia
Cruise stage and entry system	JPL	JPL, AMES, LaRC	None
Spacecraft	JPL	JPL	None
Sample Analysis at Mars (SAM)	JPL	GSFC	CNES (France)
Chemistry & Mineralogy Instrument (CheMin)	JPL	ARC	None

Acquisition Strategy

All major acquisitions are in place. All major instruments were competitively selected.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ/SRB	05/2009	Assess maturity of MSL design, technical state, and adequacy of resources. Design was deemed adequate to achieve mission science goals, but project needs additional time and resources to work the technical problems and perform adequate testing. The finding resulted in an additional $95M, consistent with NASA risk management plan and strategy, to resolve problems and to ensure mission success.	11/2009

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Actuators	Actuator production, life tesing, and assembly delays can possibly threaten overall schedule.	Plans are in place to have Actuator Flight Model complete all of its required life test by March 2010.
Instrument - Sample Analysis at Mars (SAM)	Vacuum pump life could impact SAM science return	Plans are in place to life test a backup pump design by September 2010.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**6.7**	**53.4**	**161.2**	**210.9**	**170.5**	**25.8**	**18.4**
FY 2010 President's Budget Request	**6.7**	**53.4**	**168.7**	**182.6**	**138.4**	**30.6**	**--**
Total Change from 2010 President's Budget Request	**0.0**	**0.0**	**-7.5**	**28.3**	**32.2**	**-4.8**	**--**

Note: Rephased project reserve profile, and added funds for a higher than anticipated launch vehicle cost.

Project Purpose

Mars Atmosphere and Volatile EvolutioN (MAVEN) was selected in September 2008 under the 2006 Mars Scout Announcement of Opportunity. The MAVEN mission will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses. MAVEN will deliver comprehensive answers to long-standing questions regarding the loss of 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. Specific MAVEN science objectives consist of:

- Determine structure and composition of the atmosphere and ionosphere;
- Determine the physical and chemical processes that control loss processes;
- Determine escape rates of neutrals;
- Determine escape rates of ions;
- Determine the external inputs that control upper atmosphere and ionosphere structure and that drive escape; and
- Determine the relative escape rates of the stable isotopes and the resulting isotopic fractionation.

Additional information can be found in http://lasp.colorado.edu/maven/

Project Preliminary Parameters

MAVEN will deliver its science using three instrument packages: a stand-alone neutral gas and ion mass spectrometer (NGIMS), capable of measuring thermal neutrals and ions; a stand-alone imaging ultraviolet spectrometer (IUVS); and the Particles and Fields (P&F) package, consisting of six instruments measuring ionospheric properties, energetic ions, solar wind and solar energetic particles, magnetic fields, and solar extreme ultraviolet irradiance.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN

Estimated Project Deliverables

The MAVEN measurements will be made from an elliptical orbit with periapsis at 150 km and apoapsis at 6220 km (4.5-hour period). MAVEN will use a sun-pointing, three-axis stabilized spacecraft, with a two-axis gimballed, Mars-pointing platform for the NGIMS, IUVS, and the SupraThermal And Thermal Ion Composition (STATIC) instruments. The spacecraft has a body-mounted high-gain antenna.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Launch Services	United Launch Alliance (ULA)	Intermediate Class launch service	New	Same
Spacecraft	Lockheed Martin	MRO spacecraft bus and avionic suite, with cross strapping and monopropellant propulsion system	New	Same

Estimated Project Schedule

MAVEN will be launched in November 2013, and will arrive at Mars in September 2014.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
PDR	07/2010	New	Same
CDR	07/2011	New	Same
ATLO	07/2012	New	Same
Launch	11/2013	New	Same
Mars Orbit Insertion	09/2014	New	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN

Project Management

The MAVEN is part of the Mars Exploration Program managed by the JPL. The PI from the University of Colorado has delegated the day-to-day management to GSFC.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Project management, msn sys engineering, safety and mission assurance, and project scientist	GSFC	GSFC	
Neutral gas and ion mass spectrometer (NGIMS)	GSFC	GSFC	
Navigation, trajectory, and orbit maintenance analysis	GSFC	JPL	
Magnetometer (MAG) - Measures interplanetary, solar wind, and ionospheric magnetic fields	GSFC	GSFC	

Acquisition Strategy

All major acquisitions are in place. MAVEN was selected competitively on September 15, 2008 under the Mars Scout 2006 Announcement of Opportunity (AO- NNH06ZDA002O).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO & SRB	08/2009	The MAVEN Project passed the System Requirements Assessment conduced by the independent Standing Review Board in August 2009. Will also assess cost, schedule, and risk status of project during PDR.	07/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Fault Management Strategy and Science Measurements	If the spacecraft fault-management strategy protecting the spacecraft from the effects of solar-energetic particles is not tailored properly, then solar events and Mars atmospheric measurements key to MAVEN science will be missed.	Tailor inherited spacecraft fault management approach to support MAVEN science. Analysis in Phase B with closure by Fault Protection Peer Review in 2010.
Limited Contact with Spacecraft While Flying Through Atmosphere	If atmospheric density blooming occurs (due to a dust storm, etc) while out of contact and autonomy/safing do not work as expected, then the instruments or spacecraft may be damaged.	Refine Periapsis Timing Estimator algorithm to develop robust safing strategy with closure by Fault Protection Peer Review in 2010.
Aerodynamic Stability During Deep Dips	If the observatory is not aerodynamically stable during deep dips, then the spacecraft may tumble.	Preliminary aerodynamic analysis scheduled as part of Phase B activities. Closure by spacecraft CDR.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**104.8**	**98.6**	**103.5**	**157.9**	**152.0**	**144.0**	**155.8**
Outer Planets	**104.8**	**98.6**	**103.5**	**157.9**	**152.0**	**144.0**	**155.8**
FY 2010 President's Budget Request	**101.1**	**98.6**	**97.1**	**140.3**	**117.7**	**118.5**	**--**
Outer Planets	**101.1**	**98.6**	**97.1**	**140.3**	**117.7**	**118.5**	**--**
Changes from FY 2010 Request	**3.7**	**0.0**	**6.4**	**17.6**	**34.2**	**25.5**	**--**

Note: The current available funds within Planetary Science Theme do not provide for the OPF/EJSM mission beyond its formulation and technology development phases.

Program Overview

The Outer Planets Program consists of three strategic elements: The ongoing Cassini mission to Saturn, a future major outer planets mission, and Supporting Research and Technology (SR&T). These elements enable science investigations across a broader array of disciplines and in more depth than smaller, tightly focused competed missions. The science discoveries made by these strategic missions are not expected to be easily displaced with time and are expected to overthrow previous paradigms and create new ones in their place.

Plans For FY 2011

The Senior Review Board will determine whether the Cassini project will start its second extended mission to observe seasonal and temporal change in the Saturn system, and will conduct over a dozen flybys of Titan, Enceladus, and other Saturnian moons during FY 2011.

The recommendations of the next planetary science decadal survey, expected in 2011, will play a large role in the selection of the next major outer planets mission.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

Project Descriptions and Explanation of Changes

Outer Planets

Cassini-Huygens, in its extended operations phase, is an Outer Planets Flagship mission to Saturn that has profoundly altered our understanding of that planet, its famous rings, magnetosphere, icy satellites, and particularly the moons Titan and Enceladus. Cassini-Huygens is an international collaborative effort. It was launched in October 1997 and arrived at Saturn in July 2004 to explore 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. Cassini completed its prime mission in July 2008 and will complete its first extended mission in FY 2010. The senior review, which was held in February 2009, has recommended that Cassini continue into its second extended science mission. The primary objective of the second extension, the Cassini Solstice mission, is to observe seasonal and temporal change in the Saturn system, especially at Titan, to understand underlying processes, and prepare for future missions. Upon approval, the Cassini Solstice mission will continue to operate through FY 2017.

The Outer Planets program awaits the determination of priorities within the Planetary Science Decadal Survey, currently underway, before proposing a budget and schedule for development of a new major outer planets mission.

The Supporting Research and Technology (SR&T) effort dramatically increases the scientific return of NASA missions and guides current mission operations (e.g., selecting Cassini imaging targets) as well as future mission planning (e.g., mission concept studies for Titan missions). The competitive programs within the SR&T effort increase our understanding of the outer solar system and broaden the science community participation in the analysis of data returned by Cassini, Galileo, and other missions.

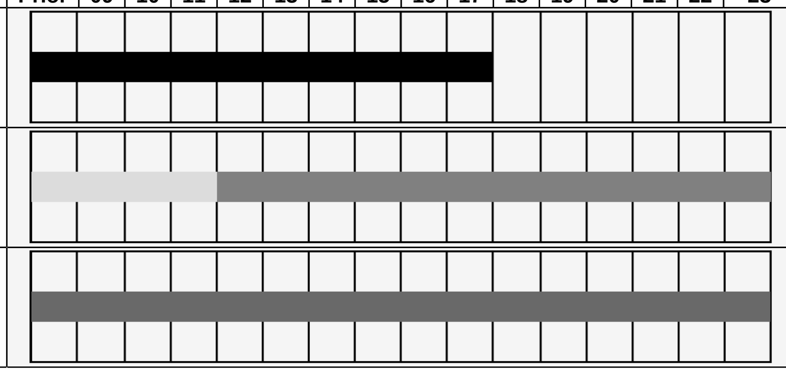
Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Deliver science data to Planetary Data Systems (PDS) consistent with science archive plan (in increments within 6 - 9 months)	Cassini	Same
Publically release study reports	Major Outer Planets Future Mission	Same
Release ROSES and make selections	Research Data Analysis	Same

Mission Directorate: Science
Theme: Planetary Science
Program: Outer Planets

Implementation Schedule

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23



Project	Phase	Beg	End
Cassini	Tech		
	Form		Sep-89
	Dev	Oct-89	Oct-97
	Ops	Oct-97	Sep-17
	Res	Oct-97	Sep-17
Outer Planets Future Mission	Tech	Jan-07	Sep-11
	Form	Oct-11	Sep-26
	Dev		
	Ops		
	Res		
Research Data Analysis	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-97	Sep-23

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

Program management responsibility for the Cassini and OPF/Outer Planets Future projects resides at JPL. Scientific mission priorities for the program and the Research efforts reside within SMD/Planetary Science Division.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Cassini	JPL	JPL	The Italian Space Agency provided Cassini's high-gain communication antenna and the Huygens probe was built by the European Space Agency (ESA).
Outer Planets Future Mission	JPL	JPL	ESA
Research Data Analysis	HQ	Multi-Center	None

Acquisition Strategy

All major acquisitions contracts for Cassini are in place. The acquisition strategy for future Outer Planets Missions are expected to be similar to Cassini. The science payloads will be competitively selected for the Outer Planets Future Mission.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	02/2009	Cassini senior review for the Solstice extended mission recommended approval of the extended mission science. Decision on the Cassini Solstice mission extension is expected in CY 2010.	02/2011
Performance	Independent Science & Technical Review	12/2008	Independent science, technical, management, and cost review of concept studies.	9/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	72.4	89.0	106.5	101.1	88.7	82.0	85.1
Technology	72.4	89.0	106.5	101.1	88.7	82.0	85.1
FY 2010 President's Budget Request	64.9	89.0	98.4	102.1	93.5	91.4	--
Technology	64.9	89.0	98.4	102.1	93.5	91.4	--
Changes from FY 2010 Request	7.5	0.0	8.2	-1.0	-4.9	-9.4	--

Program Overview

Planetary Science is a challenging endeavor. Future Planetary Science missions will demand advances in both power and propulsion systems to enable successful trips to harsh environments, far from the Sun, with highly challenging trajectories. To meet these needs, the Planetary Science Technology Program includes the In-Space Propulsion (ISP), Radioisotope Power Systems (RPS), and Advanced Multi-Mission Operations System (AMMOS) Projects.

The ISP Project develops in-space propulsion technologies that can enable or benefit near- and mid-term NASA missions. These technologies will enhance the performance of planetary science missions by allowing increased science payload mass, reduced launch costs, and decreased mission trip times. The Radioisotope Power System (RPS) Project advances the capabilities of spacecraft power systems, thereby making it possible for missions to travel to destinations distant from the sun, or where sunlight is obscured or infrequent. RPS is developing flight Advanced Stirling Radioisotope Generators (ASRG) for the 2014 time frame and is conducting a concept study of a small RPS system for use in possible distributed network mission environments. The Advanced Multi-Mission Operations System (AMMOS) Project provides planetary science missions with a set of operations, navigation and design software tools and services for flight mission training, mission operations, space communications resources allocation, and improved space communication.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

Plans For FY 2011

The In-Space Propulsion (ISP) Project will continue electric propulsion life validation testing and analysis of NASA's Evolutionary Xenon Thruster (NEXT) throughout FY 2011 with the goal for completion by FY 2013. The ISP project will also continue electric propulsion Hall thruster development task towards Technology Readiness Level 6 (TRL6) in FY 2010, and initiate Hall system power processing unit (PPU) development in FY 2011.

The Radioisotope Power Systems (RPS) Project will continue an extended performance testing of the Advanced Stirling Radioisotope Generator (ASRG) engineering unit, and continue the development of a qualification unit to enable delivery of one ASRG flight unit for the 2014-2016 Discovery flight opportunity. The RPS will project will demonstrate 1500-hour lifetime Radioisotope Thermoelectric Generator couples and validate four couple module power by the end of FY 2011.

Advanced Multi-Mission Operations System (AMMOS) will continue to develop multi-mission operations software tools for spacecraft navigation and mission planning, efficient spacecraft communication, and data handling.

In addition, this Technology Program within the Planetary Science theme will pursue complimentary collaborations with the new cross-cutting Space Technology Program within the Office of the Chief Technologist.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

Project Descriptions and Explanation of Changes

Technology

The In-Space Propulsion (ISP) project will enable access to more challenging and interesting science destinations, including enabling sample return missions. The ISP Project is completing development of several propulsion technologies in support of future Flagship, Discovery, Mars, and New Frontiers missions. ISP portfolio continues to invest in high-priority technology areas such as the Electric Propulsion and Aerocapture technologies identified in the Solar System Exploration (SSE) Roadmap and the 2007 SMD Science Plan. ISP will continue increasing its emphasis on sample return propulsion technology development. The foci will be: completing studies and developing requirements to initiate technology development for Planetary Ascent Vehicles (PAV); completing trade studies and requirements development to kick off technology development for multi-mission Earth Entry Vehicles (MMEEV); continuing advanced chemical propulsion technology development; and initiating other subsystem technology developments for the High Voltage Hall Accelerator (HiVHAC) thruster technology applicable to Earth Return Vehicles (ERV), transfer stages, and low-cost electric propulsion systems for Discovery-class missions.

The Radioisotope Power Systems (RPS) Project continues low-level investments in advanced stirling, thermoelectric conversion and thermal photovoltaic technologies as seeds to meet future needs late in the next decades. The RPS project also funds cross-cutting multi-mission activities to keep them off the critical path, such as NEPA and launch approval engineering. The RPS project is structured to manage both the technology investments and systems development, such as the development and testing of the Advanced Stirling Radioisotope Generator (ASRG). The project transitions acquisition of flight units to a mission-specific user. The project also assumes responsibility for multi-mission RPS studies, sustaining capabilities, and cross-cutting launch approval activities. However, funds are not included within the RPS budget for the procurement of nuclear material required to support missions in formulation.

The Advanced Multi-Mission Operation Support (AMMOS) Project provides multi-mission operations, navigation, design, and training tools for Planetary Science flight missions, and undertakes technology investments for improved communications and navigation technologies.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
HiVHAC Engineering Model (EM) thruster performance acceptance test will be completed	ISP	Same
2.65m high temp aeroshell with ablative TPS will be fabricated to demonstrate manufacturing scale-up.	ISP	Same
Advanced Stirling Radioisotope Generator engineering model will demonstrate extended operations (14,000 hours).	RPS	Same
Provide standard interfaces in order to enable interoperability among missions.	AMMOS	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

Program Management

SMD provides overall oversight of the technology program. GRC is responsible for the ISP and RPS projects. JPL is responsible for the AMMOS project.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
ISP	GRC	GRC, MSFC, JPL, LARC, ARC	None
RPS	GRC	JPL, GRC, KSC	Department of Energy
AMMOS	JPL	JPL	None

Acquisition Strategy

Technology activities are solicited using the NASA Research Opportunities in Space and Earth Sciences (ROSES) announcement, and selections are made using a competitive, peer-reviewed process. The Department of Energy completed an acquisition for ASRG flight system development (Lockheed Martin) for RPS. JPL provides management and the navigation and space communication software tools.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Research Council (NRC)	07/2009	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.	12/2010

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Mission Directorate:	Science
Theme:	Astrophysics

Theme Overview

NASA's goal in Astrophysics is to discover how the universe works, explore how the universe began and developed into its present form, and search for life elsewhere. Three broad scientific questions emanate from this goal: 1) How do matter, energy, space and time behave under the extraordinarily diverse conditions of the cosmos? 2) How did the universe originate and evolve to produce the galaxies, stars, and planets we see today? 3) What are the characteristics of planetary systems orbiting other stars, and do they harbor life?

The Astrophysics Theme addresses these questions via an integrated strategy incorporating a robust research program, 14 operating missions, and 10 flight projects in various stages of planning and execution. Considerable concept definition and technology work is being conducted to define future mission candidates for Astrophysics, and these will be prioritized in the National Research Council's (NRC) decadal survey process now underway. The Astrophysics programs that support the integrated strategy are as follows:

The Physics of the Cosmos Program (which incorporates the former Beyond Einstein Program) contains missions that can explore the most fundamental and extreme physical conditions of the universe, from black holes to dark energy. They will study the building blocks of our own existence at the most basic level: the matter, energy, space and time that create the living Universe.

The Cosmic Origins program comprises projects that enable the study of how galaxies, stars and planetary systems came into being, how they evolve, and ultimately how they end their lives.

The Exoplanet Exploration program conducts advanced telescope searches for Earth-like planets and habitable environments around other stars.

The Astrophysics Explorer Program conducts small PI-led missions that are selected under the Heliophysics Explorer program. Explorer missions are opportunities for innovative science that fill the scientific gaps between the larger missions.

The Astrophysics Research Program prepares for the next generation of missions by supporting both theoretical research and applied technology investigations. These research activities exploit data from current missions and suborbital science investigations to advance NASA science goals, and also provide hands-on workforce training of students and early-career scientists and engineers.

For more information, please see http://nasascience.nasa.gov/astrophysics

Mission Directorate:	Science
Theme:	Astrophysics

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**1,304.9**	**1,103.9**	**1,076.3**	**1,109.3**	**1,149.1**	**1,158.7**	**1,131.6**
Astrophysics Research	136.0	149.0	156.1	178.1	188.4	194.6	199.6
Cosmic Origins	850.0	684.1	687.7	669.4	667.5	640.5	599.2
Physics of the Cosmos	111.1	116.8	103.3	114.4	151.7	176.4	202.0
Exoplanet Exploration	72.1	46.2	42.5	54.1	83.0	93.8	117.6
Astrophysics Explorer	135.7	107.9	86.7	93.3	58.5	53.3	13.2
FY 2010 President's Budget Request	**1,281.2**	**1,120.9**	**1,074.1**	**1,042.7**	**1,126.3**	**1,139.6**	**--**
Astrophysics Research	135.0	151.9	160.0	165.0	177.2	188.0	--
Cosmic Origins	819.2	667.2	598.9	550.3	523.8	452.3	--
Physics of the Cosmos	128.3	147.7	188.5	213.9	291.4	330.3	--
Exoplanet Exploration	68.1	46.2	57.3	86.9	123.5	167.3	--
Astrophysics Explorer	130.7	107.9	69.5	26.6	10.4	1.7	--
Total Change from FY 2010 Request	**23.6**	**-17.0**	**2.2**	**66.6**	**22.7**	**19.1**	**--**

Plans for FY 2011

Astrophysics Research

Senior Reviews for operating missions and archives will be conducted in the spring of 2010. A comparative evaluation of all Astrophysics operating missions is conducted every two years. A comparative evaluation for the archives is conducted every four years. The science output is evaluated by an independent expert panel, and decisions are made as to which missions will receive funding for extended operation.

In R&A, peer-reviewed investigations will be selected in the areas of past missions data analysis, theoretical studies, and modeling of the astrophysical phenomena targeted by past, current, and future missions. Laboratory studies of astrophysical phenomena, limited ground-based observing, and suborbital missions will also continue in FY 2011.

The Balloons Project will continue to work toward advancing the capability of the new super-pressure balloon, which will be used to carry large scientific experiments to the brink of space for 100 days or more.

Cosmic Origins

The James Webb Space Telescope will continue to make progress towards its launch date in June, 2014.

Hubble Space Telescope will continue operations.

The Stratospheric Observatory For Infrared Astronomy (SOFIA) will complete open door flight testing and will conduct the first competed science observations.

Herschel (moved to Cosmic Origins from the Physics of the Cosmos Program) will continue prime operations.

Physics of the Cosmos

Planck will continue prime operations. Fermi will remain in its prime operations phase and Chandra will continue on in extended operations.

Exoplanet Exploration

Kepler will continue prime mission operations.

Astrophysics Explorer

The High-Resolution Soft X-Ray Spectrometer (SXS) instrument (scheduled to fly on the Japanese Astro-H mission in FY 2014) will complete mission Critical Design Review.

The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will complete integration and testing in FY 2011, in preparation for launch in January 2012.

The WISE (Wide-field Infrared Survey Explorer) Mission will be in prime operations. The Gravity and Extreme Magnetism (GEMS) mission, selected in FY 2009 for a launch in FY 2014, will be in formulation.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's Astrophysics Theme is guided by the Space Act and subsequent legislation, and by U.S. National Space Policy and related policies, which call on NASA to conduct space missions to advance scientific understanding of the universe. In doing so, NASA follows a long-standing tradition of establishing its science priorities through consultation with world-class experts via the National Research Council's decadal survey process. The most recent Astrophysics decadal survey was published in 2001, and the next one is under development for release in 2010. Astrophysics also receives tactical-level advice from the external science community via the Astrophysics Subcommittee of the NASA Advisory Council, and advice on cooperative activities from the Congressionally chartered, NSF-managed Astronomy and Astrophysics Advisory Committee.

NASA enables research to understand the structure, content, and evolution of the universe. This research provides information about humankind's origins and fundamental physics that govern the behavior of matter, energy, space, and time. NASA leads the world in space-based research into the most compelling questions of modern physics, such as the nature of dark matter and dark energy, high-energy cosmic rays, tests of gravity and general relativity, and insight into cosmic inflation during the very early universe. NASA works proactively with the National Science Foundation and Department of Energy in exploring the interfaces between astronomy and physics, and in the search for life in the universe.

Relevance to education and public benefits:

Stunning images produced from Astrophysics operating missions continue to inspire the public, revealing the beauty of our universe and the science behind those images. NASA provides the tools to translate the science for the classroom and other learning venues in ways that meet educator needs.

Hubble images are featured on the Space Telescope Science Institute's "Amazing Space" Web site which provides curriculum support tools to classrooms in every state in the union. Spitzer's "Cool Cosmos" Web site offers explorations into the world of the infrared, and Chandra delivers authentic data sets to educators to enhance lessons by allowing students to use the same data that professional researchers use.

A consortium of Astrophysics missions have been featured in a traveling museum exhibit, "Alien Earths", to inform and inspire the public on critical questions related to the search for life elsewhere in our universe. The Astrophysics Exoplanet Exploration Program, in conjunction with the Astronomical Society of the Pacific, has sponsored the creation of "Night Sky Network" amateur astronomy clubs around the nation. NASA also provides toolkits and professional development training to support these groups of space enthusiasts as they help strengthen the public understanding of astronomy and space science.

Performance Achievement Highlights:

The fourth Hubble Servicing Mission (SM4) was completed successfully in May, 2009. Herschel and Planck launched in May 2009 as well. The JWST mission made progress toward launch in FY 2014 and held a successful Critical Design Review (CDR) for the Integrated Science Instrument Module (ISIM) in March 2009. The Kepler mission, designed to survey our region of the Milky Way Galaxy to detect and characterize hundreds of Earth-size and smaller planets in or nearby the habitable zone sucessfully launched March 6, 2009.

Astronomers have taken a direct image of an extra solar planet with the Hubble Space Telescope. The planet circles the bright southern star Fomalhaut, located in the constellation Piscis Australis. The astronomers estimate that the planet, called Fomalhaut b, is no more than three times Jupiter's mass, which is enormous compared to Earth but a proverbial needle in a haystack for planet hunters, considering it is located 25 light-years away. Since the Fomalhaut system is only 200 million years old, extremely young by planetary standards, images like this help astronomers study how planets and planetary systems evolve around stars.

NASA's Wilkinson Microwave Anisotropy Probe (WMAP) satellite observes the most ancient light in the universe, cosmic microwave background radiation which is the radiant heat left over from the Big Bang. Recent publications based on WMAP data accurately describe the features of the early universe and reveal hints about how it began. The WMAP team determined the universe's age to be 13.7 billion years, with accuracy better than one percent (or 0.12 billion years, a small amount when working on such a vast scale), its shape (uncurved) with a precision of 0.5 percent, and its rate of expansion with accuracy better than four percent. The WMAP results also show that only 4.6 percent of the universe exists in atoms, with the remainder in dark matter and dark energy. This supports the theory that the vast majority of the mass in the observable universe is made up of dark matter and dark energy. For more on this mission go to map.gsfc.nasa.gov/.

The Spitzer Space Telescope was prolific in star formation science this year, providing new insights into how stars form and how their natal disks of dust and gas go on to form their planetary systems. Using Spitzer infrared images researchers have uncovered newborn stars at the center of the Milky Way galaxy. Before now, there were only a few clues that stars can form in the galaxy's core. The heart of the Milky Way is cluttered with stars, dust, and gas, and at its very center is a supermassive black hole. Conditions there are harsh, with fierce stellar winds, powerful shock waves, and other factors that make it difficult for stars to form. The dust made it difficult to locate baby stars. However, the Spitzer infrared instruments made it possible to identify more than 100 candidates for young stars, all less than one million years old. The press release and images are available at www.spitzer.caltech.edu/Media/releases/ssc2009-13/release.shtml.

NASA's Chandra X-ray Observatory has been helping researchers better understand the nature of dark energy and through it, a better understanding of the origin and destiny of the universe. Dark energy is responsible for the acceleration of the universe's expansion. In December 2008, researchers released illustrations from their examination of galaxy cluster Abell 85, one of 86 clusters observed by Chandra to trace how dark energy has stifled the growth of these massive structures over the last seven billion years. By using Chandra to observe the hot gas in the galaxy clusters, they determined the change in the masses of clusters over time. The growth of the galaxy structures was initially driven only by the attractive force of gravity, but then the repulsive force of dark energy helped drive expansion. For more information and images go to chandra.harvard.edu/press/08_releases/press_121608.html.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Senior Review Panel	04/2008	Comparative review of operating missions. Missions are ranked in terms of science return. In the most recent review, Swift and Chandra missions ranked highest, while RXTE and GP-B ranked lowest. Results and the report can be found at http://nasascience.nasa.gov/about-us/science-strategy/senior-reviews/AstroSR08_Report.pdf	04/2010
Performance	National Research Council	05/2006	Congressionally-mandated review by the NRC. The resulting letter report found that "It is vital that the strong, balanced science program in astronomy and astrophysics that has served the nation so well continue to be sustained as any new policy is implemented."	TBD
Relevance	National Research Council	05/2001	Decadal survey to set science and mission priorities for NASA's Astrophysics program. The report, Astronomy and Astrophysics in the New Millennium (NRC, 2001), found that "NASA's Great Observatories have revolutionized understanding of the cosmos, while the extremely successful Explorer program provides many targeted small-mission opportunities. There are now fewer opportunities for missions of moderate size, however..." The process to create the next Decadal Survey began in 2008.	2010

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**136.0**	**149.0**	**156.1**	**178.1**	**188.4**	**194.6**	**199.6**
Astrophysics Research and Analysis	**60.0**	**60.0**	**60.2**	**64.7**	**65.8**	**67.4**	**69.1**
Balloon Project	**25.6**	**26.7**	**27.1**	**32.4**	**32.7**	**35.3**	**36.8**
Other Missions and Data Analysis	**50.4**	**62.3**	**68.7**	**80.9**	**89.8**	**91.9**	**93.7**
FY 2010 President's Budget Request	**135.0**	**151.9**	**160.0**	**165.0**	**177.2**	**188.0**	**--**
Astrophysics Research and Analysis	**60.0**	**61.1**	**62.5**	**64.0**	**66.2**	**67.8**	**--**
Balloon Project	**24.6**	**26.7**	**28.8**	**32.4**	**33.2**	**35.8**	**--**
Other Missions and Data Analysis	**50.4**	**64.1**	**68.6**	**68.5**	**77.9**	**84.4**	**--**
Changes from FY 2010 Request	**1.0**	**-3.0**	**-3.9**	**13.1**	**11.2**	**6.7**	**--**

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Program Overview

The Astrophysics Research Program provides funding to analyze the data from NASA missions to understand astronomical events such as the explosion of a star, the birth of a distant galaxy, or the motion of planets around their parent stars. The program also supports basic research for scientists to work out the consequences of their theories, and to understand how they can best use data from NASA missions to develop new knowledge about the cosmos.

NASA's policy is to make the data from its space science missions available to everyone. This data is archived in the Astrophysics Data Centers, located at universities and NASA centers throughout the country, from which users can download them. The Centers also provide tools that enable users to combine different sets of data, or to examine how the appearance of the sky changes when it is observed with different kinds of light. For example, the remnant of an exploding star (a supernova) looks very different in pictures taken in visible light and in X-rays. More information can be found at http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers.

The Astrophysics Research Program also supports the early development of new technologies for future NASA missions. The first step is usually to show that the technology can work in the laboratory. The next step in developing a new type of scientific instrument is often to fly it on a high-altitude balloon mission, or on a sounding rocket flight that takes it briefly outside the Earth's atmosphere. Instruments for balloons and sounding rockets are not as costly as for an orbital mission, and they can be built quickly to respond to unexpected opportunities. The equipment is usually retrieved after the flight, so that novel instruments can be tested, improved and flown again. These suborbital flights are important in training the next generation of scientists and engineers to better compete in the 21st century, and to maintain U.S. leadership in science, engineering, and technology.

For more information on the Astrophysics Research Program, please see http://nasascience.nasa.gov/researchers/sara/highlights.

Plans For FY 2011

The Astrophysics Research Program will continue to conduct and enable high-quality astrophysical research consistent with NASA's goals and science programs.

The Balloons project will conduct 16-20 flights and conduct 2 foreign campaigns.

In addition to ongoing awards, the Education and Public Outreach Project will competitively select approximately 40 new proposals for small awards averaging $15,000 a year and approximately 15 new proposals for mid-range awards averaging $130,000 a year.

Project Descriptions and Explanation of Changes

Astrophysics Research & Analysis (R&A)

This project solicits basic research proposals for investigations that are relevant to NASA's programs in astronomy and astrophysics and includes research over the entire range of photons, gravitational waves, and particles of cosmic origin. The R&A project seeks to support research that addresses the best possible state-of-the-art detector technology development for instruments that may be proposed as candidate experiments for future space flight opportunities; science and/or technology investigations that can be carried out with instruments flown on suborbital sounding rockets, stratospheric balloons, or other platforms; and supporting technology, laboratory research, and/or (with restrictions) ground-based observations that are directly applicable to space astrophysics missions.

Within the R&A project, the Astrophysics Theory program (ATP) supports efforts to develop the basic theory for NASA's space astrophysics programs. Astrophysics Theory topics include: star formation, supernovae and gamma-ray bursts, large scale cosmic structures and dark matter, and dark energy and the cosmic microwave background.

All Research and Analysis grants selected for funding by the Astrophysics Theme are broadly competed through NASA's Research Opportunities in Space and Earth Sciences (ROSES). Grant proposals must relate directly to both Agency and Theme goals and objectives, and all proposals are peer-reviewed by a mix of scientific disciplines and are selected based upon merit.

Balloons

Balloons have been used for decades to conduct scientific studies. While the basics of ballooning have not changed, balloon size and capabilities have increased, and their dependability has improved greatly. The Wallops Flight Facility manages the NASA Balloon Project. The project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to spaceflight application. The science experiments being done by balloons cover a wide range of disciplines such as astrophysics, solar and heliospheric physics, as well as Earth upper-atmosphere chemistry.

The Columbia Scientific Balloon Facility (CSBF) provides the services of launching large (400 ft. dia), unmanned, high-altitude (120,000 ft.) research balloons, tracking, and recovering the scientific experiments suspended beneath them, for NASA centers and universities from all over the world. Balloons operating above the polar regions are deployed from Antarctica, Australia, and Sweden.

Other Missions and Data Analysis

Included in this line item are the following projects:

-Astrophysics Data Curation and Archival Research (ADCAR): The Astrophysics Theme has established an archive structure beyond the scope of individual missions, to receive data and make them accessible by creating an ensemble of primarily wavelength-specific astrophysics archives. After the completion of a mission, all archive activities are taken over by the relevant active multi-mission archive. ADCAR covers the activities of the Astrophysics Data Centers and NASA's participation in the Virtual Astronomical Observatory (VAO). For more information see http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers

-Astrophysics Data Program: Over the years, NASA has invested heavily in the development and execution of an extensive array of space astrophysics missions. The magnitude and scope of the archival data from those missions enables science that transcends traditional wavelength regimes and allows researchers to answer questions that would be difficult, if not impossible, to address through an individual observing program. To capitalize on this invaluable asset and enhance the scientific return on NASA mission investments, Astrophysics Data Analysis provides support for investigations whose focus is on the analysis of archival data from NASA space astrophysics missions.

-The Astrophysics Senior Review budget provides funding for future operating mission extensions. The Senior Review is conducted every two years and is a comparative evaluation of all operating missions in their extended phase. Science output for these missions is evaluated, and a ranking process determines which missions will continue to receive funding for extended operations.

-Keck Single Aperture is a data archive for the High Resolution Echelle Spectrometer (HIRES) instrument in the Keck Observatory. This instrument provides the radial velocity data used to find exoplanets.

-Directorate Support, Space Science: This project funds Agency-level services provided to the Science Mission Directorate. These services include Defense Contract Audit Service (DCAS) contract administration, Defense Contract Audit Agency (DCAA) audit services and NASA Contract Assurance Services (NCAS) for all of SMD's projects.

-Education and Public Outreach: This project supports development and dissemination of new educational and outreach products that utilize SMD science discoveries. Opportunities are provided for students and educators, citizen scientists, and the public to engage in authentic experiences working with NASA data and NASA research communities. Efforts are carried out through competitively selected awards, ranging from $15,000-$130,000 per year. The project also supports four Science Education and Public Outreach Forums to foster ongoing engagement of the target audiences through community communication and feedback.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Annual peer-reviewed solicitation for research grant opportunities	Research Program/R&A	None

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Program Management

The Science Mission Directorate provides program management, with individual projects managed at Goddard Space Flight Center and the Jet Propulsion Laboratory.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Mission Senior Review Panel	5/2008	A comparative evaluation of all the Astrophysics operating missions.	4/2010
Quality	Archival Senior Review Panel	05/2008	Comparative review of the efficiency and cost effectiveness of the archives. For more information on the 2008 Senior Archival review see: http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers/ApArchSR-2008_final.pdf	05/2012
Quality	Balloon working group	06/2009	Evaluate the operation of the Balloon project from a scientific standpoint. The main result of this meeting was a review of the Super-Pressure Balloon development in preparation of an invited oral presentation on June 9, 2009 to the Particle Astrophysics and Gravitation Panel of the on-going Astro2010 Decadal Study. The Decadal Study recommendations are expected in the August-September 2010 timeframe.	06/2010

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	850.0	684.1	687.7	669.4	667.5	640.5	599.2
Hubble Space Telescope (HST)	203.1	112.6	102.7	104.5	99.8	98.0	98.6
James Webb Space Telescope (JWST)	466.9	440.3	444.8	379.2	335.2	259.3	119.2
Stratospheric Observatory for Infrared Astronomy (SOFIA)	77.4	72.8	79.6	80.1	79.2	81.1	81.3
Other Missions And Data Analysis	102.5	58.4	60.6	105.7	153.4	202.2	300.1
FY 2010 President's Budget Request	836.3	690.2	621.9	573.2	544.6	466.7	--
Other Missions and Data Analysis	17.2	23.0	23.0	22.9	20.8	14.4	--
Hubble Space Telescope (HST)	207.7	112.6	101.6	94.6	91.1	93.2	--
James Webb Space Telescope (JWST)	446.9	441.4	385.1	354.6	335.6	259.8	--
Stratospheric Observatory for Infrared Astronomy (SOFIA)	72.8	72.8	74.0	75.8	77.6	79.1	--
Other Missions And Data Analysis	91.7	40.4	38.3	25.3	19.4	20.2	--
Changes from FY 2010 Request	13.6	-6.1	65.8	96.2	123.0	173.9	--

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Program Overview

The science goal of Cosmic Origins is to understand the entire sweep of evolution of the universe, from the cosmic big bang to the present. Cosmic Origins missions explore how the expanding universe grew into a grand, cosmic web of galaxies, how stars and planets formed within the galaxies, and how stars create the heavy elements, such as carbon, that are essential for life. Even though major breakthroughs in our knowledge of the cosmos have already been made with the current suite of missions, Cosmic Origins science questions remain vital. How did the rich structure we observe in the universe today, its planets, stars and galaxies, originate from the tiny fluctuations in the density of matter and energy imprinted by the big bang? What was the nature of the first stars and galaxies, which are so faint and distant that they have never been observed? How did galaxies and the enormous black holes within them form and evolve? How do stars and planets form? What are the conditions needed for life to originate? Are we alone? To address these fundamental questions NASA has developed the world's most sophisticated space observatories and is now building even more advanced facilities such as the James Webb Space Telescope. The submillimeter and far-infrared parts of the spectrum are just now being examined by missions like Herschel and soon by SOFIA. In the future, larger telescopes (with mirror diameters of 10 meters or longer) will be required to resolve galaxies and stellar nurseries at these wavelengths and in the ultraviolet. Future collaboration will also be critical for continued progress answering the questions that form the intellectual impetus behind Cosmic Origins.

For more information, please see: http://nasascience.nasa.gov/about-us/smd-programs/cosmicorigins

Plans For FY 2011

Hubble Space Telescope plans to start a multi-cycle treasury program to coordinate scientific observations over several years.

JWST will continue to make progress towards its launch date in June 2014. The Optical Telescope Element Flight Backplane Assembly is scheduled to be completed, and the Flight Model Science Instruments are scheduled to start delivery.

SOFIA will complete open door flight testing and will conduct the first competed science observations.

If successful during the 2010 Senior review process, Spitzer will continue warm science operations.

Herschel will continue its prime operations in FY 2011.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Project Descriptions and Explanation of Changes

Hubble Space Telescope (HST)

Hubble Space Telescope launched in FY 1990 and is currently in an extended operations phase. Servicing Mission 4 (SM4), completed in FY 2009, added new batteries, gyros and instruments to extend its life even further into the future. One of NASA's most successful and long-lasting science missions, HST has beamed hundreds of thousands of images back to Earth, shedding light on many of the great mysteries of astronomy. Its gaze has helped determine the age of the universe, the identity of quasars, and the existence of dark energy. Development of the capability to safely de-orbit HST after its mission has concluded is underway within the Cosmic Origins program. The timing for this activity will be determined by the status of the observatory and the orbital conditions that would drive an uncontrolled reentry.

James Webb Space Telescope

JWST is currently in development phase and launch is scheduled for FY 2014 on a European Space Agency-supplied Ariane-5 rocket for a five-year science mission (10-year goal) to study the origin and evolution of galaxies, stars, and planetary systems. The JWST spacecraft will have a large mirror, 21.3 feet in diameter, and a sunshield the size of a tennis court. Neither the mirror nor the sunshield fit into the rocket fully open, so both will fold up and open only after JWST is in space. JWST will reside at the Sun-Earth L2 point, which is about one million miles from the Earth. The telescope and instruments will operate at cryogenic temperature in order to achieve infrared performance. Additional funding has been added to restore depleted reserve levels. See project page for more detail.

Stratospheric Observatory for Infrared Astronomy (SOFIA)

SOFIA, currently in development, is a Boeing 747SP airborne observatory with a 2.5 meter reflecting telescope that will study the universe in the infrared spectrum. Besides this contribution to science progress, SOFIA will be a major factor in the development of new observational techniques, new instrumentation and in the education of young scientists and teachers in the discipline of infrared astronomy. The project will be at Full Operational Capability (FOC) in CY 2014. See project page for more detail.

Other Missions and Data Analysis

Included in this line item are:

-The Spitzer Space Telescope, in extended operations, is an infrared telescope utilizing 2 channels of the IRAC instrument to study the atmosphere of exoplanets, looking for the earliest clusters of galaxies, near earth asteroids and providing a 360 degree map of our galaxy. Spitzer completed its cryogenic mission in FY 2009, and is now conducting warm operations. Continued warm operations will be reviewed in the 2010 Senior Review.

-The Herschel Space Observatory is a collaborative mission with the European Space Agency and launched on May 14, 2009. It has the largest single mirror ever built for a space telescope and it will collect long-wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed to instruments onboard Herschel and will also host U.S. astronomer access to data through the NASA Herschel Science Center.

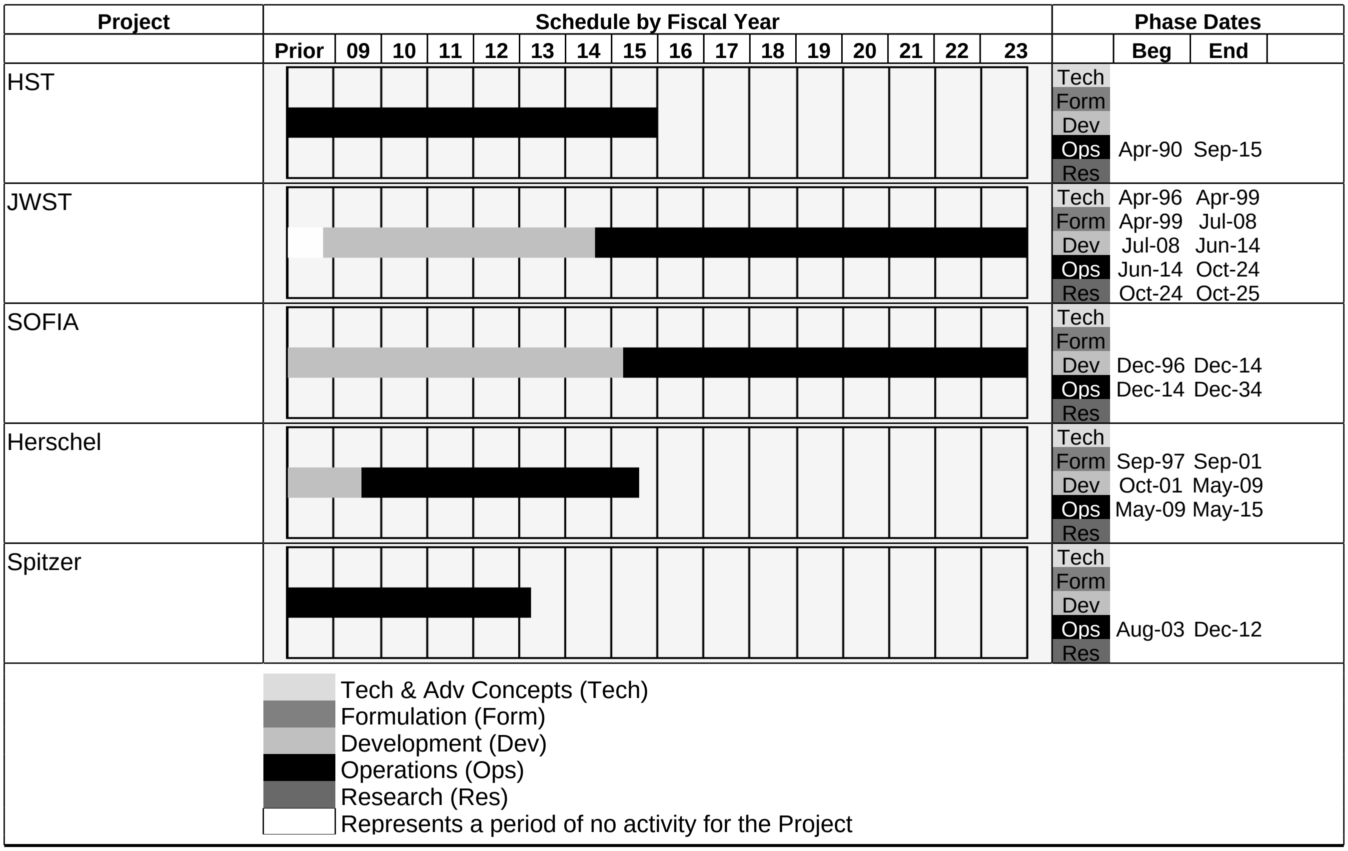
-Cosmic Origins Supporting Research & Technology supports Hubble fellowships and program-specific research and early technology development efforts.

-Cosmic Origins Future Missions supports future mission studies based on the recommendations of the upcoming Astrophysics decadal review.

-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.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Implementation Schedule



Program Management

Cosmic Origins project management responsibility is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
HST	GSFC	GSFC	None
JWST	GSFC	GSFC, JPL, JSC	European Space Agency (ESA) and Canadian Space Agency (CSA)
SOFIA	DFRC	DFRC, ARC	German Space Agency (DLR)
Spitzer	JPL	JPL	None
Herschel	JPL	JPL	European Space Agency (ESA)

Acquisition Strategy

The HST Space Telescope Science Institute (STScI) is run under contract to NASA by the Association of Universities for Research in Astronomy (AURA). The STScI is responsible for the science program selection, grant administration, planning, scheduling, and public outreach activities for the Hubble Space Telescope (HST). The Basic Period of the HST STScI Contract with AURA ends on April 30, 2010. There are two contract options, the first of which runs May 1, 2010-April 30, 2013, and is planned to be exercised in FY 2010.

The HST Mission Operations functions (observatory engineering analysis, trending, and health and safety activities) are performed under a separate contract. The HST Mission Operations and Systems Engineering Services contract extension will expire on June 30, 2011. A new HST Missions operations contract will be required, and contract procurement activity has started for this activity.

As a result of the ongoing 2010 decadal survey, there may be priority missions identified that will require acquisition strategy decisions in the FY 2011 time frame leading to initiating of formulation activities.

No changes to acquisition activities are planned for JWST or SOFIA.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**2,085.3**	**466.9**	**440.3**	**444.8**	**379.2**	**335.2**	**259.3**	**119.2**	**517.3**	**5,047.3**
Formulation	1,800.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,800.2
Development / Implementation	285.1	466.9	440.3	444.8	379.2	335.2	259.3	52.0	0.0	2,662.8
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.2	517.3	584.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
FY 2010 President's Budget Request	**2,085.3**	**446.9**	**441.4**	**385.1**	**354.6**	**335.6**	**259.8**	**--**	**634.9**	**4,943.6**
Formulation	1,800.2	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	1,800.2
Development / Implementation	285.1	446.9	441.4	385.1	354.6	335.6	259.8	--	72.8	2,581.3
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	562.1	562.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.0**	**20.0**	**-1.1**	**59.7**	**24.5**	**-0.5**	**-0.5**	**--**	**-117.6**	**103.7**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	20.0	-1.1	59.7	24.6	-0.4	-0.5	--	-72.8	81.5
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	-44.8	22.4
Other	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	--	0.0	-0.2

Note: The FY 2011 LCC number in the table above is understated by $47.6M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan, and the removal of Construction of Facilities funds. Assuming approval of the initial operating plan, and with the inclusion of CofF funds, the estimated lifecycle cost will be $5095.2M, and the estimated development cost will be $2710.4M.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Explanation of Project Changes

Since confirmation in late 2008, the JWST project has made excellent progress. All Observatory components have successfully completed their preliminary design reviews. All science instruments have successfully completed their critical design reviews, and the Integrated Science Instrument Module (ISIM) Critical Design Review (CDR) was successfully held in March 2009. The ISIM structure was delivered to GSFC in August 2009. The Spacecraft Bus PDR was successfully completed in July 2009, and the Optical Telescope Element CDR was also held successfully in October 2009. The Engineering Development Unit Primary Mirror Segment was cryogenically tested in April 2009 and has almost competed its final planned polishing.

Several technical issues have occurred with the NIRCam instrument optics meeting wavefront error specifications, which have required additional project funds in FY 2011 and FY 2012 to correct. The JWST project is replanning the remaining work in all areas and working to maintain the current schedule, requirements, and LRD. Any revisions to project schedule and cost will be evaluated by the JWST SRB as part of the Critical Design Review (CDR) currently scheduled for April 2010.

Funding in FY 2010 through FY 2012 for the construction of the Thermal Vacuum Chamber A facilities at Johnson Space Center has been removed from the project budget, per Congressional direction.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Purpose

The James Webb Space Telescope (JWST) was identified by the National Research Council as a top priority new initiative for astronomy and physics for the decade. JWST is a large, deployable, space-based infrared astronomical observatory, scheduled for launch in June 2014. The mission is a logical successor to the Hubble Space Telescope (HST), extending beyond Hubble's discoveries by looking into the infrared spectrum, where the highly red-shifted early universe must be observed, where cool objects like protostars and protoplanetary disks emit 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.
- Measure the physical and chemical properties of planetary systems and investigate the potential for life in those systems.

Hubble has told us much about distant objects, but its infrared coverage is limited. Light from distant galaxies is redshifted, by the expansion of the universe, into the infrared part of the spectrum (from the visible). By examining light redshifted beyond Hubble's sight, JWST will be able to observe things farther away, as their light has taken longer to reach us. Hence it will be looking back further in time.

JWST will explore the mysterious epoch when the first luminous objects in the universe came into being after the big bang. The focus of scientific study will include first light of the universe, assembly of galaxies, origins of stars and planetary systems, and origins of the elements necessary for life.

The telescope is scheduled to launch in June 2014 from Kourou, French Guiana, on an ESA-supplied Ariane 5 rocket. Its operational location is the L2 Lagrange point, which is about one million miles from the Earth.

For more information, please see: http://www.jwst.nasa.gov

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Parameters

JWST will be optimized for infrared astronomy, with some capability in the visible range. JWST's instruments are Near Infrared Camera (NIRCam), Mid Infrared Instrument (MIRI), Near Infrared Spectrograph (NIRSpec), and the Fine Guidance Sensor (FGS).

NIRCam is an imager with a large field of view and high angular resolution. It covers a wavelength range of 0.6 - 5 micrometers and has 10 mercury-cadmium-telluride (HgCdTe) detector arrays. These are analogous to charge coupled devices found in ordinary digital cameras. NIRCam is a science instrument but also a wavefront sensor, which is used to align and focus the optical telescope.

NIRSpec enables scientists to obtain simultaneous spectra of more than 100 objects in a 9-square-arcminute field of view. It provides medium-resolution spectroscopy over a wavelength range from 0.6 - 5 micrometers. NIRSpec employs a micro-electromechanical system "microshutter array" for aperture control, and it has two HgCdTe detector arrays.

MIRI is an imager/spectrograph that covers the wavelength range of 5 - 28 micrometers and it has three arsenic-doped silicon detector arrays. The camera module provides wide-field broadband imagery, and the spectrograph module provides medium-resolution spectroscopy over a smaller field of view compared to the imager. The nominal operating temperature for the MIRI is 7 degrees above absolute zero, which is possible through an on-board cooling system.

The FGS is a guider camera that is incorporated into the instrument payload in order to meet the image motion requirements of JWST. This sensor is used for both guide star acquisition and fine pointing. The sensor operates over a wavelength range of 1 - 5 micrometers and has two HgCdTe detector arrays. Its field of view provides a 95% probability of acquiring a guide star for any valid pointing direction. The FGS tunable filter camera is a wide-field, narrow-band camera that provides imagery over a wavelength range of 1.6 - 4.9 micrometers, via tunable Fabry-Perot etalons that are configured to illuminate the detector array with a single order of interference at a user-selected wavelength. The camera has a single HgCdTe detector array.

The JWST Ground Operations, Science Support Center and archives will be at the Space Telescope Science Institute in Baltimore, MD.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Commitments

JWST is scheduled to launch in June 2014 and, after six months of on-orbit checkout and commissioning, it will complete five years of mission operations (with a goal of 10 years of operations.)

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Observatory	Northrop Grumman Aerospace Systems, Redondo Beach, California	Includes Optical Telescope Element (OTE), Spacecraft, Sunshield, Observatory AI&T and commissioning. The Observatory shall be designed for at least a 5-year lifetime.	Same	Same
Integrated Science Instrument Module (ISIM)	NASA Goddard Space Flight Center	Contains the Science Instruments (SIs) and Fine Guidance Sensor (FGS). Provides structural, thermal, power, command and data handling resources to the SIs and FGS.	Same	Same
Near-Infrared Camera (NIRCam) instrument	University of Arizona; Lockheed Martin	Optimized for finding first light sources, and operating over the wavelength range 0.6-5 microns.	Same	Same
Near-Infrared Spectrometer (NIRSpec)	European Space Agency (ESA)	Operating over the wavelength range 0.6-5 microns with three observing modes.	Same	Same
Mid-Infrared Instrument (MIRI)	ESA; University of Arizona; Jet Propulsion Laboratory	Operating over the wavelength range 5-27 microns, providing imaging, coronagraphy, and spectroscopy.	Same	Same
Fine Guidance Sensor	Canadian Space Agency (CSA)	Provides scientific target pointing information to the observatory's attitude control sub-system.	Same	Same
Launch Vehicle	European Space Agency (ESA)	Ariane V ECA	Same	Same
Science Operations Center and Mission Operations	Space Telescope Science Institute (STScI)	Mission Operations and Science Operations Center	Same	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Schedule Commitments

JWST was approved to enter implementation in July 2008.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Non-Advocate Review/Preliminary Design Review	March,2008	Same	Same
Start phase C/Implementation	July 2008	Same	Same
Critical Design Review	April 2010	Same	Same
Systems Integration Review (SIR)	May 2012	Same	February 2013
Launch Readiness Date	June 2014	Same	Same
Start Phase E	December 2014	Same	Same

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
James Webb Space Telescope	2009	2,581.1	2010	2,710.4	5	Launch	06/2014	06/2014	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**2,581.1**	**2,710.4**	**129.3**
Payload	178.4	293.3	114.9
Spacecraft	875.4	1,422.1	546.7
Systems I&T	67.3	68.7	1.4
Ground Systems	206.8	242.0	35.2
Science/technology	10.5	11.9	1.4
Other (launch services and project management)	1,242.7	624.3	-618.4
Programmatic Construction of Facilities (transferred to Construction appropriation)	0.0	48.1	48.1

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Management

Goddard Space Flight Center is responsible for James Webb Space Telescope project management.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Observatory	GSFC	GSFC	None
Mission management and System Engineering	GSFC	GSFC	None
Integrated Science Instrument Module (ISIM)	GSFC	GSFC	None
NIRCam	GSFC	GSFC	None
NIRSpec	ESA	None	ESA
MIRI	GSFC	JPL, ARC	ESA
Fine Guidance Sensor - Tunable Filter (FGS-TF)	CSA	None	CSA
Ariane 5 ESA launch vehicle and launch operations	ESA	None	ESA
Ground control systems and science operations and control center	GSFC	None	None

Acquisition Strategy

JWST is being built by Northrop Grumman Aerospace Systems (Redondo Beach, CA), teamed with Ball (Boulder, CO), ITT (Rochester, NY) and Alliant Techsystems (Edina, MN). Selections were made via NASA Request For Proposal.

The Space Telescope Science Institute (STScI), in Baltimore, MD, is developing the Science and Operations Center and associated services.

The Integrated Science Instrument Module (ISIM) is being provided by GSFC.

The University of Arizona, Tucson is providing the near-infrared science camera (NIRCam), along with Lockheed Martin's Advanced Technology Center in Palo Alto, California. The selection was made via a NASA Announcement of Opportunity.

The European Space Agency is providing the Mid-Infrared Instrument (MIRI) with management and technical participation by ARC and JPL, which was selected for this role after an internal NASA competition. The Europeans are also providing the Near-Infrared Spectrometer (NIRSpec) and an Ariane 5 launch vehicle.

The Canadian Space Agency is providing the Fine Guidance Sensor.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Critical Design Review	04/2010
Performance	SRB	N/A	Systems Integration Review/Authority to Proceed into Assembly Integration and Testing	05/2012
Performance	SRB	N/A	Flight Readiness Review/Authority to Launch	06/2014

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
JWST Manufacturing, I&T	JWST has a long, complicated cryogenic integration and test which has never been performed at this scale.	JWST Standing Review Board regularly reviews the optical telescope element (OTE) testing and observatory-level integration and test planning.
JWST Partnership Risk	Because JWST is an international collaboration, NASA may incur schedule and cost impacts caused by challenges in Europe and Canada that are outside of NASA's control. Experience with similar collaborations indicates that this is likely to occur.	NASA has written clearly-defined interfaces and is actively managing and complying with export controls (ITAR).

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**660.1**	**77.4**	**72.8**	**79.6**	**80.1**	**79.2**	**81.1**	**81.3**	**1,761.9**	**2,973.3**
Formulation	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Development / Implementation	625.1	77.4	72.8	79.6	80.1	79.2	81.1	0.0	0.0	1,095.3
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.3	1,761.9	1,843.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
FY 2010 President's Budget Request	**660.0**	**72.8**	**72.8**	**74.0**	**75.8**	**77.6**	**79.1**	**--**	**1,843.4**	**2,955.5**
Formulation	35.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	35.0
Development / Implementation	625.0	72.8	72.8	74.0	75.8	77.6	79.1	--	0.0	1,077.1
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	1,843.4	1,843.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.0**	**4.6**	**0.0**	**5.6**	**4.3**	**1.6**	**2.0**	**--**	**-81.5**	**17.8**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.1	4.6	0.0	5.6	4.3	1.6	2.0	--	0.0	18.2
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	-81.5	-0.2
Other	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.2

Note: The FY 2011 LCC number in the table above is understated by $2.1M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $2975.4M, and the estimated development cost will be $1097.3M.

Explanation of Project Changes

SOFIA development costs were increased by $17.8M in the current budget horizon to reflect increased hanger cost requirements.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Purpose

The SOFIA mission will study many different kinds of astronomical objects and phenomena, including star birth and death, formation of new solar systems, identification of complex molecules in space, planets, comets and asteroids in our solar system, nebulae and dust in galaxies (ecosystems of galaxies), and black holes at the center of galaxies. The infrared light of these objects is only partially visible from the ground due to water vapour in the Earth's atmosphere.   However, at high altitudes the influence of water vapour is negligible, allowing better observation of these astronomical objects.

It will be NASA's only far-infrared mission when Spitzer runs out of helium, and it is the only mid-infrared mission until JWST. SOFIA's reconfigurability and flexibility ensures cutting edge technology as well as the ability to address new scientific questions. For more information, please see http://www.nasa.gov/mission_pages/SOFIA/index.html

Project Parameters

The Stratospheric Observatory for Infrared Astronomy (SOFIA) was 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 eight instruments. SOFIA will ramp up to 960 science hours per year, and flights will last six to eight hours on average.

Germany has provided the telescope assembly and assists with mission operations. NASA has provided, refurbished and modified the airplane, and provides the Science Operations Center.

The U.S. instruments include High-speed Imaging Photometer for Occultation (HIPO), First Light Infrared Test Experiment CAMera (FLITECAM), Faint Object InfrRed CAmera for the SOFIA Telescope (FORCAST), CAlTech Submillimeter Interstellar Medium Investigations Receiver (CASIMIR), Echelon-Cross-Echelle Spectrograph (EXES), and High-resolution Airborne Wideband Camera (HAWC). The two German instruments are German Receiver for Astronomy at Terahetz Frequencies (GREAT), and Field Imaging Far-Infrared Line Spectrometer (FIFI LS).

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Commitments

SOFIA will initiate science observations in FY 2010, and will begin 20 years at full operational capability as an airborne observatory in December 2014.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Platform	DFRC/L3/MPC	Refurbished Boeing 747SP modified to accommodate telescope	Same	Same
Science Center	ARC/USRA	Science Center will schedule observations, and manage data acquisition and processing	Same	Same
Telescope	Germany (DLR)	2.7m diamter, dual mirror	Same	Same
Flight Operations	DFRC/CSC DyneCorp	Flight crew, maintenance, and fuel	Same	Same
High-speed Photometer for Occultations (HIPO)	Lowell Observatory	Simultaneous high-speed time-resolved imaging photometry at two optical wavelengths	Same	Same
First Light Infrared Test Experiment Camera (FLITECAM)	UCLA	Large field-of-view, narrow- and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 µm	Same	Same
Faint Object Infrared Camera for SOFIA Telescope (FORCAST)	Cornell University	Large field-of-view, narrow- and broad-band photometric imaging and moderate-resolution spectroscopy from 4 to 42 µm	Same	Same
Caltech Submillimeter Interstellar Medium Investigations Receiver (CASIMIR)	Caltech	Modular, dual-channel heterodyne instrument for high-resolution spectroscopy between 150 and 600 µm	Same	Same
Echelon-Cross - Echelle Spectrograph (EXES)	ARC	Echelon Spectrometer, 5-28 microns R=105, 104, or 3000	Same	Same
High-resolution Airborne Wideband Camera (HAWC)	University of Chicago	Far-Infrared Bolometer Camera ,50-240 microns	Same	Same
German Receiver for Astronomy at Terahetz Frequencies (GREAT)	Germany (DLR)	TBD	Same	Same
Field Imaging Far-Infrared Line Spectrometer (FIFI LS)	Germany (DLR)	TBD	Same	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Schedule Commitments

The development and test plan has been modified to enable earlier science observations by the science community to be concurrent with the late phases of aircraft flight testing. The current plan provides for initial science observations with a subset of science instruments in FY 2010, followed by completion of the remaining science instruments and refinement of telescope performance, at which point Full Operational Capability in December 2014 is reached.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
First Flight	2000	2007	2007
First Science (Early Science)	N/A	2009	2010
Full Operational Capability (FOC)	N/A	2014	2014

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Stratospheric Observatory for Infrared Astronomy (SOFIA)	2007	919.5	2010	1,097.3	19	FOC	12/2013	12/2014	12

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**919.5**	**1,097.3**	**177.8**
Aircraft/Spacecraft	657.7	745.6	87.9
Other Costs	62.2	61.0	-1.2
Science/Technology	199.6	290.7	91.1

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Management

The overall Stratospheric Observatory for Infrared Astronomy (SOFIA) project, and the SOFIA airborne system is managed by Dryden Flight Research Center. The SOFIA science is managed by Ames Research Center.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Platform	DFRC	DFRC	Germany - DLR/DSI
Science	ARC	None	Germany - DLR/DSI
Mission Operations and Data Analysis	ARC	None	Germany - DLR/DSI
Instruments	ARC	None	Germany - DLR/DSI

Acquisition Strategy

Dryden Flight Research Center (DFRC) manages the program and the platform project (airframe and telescope). DFRC is working with L-3 Communications (Waco,Texas), and MPC Products Corporation (Skokie,IL) to support the completion of the development, integration and test of the airborne platform system. L-3 modified the Boeing 747SP aircraft to install the telescope provided by Germany (DLR/DSI). MPC is developing the telescope cavity door drive system. DFRC is also working with CSC DynCorp (El Segundo, CA) to provide aircraft maintainence support.

Ames Research Center (ARC) manages the science project. ARC is working with University Space Research Association (Columbia, MD) for the science planning, ground science facilities, science instrument and technology development, and education and public outreach for SOFIA.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Standing Review Board	7/2009	Early science project review. Determined that plan for early science had merit.	4/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Telescope cavity acoustics	If the telescope cavity acoustic resonance occurs above specified sound pressure levels, then additional mitigation work would be required	External wind tunnel and computational fluid dynamics modeling have been complete to design the cavity, and mitigation approaches.
Late delivery of Cavity Door Drive System	Late delivery of software that operates the telescope observation doors on the aircraft will impact the schedule to initiate open door flight testing and science observations.	NASA has stationed a NASA representative at the vendor's facility to support and oversee the vendor until delivery of the software. NASA has reviewed and revised the schedule for testing of the software for schedule efficiency.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**111.1**	**116.8**	**103.3**	**114.4**	**151.7**	**176.4**	**202.0**
Other Missions and Data Analysis	111.1	116.8	103.3	114.4	151.7	176.4	202.0
FY 2010 President's Budget Request	**111.1**	**124.7**	**165.5**	**191.0**	**270.6**	**315.9**	**--**
Other Missions and Data Analysis	111.1	124.7	165.5	191.0	270.6	315.9	--
Changes from FY 2010 Request	**0.0**	**-7.9**	**-62.2**	**-76.6**	**-118.9**	**-139.5**	**--**

Program Overview

The Physics of the Cosmos (PCOS) Program focuses on some of the most profound questions in contemporary science: How did the universe begin? What is the universe composed of, and what is its ultimate fate? What are the fundamental laws that govern the workings of space, time, matter and energy?

These fundamental questions can be approached by asking more specific questions: What happens to matter, energy, and time at the edge of a black hole where Einstein's theory of gravity is put to its harshest test? What are the natures of dark matter, the unidentified matter that assisted the formation of galaxies, and the mysterious dark energy that is causing the Universe to accelerate? It is possible that the answers to these questions will usher in a revolutionary new understanding of physics.

The Fermi mission, for example, is searching for signs of new laws of physics and what composes the mysterious dark matter. It will attempt to explain how black holes accelerate immense jets of material to nearly the speed of light. The Planck mission will provide the best possible map of the cosmic microwave background, the earliest baby picture of the Universe. The XMM-Newton mission has helped scientists solve a number of cosmic mysteries, ranging from enigmatic black holes to the origins of the universe itself. Chandra will continue to reveal new details of celestial X-ray phenomena such as the collisions of galaxies that directly detect the presence of dark matter. New missions under consideration in the current Astronomy and Astrophysics Decadal survey include the International X-ray Observatory (IXO), which would observe regions near the surfaces of super massive black holes; the Laser Interferometer Space Antenna (LISA), which would peer back to the very beginning of time using the completely unexplored spectrum of gravitational radiation; and the Joint Dark Energy Mission (JDEM), which would focus on the nature and behavior of dark energy.

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

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Plans For FY 2011

In FY 2011 Planck will be in full science operations. Planck will complete the first full-sky survey of the cosmic microwave background, and will process the science data to produce the first Planck science results. Then the second full-sky survey will begin to provide critical refinement of cosmic microwave background and further science results.

The Fermi Gamma Ray Space Telescope will continue in its prime operations phase, making observations selected by peer review of observation proposals. Chandra will continue extended mission operations, making observations selected by peer review of observation proposals.

Future PCOS mission studies will continue pending the outcome of the NRC Decadal Survey on Astrophysics, which will evaluate JDEM, IXO, LISA, and other missions in the Astrophysics portfolio.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Project Descriptions and Explanation of Changes

Other Missions and Data Analysis

Included in this line item are:

-Planck, launched in May 2009, is an ESA-led mission with substantial NASA contributions. It will reveal the geometry and contents of the universe, how the universe grew immediately after its birth, and how the stage was set for the universe to evolve into structures that are seen today, such as galaxies. It will provide an order of magnitude increase in precision in its measurement of the Cosmic Microwave Background (CMB).

-Fermi Gamma-ray Space Telescope is a joint NASA/DOE mission formerly called GLAST. Fermi launched in June 2008 and is currently in operational phase. It is designed to detect the highest energy gamma-rays ever measured in a space-based mission and will provide a full-sky map filled with thousands of gamma-ray sources, increasing the current tally by orders of magnitude.

-Chandra, a flagship X-ray observatory currently in extended operations, has allowed scientists to image complex systems in exquisite detail, and to determine the positions of thousands of distant X-ray sources. Chandra has also provided unique information on diverse subjects ranging from the presence and amount of dark matter in the universe to phenomena occurring near the horizons of black holes.

- Physics of the Cosmos Supporting Research & Technology supports Einstein Fellowships and program-specific research and early technology development efforts.

- Physics of the Cosmos Program Management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

- Physics of the Cosmos Future Missions supports future mission studies based on the recommendations of the upcoming Astrophysics Decadal Survey by the National Academy of Sciences. Three missions have completed early technology activities and are under consideration by the 2010 Decadal Survey:

-The Laser Interferometer Space Antenna (LISA), a joint mission with the European Space Agency, will provide a first view of the gravitational radiation spectrum from space, enabling scientists to "see" in new ways how the universe evolved, and allowing powerful new tests of fundamental laws.

-The International X-ray Observatory (IXO) is a joint X-ray observatory with participation from NASA, the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA). Science objectives are the study of black holes and matter under extreme conditions, and the life cycles of matter and energy in the universe.

-The Joint Dark Energy Mission (JDEM) is a space-based observatory that will make precision cosmological observations to measure the effects of dark energy on the recent expansion history of the universe and on the growth of structure in the universe.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Implementation Schedule

Project	Phase	Beg	End
Fermi	Tech	Jun-98	Dec-99
	Form	Dec-99	Dec-03
	Dev	Dec-03	Jun-08
	Ops	Jun-08	Aug-18
	Res	Sep-18	Feb-20
Planck	Tech		
	Form	Sep-97	Sep-01
	Dev	Oct-01	May-09
	Ops	May-09	Mar-11
	Res	Mar-11	Mar-12
Chandra	Tech		
	Form		
	Dev		
	Ops	Jun-99	Sep-14
	Res		

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

- Tech & Adv Concepts (Tech)
- Formulation (Form)
- Development (Dev)
- Operations (Ops)
- Research (Res)
- Represents a period of no activity for the Project

Program Management

Goddard Space Flight Center has Program management responsibility. Project management is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Fermi	GSFC	GSFC	DOE, Japan, Italy, France, Sweden, and Germany
Planck (Instrumentation)	JPL	JPL	ESA
Chandra	MSFC	MSFC	None

Acquisition Strategy

The acquisition strategies for future Astrophysics missions (such as JDEM, IXO, or LISA) are under development. NASA will seek to maximize the amount of competition to ensure that the best concepts and science are supported.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	72.1	46.2	42.5	54.1	83.0	93.8	117.6
Other Missions and Data Analysis	72.1	46.2	42.5	54.1	83.0	93.8	117.6
FY 2010 President's Budget Request	68.1	46.2	57.3	86.9	123.5	167.3	--
Other Missions and Data Analysis	68.1	46.2	57.3	86.9	123.5	167.3	--
Changes from FY 2010 Request	4.0	0.0	-14.7	-32.8	-40.5	-73.6	--

Program Overview

Today we stand on the threshold of a voyage of unprecedented scope and ambition, promising insight into one of humankind's most timeless questions: Are we alone? Is Earth unique, or are other 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 400 planets orbiting nearby stars. Most of these planets are gas giants, similar in size to the four outer planets in our own Solar System, although the majority orbit much closer to their parent stars than do the giant planets in our system, some as close as 0.04 AU (1 AU = 1 astronomical unit = mean Earth-Sun distance, 93 million miles). Mercury, by comparison, orbits the Sun at a distance of about 0.4 AU (about 37 million miles). This means the planets have "hot" surface temperatures compared to our Earth.

Most of the known extrasolar planets have been discovered with ground-based telescopes using the radial velocity, or the Doppler method, in which one measures the tiny back-and-forth motion of a star as a planet orbits around it. The Doppler method tends to favor the detection of massive planets since the greater the mass of the planet, the greater the "wobble" it induces in the parent star. Approximately sixty planets have been found using a second technique, the transit method, in which one measures the slight dimming of a star's light that occurs as a planet passes between it and the observer, blocking out a bit of the light. The transit method only works on systems in which the planet's orbital plane is nearly parallel to one's line of sight. NASA's Kepler mission, the Agency's first mission dedicated to the study of extrasolar planets, is specifically designed to use the transit method to detect Earth-size and smaller planets, and will provide the first quantitative estimate of how many of the billions of stars in our galaxy have such planets.

In the future, through the use of advanced measurement techniques such as astrometry, interferometry, microlensing and coronagraphy, NASA plans to embark on a series of missions designed to detect and characterize Earth-sized planets that are orbiting in the "habitable zone" of nearby stars (the range of distances at which liquid water could be stable at the planet's surface). The Agency's long-term vision for exoplanet exploration includes missions optimized not only to detect extrasolar planets, but also to directly measure their characteristics and search for the chemical fingerprints of life. For more information, please see: http://exep.jpl.nasa.gov/

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Plans For FY 2011

The Exoplanet Exploration Program (EXEP) will fund technology maturation activities for a variety of different techniques for detecting and characterizing extrasolar planets, including space-based interferometric, coronagraphic, and statistical concepts.

Keck Interferometer is operational and will provide U.S. astronomers access to this unique observational facility in support of NASA astrophysics science goals.

Kepler will be in full operations phase, making progress towards identifying potential Earth-size planets.

Project Descriptions and Explanation of Changes

Other Missions and Data Analysis

This line item contains the following projects:

-Kepler, launched in March 2009, finished its in-orbit checkout and began its operations phase during the summer of 2009. It is specifically designed to survey the distant stars in our region of the Milky Way galaxy to detect and characterize hundreds of Earth-size and smaller planets in or near the "habitable zone." The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface.

-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: Exoplanet Exploration, Cosmic Origins and Physics of the Cosmos. Observation time is competed, selected and managed by the NASA Exoplanet Science Institute (NExScI).

-Exoplanet Exploration Supporting Research & Technology supports Sagan Fellowships and program-specific research and early technology development efforts.

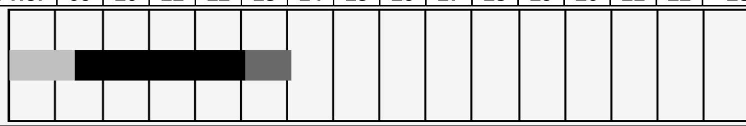
- Exoplanet Exploration Program Management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

- Exoplanet Exploration Future Missions supports future mission studies based on the recommendations of the upcoming 2010 Astrophysics decadal survey. Missions under consideration include the Space Interferometry Mission (SIM). SIM is a mission under study in support of NASA's goal of searching for habitable planets. The project has completed risk reduction engineering, and is studying alternate designs over a range of cost and performance levels.

-If approved for further development, the Large Binocular Telescope Interferometer (LBTI) is the NASA portion of the Large Binocular Telescope (LBT) partnership. The instrument will perform a key science program of exo-zodiacal dust survey around nearby stars.

Mission Directorate: Science
Theme: Astrophysics
Program: Exoplanet Exploration

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
Kepler																	Tech		
																	Form	Dec-01	May-05
																	Dev	May-05	Mar-09
																	Ops	Mar-09	Nov-12
																	Res	Nov-12	Nov-13

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The Jet Propulsion Laboratory is resposible for program management. Program management is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Kepler	ARC	ARC	None

Acquisition Strategy

The acquisition strategy for the next Exoplanet mission has not yet been determined.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Exoplanet Task Force	01/2008	Determine planet-finding research and technology approach & prioritization leading up to the next decadal survey. Report and recommended strategy published and sent to respective agencies. For more information, please see: http://nasascience.nasa.gov/about-us/NAC-subcommittees/nac-documents/2008-01_APS_ExoPTF.pdf	N/A
Performance	SRB	N/A	To conduct an overall assessment of the life cycle cost, schedule and deliverables of the program.	2013

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**135.7**	**107.9**	**86.7**	**93.3**	**58.5**	**53.3**	**13.2**
Nuclear Spectroscopic Telescope Array (NuStar)	38.7	59.9	32.1	10.8	6.2	0.0	0.0
Gravity and Extreme Magnetism	1.7	0.0	21.0	57.7	44.7	40.8	2.1
Other Missions and Data Analysis	95.2	48.0	33.6	24.8	7.6	12.6	11.1
FY 2010 President's Budget Request	**130.7**	**107.9**	**69.5**	**26.6**	**10.4**	**1.7**	**--**
Wide - Field Infrared Survey Explorer (WISE)	65.2	13.0	5.2	1.6	0.2	0.0	--
Nuclear Spectroscopic Telescope Array (NuStar)	38.7	59.9	33.7	6.8	6.4	0.0	--
Other Missions and Data Analysis	26.8	35.0	30.6	18.2	3.8	1.7	--
Changes from FY 2010 Request	**5.0**	**0.0**	**17.2**	**66.6**	**48.0**	**51.6**	**--**

Program Overview

The Explorer Program provides frequent flight opportunities for world-class astrophysics and heliophysics investigations using innovative and streamlined management approaches for spacecraft development and operations. Explorer missions are 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 also enables participation in missions of opportunity provided by other U.S. or international agencies. The program emphasizes missions that can be accomplished under the control of the scientific research community within constrained mission life-cycle costs. The program also seeks to enhance public awareness of space science by incorporating educational and public outreach activities into each mission. For more information, please see Explorer Program at http://explorers.gsfc.nasa.gov/missions.html.

Currently, there are three Explorer missions in the Astrophysics Division: Nuclear Spectroscopic Telescope Array (NuSTAR) is in development, Astro-H and Gravity and Extreme Magnetism (GEMS) (the most recently selected mission) are in formulation. Five previously-launched missions are also supported in this program, as they continue to produce world-class science in their extended mission phases.

Plans For FY 2011

The Nuclear Spectroscopic Telescope Array (NuSTAR) will complete the science instrument integration and test activities, and begin final overall integration and test of the combined NuSTAR science instrument/spacecraft bus, in preparation for a FY 2012 launch.

The SXS instrument for Astro-H will complete its critical design review.

Gravity and Extreme Magnetism (GEMS) will complete preliminary design review and confirmation review.

WISE will complete its first sky map and complete its prime mission phase.

Project Descriptions and Explanation of Changes

Nuclear Spectroscopic Telescope Array (NuSTAR)

The Nuclear Spectroscopic Telescope Array (NuSTAR), currently in development, is planned for launch in January 2012. NuSTAR will provide a greater capability for using high-energy X-rays to detect black holes than any currently existing instrument. NuSTAR has been designed to answer fundamental questions about the universe, such as: How are black holes distributed through the cosmos? How were the elements of the universe created? What powers the most extreme active galaxies? This mission will expand the ability to understand the origin of cosmic rays and help predict the destinies of stars and galaxies.

Gravity and Extreme Magnetism SMEX (GEMS)

The Gravity and Extreme Magnetism (GEMS) mission was recently selected to proceed into formulation. GEMS will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than Earth's.

Other Missions and Data Analysis

Included in this line item are the following projects:

-Launched in December 2009, the Wide-field Infrared Survey Explorer (WISE) will provide an all-sky survey of galaxies in the infrared. During its six-month mission, WISE will map the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. WISE's infrared survey will provide an essential catalog for the James Webb Space Telescope. As the telescope orbits from the North Pole to the South Pole and then back up to the North Pole, it will observe a circle in the sky. As Earth moves around the Sun, this circle will shift, until WISE has observed the entire sky.

-Suzaku is Japan's fifth X-ray astronomy mission, on which NASA provided five X-ray mirrors, as well as one instrument, the micro-calorimeter spectrometer. Suzaku studies black holes, neutron stars, and quasars, to unravel the physics of high-energy processes and the behavior of matter under extreme conditions.

-Swift studies the position, brightness, and physical properties of gamma-ray bursts. Within seconds of detecting a burst, Swift relays a burst's location to ground stations, allowing both groundbased and space-based telescopes around the world the opportunity to observe the burst's afterglow.

-The Galaxy Evolution Explorer (GALEX) is exploring the origin and evolution of galaxies, the origins of stars and heavy elements, and is conducting an all-sky ultraviolet survey.

-The Wilkinson Microwave Anisotropy Probe (WMAP) studies the early universe by measuring the cosmic microwave background radiation over the full sky. WMAP produced the earliest "baby picture" of the universe, showing temperature variation of microwave light 379,000 years after the big bang, over 13 billion years ago.

-Astro-H is a mission of opportunity currently in formulation, in which NASA will provide the High-Resolution Soft X-Ray Spectrometer (SXS) instrument onboard the Astro-H spacecraft. Astro-H is an X-ray observation satellite under development by JAXA, scheduled for a FY 2014 launch. The mission will trace the growth history of the largest structures in the universe, provide insights into the behavior of material in extreme gravitational fields, determine the spin of black holes and the equation of state of neutron stars, trace shock acceleration structures in clusters of galaxies, and investigate the detailed physics of jets.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Implementation Schedule

Project	Schedule by Fiscal Year (Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23)	Phase Dates	Beg	End
WISE		Tech		
		Form	Apr-02	Oct-06
		Dev	Oct-06	Dec-09
		Ops	Dec-09	Oct-10
		Res	Nov-10	Nov-12
Swift		Tech		
		Form		
		Dev		
		Ops	Apr-04	Sep-12
		Res		
Suzaku		Tech		
		Form		
		Dev		
		Ops	May-05	Sep-11
		Res		
WMAP		Tech		
		Form		
		Dev		
		Ops	Jun-01	Sep-11
		Res		
GALEX		Tech		
		Form		
		Dev		
		Ops	Apr-03	Sep-12
		Res		
NuSTAR		Tech		
		Form	Feb-08	Nov-09
		Dev	Nov-09	Jan-12
		Ops	Jan-12	Sep-14
		Res		
Astro-H		Tech		
		Form	Jun-08	Aug-09
		Dev	Aug-09	Feb-14
		Ops	Feb-14	Feb-16
		Res		
GEMS		Tech		
		Form	Jun-09	Jul-11
		Dev	Jul-11	Apr-14
		Ops	Apr-14	Jan-15
		Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Program Management

Management of the Astrophysics Explorer Program is assigned to Goddard Space Flight Center (GSFC).

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
WISE	GSFC	JPL	None
GALEX	GSFC	N/A	None
NuSTAR	GSFC	JPL	None
Astro-H	GSFC	GSFC	Japan (JAXA)
Swift	GSFC	N/A	None
Suzaku	GSFC	N/A	Japan (JAXA)
WMAP	GSFC	N/A	None
RXTE	GSFC	N/A	None
GEMS	GSFC	GSFC	None

Acquisition Strategy

Explorer projects are selected through competitive Announcements of Opportunity, from which multiple investigations are selected for initial concept studies, followed by a competitive down-select to proceed to the next stage of formulation. Investigations are selected to proceed from one phase to the next through execution of contract options, based on successful technical, cost, and schedule performance in the previous phases.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**16.7**	**38.7**	**59.9**	**32.1**	**10.8**	**6.2**	**0.0**	**0.0**	**0.0**	**164.3**
Formulation	16.7	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.3
Development / Implementation	0.0	17.1	59.9	32.1	4.5	0.0	0.0	0.0	0.0	113.6
Operations / Close-out	0.0	0.0	0.0	0.0	6.3	6.2	0.0	0.0	0.0	12.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**16.7**	**38.7**	**59.9**	**33.7**	**6.8**	**6.4**	**0.0**	**--**	**0.0**	**162.2**
Formulation	16.7	21.6	0.0	0.0	0.0	0.0	0.0	--	0.0	38.3
Development / Implementation	0.0	17.1	59.9	33.7	0.0	0.0	0.0	--	0.0	110.7
Operations / Close-out	0.0	0.0	0.0	0.0	6.8	6.4	0.0	--	0.0	13.2
Changes from FY 2010 Request	**0.0**	**0.0**	**0.0**	**-1.6**	**4.0**	**-0.3**	**0.0**	**--**	**0.0**	**2.1**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	-1.6	4.5	0.0	0.0	--	0.0	2.9
Operations / Close-out	0.0	0.0	0.0	0.0	-0.6	-0.3	0.0	--	0.0	-0.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0

Note: The FY 2011 LCC number in the table above is overstated by $3.7M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $160.6M, and the estimated development cost will be $109.9M.

Explanation of Project Changes

NuSTAR was approved to enter development at its confirmation review in August 2009. It was confirmed at a budget slightly higher than the FY 2010 President's budget, consistent with the recommendation of the Senior Review Board.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Project Purpose

The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will observe the universe at high X-ray energy levels. By focusing higher energy X-rays, NuSTAR will start to answer several fundamental questions about the universe including: How are black holes distributed through the cosmos? How were heavy elements forged in the explosions of massive stars? What powers the most extreme active galaxies?

NuSTAR's primary science goal is to make the first deep observations of regions of the sky in the high energy X-ray band in order to locate massive black holes in other galaxies, locate and examine the remnants of collapsed stars in our galaxy, observe selected very high energy gamma-ray sources, and observe any supernovae of opportunity in the local group of galaxies. NuSTAR's key science products will be sensitive high-energy X-ray survey maps of the celestial sky that will guide the X-ray astronomy community research for several years to come.

For more information see: http://www.nustar.caltech.edu/

Project Parameters

NuSTAR will image the sky in the high energy X-ray band (6-79 KeV) and the spacecraft will be 3-axis stabilized. The primary science instruments will be two identical focusing X-ray telescopes which utilize an extendable 10-meter mast. The launch vehicle will be a Pegasus XL.

Project Commitments

NuSTAR will be launched in January 2012 into a 550km circular orbit around the Earth, with an orbital inclination currently planned for 6 degrees. Prime operations phase is two years.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	Orbital Sciences Corporation	Spacecraft design, fabrication and testing.	N/A	Same
Mission operations, focal plane assembly and instrument electronics	University of California, Berkeley	Aperture stop, active shield module and mechanical enclosures	N/A	Same
X-ray optics	Columbia University, GSFC and the Danish Technical University	Overall optics assembly management and manufacturing	N/A	Same
Mast, canister and instrument structure	ATK	Delivery of mast, canister and instrument structure for the spacecraft	N/A	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Schedule Commitments

NuSTAR was authorized for mission re-start in September 2007 and was authorized to proceed into Phase B in January 2008. Confirmation to proceed into Phase C (implementation) was approved in August 2009.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Preliminary Design Review	N/A	N/A	June 2009
Confirmation Review	N/A	N/A	August 2009
Critical Design Review	February 2010	N/A	February 2010
Launch	January 2012	N/A	January 2012

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Nuclear Spectroscopic Telescope Array	2010	109.9	2010	109.9	0	Launch	01/2012	01/2012	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**109.9**	**109.9**	**0.0**
Aircraft/Spacecraft	15.4	15.4	0.0
Payload(s)	21.5	21.5	0.0
Systems I&T	5.9	5.9	0.0
Launch Vehicle Services	35.8	35.8	0.0
Ground Systems	2.1	2.1	0.0
Science/Technology	1.7	1.7	0.0
Other Costs	27.5	27.5	0.0

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Project Management

The Jet Propulsion Laboratory is responsible for NuSTAR Project Management. The Principal Investigator at the California Institute of Technology is responsible for mission science.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Mission Science	JPL	N/A	N/A
Launch Vehicle	KSC	N/A	N/A
Spacecraft, instruments, mast, optics	JPL	GSFC	N/A

Acquisition Strategy

NuSTAR was selected via a NASA Explorers Announcement of Opportunity. The spacecraft is being developed by Orbital Sciences Corporation (OSC) in Dulles, Virginia. X-ray optics are being developed by Columbia University (NY), GSFC (MD), and the Danish Technical University. Launch vehicle acquisition is through KSC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	6/2009	Preliminary Design Review (PDR); received authority to enter Phase C	02/2010
Quality	SRB	N/A	Critical Design Review (CDR). Demonstrates that the preliminary design is appropriate to support proceeding with full scale fabrication, assembly, integration and testing.	2/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Observatory Mass Margin	The combined mass of the spacecraft and instrument forces design changes that tax project programmatic resources.	Remove shells from each object. This would free up about 6-10kg from the instrument.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Gravity and Extreme Magnetism (SMEX 13)

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**1.7**	**0.0**	**21.0**	**57.7**	**44.7**	**40.8**	**2.1**
Total Change from 2010 President's Budget Request	**1.7**	**0.0**	**21.0**	**57.7**	**44.7**	**40.8**	**--**

Project Purpose

GEMS will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than Earth's.

Current missions cannot do this because the required angular resolution is far beyond what is technically feasible and, in the case of magnetic field imaging, can't do this because magnetic fields are invisible. GEMS will use a new technique to accomplish what has been impossible until now. It will build up a picture indirectly by measuring the polarization of X-rays emitted from these violent regions. This will open new discovery space because GEMS is orders of magnitude more sensitive than previous X-ray polarization experiments.

GEMS will be able to tell the shapes of the X-ray-emitting matter trapped near black holes better than existing missions can -- in particular, whether matter around a black hole is confined to a flat disk or puffed into a sphere or squirting out in a jet. Since X-rays are polarized by the space swirling around a spinning black hole, GEMS also provides a method of determining black hole spin independent of other techniques.

Project Preliminary Parameters

The nominal science mission is 9 months in duration. The X-ray Polarimeter Instrument (XPI) will be sensitive from 2 to 10 kev to polarization amplitude and angle. GEMS will study 35 targets including stellar-mass, black holes, seyfert galaxies and quasars, blazars, neutron star pulsars, shell supernovae remnants, and pulsar wind nebulae.

Estimated Project Deliverables

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	Orbital	Small spacecraft based on reusuable design	N/A	Same
Instrument Payload	GSFC	X-ray Polarimeter Instrument (XPI)	N/A	Same
Launch Vehicle	TBD	Small Class	N/A	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Gravity and Extreme Magnetism (SMEX 13)

Estimated Project Schedule

The GEMS project was selected for formulation in June 2009.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
SRR (Mission)	July 2010	N/A	Same
KDP-C	July 2011	N/A	Same
Launch	April 2014	N/A	Same

Project Management

GEMS is part of the Explorers Program managed by GSFC.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	None	N/A
X-ray Polarimeter Instrument (XPI)	GSFC	GSFC	N/A
Launch Vehicle	KSC	None	N/A

Acquisition Strategy

The largest portion of the overall project effort has been awarded to Orbital. In Phase B/C/D/E, the contract with Orbital is a cost-plus-award fee.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Preliminary Design Review; determine if the project is ready to proceed into development	06/2011

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Late Polarimeter Delivery to Instrument I&T	If the Polarimeter does not meet the delivery date to the Instrument I&T, then the mission schedule will be impacted.	The project plans to develop two ETUs of the Polarimeter to test in parallel.

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Mission Directorate:	Science
Theme:	Heliophysics

Theme Overview

Our planet is immersed in a seemingly invisible yet exotic and inherently hostile environment. Above the protective cocoon of Earth's lower atmosphere is a plasma soup composed of electrified and magnetized matter entwined with penetrating radiation and energetic particles. Our Sun's explosive energy output forms an immense structure of complex magnetic fields. This colossal bubble of magnetism, known as the heliosphere, stretches far beyond the orbit of Pluto. On its way through the Milky Way, this extended atmosphere of the Sun affects all planetary bodies in the solar system. It is itself influenced by slowly changing interstellar conditions that in turn can affect Earth's habitability. In fact, the Sun's extended atmosphere drives some of the greatest changes in our local magnetic environment affecting our own atmosphere, ionosphere, and potentially our climate. This immense volume is our cosmic neighborhood; it is the domain of the science called heliophysics.

Heliophysics seeks understanding of the interaction of the large complex, coupled system comprising the Sun, Earth, and Moon, other planetary systems, the vast space within the solar system, and the interface to interstellar space. Heliophysics flight missions form a fleet of solar, heliospheric, and geospace spacecraft that operate simultaneously to understand this coupled Sun-Earth system.

A robust heliophysics research program is critical to human and robotic explorers venturing into space. Solar radiation drives the climate system and sustains the biosphere of Earth. Solar particles and fields drive radiation belts, high-altitude winds, heat the ionosphere, and alter the ozone layer. The resulting space weather affects radio and radar transmissions, gas and oil pipelines, electrical power grids, and spacecraft electronics. As a result, scientific research in this area has the potential to return economic and political value to modern society. An effective plan incorporates studying the Sun, heliosphere, and planetary environments as elements of a single interconnected system: one that contains dynamic space weather, and one that evolves in response to solar, planetary, and interstellar conditions. NASA is working to advance this science that enables space weather prediction by answering fundamental questions about this system's behavior:

- What causes the Sun to vary?
- How do the Earth and the Heliosphere respond?
- What are the impacts on humanity?

Heliophysics strategic goals are achieved through four program/mission lines: two strategic programs/missions, one competed program, and a Research and Analysis program. Solar Terrestrial Probes, a strategic program, provide understanding of the fundamental processes inherent in all astrophysical systems and how they affect the nature of our home in space. Living With a Star, the other strategic program, emphasizes the science necessary to understand those aspects of the Sun and space environment that most directly affect life and society and that enable robotic and human exploration of the solar system. The Explorer Program consists of competitively selected small PI-led missions that can be developed relatively quickly, providing frequent flight opportunities for world-class scientific investigations from space. The Heliophysics Research Program supports physics-based modeling that has played an increasingly important role both in defining the missions and interpreting their observations.

Mission Directorate:	Science
Theme:	Heliophysics

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**607.8**	**627.4**	**641.9**	**647.6**	**679.8**	**704.4**	**750.8**
Heliophysics Research	204.7	173.0	166.9	165.4	168.7	172.9	172.9
Living with a Star	222.6	240.2	214.3	207.9	216.5	243.0	288.8
Solar Terrestrial Probes	143.0	143.0	162.9	175.1	178.5	161.7	121.4
Heliophysics Explorer Program	34.8	69.4	97.7	99.2	116.1	126.8	167.8
New Millennium	2.7	1.8	0.1	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**591.6**	**605.0**	**672.6**	**720.5**	**742.7**	**762.6**	**--**
Heliophysics Research	195.9	178.6	178.1	183.1	190.6	194.3	--
Living with a Star	238.6	212.2	204.6	208.7	230.0	236.6	--
Solar Terrestrial Probes	123.1	143.0	169.1	170.6	160.8	164.3	--
Heliophysics Explorer Program	31.4	69.4	119.7	158.1	161.3	167.4	--
New Millennium	2.7	1.8	1.1	0.0	0.0	0.0	--
Total Change from FY 2010 Request	**16.2**	**22.3**	**-30.7**	**-72.9**	**-62.9**	**-58.2**	**--**

Note: Budget of $169 million for GEMS has been transferred from Heliophysics to Astrophysics Theme.

Plans for FY 2011

Heliophysics Research

The Research program will continue to operate 16 missions comprising 27 spacecraft through FY 2010 and conduct another senior review in April 2010 to determine whether to continue those missions into FY 2011. Heliophysics data centers will continue to archive and distribute collected science data.

Living with a Star

The Radiation Belt Probes (RBSP) mission will complete manufacturing of its hardware and begin integration and testing. The Solar Orbiter Collaboration will transition into Phase B for formulation. Solar Probe Plus will develop draft program-level requirements and memoranda of agreement during Phase A and end in an Initial confirmation Assessment. SDO will continue mission operations.

Solar Terrestrial Probes

The Magnetospheric Multiscale Mission (MMS) will continue the implementation phase. STEREO and Hinode will continue mission operations. The program will begin preliminary studies to define the next STP mission.

Heliophysics Explorer Program

IRIS, a Small Explorers (SMEX) selected in FY 2009, plans on conducting its Critical Design Review in FY 2011. The IBEX, CINDI, TWINS, AIM, and THEMIS missions will continue mission operations. An Announcement of Opportunity for the next Explorer missions will be developed and prepared for release.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The Heliophysics Program is guided by U.S. National Space Policy and follows NASA's tradition of establishing its priorities through consultation with world-class experts. Heliophysics relies on two advisory bodies for scientific assessments and decadal surveys: the National Research Council's Space Studies Board and the NASA Advisory Council. Heliophysics missions such as the Advanced Composition Explorer provide critical data to the Department of Defense, the Federal Aviation Administration, and the National Oceanographic and Atmospheric Administration to guard against space weather impacts. The Living With a Star (LWS) program targets research and technologies that are relevant to the operational needs of these agencies. The nation's safety, security, and economy have become increasingly dependent on technologies that are susceptible to the extremes of space weather i.e. severe disturbances of the upper atmosphere and of the near-Earth space environment that are driven by the magnetic activity of the Sun. Space weather events can damage satellites and power grids, and disrupt air traffic communications. Inter-agency activities are coordinated through the National Space Weather Program Council (NSWPC) within the Office of the Federal Coordinator for Meteorology. Organizations around the world also access Heliophysics data via the International Space Environment Service.

Heliophysics is also working to improve our understanding of magnetic reconnection, a process that occurs throughout the universe when stressed magnetic field lines suddenly transition to a new shape. This understanding is expected to greatly benefit the Department of Energy's efforts in the area of fusion energy, as magnetic reconnection phenomena play a critical role in virtually every configuration that is being explored to confine high-temperature plasmas. Internationally, NASA's Heliophysics Program plays a leadership role with both the International Heliophysical Year and International Living With a Star activities, leveraging space assets and resources to achieve greater scientific advancement now and in the future.

Relevance to education and public benefits:

Society is increasingly dependent on modern technology, including power grids, global positioning, weather forecasting and satellite communications. The valuable assets that support these technologies are vulnerable to solar activity and space weather events, so the need to predict solar events and mitigate their effect is critical to the public's safety, security, and the Nation's economy. A newly released report by the National Academy of Sciences titled "Severe Space Weather Events -- Understanding Societal and Economic Impacts" for the first time attempts to quantify the effects of extreme space weather on the nation (www.nap.edu/catalog/12507.html). The report concludes that improving forecasting capabilities and raising public awareness are instrumental in mitigating severe consequences. The Heliophysics Program supports the rapid transition of research results, models and data into operational products that benefit the public and other segments of the United States Government.

Heliophysics education programs include the award-winning Family Science Night, which introduces local communities to a wide range of Heliophysics-related topics. The Program partners with Astrophysics and Earth Science for a multi-disciplinary approach to such topics as light and spectrum, the seasons, and solar power. The IBEX mission has partnered with Adler Planetarium in Chicago to develop a planetarium show that communicates the scientific goals and results of the IBEX mission. The STEREO mission regularly provides selected images and movies to over 250 science centers through outreach program and through the American Museum of National History in New York.

The combined community Modeling center, a collaborative partnership with NSF, NOAA, and the USAF, provides the nation with verification and validation of innovative space weather numerical models. This data is widely used by academia, other U.S. government agencies and the space weather forecast industry.

Mission Directorate:	Science
Theme:	Heliophysics

Performance Achievement Highlights:

Even though Earth is 93 million miles away from the Sun, our planet is affected by what happens on the Sun's surface. We are currently in an extended solar minimum and 2009 has been the quietest year on the Sun since 1913. The Heliophysics fleet of 16 operating missions and the R&A programs were coordinated to study this unusual pattern enabling scientists worldwide to uncover effects never before seen. In 2008, there were 266 spotless days, and up through September 30, there were 215 days without sunspots for 2009. No 11-year solar cycle is exactly the same as another, but this research showed that sunspot activity during this 2007 - 2010 minimum is surprisingly low as compared to cycles of the last century.

These observations have brought many new discoveries about the underlying physics of the sunspot cycle. For example, the NASA measurements showed that solar wind pressure dropped 20 percent since the mid-1990s. Since the solar wind helps keep galactic cosmic rays out of the inner solar system, with the solar wind flagging more cosmic rays reach Earth, resulting in increased health hazards for astronauts. Weaker solar wind also meant fewer geomagnetic storms and auroras, the northern and southern (polar) lights we see on Earth. Other NASA measurements showed that the Sun's brightness dimmed 0.02 percent at visible wavelengths and six percent at extreme ultraviolet wavelengths since the previous solar minimum. One effect of this change is that the upper atmosphere is less heated and not as "puffed up," which means that satellites in low Earth orbit experience less atmospheric drag, extending their operational lifetimes.

The NASA observations were incorporated into state-of-the-art prediction models. It is now believed that the upcoming solar cycle will be significantly different than previous cycles sampled since the start of the space age. This new understanding of our Sun's connection to Earth has provided essential information on space weather effects and will be used to improve the reliability of space weather warnings that affect technologies on Earth and the productivity and safety of explorers in space.

Preparing for the next solar maximum, the Solar Dynamics Observatory completed its development phase smoothly and is awaiting launch in early 2010. The Radiation Belt Storm Probes (RBSP) and Magnetospheric Multiscale (MMS) missions were confirmed and approved to proceed into Implementation (Phase C). Four investigations were selected for Phase A studies for Solar Orbiter collaboration mission. Solar Probe Plus, completed the Mission Concept Review in September 2009 and was approved to proceed into Phase A in December 2009. Three Heliophysics missions, AIM, THEMIS and STEREO, successfully completed their prime missions in FY 2009, meeting all mission science requirements.

The selection of two new Small Explorer (SMEX) missions was announced: Interface Region Imaging Spectrograph (IRIS) and Gravity and Extreme Magnetism (GEMS). The Balloon Array for Radiationbelt Relativistic Electron Losses (BARREL) completed the Mission Readiness Review in August 2009, and an Antarctic test campaign in December 2009. In the New Millennium Program (NMP), the Space Technology ST7 Disturbance Reduction System, shipped to the United Kingdom for integration with the Astrium testbed. The Sounding Rockets program completed 14 suborbital launches. Wallops Range provided services for 5 Shuttle missions, the 14 NASA suborbital launches, and launch services for the USAF TacSat-3 mission.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	National Research Council	12/2003	The Decadal Research Strategy assessed the current status and future directions of NASA's programs in solar and space physics research. The report identifies broad scientific challenges that define the focus and thrust of solar and space physics research for the decade 2003 through 2013 and presents a prioritized set of missions, facilities, and programs designed to address those challenges.	12/2012
Relevance	NAC/Helio-physics Subcommittee	07/2009	Release of new Heliophysics Roadmap including science and program implementation strategies and relevance to the NASA Strategies and goals. Roadmap lays out a new paradigm for mission planning and implementation that is expected to help control mission lifetime cost. Subcommittee concerns remain with regard to R&A and Explorer program funding.	06/2010
Quality	Senior Review Panel	04/2008	All Heliophysics Operating Missions were reviewed for their continued relevance to the strategic goals of the Heliophysics division. All missions except FAST received satisfactory or excellent ratings.	04/2010
Performance	NAC/Helio-physics Subcommittee	07/2009	Reviews of selected annual performance goals as documented in Performance and Accountability Report (PAR). Review found that Heliophysics has achieved its annual goals, and made significant progress toward understanding our local space environment and the fundamental science that is beginning to enable a reliable space weather predictive capability.	07/2010
Other	National research Council	03/2009	An ad hoc panel of the NRC conducted a mid-term performance assessment of the NASA Heliophysics program, ISBN:0-309-13657-1. The report assessed NASA's progress against 2003 Decadal survey.	03/2013

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	204.7	173.0	166.9	165.4	168.7	172.9	172.9
Heliophysics Research and Analysis	31.5	31.0	31.7	32.2	33.0	33.8	34.2
Sounding Rockets	45.1	65.3	48.9	49.7	51.8	53.0	53.8
Research Range	32.3	19.2	19.6	20.1	20.6	21.1	21.4
Other Missions and Data Analysis	95.8	57.5	66.7	63.4	63.4	65.0	63.5
FY 2010 President's Budget Request	195.9	178.6	178.1	183.1	190.6	194.3	--
Heliophysics Research and Analysis	31.0	35.4	38.4	39.1	40.1	41.1	--
Sounding Rocket Operations	77.4	66.5	67.5	68.9	71.4	73.1	--
Other Missions and Data Analysis	87.5	76.7	72.3	75.1	79.1	80.1	--
Changes from FY 2010 Request	8.8	-5.6	-11.2	-17.7	-21.9	-21.5	--

Program Overview

NASA's Heliophysics Research Program supports activities that address understanding of the Sun and planetary space environments, including the origin, evolution, and interactions of space plasmas and electromagnetic fields throughout the heliosphere and in connection with the galaxy. Understanding the origin and nature of solar activity and its interaction with the space environment of the Earth is a particular focus. The program seeks to characterize these phenomena on a broad range of spatial and temporal scales, to understand the fundamental processes that drive them, to understand how these processes combine to create space weather events, and to enable a capability for predicting future space weather events.

The Heliophysics Research Program supports investigations of the Sun and planetary space environments from the 16 operating missions involving 27 spacecrafts. This fleet of spacecraft is informally termed the "Heliophysics System Observatory" since the aggregation of data from all the spacecraft results in research synergies not possible with single observatories.

Heliophysics Research & Analysis routinely solicits proposals in several broad areas in order to advance our knowledge in support of NASA strategic goals. In addition, NASA occasionally offers special solicitations to take advantage of research opportunities that arise from the current solar environment. The Research Program also 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. The Research and Analysis and Guest Investigator Projects fund more in-depth scientific investigations using all of this collected data via a competitive process that is held each year.

Plans For FY 2011

NASA's Heliophysics research program supports NASA flight program by formulating the theories of the phenomena to be studied; the design of the experiments to test these theories; the development of the instrument technology; experiments in the laboratory and from an appropriate set of balloon or sounding rocket platforms; provides the results to increase basic knowledge; incorporates results into computational models that can be used to more fully characterize the present state and future evolution of the Heliophysics system.

The Supporting Research and Technology Program will hold its annual competition for new research awards. Participation will be open to all categories of U.S. organizations, including educational institutions, industry, not-for-profit organizations, Federally Funded Research and Development Centers, NASA Centers and other Government agencies.

The Geospace Science, and Solar and Heliospheric Science subelements will hold their annual competition for new research awards: approximately $9 million will be available for competition, resulting in approximately 65 new awards. These subelements support detailed research tasks that employ a variety of research techniques (e.g., theory, numerical simulation, and modeling), analysis and interpretation of space data, development of new instrument concepts, and laboratory measurements of relevant atomic and plasma parameters, all to the extent they have a clear application to heliophysics program goals.

The Theory subelement will fund 10 new teams in FY 2011 based on a competition to be held in mid-2010. The Theory Program supports large PI-proposed team efforts that require a critical mass of expertise to make significant progress in understanding complex physical processes with broad importance.

Heliophysics data centers will be supported to continue the archival and distribution of collected science data.

The Guest Investigator competition, canceled in FY 2010 due to budget reductions, will resume to support and extend the scientific impact of the currently operating missions: approximately $13 million will be available for competition.

The Low Cost Access to Space subelement supports the science investigation and new instrument concepts to be flown on sounding rockets or balloons. This subelement will support approximately 22 teams to prepare payloads for future sounding rockets and 2-3 teams for future balloon launches.

Science Data and Computing Technology will hold its annual competition for the Applied Information Systems Research Program where approximately $2 million will be available for new research awards.

All missions operating beyond their prime phase will be evaluated by a NASA-sponsored Senior Review in April 2010 to determine their status and optimize the allocation of funding for FY 2011 and beyond in order to address NASA's strategic science goals   The Research Range will provide launch instrumentation for NASA suborbital programs and projects at both local and remote locations. Science Data and Computing Technology will continue to sustain the National Space Science Data Center.

Project Descriptions and Explanation of Changes

Heliophysics Research and Analysis

Supporting Research and Technology comprises an ever-evolving suite of individual Principal Investigator-proposed investigations that cover the complete range of science disciplines and techniques essential to achieve the Heliophysics Theme objectives and to take full advantage of the scientific data collected by NASA missions. Supporting Research and Technology covers five subelements: Heliophysics Theory, Geospace Science, Solar and Heliospheric Science, Low-Cost Access to Space (LCAS), and Instrument Development.

The Theory subelement is the intellectual compass of the Heliophysics Division. Teams work to consolidate the scientific understanding of previous missions and determine the scientific hypotheses to be tested by future strategic missions. The Theory Program supports large PI-proposed team efforts that require a critical mass of expertise to make significant progress in understanding complex physical processes with broad importance.

Geospace Science subelement funds studies of the physics of magnetospheres, including their formation and fundamental interactions with plasmas, fields, and particles (Earth's magnetosphere is emphasized, but studies of the magnetospheres of planets, comets, and other primordial bodies are also supported). Geospace Science deals with the physics of the mesosphere, thermosphere, ionosphere, and aurorae of Earth, including the coupling of these phenomena to the lower atmosphere and magnetosphere.

Solar and Heliospheric Science subelement funds studies that treat the Sun as a typical star, as the dominant, time-varying source of energy, plasma, and energetic particles in the solar system (especially concerning its influence on Earth). This project investigates processes taking place throughout the solar interior and atmosphere: the evolution and cyclic activity of the Sun; the origin and propagation of the solar wind and magnetic field from the Sun to the Heliopause (the boundary between the solar wind and the interstellar medium); the acceleration and transport of energetic particles in the heliosphere; and the interface of solar influence with the interstellar medium.

Low-Cost Access to Space funds the science investigations that utilize suborbital sounding rockets, commercial reusable suborbital vehicles, or high altitude balloons, as well as proof-tests of new concepts in experimental techniques that may ultimately find application in free-flying Heliophysics space missions. These investigations are developed and flown in a rapid turnaround environment. LCAS investigations address open science questions, but serve additional purposes not addressed in other flight programs: the training of experimental space physicists and engineers, and the development and flight verification of new technology.

Instrument development investigations have as their objective the development of instrument technologies that show promise for use on future Heliophysics science missions, including the development of prototypes. The goal is to define scientific instruments to the point where complete instruments may be proposed in response to future Announcements of Opportunity without significant additional development.

Sounding Rockets

This project funds all suborbital mission activities (payload integration, launch, and mission operation) that support the science investigations funded in other parts of the research program. Sounding Rockets present unique low-cost platforms that provide direct access to Earth's mesosphere (50-90 kilometers), lower thermosphere (90-120 kilometers), and the Earth's magnetosphere (up to 1,500 kilometers). Because of their short duration and access to Earth's upper atmosphere and the space environment, sounding rocket suborbital missions also enable calibration under-flights of orbital missions, repeated proof-of-concept technology demonstration missions, and valuable end-to-end space mission experience for scientists and engineers learning to develop and execute discovery-oriented orbital missions.

Research Range

The Research Range effort funds NASA's only test range, located at Wallops Flight Facility, for launch of suborbital and orbital vehicles, supporting launch operations, tracking, telemetry and command (TT&C) capabilities. The Wallops Research Range also supports a mobile TT&C capability to support launches safely from a number of woldwide launch sites. The NASA Research Range is one of the few ranges in the Nation to offer a mobile capability. The Range maintains it own airspace and supports a wide variety of small launch vehicles, suborbital missions, and airborne missions utilizing non-FAA-certified vehicles such as unmanned aircraft systems.

Other Missions and Data Analysis

Following the commissioning and checkout phase of any spacecraft, Headquarters management responsibility for operations and data analysis transitions to the Heliophysics Research Program. However, a number of operating spacecraft still receive funding from their respective development programs. The Research Program is responsible for collecting, archiving, and distributing the data collected by all operating spacecraft. Current operating spacecraft include: Cluster II, AIM, ACE, THEMIS, Voyager, Wind, Geotail, TWINS, RHESSI, CINDI,SOHO, TIMED. It is this collective asset that provides the data, expertise, and research results that contribute directly to the national goal of real-time space weather prediction and to fundamental research on solar and space plasma physics. In April 2010, these missions will undergo their biannual Senior Review. New budgets for FY 2011 will be determined, consistent with their evolving scientific goals.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Annual peer-reviewed research solicitation for grant opportunities	Research & Analysis	None

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Research

Implementation Schedule

Project	Phase	Beg	End
Voyager	Tech		
	Form		
	Dev		
	Ops	Aug-77	Aug-13
	Res		Aug-14
Geotail	Tech		
	Form		
	Dev		
	Ops	Jul-92	Jul-08
	Res		Jul-10
Wind	Tech		
	Form		
	Dev		
	Ops	Nov-94	Nov-13
	Res		Nov-14
Solar and Heliospheric Observatory (SOHO)	Tech		
	Form		
	Dev		
	Ops	Dec-95	Dec-13
	Res		Dec-14
Advanced Composition Explorer (ACE)	Tech		
	Form		
	Dev		
	Ops	Aug-97	Aug-13
	Res		Aug-14
Cluster-II	Tech		
	Form		
	Dev		
	Ops	Jul-00	Jul-10
	Res		Jul-11
Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)	Tech		
	Form		
	Dev		
	Ops	Dec-01	Dec-13
	Res		Dec-14
RHESSI	Tech		
	Form		
	Dev		
	Ops	Feb-02	Feb-13
	Res		Feb-14

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Research

Program Management

NASA Headquarters has program management responsiblity for the Heliophysics Research Program.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Research and Analysis	SMD	All NASA Centers	None
Heliophysics Operating Missions	SMD	GSFC and JPL	ESA and JAXA
Sounding Rockets and Research Range	SMD	GSFC	None
Science Data and Computing	SMD	GSFC and other NASA Centers	None

Acquisition Strategy

All acquisitions in the Heliophysics Research and Analysis (R&A) component are based on full and open competition. Proposals are peer reviewed and selected based on the NASA research announcement, Research Opportunities in Space and Earth Sciences (ROSES). Universities, government research labs, and industry throughout the U.S. participate in R&A research 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.

Both the prime contracts for the Sounding Rocket Operations and for Research Range Operations are currently being re-competed. The new contracts are expected to be in place in CY 2010.

The Science Data and Computing component holds a competition where proposals have been peer reviewed and selected based on ROSES research announcement. Universities, government research labs, and industry throughout the United States participate in Science Data and Computing Technology research projects.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	05/2008	The Heliophysics operating missions will undergo a Senior Review panel in April 2010 to assess their operational effectiveness.	04/2010

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	222.6	240.2	214.3	207.9	216.5	243.0	288.8
Radiation Belt Storm Probes (RBSP)	154.4	129.1	140.0	92.2	30.2	22.0	9.1
Solar Probe Plus	18.0	40.0	14.1	49.7	104.3	104.4	148.2
Other Missions and Data Analysis	50.2	71.1	60.2	66.0	82.0	116.6	131.5
FY 2010 President's Budget Request	238.6	212.2	204.6	208.7	230.0	236.6	--
Solar Dynamics Observatory (SDO)	20.8	34.1	20.2	18.6	16.3	15.6	--
Radiation Belt Storm Probes (RBSP)	154.4	137.1	127.9	105.1	22.0	17.3	--
Solar Probe Plus	18.0	4.0	16.6	36.7	57.8	81.3	--
Other Missions and Data Analysis	45.3	37.0	39.8	48.3	134.0	122.4	--
Changes from FY 2010 Request	-16.0	28.0	9.6	-0.8	-13.5	6.4	--

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star

Program Overview

The Living with a Star (LWS) Program seeks to improve our understanding of how and why the Sun varies, how the Earth and solar system respond, and most importantly, how this variability and response affect life on Earth. This improved understanding of solar variability (i.e., space weather) and its effects will lead to a reliable predictive capability for space weather. This capability is essential to safe and successful future space exploration and increased use of complex technological systems to improve the safety and quality of life on the ground. LWS accomplishes its goals with a combination of new science missions and yearly science research grant opportunities.

The first mission of LWS, the Solar Dynamics Observatory (SDO) launched in FY 2010, will complement and improve upon major capabilities of the Solar and Helispheric Observatory (SOHO), launched in December 1995. SDO is designed to help us understand the Sun's influence on Earth and near-Earth space by studying the solar atmosphere on small scales of space and time and many wavelengths simultaneously.

The Sun's variable activity produces variability in the Earth's radiation belts. The second LWS mission, the Radiation Belt Storm Probes (RBSP), will analyze these belts in unprecedented detail. Two identical spacecraft in elliptical orbits will make simultaneous measurements of processes that accelerate and transport radiation particles as they transit through Earth's radiation belts. The RBSP results will enable the development of models for Earth's radiation belts and for other related but under-sampled planetary environments, such as Mars. Spacecraft and aeronautics engineers will apply the models to improve spacecraft design and to alert operators or pilots of predicted storms and ionizing radiation that could impact crew health or vehicle operations.

Two additional missions are currently developing mission concepts: the Solar Probe Plus (SPP) and the Solar Orbiter Collaboration (SOC) mission. Solar Probe Plus will explore the Sun from very close range (inside 10 solar radii) to improve our understanding of the generation and flow of the solar wind that links the Sun to the Earth and the solar system. The SOC, led by the European Space Agency, will investigate the links between the solar surface, corona, and inner heliosphere from as close as 45 solar radii, and image the side of the Sun not visible from Earth.

For more information, please see http://lws.gsfc.nasa.gov/.

Plans For FY 2011

The SDO mission will continue prime operations in space. The RBSP mission will complete manufacturing of flight hardware during the first quarter of this year and transition to integration and testing. The Solar Orbiter Collaboration and Solar Probe Plus missions will develop detailed requirements and further define their mission concepts during formulation. Solar Probe Plus will also continue to retire technology risk. The Space Environment Testbed awaits its upcoming launch in FY 2012. The BARREL project will use the results of the FY 2010 test campaign to fabricate 20 flight payloads for the first science campaign in FY 2013.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star

Project Descriptions and Explanation of Changes

Radiation Belt Storm Probes (RBSP)

The RBSP mission will improve the understanding of how solar storms interact with and change particles, fields, and radiation in Earth's Van Allen radiation belts and atmosphere. This knowledge could be applied to any planet in our solar system that has a magnetic core. This mission was recently approved to begin hardware fabrication and is scheduled to launch in May 2012. Additional detail can be found in the RBSP development section of this document.

Solar Probe Plus

The Solar Probe Plus mission is currently in formulation. It will perform the first in-situ measurements very close to the Sun (as close as 10 solar radii) to improve our understanding of the generation and flow of the solar wind that links the Sun to the Earth and the solar system. Instruments will be selected in FY 2010 in support of a FY 2018 launch. Additional detail can be found in the Solar Probe Plus formulation section of this document.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star

Other Missions and Data Analysis

Solar Dynamics Observatory (SDO): The SDO mission will launch February 2010 after a delay of 14 months due to problems securing a spot on the Atlas V launch vehicle manifest. SDO will investigate how the Sun's magnetic field is structured, as well as how its energy is converted and released into the heliosphere in the forms of solar wind, energetic particles, and variations in solar irradiance.

Space Environment Testbeds (SET): The Space Environment Testbeds (SET) will improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design and operations. It has two components: a data mining element that has been completed and a space flight mission. The flight mission is a testbed that has been integrated onto the Air Force Research Lab's Demonstration and Science Experiments (DSX) mission. The DSX launch is scheduled for FY 2012 as a secondary payload.

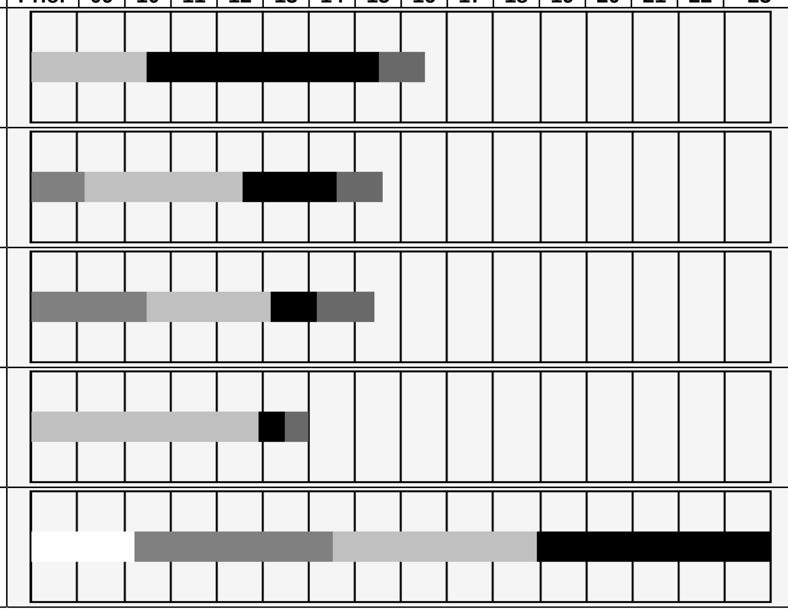
Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL): BARREL is a balloon-based mission that will launch a series of science instruments to complement the measurements made on the Radiation Belt Storm Probes (RBSP) mission. BARREL will measure the precipitation of relativistic electrons from the radiation belts. Implementation responsibility has been assigned to the Wallops Balloon Program Office.

Solar Orbiter Collaboration (SOC): The Solar Orbiter Collaboration (SOC) is a joint mission with the European Space Agency (ESA) wherein ESA provides the spacecraft operations and majority of the instruments. The LWS Program provides the launch vehicle up to four science investigations. These instruments were selected in FY 2009 and will continue formulation work in FY 2011. The SOC will provide close-up views of the Sun's polar regions and its back-side, and tune its orbit to match the Sun's rotation. This will permit the spacecraft's instruments to observe emissions and solar wind from one specific area for much longer than currently possible and will provide more insight into the evolution of sunspots, active regions, coronal holes and other solar features and phenomenona than past missions.

Living with a Star Science: LWS science funds competitively-selected proposals that improve the understanding of the physics of the integrated system that links the Sun to the heliosphere and planetary atmospheres. This improved understanding will be achieved through data analysis supporting the development of new or revised theories and numerical models. This step is necessary for development of a predictive capability for space weather.

Implementation Schedule

Schedule by Fiscal Year: Prior, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23



Project	Phase	Beg	End
SDO	Tech		
	Form	Aug-02	Jul-04
	Dev	Jul-04	Apr-10
	Ops	Apr-10	Apr-15
	Res	Apr-15	Apr-16
RBSP	Tech		
	Form	Sep-06	Dec-08
	Dev	Dec-08	May-12
	Ops	May-12	May-14
	Res	May-14	May-15
BARREL	Tech		
	Form	Sep-06	Apr-10
	Dev	Apr-10	Dec-12
	Ops	Dec-12	Dec-13
	Res	Dec-13	Mar-15
SET	Tech		
	Form	Jan-04	Jan-06
	Dev	Jan-06	Sep-12
	Ops	Sep-12	Apr-13
	Res	Apr-13	Oct-13
SPP	Tech		
	Form	Dec-09	Mar-14
	Dev	Apr-14	Aug-18
	Ops	Aug-18	Sep-25
	Res	Sep-25	Sep-26

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

Program management responsibility for the LWS Program is assigned to the Goddard Space Flight Center(GSFC). Projects are managed by GSFC or Johns Hopkins University-Applied Physics Labortory (JHU-APL).

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
SDO	GSFC	GSFC	None
RBSP	JHU/APL	None	National Reconnaissance Office (NRO)
BARREL	GSFC	GSFC	None
Solar Probe Plus	JHU/APL	None	None
SOC	GSFC	GSFC	European Space Agency, ESA member states
SET	GSFC	GSFC	CNES (French Space Agency, Centre National d'Etudes Spatiales), DERA (Defence Evaluation and Research Agency)

Acquisition Strategy

LWS missions will be managed either by Goddard Space Flight Center (GSFC) or by Johns Hopkins University - Applied Physics Laboratory (JHU-APL). All missions will report to GSFC as the managing center for the program. The Science Mission Directorate Associate Administrator will determine which organization will manage each mission, and whether the spacecraft will be procured or built in-house at the managing organization for the mission.

Four instrument suites for the Radiation Belt Storm Probes (RBSP) were selected through full and open competition, and one instrument is being provided by the National Reconnaissance Office. The launch vehicle was selected through full and open competition, and the spacecraft is an in-house build at JHU/APL.

BARREL was selected through full and open competition through the same solicitation as the RBSP instruments. Two SET experiments were selected through full and open competition, and two were contributed by CNES and DERA.

NASA-led Solar Orbiter Collaboration (SOC) instruments were selected for Phase A using full and open competition as will the Solar Probe Plus (SPP) and SOC launch vehicles. The SPP spacecraft will be built in-house at JHU/APL.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	02/2009	Overall assessment of the life cycle cost, schedule and deliverables of the LWS Program. Review board concluded that these programs have met their success criteria and should continue in accordance with their existing plans.	02/2011

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**116.8**	**154.4**	**129.1**	**140.0**	**92.2**	**30.2**	**22.0**	**9.1**	**0.0**	**693.8**
Formulation	88.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.2
Development / Implementation	28.8	154.2	129.1	140.0	81.5	8.3	0.0	0.0	0.0	541.9
Operations / Close-out	0.0	0.0	0.0	0.0	10.7	21.9	22.0	9.1	0.0	63.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**116.8**	**154.4**	**137.1**	**127.9**	**105.1**	**22.0**	**17.3**	**--**	**5.2**	**685.8**
Formulation	88.0	0.2	0.0	0.0	0.0	0.0	0.0	--	0.0	88.2
Development / Implementation	28.8	154.2	137.1	127.9	85.9	0.0	0.0	--	0.0	533.9
Operations / Close-out	0.0	0.0	0.0	0.0	19.2	22.0	17.3	--	5.2	63.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	**0.0**	**0.0**	**-8.0**	**12.1**	**-12.9**	**8.2**	**4.7**	**--**	**-5.2**	**8.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	-8.0	12.1	-4.4	8.3	0.0	--	0.0	8.0
Operations / Close-out	0.0	0.0	0.0	0.0	-8.5	-0.1	4.7	--	-5.2	--
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0

Note: The FY 2011 LCC number in the table above is overstated by $7.9M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $685.8M and the estimated development cost will be $533.9M

Explanation of Project Changes

RBSP was confirmed in CY 2008 to proceed into the development phase, and will still launch in May 2012. The total funding for RBSP did not change.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

Project Purpose

The Radiation Belt Storm Probes (RBSP) mission will observe the fundamental processes that energize and transport radiation particles in Earth's inner magnetosphere (the area in and around the Earth's radiation belts). These dynamic processes operate throughout the universe at other planets and stars, and they continuously operate within Earth's immediate space environment.

The primary science objective of the RBSP mission is to provide 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. The RBSP mission lifetime will provide sufficient local time, altitude, and event coverage to improve our understanding, and determine the relative significance of the various mechanisms that operate within the radiation belts.

RBSP 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.

Project Parameters

The RBSP mission is comprised of two identical spacecraft in elliptical, low-inclination orbits that travel independently through Earth's radiation belts to distinguish time and space variations in the measured ions, electrons, and fields.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

Project Commitments

The Radiation Belt Storm Probes (RBSP) project will launch two identical spacecraft in FY 2012 to begin a two-year prime mission.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
EELV	KSC	Deliver a spacecraft to operational orbit	Same	Same
Energetic Particle, Composition and Thermal Plasma Suite (ECT)	Boston University	Measure the electron & ion spectra & composition to understand the electron & ion changes	Same	Same
Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE)	New Jersey Institute of Technology	Measure the ring current in the magnetosphere during geomagnetic storms	Same	Same
Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS)	University of Iowa	Measure the magnetic fields & plasma waves	Same	Same
Electric Field and Waves Instrument for the NASA RBSP Mission (EFW)	University of Minnesota	Measure the electric fields in the radiation belts	Same	Same
Proton Spectrometer Belt Research (PSBR)	National Reconnaissance Office	Measure the inner Van Allen belt protons	Same	Same
Spacecraft	JHU-APL	Operate science instruments in high radiation; transmit science data to ground	Same	Same
Ground System	Primary ground station at JHU/APL; instrument operation is distributed among investigators	Receive science data from two spacecraft; distribute to archive	Same	Same

Schedule Commitments

The RBSP project was authorized to begin formulation in September 2006 when the selections for science investigations were announced. It was confirmed to proceed into development on December 19, 2009. Schedule details are still under development and are subject to change.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Begin Implementation	January 2009	January 2009	January 2009
Critical Design Review	December 2009	December 2009	December 2009
System Integration Review	November 2010	November 2010	November 2010
Launch Readiness Review	May 2012	May 2012	May 2012

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Radiation Belt Storm Probes (RBSP)	2009	533.9	2010	533.9	0	Launch Readiness	05/2012	05/2012	0

Development Cost Details

Development cost details are still under work by the project and are subject to change.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**533.9**	**533.9**	**0.0**
Spacecraft	85.6	85.6	0.0
Payload	95.4	95.4	0.0
System I&T	36.9	36.9	0.0
Launch Vehicle	133.6	133.6	0.0
Ground System	16.3	16.3	0.0
Science/Technology	3.1	3.1	0.0
Other	163.0	163.0	0.0

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

Project Management

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Ground Systems	APL	None	None
Data Analysis	APL	None	National Reconnaissance Office
Instrument Development	APL	None	National Reconnaissance Office
Spacecraft design, integration with instrument, and test	APL	None	None
Mission Operations	APL	None	None
Expendable Launch Vehicle	KSC	None	None

Acquisition Strategy

The RBSP spacecraft and ground system are being designed, developed, and tested at the JHU-APL. The acquisition of sub-contracted spacecraft sub-assemblies, components, and parts is through procurement contracts issued by the JHU-APL Procurement Office. Instrument development participants include the University of Iowa, University of Minnesota, New Jersey Institute of Technology, and Boston University, as well as contributions from the National Reconnaissance Office and the Czech Republic.

The ground system components were defined during the formulation phases (Phases A and B) and include a mission operations center at the JHU-APL.

The Energetic Particle, Composition and Thermal Plasma Suite (ECT), Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS), Electric Field and Waves Instrument for the NASA RBSP Mission (EFW), and Radiation Belt Storm Probes Ions Composition Experiment (RBSPICE) science investigations were procured through the Announcement of Opportunity process. The Proton Spectrometer Belt Research (PSBR) instrument is being contributed through an agreement with the National Reconnaissance Office.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Senior Review Board	10/2008	Preliminary Design Review. Review concluded that the RBSP design was sufficiently mature to proceed to KDP-C.	12/2009
Performance	SRB	12/2009	Critical Design Review: Review concluded that there were no significant issues in the project should continue as planned.	11/2010

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Development:	Radiation Belt Storm Probes (RBSP)

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Complete Electric and Magnetic Field Instrument Suite and Integrated Science End-to-End Testing	Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) main Electronics Box Engineering Model 2(EM2) needs to be successfully integrated and tested per the EM2 test plan and schedule. If not the flight build and delivery will be delayed.	Hold Flight Manufacturing Readiness Reviews. Complete Electronics Box Engineering Model 2 environmental testing and characterization. Complete EM2 Integration and Test Peer Review.
XCVR Qualification Program	If the Transceiver qual program does not perform to their re-plan schedule, then the Project's Integration and Test schedule will be delayed.	Provide bi-weekly schedule updates to the Integrated Master Schedule. Burn Qualification Model on the RTAX, the field programmable gate array. Conduct Engineering Design Review of Qual Model.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Formulation:	Solar Probe Plus

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	18.0	40.0	14.1	49.7	104.3	104.4	148.2
FY 2010 President's Budget Request	18.0	4.0	16.6	36.7	57.8	81.3	--
Total Change from 2010 President's Budget Request	0.0	36.0	-2.6	13.0	46.5	23.0	--

Project Purpose

Solar Probe Plus will be an extraordinary and historic mission, exploring the Sun's outer atmosphere, or corona, as it extends out into space. Approaching as close as 9.5 solar radii, Solar Probe Plus will repeatedly sample the near-Sun environment, revolutionizing our 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 top priorities for decades. Moreover, by making direct, in-situ measurements of the region where some of the most hazardous solar energetic particles are energized, Solar Probe Plus will make a fundamental contribution to our ability to characterize and forecast the radiation environment in which future space explorers will work and live.

For more information please see Solar Probe project at http://nasascience.nasa.gov/missions/solar_probe.

Project Preliminary Parameters

The first near-Sun pass occurs three months after launch, at a heliocentric distance of 35 Rs (Solar Radius). Over the next several years successive Venus gravity assist maneuvers will gradually lower the spacecraft's near-Sun pass to approximately 9.5 Rs, by far the closest any spacecraft has ever come to the Sun. With an August 2018 launch, Solar Probe Plus will spend, during its seven year mission, a total of 30 hours inside 10 Rs, 961 hours inside 20 Rs, and 2149 hours inside 30 Rs, sampling the solar wind as it evolves with rising solar activity toward an increasingly complex structure.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Formulation:	Solar Probe Plus

Estimated Project Deliverables

Solar Probe will launch from KSC on an EELV in FY 2018, with an expected mission duration of 7 years.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
EELV	KSC	Deliver the spacecraft to operational orbit	Same	Same
Ground Systems	APL	Receive science data and telemetry from spacecraft, command spacecraft, distribute science data to investigator teams	Same	Same
Spacecraft	APL	Transport instruments to science destination, operate instruments, modify orbit including several Venus gravity	Same	Same
Instruments	NASA-funded investigators	Perform in situ measurements and remote observations of the Sun	Same	Same

Estimated Project Schedule

Solar Probe Plus received approval to proceed to Phase A in November 2009 and Announcement of Opportunity to solicit science investigations in December 2009. NASA anticipates announcing these selections in the fall of 2010. Phase B will begin in July 2011 following a successful preliminary Non-Advocate Review (PNAR).

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
Mission Definition Review /PNAR	01/2012	04/2012	05/2011
Preliminary Design Review/NAR	01/2014	N/A	01/2014
Critical Design Review	01/2016	N/A	11/2015
Launch	08/2018	08/2018	Same

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Living with a Star
Project In Formulation:	Solar Probe Plus

Project Management

Johns Hopkins University/Applied Physics Laboratory (JHU/APL) will manage the project. GSFC is responsible for program management and science management

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Instrument	APL	TBD	None
EELV	APL	KSC	None
Spacecraft	APL	None	None
Mission Operations	APL	None	None

Acquisition Strategy

A Solar Probe Plus Announcement of Opportunity will be used to acquire the science investigations. The spacecraft will be built by JHU-APL with the spacecraft subassemblies, components, and parts procured by JHU-APL. The ground system components will be defined during formulation and will be determined by the implementing organization for the project. The Phase E contracts will be managed by GSFC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	09/2009	SRB approved the project to proceed into Phase A.	05/2011

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
1. Thermal Protection System (TPS) thermal Performance	If TPS thermal conductivity is greater than required and/or the coating performance is less than required, the cooling system and s/c radiators may not be able to remove sufficient heat, leading to elevated solar array and s/c temperature.	- Coating development work - Early materials characterization - Early manufacture and test of prototype articles - Increased TPS thickness
2. Solar Cell and Array Performance	If solar cell and array performance in the near-Sun environment is less than expected, power system performance may not meet requirement and/or cooling system requirements may increase	- Cell technology development work - Extensive power system and solar cell modeling and test - Parallel approaches to development and design - Margins in power and cooling system design - Prototype development

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**143.0**	**143.0**	**162.9**	**175.1**	**178.5**	**161.7**	**121.4**
Magnetospheric Multiscale (MMS)	**115.9**	**118.6**	**143.8**	**155.8**	**158.9**	**141.4**	**96.1**
Other Missions and Data Analysis	**27.1**	**24.4**	**19.1**	**19.3**	**19.6**	**20.3**	**25.3**
FY 2010 President's Budget Request	**123.1**	**143.0**	**169.1**	**170.6**	**160.8**	**164.3**	**--**
Magnetospheric Multiscale (MMS)	**94.6**	**118.6**	**149.3**	**148.8**	**137.5**	**143.8**	**--**
Other Missions and Data Analysis	**28.5**	**24.4**	**19.8**	**21.8**	**23.3**	**20.5**	**--**
Changes from FY 2010 Request	**19.9**	**0.0**	**-6.3**	**4.5**	**17.7**	**-2.6**	**--**

Program Overview

Solar Terrestrial Probes (STP) provide understanding of the fundamental plasma processes inherent in all astrophysical systems. To accomplish this goal, STP investigations focus on specific scientific areas that will help us understand how plasma behaves in the space between the Sun and Earth. STP missions address processes such as the variability of the Sun, the responses of the planets to these variations, and the interaction of the Sun and solar system. STP missions are strategically defined and investigations are competitively selected. Strategic mission lines afford the space physics community the opportunity to plan specific missions to address important research focus areas and thus make significant progress in elucidating the fundamental processes of Heliophysics.

For more information please see Solar Terrestrial Probes Program at http://stp.gsfc.nasa.gov/.

Plans For FY 2011

The Magnetospheric Multiscale Mission will continue the implementation phase. The STEREO mission will commence joint observations with SDO.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes

Project Descriptions and Explanation of Changes

Magnetospheric Multiscale (MMS)

MMS is a four-spacecraft mission planned for launch in March 2015 with a two-year mission life. MMS is designed to study magnetic reconnection in key boundary regions of the Earth's magnetosphere. Reconnection is a fundamental process that occurs throughout the universe, by which magnetic energy is converted into heat, radiation, and particle acceleration. The best laboratory for understanding this process is the Earth's magnetosphere, where reconnection between the Earth's and Sun's magnetic fields power magnetic storms, and substorms on our planet. The spacecraft will probe the regions of geospace most critical to measuring reconnection. Additional detail can be found in the Magnetospheric Multiscale Project development section of this document.

Other Missions and Data Analysis

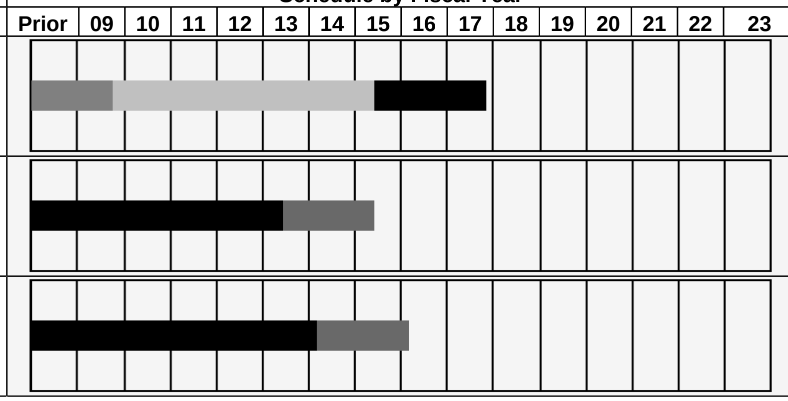
Solar TErrestrial RElations Observatory (STEREO): Launched on October 25, 2006, STEREO is now an operating mission employing two nearly identical observatories to provide three-dimensional measurements of the Sun to study the nature of coronal mass ejections. These powerful eruptions are a major source of the magnetic disruptions on Earth and a key component of space weather, which can greatly affect satellite operations, communications, power systems, the lives of humans in space, and global climate.

Solar B (Hinode): Hinode launched on September 22, 2006, from Japan's Uchinoura Space Center to begin its mission to explore the magnetic fields of the Sun. NASA developed three science instrument components: the Focal Plane Package (FPP), the X-Ray Telescope (XRT), and the Extreme Ultraviolet Imaging Spectrometer (EIS) and provides operations support for science planning and instrument command generation activities. A follow-on to the highly successful Japan/US/UK Yohkoh (Solar-A) satellite that operated between 1991 and 2001, Hinode consists of a coordinated set of optical, Extreme-Ultraviolet (EUV), and X-ray instruments that will investigate the interaction between the Sun's magnetic field and its corona.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes

Implementation Schedule

Project	Phase	Beg	End
Magnetospheric Multiscale (MMS)	Tech		
	Form	May-02	Jun-09
	Dev	Jun-09	Mar-15
	Ops	Mar-15	Jul-17
	Res		
STEREO	Tech		
	Form	May-01	Mar-02
	Dev	Mar-02	Jan-07
	Ops	Jan-07	Feb-13
	Res		Feb-15
Solar-B (Hinode)	Tech		
	Form	Dec-98	Nov-00
	Dev	Nov-00	Nov-06
	Ops	Nov-06	Nov-13
	Res		Nov-15



Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

Program management responsibility for the STP Program is assigned to the Goddard Space Flight Center (GSFC).

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
MMS	GSFC	GSFC	Austria, Sweden, France,Japan
STEREO	GSFC	None	United Kingdom

Acquisition Strategy

STP missions are strategically defined and investigations are competitively selected. The STP uses full and open competitions to the greatest extent possible for the acquisition of scientific instruments, spacecraft, and science investigations, including research and analysis.

The MMS spacecraft will be built in-house at GSFC and GSFC will also provide mission Operations Center. The Southwest Research Institute (SwRI) is the single MMS instrument suite contractor, selected through a full and open competition. All instruments are developed by the SwRI team which includes SwRI, their subcontractors, their international partners, and GSFC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	02/2009	Overall assessment of life cycle cost, schedule and deliverables of the STP Program. Review board concluded that this program has met the success criteria and should continue in accordance with their existing plans.	02/2011

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes
Project In Development:	Magnetospheric Multiscale (MMS)

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**110.2**	**115.9**	**118.6**	**143.8**	**155.8**	**158.9**	**141.4**	**96.1**	**36.0**	**1,076.7**
Formulation	108.5	64.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	173.0
Development / Implementation	1.7	51.4	118.6	143.8	155.8	158.9	141.4	79.8	0.0	851.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	36.0	52.3
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**110.1**	**94.6**	**118.6**	**149.3**	**148.8**	**137.5**	**143.8**	**--**	**90.5**	**993.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	110.1	94.6	118.6	149.3	148.8	137.5	143.8	--	90.5	993.0
Changes from FY 2010 Request	**0.1**	**21.3**	**0.0**	**-5.6**	**7.0**	**21.4**	**-2.4**	**--**	**-54.5**	**83.6**
Formulation	108.5	64.5	0.0	0.0	0.0	0.0	0.0	--	0.0	173.0
Development / Implementation	1.7	51.4	118.6	143.8	155.8	158.9	141.4	--	0.0	851.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	36.0	52.3
Other	-110.1	-94.6	-118.6	-149.4	-148.8	-137.5	-143.8	--	-90.5	-993.1

Note: The FY 2011 LCC number in the table above is understated by $6M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $1082.7M, and the estimated development cost will be $857.4M.

Explanation of Project Changes

MMS KDP-C decision resulted in a more conservative estimate and funding profile.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes
Project In Development:	Magnetospheric Multiscale (MMS)

Project Purpose

The Magnetospheric Multiscale (MMS) Project will use four identically instrumented spacecraft to perform the first definitive study of magnetic reconnection in space. Reconnection occurs in all astrophysical plasma systems but can be studied efficiently only in the Earth's magnetosphere. It is thought to be of great importance for energy transfer throughout the universe and is an efficient and fast acceleration mechanism. Reconnection is the primary process by which energy is transferred from the solar wind to Earth's magnetosphere and is the critical physical process determining the size of a space weather geomagnetic storm. MMS will determine why magnetic reconnection occurs, where it occurs, how it varies, how magnetic energy is coupled into heat and particle kinetic energy, and how this energy is coupled into the surrounding plasma.

For more information see http://stp.gsfc.nasa.gov/missions/mms/mms.htm.

Project Parameters

The MMS instrument payload will measure electric and magnetic fields and plasmas within the small-scale diffusion regions where magnetic reconnection occurs. High temporal and spatial resolution measurements will permit direct observation of these physical processes. The four spacecraft and instrument suites have identical design requirements. A two-phase, low-inclination orbit will probe both the dayside magnetopause and the nightside magnetotail neutral sheet where reconnection is known to frequently occur. The primary target of Phase 1 is the dayside magnetopause reconnection region. Phase 2 will focus on the near-Earth neutral line in the magnetotail. The four spacecraft will fly in a tetrahedron formation and 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.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes
Project In Development:	Magnetospheric Multiscale (MMS)

Project Commitments

NASA plans to launch four identically-instrumented spacecraft on an Evolved Expendable Launch Vehicle (EELV) into a highly elliptical Earth orbit in March 2015 and begin two years of scientific measurements that will enable an understanding of fundamental plasma physics processes associated with magnetic reconnection.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Launch Vehicle	KSC	Deliver ~4,000-kg payload consisting of 4 observatories to a highly elliptical Earth orbit	Same	Same
Ground Systems	GSFC	Provide during operations minimum science data payback of ~4 Gbits of data per observatory each day.	Same	Same
Spacecraft	GSFC	Deliver high-rate data from instruments to ground station with a high accuracy for 2 years	Same	Same
Electric Field Instruments	UNH	Provide measurements of electric fields (time resolution 1 ms) and magnetic fields (time resolution 10 ms)	Same	Same
Fast Plasma Investigation	GSFC	Provide plasma wave measurements (electric vector to 100 KHz).	Same	Same
Energetic Particle Detectors	JHU/APL	Provide high-resolution measurement of energetic particles	Same	Same
Hot Plasma Composition Analyzers	Southwest Research Institute	Three-dimensional measurements of hot plasma composition (time resolution 10s).	Same	Same
Science Operations Center	LASP	Science data to the community and archive	Same	Same

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes
Project In Development:	Magnetospheric Multiscale (MMS)

Schedule Commitments

Magnetospheric Multiscale (MMS) began formulation in FY 2002 and the project's Confirmation Review was held in June 2009 when the project was approved to enter implementation. As a result of the confirmation review, the launch date was moved to March 2015. The Mission Critical Design Review is planned for August 2010.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Formulation			
Mission Definition Review	September 2007	Same	Same
Initial Confirmation Review	November 2007	Same	Same
Development			
Confirmation Review	June 2009	Same	Same
Critical Design Review	August 2010	N/A	Same
System Integration review	January 2012	N/A	Same
Launch	March 2015	October 2014	March 2015

Development Cost and Schedule Summary

Magnetospheric Multiscale(MMS)

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Magnetospheric Multiscale (MMS)	2010	857.4	2010	857.4	0	Launch Readiness	03/2015	03/2015	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**857.4**	**857.4**	**0.0**
Payload	131.9	131.9	0.0
Spacecraft	169.0	172.3	3.3
Systems I&T	55.3	55.3	0.0
Ground Systems	19.1	19.1	0.0
Science/Technology	19.9	19.9	0.0
Other (Project Management)	268.0	264.7	-3.3
Launch Services	194.2	194.2	0.0

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Solar Terrestrial Probes
Project In Development:	Magnetospheric Multiscale (MMS)

Project Management

The Goddard Space Flight Center (GSFC) has program management responsibility for the Solar Terrestrial Probes Program and Project Management responsibility for the MMS project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Four Instrument Suites	GSFC, Southwest Research Institute	GSFC	Austrian Space Agency, Sweden (SNSB), France (CNES), and Japan (JAXA)
Launch Vehicle	KSC	KSC	None
Four Spacecraft	GSFC	GSFC	None
Mission Operations	GSFC	GSFC	None
Science Operations	GSFC, LASP	None	None

Acquisition Strategy

The MMS spacecraft is being designed, developed, and tested in-house at GSFC using a combination of GSFC civil servants and local support service contractors. The acquisition of subcontracted spacecraft sub-assemblies, components, and parts is through procurement contracts issued by the MMS Procurement office. Instrument development activities are under contract with the Southwest Research Institute (SwRI). Instrument development subcontracts include Lockheed Martin, JAXA/MEISEI, University of New Hampshire, Johns Hopkins University/Applied Physics Laboratory, Aerospace Corporation, and a team at GSFC. The Mission Operations Center and the Flight Dynamics Operations Area will be developed and operated at GSFC using a combination of GSFC civil servants and local support service contractors. The Science Operations Center for the Instruments will be developed and operated at the Laboratory for Atmospheric and Space Physics at the University of Colorado and is under contract to SwRI.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	05/2009	The Critical Design Review (CDR), a NPR 7120.5D review will assess the technical, cost, and schedule status of MMS.	08/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
MMS Instrument International Partership Risk	A component of the Sweden team with the Fields Investigation on the MMS instrument suite is at risk. Inadequate technical and programmatic progress. Design is not mature. No detailed schedule. Insufficient mission assurance.	GSFC/SwRI/UNH provide management and technical support. Assess progress. Decide on need for alternate vendor. Select new SDP supplier.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	34.8	69.4	97.7	99.2	116.1	126.8	167.8
IRIS	15.0	0.0	69.0	37.6	9.2	7.3	1.2
Other Missions and Data Analysis	19.8	69.4	28.7	61.6	106.9	119.5	166.5
FY 2010 President's Budget Request	31.4	69.4	119.7	158.1	161.3	167.4	--
Other Missions and Data Analysis	31.4	69.4	119.7	158.1	161.3	167.4	--
Changes from FY 2010 Request	3.4	0.0	-21.9	-58.9	-45.2	-40.5	--

Note: Budget of $169 million for GEMS has been transferred from Heliophysics to Astrophysics Division.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program

Program Overview

The Heliophysics Explorer Program provides frequent flight opportunities for world-class astrophysics and space physics investigations using innovative and streamlined management approaches for spacecraft development and operations. Explorer missions are 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 also enables participation in missions of opportunity provided by other U.S. or international agencies. The program emphasizes missions that can be accomplished under the control of the scientific research community within constrained mission life-cycle costs. The program also seeks to enhance public awareness of space science by incorporating educational and public outreach activities into each mission. All investigations are competitively selected. Full missions can either be Medium-Class Explorers (MIDEX) or Small Explorers (SMEX). Mission of Opportunity (MO) space science investigations are typically instruments flown as part of a non-NASA space mission. MOs are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission.

Following the commissioning and checkout phase of the spacecraft, HQ management responsibility for the operational phase transitions to the Heliophysics Research Program. While the Research Program assumes management responsibilities, funds for operating missions are provided by the Explorer Program.

The Heliophysics Explorer Program made two full mission selections from its SMEX Announcement of Opportunity (AO) competition during FY 2009. The Interface Region Imaging Spectrograph (IRIS) is a Heliophysics small explorer mission scheduled for launch in CY 2012. The Gravity and Extreme Magnetism SMEX (GEMS) is an Astrophysics small explorer mission selected for launch in FY 2014.

The Interstellar Boundary Explorer (IBEX) launched in October 2008 is now operating. The Coupled Ion Neutral Dynamics Investigation (CINDI), and Two Wide-angle Imaging Neutral-atom Spectrometers B (TWINS) were also launched in FY 2008 and conducting prime science operations.

The Explorer Program also has four Explorer missions currently in the Astrophysics Division. Details and the associated budget can be found in the Astrophysics Division section. For more information on any of the Explorer mission and new science discoveries, please see http://explorers.gsfc.nasa.gov/missions.html

Plans For FY 2011

The newly selected SMEX mission, IRIS will progress towards its development phase. The IBEX mission will complete its mission criteria, and will continue its primary science mission of mapping the heliosphere and uncovering the global interaction between the solar wind and the interstellar medium. TWINS and CINDI will both enter their third year on orbit. THEMIS and AIM will continue their extended Phase E operations (subject to the outcome of the FY 2010 Heliophysics Senior Review for operating missions).

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program

Project Descriptions and Explanation of Changes

IRIS

The Interface Region Imaging Spectrograph (IRIS) is a Small-Class Explorer (SMEX) selected in June 2009 and expected to launch December 2012. This mission opens a window of discovery by tracing the flow of energy and plasma through the chromosphere and transition region into the corona. IRIS will revolutionize 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 our knowledge of this dynamic region of the solar atmosphere. The mission will greatly extend the scientific output of existing heliophysics spacecraft that follow the effects of energy release processes from the sun to Earth.

Other Missions and Data Analysis

Aeronomy of Ice in Mesophere (AIM): The primary objective of the AIM mission is to understand why polar mesospheric clouds (PMCs) form and why they vary. AIM will also determine the causes of Earth's highest-altitude clouds, which form in the coldest part of the atmosphere about 50 miles above the polar regions every summer. AIM launched on April 25, 2007, on board a Pegasus XL from Vanderberg Air Force Base and completed it's prime mission in FY 2009. This mission supplies spectacular data, which has led to new science discoveries.

Coupled Ion-Neutral Dynamics Investigation (CINDI): CINDI is a NASA-sponsored Mission of Opportunity (MO) managed by the University of Texas at Dallas (UTD). CINDI will discover the role of ion-neutral interactions in the generation of small- and large-scale electric fields in Earth's upper atmosphere. In addition, the CINDI instruments will provide measurements of the three-dimensional neutral winds and ion drifts. This mission launched April 16, 2008, aboard the Air Force Research Laboratory's Communication/Navigation Outage Forecast System (C/NOFS) spacecraft.

Interstellar Boundary Explorer (IBEX): IBEX allows the first glimpse into the edge of the solar system, where the solar wind interacts with winds from other stars. This region is a breeding ground for anomalous cosmic rays that form a component of energetic particles from beyond the solar system that may pose health and safety hazards for humans exploring beyond Earth's orbit. IBEX will make observations from an elliptical Earth orbit that takes it beyond the interference of Earth's magnetosphere. IBEX launched on October 5, 2008, on a Pegasus XL from Kwajalein. The IBEX spacecraft has made it possible for scientists to construct the first comprehensive sky map of our solar system and its location in the Milky Way galaxy. The new view will change the way researchers view and study the interaction between our galaxy and sun.

Time History of Events and Macroscale Interactions during Substorms (THEMIS): THEMIS has provided breakthroughs in our understanding of the onset and evolution of magnetospheric substorms. NASA's THEMIS mission uses five identical micro-spacecraft (probes) to answer the fundamental questions regarding magnetospheric substorm instability, a dominant mechanism of transport and explosive release of solar wind energy within geospace. In addition to addressing its primary objective, THEMIS answers critical questions in radiation belt physics and solar wind-magnetosphere energy coupling. THEMIS is a Medium-Class Explorers(MIDEX) mission that launched on February 17, 2007.

Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS): TWINS will provide the second half of the stereo imaging capability of Earth's magnetosphere in conjunction with the TWINS-A mission. The region surrounding the planet is controlled by its magnetic field and contains the Van Allen radiation belts and other energetic charged particles. TWINS-B will enable three-dimensional global visualization of this region, which will lead to a greatly enhanced understanding of the connections between different regions of the magnetosphere and their relation to the solar wind. TWINS-B was launched as a NASA-sponsored Mission of Opportunity in February 2008.

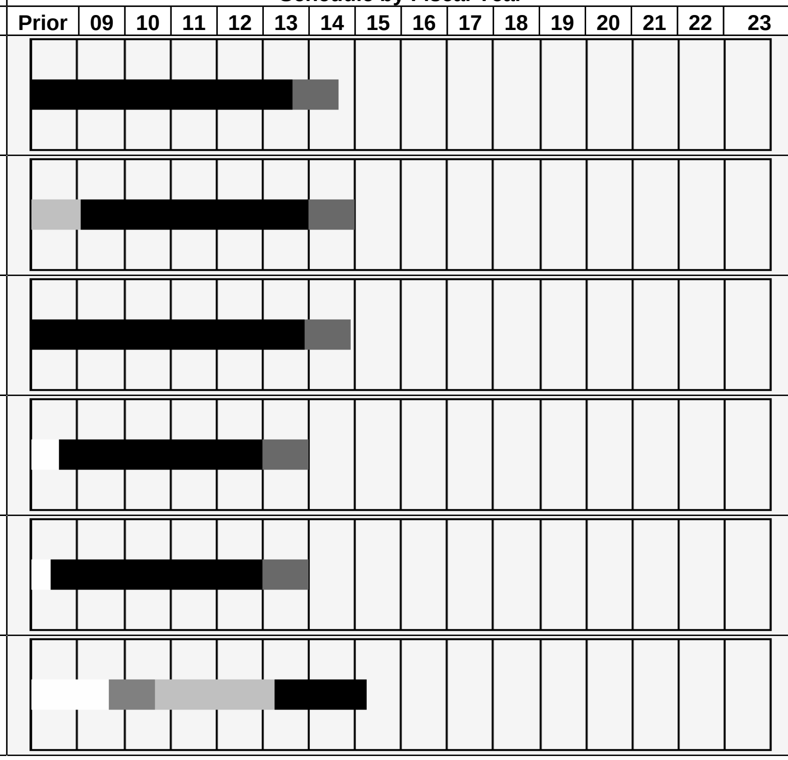
Explorer Future Missions: The Program funds future Explorer mission selections for the Medium-Class Explorers (MIDEX), the Small Explorer (SMEX), and Mission of Opportunity (MO).

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Release Explorer Announcement of Opportunity	Explorer Future Mission	New

Implementation Schedule



Project	Phase	Beg	End
AIM	Tech		
	Form	Jul-02	Apr-04
	Dev	Apr-04	May-07
	Ops	May-07	May-13
	Res	May-13	May-14
IBEX	Tech		
	Form	Jan-05	Mar-06
	Dev	Mar-06	Oct-08
	Ops	Oct-08	Sep-13
	Res	Sep-13	Sep-14
THEMIS	Tech		
	Form	Oct-02	Apr-04
	Dev	Apr-04	Aug-07
	Ops	Aug-07	Aug-13
	Res	Aug-13	Aug-14
CINDI	Tech		
	Form	Sep-00	Nov-01
	Dev	Nov-01	Apr-08
	Ops	Apr-08	Sep-12
	Res	Sep-12	Sep-13
TWINS-B	Tech		
	Form		
	Dev	Apr-99	Feb-08
	Ops	Feb-08	Sep-12
	Res	Sep-12	Sep-13
IRIS	Tech		
	Form	Jun-09	Jun-10
	Dev	Jun-10	Dec-12
	Ops	Dec-12	Jan-15
	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program

Program Management

Goddard Space Flight Center (GSFC) has Program Management responsibility for all Heliophysics Explorer Programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
AIM	GSFC	None	N/A
IBEX	GSFC	GSFC	N/A
THEMIS	GSFC	None	N/A
CINDI	GSFC	None	DoD
TWINS-B	GSFC	None	DoD
IRIS	GSFC	AMES	N/A

Acquisition Strategy

The Heliophysics Explorer Program has established an acquisition strategy that contracts for the whole mission (concept through delivery of science data and analysis), with emphasis on performance incentives and a cost cap for each mission.

Investigations are selected through the Announcement of Opportunity (AO) process, where multiple investigations are selected competitively for initial concept studies with a competitive down-select to proceed to the next stage of formulation. The investigations are selected to proceed from one phase to the next through execution of contract options, based on successful technical, cost, and schedule performance in the previous phases.

The following selection has been made for development:
IRIS: Lockheed Martin Space Systems Company and NASA AMES Research Center

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Space Science Support Office	06/2009	Reviewed and evaluated Small Explorers (SMEX) Announcements of Opportunity proposals for selection. Written evaluations were provided and IRIS mission was selected for development as the next SMEX mission.	01/2011
Performance	IPAO	02/2009	Overall assessment of life cycle cost, schedule and deliverables of the Explorer Program. Review board concluded that these programs have met their success criteria and should continue in accordance with their existing plans.	02/2011

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program
Project In Formulation:	Interface Region Imaging Spectograph (IRIS)

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**15.0**	**0.0**	**69.0**	**37.6**	**9.2**	**7.3**	**1.2**
Total Change from 2010 President's Budget Request	**15.0**	**0.0**	**69.0**	**37.6**	**9.2**	**7.3**	**--**

Project Purpose

Understanding the interface between the photosphere and corona remains a fundamental challenge in solar and heliospheric science. The Interface Region Imaging Spectrograph mission will use a solar telescope and spectrograph to explore the solar chromospheres. This mission opens window of discovery into this crucial region by tracing the flow of energy and plasma through the chromosphere and transition region into the corona using spectrometry and imaging. Recent discoveries have shown the chromosphere is significantly more dynamic and structured than previously thought. IRIS will revolutionize 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 our knowledge of this dynamic region of the solar atmosphere. The mission will greatly extend the scientific output of existing heliophysics spacecraft that follow the effects of energy release processes from the sun to Earth.

Project Preliminary Parameters

IRIS is a sun-pointed mission that studies the chromospheres in the FUV & NUV with 0.33 arcsec spatial resolution, 0.4 km/v velocity resolution and a FOV of 171 arcsec. This 2-year mission fills in critical gap by providing simultaneous, co-spatial and comprehensive coverage from photosphere (~4,500K) up to corona (<= 10 MK). IRIS has a 20-cm UV telescope which has 1/6 arcsec pixels, a multi-channel spectrograph and a slit-jaw imaging.

Estimated Project Deliverables

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Ground Systems	Lockheed Martin Space Systems Company	Receive science data and telemetry from spacecraft, command spacecraft, distribute science data to investigator teams	N/A	NEW
Spacecraft	Lockheed Martin Space Systems Company	Transport instruments to science destination, operate instruments	N/A	NEW
Instruments	Lockheed Martin Space Systems Company	Perform in situ measurements and remote observations of the Sun	N/A	NEW
Launch vehicle TBD	TBD	Deliver the spacecraft to operational orbit	N/A	NEW

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program
Project In Formulation:	Interface Region Imaging Spectograph (IRIS)

Estimated Project Schedule

The IRIS Confirmation review is planned for June 2010. IRIS launch is planned for December 2012.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
System Readiness Review	01/2010	N/A	01/2010
Preliminary Design Review	04/2010	N/A	04/2010
Confirmation Review	06/2010	N/A	06/2010
Critical Design Review	02/2011	N/A	02/2011
Pre-Environmental Review	10/2011	N/A	10/2011
Pre-Ship Review	07/2012	N/A	07/2012
Launch Readiness Date	12/2012	N/A	12/2012

Project Management

Lockheed Martin Space Systems is leading the formulation and implementation of the project. GSFC is responsible for oversight and science management including data analysis during operations.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Instrument	GSFC	GSFC	None.
Launch Vehicle	GSFC	KSC	None.
Spacecraft	GSFC	GSFC	None.
Mission Operations	GSFC	GSFC	None.

Acquisition Strategy

The Interface Region Imaging Spectrograph (IRIS)awarded in June 2009, is a PI led project that was competitively selected under the Small Explorer (SMEX) program. The contractor's final proposal for Phase B has been submitted and is in the process of review and negotiation. Contractor proposals for Phases C-E are expected in December 2009. The Phase E contracts will be managed by GSFC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	SRB	N/A	System Readiness Review	1/2010
All	PDR	N/A	Preliminary Design Review	04/2010
All	CR	N/A	Confirmation Review	06/2010
All	CDR	N/A	Critical Design Review	02/2011

Mission Directorate:	Science
Theme:	Heliophysics
Program:	Heliophysics Explorer Program
Project In Formulation:	Interface Region Imaging Spectograph (IRIS)

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
TBD	TBD	TBD

Mission Directorate:	Science
Theme:	Heliophysics
Program:	New Millennium

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	2.7	1.8	0.1	0.0	0.0	0.0	0.0
New Millennium	2.7	1.8	0.1	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	2.7	1.8	1.1	0.0	0.0	0.0	--
New Millennium	2.7	1.8	1.1	0.0	0.0	0.0	--
Changes from FY 2010 Request	0.0	0.0	-1.0	0.0	0.0	0.0	--

Program Overview

The New Millennium Program (NMP) is a technology flight validation program designed to mature key emerging and breakthrough technologies that will enable future NASA science missions. The objective of the program is to accelerate the incorporation of new technologies into future NASA science missions by conducting in-space validation and testing. The NMP allows NASA to conduct technology maturation and validation activities in low cost projects, rather than during science mission development of larger, more expensive missions.

The NMP is being phased out and all current activities will be finished by FY 2012. A small amount of funding remains to cover closeout costs.

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

Plans For FY 2011

Program closeout activities will continue for Space Technology 8 disturbance reduction system.

Project Descriptions and Explanation of Changes

New Millennium

Space Technology 7's Disturbance Reduction System (DRS) incorporates enhanced micro-Newton thruster technology, which works with enhanced sensor technology provided by the European Space Agency. Together, these technologies will demonstrate precision spacecraft control, validating position-measurement of objects in weightlessness with 100-times greater accuracy than ever before.

Mission Directorate:	Science
Theme:	Heliophysics
Program:	New Millennium

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
Space Technology 7																	Tech	Apr-01	Apr-03
																	Form	Apr-03	Jul-03
																	Dev	Jul-03	Apr-12
																	Ops	Apr-12	Apr-13
																	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The New Millennium Program is managed by Jet Propulsion Laboratory.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Space Technology 7	JPL	JPL	European Space Agency and Busek Corporation

Acquisition Strategy

No further acquisitions are planned.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	01/2007	Program Implementation Review. Results were reported to the Agency PMC on 9/12/2007. Review concluded that there should be more emphasis on technology infusion.	N/A

Overview

NASA research continues to contribute directly to aeronautics breakthroughs. As the agency's lead organization for aeronautics research, NASA's Aeronautics Research Mission Directorate (ARMD) oversees cutting-edge research whose goal is to generate the innovative concepts, tools and technologies that will enable revolutionary advances in future aircraft, as well as to the airspace in which they will fly. NASA has put together a robust research portfolio that addresses these advances and the challenges facing our nation as it transforms its air transportation system to meet growing capacity needs. In addition, the portfolio ensures aeronautics research and critical core competencies will continue to play a vital role in supporting NASA's manned and robotic space exploration activities.

Growth in the air transportation system is vital to the well being of our nation, indirectly or directly providing 997,000 American jobs. (1) In 2006, aviation manufacturing and services accounted for $445B in direct and indirect economic activity, an increase of $9B since 2004. (2) In the United States, 66 certified domestic carriers fly 6,758 aircraft, servicing almost a million travelers every day, and annual operating revenue for commercial flight stands at $186 billion in 2008. (1)

Future needs will exceed the limited solutions that aviation currently offers, requiring improvements in capacity, environmental compatibility, robustness and freedom of mobility throughout the global airspace while simultaneously transferring safety of flight from reactionary to anticipatory (how to avoid accidents before they occur) practices. In the next two decades, we must develop advances that improve aircraft and system efficiency, reduce aviation's impact on the environment and allow more people to utilize air travel in ways that are more significant than all the gains realized over the last three decades.

NASA's aeronautics programs can enable the realization of these advances. Each of NASA's five programs - Aviation Safety, Airspace Systems, Fundamental Aeronautics, Integrated Systems Research and Aeronautics Test - uniquely addresses specific aeronautical-research needs while taking an integrated approach on addressing critical long term challenges. By continuing to expand the boundaries of aeronautical knowledge for the benefit of the nation through NASA's partnering arrangements in academia, industry and other government agencies, NASA's programs are also helping to foster a collaborative research environment in which ideas and knowledge are exchanged across all communities.

NASA Aeronautics currently administers a robust fundamental research program that is well aligned with the principles, goals and objectives of the National Aeronautics Research and Development (R&D) Policy and Plan and directly supports the development of the Next Generation Air Transportation System (NextGen). NASA's commitment to technical excellence and strong partnerships will ensure our continued focus on those challenges needed to support the needs of the nation's air transportation system and the Agency's space exploration vision.

(1) U.S. DOT Bureau of Transportation Statistics Research and Innovative Technology Administration
(2) "The Economic Impact of Civil Aviation on the U.S. Economy", October 2008, FAA Air Traffic Organization

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**650.0**	**507.0**	**579.6**	**584.7**	**590.4**	**595.1**	**600.3**
Aeronautics	650.0	507.0	579.6	584.7	590.4	595.1	600.3
FY 2010 President's Budget Request	**650.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**	**--**
Aeronautics	650.0	507.0	514.0	521.0	529.0	536.0	--
Total Change from FY 2010 President's Budget Request	**0.0**	**0.0**	**65.6**	**63.7**	**61.4**	**59.1**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Aeronautics Research

Aeronautics

New Initiatives:

NASA will begin the following three new initiatives in FY 2011:
- Research that will enhance NASA's ability to verify and validate complex software-based systems with a focus on promoting reliable, secure and safe use in the national airspace;
- Research to address operational and safety issues related to the integration of unmanned aircraft systems into the national airspace; and
- Research and technology development efforts, including grants and cooperative agreements, to support NASA's environmentally responsible aviation program.

Major Changes:

None

Major Highlights for FY 2011

In FY 2011, NASA will continue its commitment to conducting long-term cutting edge research for the benefit of the broad aeronautics community. Each of the five programs within Aeronautics will play a significant role in FY 2011 in addressing the challenge of meeting the growing capacity needs of the Next Generation Air Transportation System (NextGen) as well as contributing to the R&D challenges in aviation safety, promising new flight regimes, and aviation environmental impacts. Specifically:

- The Fundamental Aeronautics Program focuses on conducting cutting-edge research to achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions, and fuel consumption, and increased mobility through a faster means of transportation.

- The Airspace Systems Program will develop and enable future concepts, capabilities, and technologies that will enable major increases in air traffic management efficiency and flexibility while maintaining safety, to meet capacity and mobility requirements of the NextGen.

- The Aviation Safety Program will take a proactive approach to safety challenges with new and current vehicles and with operations in the nation's current and future air transportation system. In addition, the Program will continue the effort to examine key challenges in verifying and validating flight critical systems.

- The Integrated Systems Research Program's initial effort will conduct research on promising concepts and technologies at an integrated system-level and explore, assess and demonstrate their benefits in a relevant environment.

- The Aeronautics Test Program will ensure the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities and flight operations assets necessary to meet Agency and national aeronautics testing needs.

Mission Directorate: Aeronautics Research
Theme: Aeronautics

Theme Overview

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**650.0**	**507.0**	**579.6**	**584.7**	**590.4**	**595.1**	**600.3**
Aviation Safety	89.3	75.0	79.3	78.9	81.2	81.9	82.7
Airspace Systems	121.5	80.0	82.2	82.9	85.9	86.6	87.4
Fundamental Aeronautics	307.6	220.0	228.5	231.4	236.0	241.8	244.6
Aeronautics Test	131.6	72.0	76.4	76.4	75.6	77.4	78.2
Integrated Systems Research	0.0	60.0	113.1	115.1	111.7	107.4	107.4
FY 2010 President's Budget Request	**650.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**	**--**
Aviation Safety	89.3	60.1	59.6	59.2	61.7	62.5	--
Airspace Systems	121.5	81.4	82.9	83.9	87.2	88.3	--
Fundamental Aeronautics	307.6	228.4	230.0	233.6	239.0	245.9	--
Aeronautics Test	131.6	74.7	77.1	77.2	76.6	78.7	--
Integrated Systems Research	0.0	62.4	64.4	67.1	64.4	60.5	--
Total Change from FY 2010 Request	**0.0**	**0.0**	**65.6**	**63.7**	**61.4**	**59.1**	**--**

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's aeronautics research programs are focused on the technologies that support the realization of the Next Generation Air Transportation Systems (NextGen), including the air traffic management system and the vehicles that operate in this system. The research conducted by NASA addresses aviation safety, energy efficiency and environmental compatibility, and airspace capacity and operational efficiency to ensure the nation's future aviation industry competitiveness. It also addresses the long-term research needs in access-to-space technologies that will be required for future NASA missions. The Office of Science and Technology Policy (OSTP) National Science and Technology Council (NSTC) Committee on Technology chartered an Aeronautics Science and Technology (AS&T) Subcommittee in September 2005. NASA's Associate Administrator for Aeronautics is a co-chair of the Subcommittee, which drafted the Nation's first Aeronautics Research and Development Policy, released by the White House in December 2006. The policy establishes a set of U.S. aeronautics research objectives, defines the appropriate role of the federal government in aeronautics research and development (R&D), defines the roles and responsibilities of the various departments and agencies in aeronautics R&D, addresses R&D test and evaluation infrastructure, and addresses the coordination of aeronautics research across the federal government. NASA's efforts are aligned with the policy. In December 2007, the first National Plan for Aeronautics R&D and Related Infrastructure was approved, and in December 2008, a Technical Appendix to the Plan was released. The Aeronautics research portfolio is closely aligned with this National Plan and includes research content as the key areas called outreach plan of mobility, energy and environment, safety and national security.

Relevance to education and public benefits:

NASA's aeronautics programs ensure long-term focus in fundamental research in both traditional aeronautical disciplines and relevant emerging fields for integration into multidisciplinary system-level capabilities for broad application. This approach will enable revolutionary changes to both the airspace system and the aircraft that fly within it, leading to a safer, more environmentally friendly, and more efficient national air transportation system. Furthermore, NASA will disseminate all of its research results to the widest practicable extent. Through this process, we are able to bring numerous professors and students (graduate research and scientists) into the NASA aeronautics research programs.

NASA uses the NASA Research Announcement (NRA) process to foster collaborative research partnerships with the academic and private sector communities. They are encouraged to spend time at NASA centers in order to enhance the exchange of ideas and expand the learning experience for everyone involved. NASA has focused its educational activities and resources to better attract the nation's best and brightest students to aeronautics. These activities include design competitions and the establishment of graduate and undergraduate scholarships and internships.

Performance Achievement Highlights:

The Airspace Systems Program and the University of California at Santa Cruz successfully demonstrated a prototype separation-assurance system in the presence of time-based constraints. In real-time high-fidelity simulations, ground-based automation was able to maintain safe separation for the entire Fort Worth Center airspace above 10,000 feet. Traffic demand was increased up to twice that of today, and system performance was found to be comparable or better than today. At critical merge points in transition airspace where demand exceeded capacity the system efficiently sequenced and spaced aircraft for arrival. Modeling uncertainties included wind, aircraft performance and trajectory intent.

The Aviation Safety Program disseminated data mining technology, which has resulted in NASA methods being deployed in a prognostic way in a real, operational airline environment. NASA has open-sourced many of its key data mining algorithms for analysis of data from flight data recorders through DASHlink, our Web 2.0 portal. Southwest Airlines sought sequenceMiner and Orca, two advanced anomaly detection techniques. Initial application of these algorithms in their own safety data analysis system has discovered operationally significant events that would not be triggered by their existing methods alone. The airline plans to incorporate these algorithms into their daily operations.

The Fundamental Aeronautics Program made significant research progress to enable more effective use of alternative fuels and in increased knowledge of fuel characterization and performance. Lab and field experiments were conducted to evaluate new synthetic and biofuels for aviation applications. NASA partnered with DoD, EPA, and FAA in this effort. An experiment to examine the performance and emissions of alternative fuels was conducted with the NASA Dryden Flight Facility DC-8 aircraft. During this experiment, several Fischer/Tropsch (FT) fuels were tested. This test resulted in an extensive dataset related to jet engine performance and emissions. Researchers found that burning FT fuel did not appreciably affect engine performance, but did lead to aircraft and storage tank fuel leaks due to seal shrinkage from exposure to these fuels. The most profound effect of the alternative fuels was to reduce engine black carbon number density and mass emissions by more than 75% compared to JP-8, the current aviation fuel of choice. FT fuels also reduced Hazardous Air Pollutant emissions (HAPs) and the fuel's lack of sulfur impurities reduced formation of volatile aerosols in the test engine exhaust. NASA is also developing a database for alternative fuels. The database has all standard properties for 19 alternative fuels/fuel blends and can provide reports on fuels, fuel properties, or ranges of fuel properties that can be printed or exported for further processing.

In FY 2009 the Aeronautics Test Program (ATP), with Rand Corporation, developed a five-year Strategic Plan to ensure the continuous availability of a set of NASA-owned wind tunnels/ground test facilities which are strategically important to the nation. The program continued its strategic initiative to establish the National Force Measurement Technology Capability to improve operation efficiencies. This activity is intended to address the severe erosion of NASA's capability to utilize strain gage balances in wind tunnel testing. During FY 2009, ATP staff co-authored a technical paper highlighting the issue and the ATP strategy for restoring the national capability in this area. The paper was presented at the 47th annual American Institute of Aeronautics and Astronautics Aero-Sciences Conference in January 2009. ATP is collaborating with DoD communities of practice in this initiative, standardizing and developing a best-practices guide, re-capitalizing the NASA strain-gage balance inventory, and increasing research and development investment in critical force measurement technologies and capabilities.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Expert	10/2008	An assessment of NASA's aeronautics research portfolio was performed by the National Research Council (NRC) to determine how NASA is addressing the research challenges identified in the NRC Decadal Survey of Civil Aeronautics. The assessment found that NASA is addressing most of the 51 challenge areas but noted concerns about the lack of research in several areas, including UAS integration in the NAS. NASA has worked to address these concerns by including UAS research in ARRA funded activities.	N/A

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	89.3	75.0	79.3	78.9	81.2	81.9	82.7
Aviation Safety	89.3	75.0	79.3	78.9	81.2	81.9	82.7
FY 2010 President's Budget Request	89.3	60.1	59.6	59.2	61.7	62.5	--
Aviation Safety	89.3	60.1	59.6	59.2	61.7	62.5	--
Changes from FY 2010 Request	0.0	14.9	19.7	19.7	19.5	19.4	--

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

Program Overview

By 2025, air traffic within American airspace may double or triple.(1) Radical innovation will be required to meet such demand. The goal of the NextGen is to make passage through increasingly crowded skies efficient and speedy while maintaining or increasing safety. NextGen will achieve its mandates with state-of-the-art networking technology, continually updating its data and sharing that information with pilots and controllers. Aircraft will be able to immediately adjust to changing factors such as weather, traffic congestion, the position of other aircraft, flight trajectories and any terrestrial or airborne security concerns.

NASA's Aviation Safety Program (AvSP) helps to realize NextGen's full potential by examining concerns to further reduce risk in any complex, dynamic operating domain. AvSP's contribution ranges from providing fundamental research in known safety concerns, to working with partners to address the challenges created as we transition to NextGen, where we expect significant increases in air traffic, introduction of new vehicle concepts, continued operation of legacy vehicles, increased reliance on automation, and increased operating complexity.

AvSP is looking at hardware and software systems that will operate in the NextGen. The program is initiating an effort to examine key challenges in verifying and validating (V&V) that flight-critical systems meet the extremely high levels of safety required for NextGen operations. The program seeks to provide increasing capabilities to predict and prevent safety issues, to monitor for safety issues in-flight and mitigate against them should they occur, to analyze and design safety issues out of complex system behaviors, and to constantly analyze designs and operational data for potential hazards. These technologies can be leveraged to support safety in other complex systems, such as NASA long-duration missions in space science and exploration.

For example, one goal of AvSP is to develop validated tools, technologies and techniques for automated detection, diagnosis and prognosis of adverse events that occur in flight. Another goal is pursing flight-deck-related technologies to ensure crew workload and situational awareness are both safely optimized and adapted to the NextGen operational environment.

The program also advances state-of-the-art design tools to detect, avoid, and protect against loss-of-control due to potential adverse events including atmospheric and vehicle system factors, and develops advanced capabilities for detection and mitigation of aging-related hazards before they become critical.

For more information, see http://www.aeronautics.nasa.gov/programs_avsp.htm.

(1) Joint Planning and Development Office, http://www.jpdo.gov/nextgen.asp

Plans For FY 2011

AvSP has developed 5-year research plans with milestones and metrics in four research areas. Research into integrated vehicle health management (IVHM) addresses the challenge of using a prognostic approach to vehicle health management, in particular the integration, processing, and effective use of large amounts of data across highly integrated and complex flight critical systems. Aircraft aging and durability (AAD) research addresses the challenge of improving the operational resiliency of future structures and advanced materials against aging related hazards. The research into integrated intelligent flight deck (IIFD) technologies addresses the future challenges to ensure the proper integration of the human operator in a highly automated and complex operational environment. The integrated resilient aircraft control (IRAC) research seeks to prevent loss-of-control incidents through better understanding of upset flight conditions due to a variety of causes, including icing and structural degradation, and through detection, avoidance, and mitigation methods.

Research into verification and validation of flight critical systems seeks to provide the fundamental knowledge required to safely manage increasing complexity by the development of theories and methods capable of verifying and validating a wide range of complex, flight-critical systems with confidence and in a cost- and time-effective manner. Highlighted here are key performance deliverables for FY 2011.

AvSP will demonstrate self-healing material concepts to mitigate damage in structural elements. In 2011, the program will develop an integrated system concept for the future production of commercial self-healing metallic structural elements.

The program will develop an aging mitigation technique that demonstrates a 25% improvement over the 2007 baseline, and in 2011 will develop corrosion resistant coatings for Ni-base Superalloy disks that will prevent corrosion pitting damage during hot corrosion and reduce the corrosion debit on 704ºC fatigue life by at least 25%.

The program will evaluate selected results from NextGen-based simulator or flight environment experiments and, based on these results, revise concepts of operation for display, decision support, and human-automation designs. In 2011, the program will evaluate solution concepts specified for flight deck system function allocation, decision-support, and human-automation interactions during 4-D trajectory-based operations in the terminal area; to include operations and conceptual system designs for displays, flight management tasks, role/responsibility assignments, and technology/human functions, as well as the performance metrics that the solution concepts seek to improve. Concepts and performance metrics will be derived from results of high-fidelity simulation studies and/or flight testing.

AvSP will also be developing designs and tools that detect or avoid the onset of loss of control as well as mitigate its effects, and will assess strategies for avoidance and recovery from potential loss-of-control conditions.

Project Descriptions and Explanation of Changes

Integrated Vehicle Health Management

The goal of the IVHM research is to advance the state of highly integrated and complex flight-critical health management technologies and systems. These technologies will enable nearly continuous onboard situational awareness of the vehicle health state for use by the flight crew, ground crew, and maintenance depot. Improved safety and reliability will be achieved by onboard systems capable of performing self-diagnostics and self-correction of anomalies that could otherwise go unattended until a critical failure occurs in structures, propulsive systems, avionics hardware, or software. A key enabling technology will be the ability for sharing and processing large amounts of information among the various vehicle subsystems to more accurately diagnose the system health state and execute the logic to self-correct any critical anomalies detected. This data mining capability can also be applied to operational data about both aircraft and airspace.

Aircraft Aging and Durability

The goal of the AAD research is to develop advanced diagnostic and prognostic capabilities for detection and mitigation of aging-related hazards. The research and technologies to be pursued will decrease the susceptibility of current and next generation aircraft and onboard systems to premature deterioration, thus greatly improving vehicle safety and mission success. Emerging civilian and military aircraft are introducing advanced material systems, fabrication techniques, and structural configurations for which there is limited service history. There will be an emphasis on new material systems/fabrication techniques and the potential hazards associated with aging-related degradation. The intent is to take a proactive approach to identifying aging-related hazards before they become critical, and to develop technology and processes to incorporate aging mitigation into the design of future aircraft. Foundational research in aging science will ultimately yield multidisciplinary subsystem and system-level integrated, and mitigation/management of aging-related hazards for future civilian and military aircraft.

Integrated Intelligent Flight Deck

The goal of the IIFD research is to develop tools, methods, principles, guidelines, and technologies for revolutionary flight deck systems. In doing so, the program seeks to expand our ability to predict and create the comprehensive set of developments (technologies, procedures, and specifications for crew training) demanded for truly novel concepts of operation, such as those proposed for the Next Generation Air Transportation System (NextGen). Trajectories may be defined in distinctly new ways, pilots' tasks may expand to include collaboration and negotiation with other aircraft and with air traffic controllers, and may require managing large disparate sets of information to support a wide range of decisions made both individually and collaboratively. Current projections for NextGen operations also prescribe an increased use of automation, much of which will need to interact with, and support, the cognitive activities of pilots and air traffic controllers. The scope of the IIFD research also includes the development of a comprehensive surveillance system design that enables robust detection of external hazards with sufficient time-to-alarm for safe maneuvering to avoid the hazards. The products of the IIFD research should enable system designers to eliminate the safety risk of unintended consequences when introducing new and advanced systems into an operational environment.

Integrated Resilient Aircraft Control

The goal of the IRAC research is to advance our ability to detect, avoid and prevent loss-of-control in flight. Taking into account the advanced automation and autonomy capabilities as envisioned by NextGen, the research will pursue methodologies to enable an aircraft to automatically detect, mitigate, and safely recover from an off-nominal condition that could lead to a loss of control. Key components of the research will be to develop technologies that would enable an aircraft control system to avoid or mitigate the effects of loss-of-control and the rigorous verification and validation of such software-based flight-critical systems. Likewise, research seeks to better understand causes of upset flight conditions, including icing and this structural degradation, and to detect the existence of degraded conditions.

V&V of Flight Critical Systems

The goals of verification and validation of flight critical systems research include providing methods for rigorous and systematic high-level validation of system safety properties and requirements from initial design through implementation, maintenance and modification, as well an understanding of trade-offs between complexity and verification methods for supporting robustness and fault-tolerance in distributed systems, especially considering effective human-interaction. Further, the development of tools to reduce cost and increase safety through improved software assurance and dependability, as well as analysis and testing capabilities of systems-of-systems, will be pursued.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
In 2012, demonstrate forecasting technology that can predict known anomalies in large data sources	Aviation Safety	Same
In 2012, develop life-prediction methodologies for refined physics based models for composite structural components	Aviation Safety	New
In 2012, compare test results to models of human-automation interaction concepts for NextGen	Aviation Safety	Same
In 2012, assess flight planning and control strategies for aircraft recovery from adverse conditions	Aviation Safety	Same
Deliver validated tools and methods that enable implementation of aircraft aging mitigations by 2016	Aviation Safety	Same
In 2016, deliver tools and flight deck technologies to enable advanced automation to support NextGen	Aviation Safety	Same
Demonstrate sensors, software and guidelines that will enable implementation of onboard IVHM by 2016	Aviation Safety	Same
Deliver multidisciplinary adaptive control design tools for loss-of-control and recovery by 2016	Aviation Safety	Same

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

Program Management

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/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aviation Safety	Program Director	LARC, GRC, ARC, DFRC	FAA, JPDO, CAST (Commercial Aviation Safety Team), NOAA, DoD, Moog, and Boeing , JCAA (Joint Council on Aging Aircraft), Center for Rotorcraft Innovation, Alcoa, Williams International and Luna Innovations, National Research Council Canada, Air Force Research Lab (AFRL), American Kestrel Company, Goodrich

Acquisition Strategy

The Aviation Safety Program spans research and technology from foundational 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.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that compliment NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The AvSP will award approximately $8.0 million in FY 2011 in grants, contracts, and cooperative agreements, including renewals of multi-year awards made under previous NRAs, primarily with industry, academia and non-profit institutions. These awards will also help to strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	11/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010
Relevance	National Research Council	Ongoing	The review will assess whether the program: (a) has well-defined, prioritized, and appropriate research objectives; (b) is properly coordinated with the safety research programs of the FAA and other relevant Federal agencies; (c) has allocated appropriate resources to each of the research objectives; and (d) suitable mechanisms exist for transitioning the results from the program into operational technologies/ procedures and certification activities in a timely manner.	N/A

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Airspace Systems

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**121.5**	**80.0**	**82.2**	**82.9**	**85.9**	**86.6**	**87.4**
Airspace Systems	121.5	80.0	82.2	82.9	85.9	86.6	87.4
FY 2010 President's Budget Request	**121.5**	**81.4**	**82.9**	**83.9**	**87.2**	**88.3**	**--**
Airspace Systems	121.5	81.4	82.9	83.9	87.2	88.3	--
Changes from FY 2010 Request	**0.0**	**-1.4**	**-0.7**	**-0.9**	**-1.4**	**-1.7**	**--**

Program Overview

The Airspace Systems Program (ASP) focuses on mastery, intellectual stewardship, and technical excellence in fundamental air traffic management research. The ASP directly addresses the air traffic management research needs of the Next Generation Air Transportation System (NextGen) in collaboration with the member agencies of the Joint Planning and Development Office (JPDO). NASA is working closely with the JPDO as well as other government, industry, and academic partners to enable the formation, development, integration, and demonstration of revolutionary concepts, capabilities, and technologies allowing significant increases in capacity, efficiency, and flexibility of the National Airspace System (NAS). These goals are in direct support of the guidelines in the National Aeronautics research and development policy and plan.

Increasing the capacity and efficiency of the air transportation system in a manner that does not negatively impact the environment or safety is critically important for the nation's economic well-being. More than half of the nation's busiest airports are already at capacity or will reach capacity limits in the next 10-20 years. Creating new capacity en route or on the airport surface is extraordinarily expensive and can take decades to complete, particularly if environmental constraints and safe separation standards are at issue. Specifically, environmental concerns forced 12 major commercial airports to cancel or indefinitely postpone expansion projects since the 1990s. Despite these constraints, air traffic is expected to continue to increase substantially in the next 20 years. All other factors remaining constant, increases will mean longer delays at airports already experiencing delays and create congestion delays at airports not currently experiencing any. The associated environmental impact and economic inefficiencies have been predicted by some to cost the nation tens of billions of dollars annually. The risk of loss of aircraft separation both during airborne and ground operations could increase as the volume of air traffic exceeds the capacity of the airspace and airports to safely and efficiently accommodate the increased growth.

For more information, please see http://www.aeronautics.nasa.gov/programs_asp.htm.

Plans For FY 2011

ASP conducts research into NextGen concepts and technology development and NextGen systems analysis, integration and evaluation.

The NextGen concept and technology development research focuses on developing capabilities in traffic flow management, dynamic airspace configuration, separation assurance, super density operations, and airport surface operations. Key aspects include optimization for traffic scheduling and route planning, and balanced allocation of resources to maximize airspace productivity in response to arrival, departure, and surface traffic demands. Selected non-normal and off-nominal situations, including system failures, emergency events, and weather impacts will be studied. Technical concepts contributing to this activity will include continuous descents, runway balancing, precision terminal area scheduling and control, surface optimization, efficient flow management, and merging and spacing. Specifically, in FY 2011 ASP will conduct the initial evaluation of terminal tactical conflict prediction and resolution functions. This research will assess the air traffic controller and flight crew acceptability of the initial automated tactical conflict avoidance functionality in dense terminal airspace. It will further determine the acceptability of the initial avoidance function in terms of workload, situational awareness, and perceived safety using mid-fidelity air traffic control and flight deck simulators.

The NextGen systems analysis, integration, and evaluation research will focus on transition from the laboratory to the field of key systems concepts currently being pursued within the NextGen concept and technology development area (i.e., surface, terminal, transitional airspace, and en route domains) that will provide operational benefits, and demonstrate these integrated capabilities in relevant flight environments. Through systems analysis, key concepts will be down-selected based on their potential benefit towards improving operational efficiency, and then matured and tested in both fast-time and real-time full mission simulations to determine their technical viability. From this testing, a sub-set of these integrated concepts will be further demonstrated and evaluated through field tests integrating both air and ground capabilities. This work will continue in FY 2011 with analysis elements, advancing over several years to culminate in relevant field experiments and demonstrations. This work will be coordinated with the FAA, the JPDO, and the Research Transition Teams to ensure transition of NASA concepts, technologies and procedures to the field to help enable the transition of today's air transportation system to NextGen. Specifically, in FY 2011 ASP will determine the initial specification of operational requirements for performing Multi-Sector Planning (MSP) functions in the mid-term, including technical and conceptual requirements, with consideration of how requirements might change as the NAS evolves towards NextGen.

Both research activities contribute to ASP's High Priority Performance Goal to increase efficiency and throughput of aircraft operations during arrival phase of flight. Specifically, in FY 2011, ASP will conduct a field test, where an Enroute Descent Advisor (EDA) prototype will be deployed for real-time decision-making by presenting speed and path adjustment advisories on air traffic controllers' displays. EDA helps save hundreds of pounds of fuel and carbon dioxide emissions per participating flight, while also reducing noise over surrounding communities by selecting optimal descent speeds and paths for arriving aircraft under heavy traffic conditions. EDA provides advanced decision support to controllers, and is a key component of the FAA's 3D-Path Arrival Management Program and NextGen. The primary mechanism for deployment is the NASA-FAA Research Transition Team (RTT), through which NASA will deliver EDA Technology Transition Documentation to the FAA in FY 2012.

Project Descriptions and Explanation of Changes

NextGen Concepts and Technology Development

Researchers focused on NextGen concepts and technology will develop and explore fundamental concepts that address the optimal allocation of ground and air automation technologies necessary for NextGen. The program will focus NASA's technical expertise and world-class facilities to address the question of where, when, how, and the extent to which automation can be applied to moving aircraft safely and efficiently through the National Airspace System (NAS) including airport surfaces. Research in ASP will address Four-Dimensional Trajectory Operations, including advances in the science and applications of multi-aircraft trajectory optimization that solves the demand/capacity imbalance problem while taking into account weather information and forecast uncertainties, and keeping aircraft safely separated. The program's research will develop and test concepts for advanced traffic flow management to provide trajectory planning and execution across the spectrum of time horizons from "strategic planning" to "separation assurance." The program will also conduct research to explore dynamic airspace configuration that addresses the technical challenges of migrating from the current structured, static homogenous airspace to a dynamic, heterogeneous airspace that adapts to user demands and meets changing constraints of weather, traffic congestion, and a highly diverse aircraft fleet. Ultimately, the roles and responsibilities of humans and automation influence every technical area and will be addressed thoroughly. The program will respond to the need to achieve the maximum possible productivity in the combined use of gates, taxiways, runways, terminal airspace, and other airportal resources. Since every airport is a unique environment, and demand is not expected to increase equally at each airport as the system grows.

Specific technical goals include:
- Increasing capacity through dynamic allocation of airspace structure and controller resources
- Effectively allocating demand through departure-time management, route modification, adaptive speed control, etc., in the presence of uncertainty
- Developing algorithms, automation prototypes, and procedures that relieve the capacity constraints imposed by human-controlled separation of aircraft in transition and cruise airspace
- Quantifying the performance-enhancing effects of emerging airborne technologies
- Optimizing surface traffic operations to enable capacity enhancements
- Exploring transformational approaches, enabled by NextGen capabilities, for increasing airportal throughput
- Maximizing the capacity of individual runways and multiple runways with airspace and taxi interactions (closely-spaced parallel and converging/intersecting runways)
- Minimizing runway incursion threats in all weather conditions
- Balancing arrival and departure traffic management to enable capacity improvements.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Airspace Systems

NextGen Systems Analysis, Integration, and Evaluation

The high-level goal of the NextGen systems analysis, integration, and evaluation research is to conduct systems analysis, integration, and evaluation of key concepts currently being pursued within the surface, terminal, transitional airspace, and en route domains that will provide operational benefits, and demonstrate these integrated capabilities in a relevant environment. Through system analysis, key concepts will be down-selected based on their potential benefit towards increasing efficiency, and then matured and tested in both fast-time and real-time full mission simulations to determine their technical viability. From this testing, a sub-set of these integrated concepts will be further demonstrated and evaluated through field tests integrating both air and ground capabilities. To accomplish this goal, the following technical objectives will be satisfied:

- Define operational issues, factors and concerns that must be considered in conducting system analysis
- Assess collective impact of these technologies using fast-time modeling and simulation and feed back results into the baseline program to enhance and validate research concepts
- Examine the feasibility of the integrated concepts and technologies using human performance models and human-in-the-loop simulations
- Demonstrate the impact of the integrated concepts and technologies using field trials
- Assess alternate fleet implications on trajectory based operations
- Collaborate with industry and government partners to transition technologies that enable increases in capacity and efficiency, while maintaining safety and environmental conditions

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2016, integrate and evaluate systems performance of future concepts, capabilities, and technologies for NextGen operations.	Airspace Systems	Same
By 2016, develop future concepts, capabilities, and technologies for NextGen operations.	Airspace Systems	Same

Program Management

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/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Airspace Systems	Program Director	ARC, LARC	FAA, JPDO, DOT, Air Force Research Lab (AFRL), Lockheed Martin, Air Services Australia and Eurocontrol

Acquisition Strategy

The 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.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Airspace Systems Program will award approximately $15.1 million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	10/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Fundamental Aeronautics

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**307.6**	**220.0**	**228.5**	**231.4**	**236.0**	**241.8**	**244.6**
Fundamental Aeronautics	**307.6**	**220.0**	**228.5**	**231.4**	**236.0**	**241.8**	**244.6**
FY 2010 President's Budget Request	**307.6**	**228.4**	**230.0**	**233.6**	**239.0**	**245.9**	**--**
Fundamental Aeronautics	**307.6**	**228.4**	**230.0**	**233.6**	**239.0**	**245.9**	**--**
Changes from FY 2010 Request	**0.0**	**-8.4**	**-1.4**	**-2.1**	**-3.0**	**-4.2**	**--**

Program Overview

The Fundamental Aeronautics Program (FAP) focuses on conducting cutting-edge research to achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions, and fuel consumption, increased mobility through a faster means of transportation, and the ability to ascend/descend through planetary atmospheres. These technological capabilities enable design solutions for performance and environmental challenges of future air vehicles. FAP is dedicated to the mastery and intellectual stewardship of the core competencies of aeronautics for the Nation across all flight regimes. Research in revolutionary aircraft configurations, lighter and stronger materials, improved propulsion systems, and advanced concepts for high lift/drag reduction all target the efficiency and environmental compatibility of future air vehicles. The program also develops physics-based, multidisciplinary design, analysis and optimization tools to enable evaluation of new vehicle designs and to assess, with known uncertainties, the potential impact of design innovations on a vehicle's overall performance. All of these advances will realize revolutionary improvements in noise, emissions and performance enabling a new generation of air vehicles to meet the challenges of the NextGen air transportation system.

Fundamental Aeronautics conducts research across four specific flight regimes. The subsonic fixed wing research focuses on new aircraft configurations, advanced propulsion systems, and enabling technologies to dramatically reduce noise, emissions, fuel burn, and runway field length for a variety of vehicles. The subsonic rotary wing research focuses on speed and range increases, payload capacity, noise reduction, propulsive efficiency, and rotorcraft unique technologies to enable development of new configurations that enhance mobility of the future air transportation system. Technologies to meet the environmental challenges specifically associated with supersonic flight, such as sonic boom and gaseous emissions, are addressed by the supersonics research. Elimination of these barriers will realize practical commercial supersonic cruise vehicles that can fly over land. Finally, the hypersonics research focuses on long-range, fundamental and multidisciplinary research to enable air-breathing launch vehicles with improved reliability for lower-cost and more routine access to space.

For more information, please see http://www.aeronautics.nasa.gov/fap.

Plans For FY 2011

Subsonic rotary wing research will result in the demonstration of new technologies and analysis methods to ensure that large rotorcraft will have sufficient crashworthiness characteristics to be viable commercial transport vehicles. The goal of using rotorcraft to carry as many passengers as current regional jets adds a level of safety consideration to the rotorcraft airframe design that is a much greater challenge than is currently considered in small rotary wing designs. Unlike fixed wing transports or automobiles, rotorcraft have the possibility of both vertical and horizontal velocities during impact. This unusual environment will be addressed through a combination of analytical tools and experimental validation using NASA's unique test facilities. New energy absorbing materials and techniques will be developed, and the goal of certification by analysis will be advanced through careful correlation between modeling and experimental verification.

Subsonic fixed wing research will result in the completion and validation of the second generation of a multi-disciplinary analysis and design toolset to evaluate the trades between noise, emissions, and performance of future aircraft. Accuracy of the toolset will be assessed by comparing predictions of noise, emissions, fuel-burn, takeoff/landing performance, and aircraft weight to known characteristics from single-aisle (B737/CFM56) and twin-aisle (B777/GE90) aircraft. The toolset will then be used to predict the performance benefits of unconventional aircraft configurations (such as hybrid wing-body) to guide the development of enabling technologies for such configurations.

Supersonics research will enable the completion of a multidisciplinary analysis and design system that enables the simultaneous achievement of high cruise efficiency and low sonic boom in future civil supersonic cruise aircraft. The system will integrate analysis tools of varying fidelity in a computational framework that allows rapid, accurate communication of data and control of the analysis and design processes. Higher order analysis tools, based on computational fluid dynamics (CFD) and rapid grid generation will be incorporated in the framework to reduce the uncertainty in the results of the design process. New tools for creating and optimizing the design targets for the sonic boom minimization will also be included. The goal for the design system is to reduce the time required to optimize an aircraft for low sonic boom from months to approximately two weeks. Such a reduction in time will enable the consideration of much more design detail early in the design process.

Hypersonics research will allow CFD predictions of ramjet-to-scramjet mode-transition and compare the predictions to available wind tunnel and/or flight data. The ability to accurately predict scramjet performance under mode-transition fueling levels is a key enabler for the design of efficient high-speed propulsion systems. This CFD assessment activity will validate and verify the accuracy of two CFD codes (WIND and VULCAN) against available data from HIFiRE Flight 2 (Hypersonic International Flight Research Experimentation) wind tunnel tests and the upcoming HIFiRE Flight 2 flight test.

Project Descriptions and Explanation of Changes

Subsonic Fixed Wing

The projected growth of the air transportation system over the next 20 years will increase emissions of greenhouse gases, such as carbon dioxide (CO2), nitrogen oxide (NOX), water vapor, and particulates, and the number of people exposed to airport noise. To meet the mobility needs of the future, the Next Generation Air Transportation System (NextGen) will also rely on the expanded use of secondary and reliever airports and may employ a new class of vehicles that are capable of short take-off and landing (STOL). Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the fixed wing regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline and system levels that will enable improved prediction methods and technologies for lower noise, lower emissions (including NOx, CO2, water vapor, volatiles, unburned hydrocarbons, particulate matter, and soot), and higher performance for subsonic aircraft. The emphasis is in technology for enabling advances to future generations of fixed-wing vehicles starting with N+1 (the generation after the current one, represented by the Boeing-787), all the way to N+3 (two generations beyond that; expected to enter into service in the 2030-35 period). Higher performance includes energy efficiency to reduce fuel burn and operability technologies that enable takeoff and landing on shorter runways. Alternative fuels research includes characterization of synthetic and biofuels to understand the impact of these fuels on combustor design, performance, and emissions and also the development and application of fluid and mass transport models for use in enhancing the growth of biomass feedstocks for use in refining of biofuels. The goal of this research is to provide technologies, novel test methods, and validated prediction tools that can be used to improve system trades for advanced concepts capable of meeting longer-term noise, emissions, and performance targets. The following objectives address the overall goals:

- Improvements in prediction tools and new experimental methods that provide fundamental properties and establish validation data
- Noise prediction and reduction technologies for airframe and propulsion systems enabling up to -71 dB cumulative, below Stage IV (1)
- Emissions reduction technologies and prediction tools enabling more than 70 percent reduction in landing and take-off NOx below the sixth state of regulation recommended by the Committee on Aviation Environmental Protection
- Improved vehicle performance through design and development of lightweight, multifunctional and durable structural components, low drag aerodynamic components, and higher bypass ratio engines with efficient power plants, and advanced aircraft configurations enabling a fuel burn reduction of more than 70% as compared to state of the art commercial subsonic transport
- Reduce take off and landing field length requirements to optimize utilization of all available runways within metropolitan areas (more than 50% reduction)
- Multi-disciplinary design and analysis tools and processes to enable design of advanced aircraft configurations with greater degree of confidence.

Since NASA does not design or manufacture aircraft that can operationally show these improvements, we will use demonstrated component technologies and system-level assessments to show that the goals could be operationally achieved.

Footnotes:
(1) Stage IV refers to a limit imposed by the International Civil Aviation Organization on the maximum allowable noise levels for current aircraft.

Subsonic Rotary Wing

Advanced rotorcraft can alleviate the capacity problems in the air transportation system by using simultaneous, non-interfering (SNI) approaches that includes non-primary runways, taxiways, and aprons. This approach would require a large, high-speed rotorcraft configuration with capability for 300+ knots cruise. The limiting factor for the cruise speed of tiltrotors has been propeller efficiency, as the designer trades cruise efficiency for hover performance, with a proprotor speed reduction of nominally 15 percent from hover to cruise. The primary limiting factor for the cruise speed of helicopter configurations has been the dynamic stall encountered on the retreating side of the rotor as the forward speed is increased.

Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the rotary wing regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline, and system levels that will enable improved prediction methods and technologies for lower noise, lower emissions, and higher performance for rotary wing aircraft. The FA program has set aggressive goals to develop technologies that enable high-speed, efficient rotorcraft of various sizes and configurations to be viable commercial vehicles operating in the NextGen airspace system. Research in the subsonic rotary wing area includes the following goals:

- Enable variable-speed rotor concepts that incorporate the ability to change rotor rotational speed by 50% without performance or handling qualities penalties to enable optimum rotor aerodynamic performance in both hover and higher forward flight speeds than currently attainable, making rotorcraft competitive with fixed wing aircraft for short and medium-range missions within the NextGen.
- Contain the external noise within the landing area and reduce internal noise to less than 77 dB, and develop scenarios for low-noise rotorcraft flight operations.
- Assess multiple active rotorcraft concepts for effectiveness in simultaneously increasing aerodynamic efficiency, controlling dynamic stall control for high speed conditions, reducing vibration, and reducing noise. The goal for high speed is to increase the state-of-the-art cruise speed for any rotary wing configuration by 100 knots while maintaining low vibration and low noise characteristics.
- Advance technologies such as crashworthiness, safe operations in icing conditions, and condition-based maintenance methodologies that are essential for rotary wing vehicles to be viable commercial transport concepts.

Supersonics

Supersonic air travel has been possible for decades, but has not been commercially viable because of the significant environmental and performance challenges inherent in this speed regime including overland sonic boom annoyance, high fuel consumption, and NOx emission at high altitudes Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the supersonic regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline and system levels that will address the technical challenges for practical supersonic cruise aircraft.

The supersonics research is organized along the following major technical challenges: efficiency (supersonic cruise, light weight and durability at high temperature); environmental challenges (airport noise, sonic boom, high altitude emissions); performance challenges (aero-propulso-servo-elastic analysis and design, cruise lift/drag ratio); and multidisciplinary design, analysis and optimization challenges.

The FA program will develop technologies to enable overland supersonic cruise with civilian and military applications at acceptable environmental impacts (no greater than subsonic fixed wing aircraft). Research in supersonics includes the following 10-year goals:

- Cruise efficiency improvements in the airframe and propulsion system leading to approximately 30 percent improvement in aircraft range factor vs. the final NASA High-Speed Research (HSR) program baseline;
- Approximately 15 EPNdB (effective perceived noise, in decibels) of jet noise reduction relative to an unsuppressed jet;
- A reduction of loudness on the order of 30 PLdB (perceived loudness, in decibels) relative to typical military aircraft sonic booms
- Minimization of impact from high-altitude emissions.

Hypersonics

The hypersonics research is motivated by the fact that all access to Earth or planetary orbit, and all entry from orbit into Earth's atmosphere or any planet with an atmosphere, requires flight through the hypersonic regime. Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the hypersonics regime, thereby producing knowledge, data, capabilities, and design tools at the foundational, discipline, multidiscipline, and system levels that will address the technical challenges for two high-payoff NASA missions: Airbreathing Reusable Launch Vehicle (RALV) and Planetary Atmospheric Entry Systems (PAES).

Cutting-edge hypersonics research on RALV will enable sustained hypersonic flight through the atmosphere with space-access applications. The research focused on PAES will result in the development of technologies and concepts that can enable the safe and accurate delivery of large payloads to the surface of Mars as well as other bodies with an atmosphere. This effort will focus on the entry, descent, and landing (EDL) phase of both human and robotic planetary missions and is closely aligned with the long-term goals of NASA's space exploration activities.

The FA Program will focus its hypersonics research on addressing some of the hardest challenges including:

- The development of materials for airframe and propulsion applications that can withstand the severe temperatures encountered in hypersonic flight for extended periods of time.
- The development of accurate predictive models for high-speed compressible flow including turbulence, heating, ablation, combustion, and their interactions in order to reduce the uncertainty in predictions of aerodynamic heat loads during the design of hypersonic vehicles. This improved knowledge and predictive capability will result in lower vehicle weight due to reduced design margins for thermal structures and thermal protection systems.
- Airbreathing propulsion systems that operate efficiently over a very wide speed range by integrating high-speed turbine engines or rockets with scramjets.
- Integrating all of the close interactions among the airframe, inlet, nozzle, and propulsion systems using a physics-based multidisciplinary design analysis and optimization approach.

The RALV mission class will help enable new air-breathing launch vehicle such as Two-Stage-to-Orbit Turbine-Based Combined-Cycle systems to eventually provide more routine low-cost access to space. The PAES mission research will push EDL technology beyond the state of the art in hypersonic atmospheric entry to successfully land payloads on Mars with masses up to two orders of magnitude greater than is practically realizable today.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2012 demonstrate a rotor concept incorporating the ability to change rotor speed without penalty	Fundamental Aeronautics	Same
By 2013 develop framework for analysis and design of supersonic aircraft that are efficient with low noise and emissions	Fundamental Aeronautics	Same
In 2013 develop Gen 1 integrated simulation tool for reusable airbreathing launch vehicles	Fundamental Aeronautics	New

Program Management

The ARMD Associate Administrator has oversight responsibility for the FA program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Fundamental Aeronautics	Program Director	ARC, DFRC, GRC, LaRC	Air Force Research Lab (AFRL), Boeing, Pratt & Whitney, Northrop Grumman, A.R. Associates, ENrG Inc., General Electric Aviation, Gulfstream Aerospace, and United Technologies Corporation, Office of the Secretary of Defense, U.S. Army, U.S. Air Force, Center for Rotorcraft Innovation (CRI), Bell Helicopter, Sikorsky, Boeing, DARPA, FAA, Polyumac, Technocore, and ONERA, JAXA, DLR, Lockheed martin, Aerion Corporation, U.S. Air Force Office of Scientific Research (AFOSR), U. S. Navy, Deputy Undersecretary of Defense for Science and Technology

Acquisition Strategy

Acquisitions within the program provide the basic elements for fundamental research, tools and methods development, enabling technologies, and validation and verification of research results. 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.

A full and open NASA Research Announcement (NRA) is used as the primary means to solicit innovative proposals in key research areas that compliment NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Fundamental Aeronautics Program will award at least $30M million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help to strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	12/2009	The 12-month review is a formal independent peer review of the program. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next 6-month review.	12/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aeronautics Test

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	131.6	72.0	76.4	76.4	75.6	77.4	78.2
Aeronautics Test	131.6	72.0	76.4	76.4	75.6	77.4	78.2
FY 2010 President's Budget Request	131.6	74.7	77.1	77.2	76.6	78.7	--
Aeronautics Test	131.6	74.7	77.1	77.2	76.6	78.7	--
Changes from FY 2010 Request	0.0	-2.7	-0.7	-0.9	-1.0	-1.3	--

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aeronautics Test

Program Overview

The Aeronautics Test Program (ATP) is a long-term, funded commitment by NASA and the Aeronautics Research Mission Directorate (ARMD) to retain and invest in test capabilities that are strategically important to both the Agency and the nation. ATP capabilities are located at the Ames Research Center (ARC), Dryden Flight Research Center (DFRC), Glenn Research Center (GRC), and Langley Research Center (LaRC). ATP offers government agencies, corporations, and academic institutions unmatched basic and applied research and experimental opportunities that reflect four generations of accumulated aerospace skill and experience encompassing every aspect of aerospace ground and flight testing and engineering. ATP's vision for the future is a portfolio of aeronautics ground and flight test capabilities that advance U.S. leadership in aeronautics in the short and long term.

Before ATP was established in 2006, a shrinking customer base and cuts in available test resources were diminishing NASA's aeronautics research capabilities. Lacking were both the strategic support and the financial resources to ensure that important national test capabilities were adequately maintained and accessible. Each of the NASA research Centers was fully responsible for its respective aeronautics test facilities, thereby limiting the potential ability to pursue agency-wide approaches and inter-Center collaboration. Occupancy costs for facilities were at risk of becoming unstable and incommensurate with the value provided to users; test customers were being increasingly burdened with broader, non-recurring infrastructure costs; and U.S. test capabilities were in danger of becoming inferior to foreign capabilities.

ATP began addressing national aeronautics test concerns by leading in the implementation of consistent processes, procedures, and pricing structures across the test capabilities within its portfolio. ATP strives to ensure safe, efficient, and cost-effective operation of its national aeronautics test assets through investments in facility workforce, maintenance, and technology development. ATP also provides leadership through national partnerships and collaborative activities, such as the National Partnership for Aeronautics Testing (NPAT) involving the Department of Defense (DoD) and the NASA ARMD.

Looking to the future, ATP will continue maturation through implementing its strategic plan with its four thrusts: (1) provide management guidance and recommendations to the NASA ARMD Associate Administrator and Research Center Directors concerning NASA aeronautics ground and flight test capabilities; (2) represent the strategic interest of NASA and the nation with respect to stewardship of NASA ground and flight test capabilities; (3) provide direction to NASA test capability managers; and, (4) provide financial support to NASA test capabilities.

For more information, see http://www.aeronautics.nasa.gov/atp.

Plans For FY 2011

Strategic initiatives for FY 2011 include the finalization of a Capability Reliance Framework, which is a top-level view of the suite of capabilities that ATP oversees and supports. This framework will inform decision makers about capability needs, which facilities and resources operated by NASA and other entities could serve those needs, and condition and life-cycle costs. The framework will integrate a number of results from measures and initiatives to allow ATP and NASA to quickly identify areas of potential concern, for example, gaps in capabilities, redundancies, and potential opportunities for consolidation. In FY 2011, ATP will incorporate data produced by other ATP initiatives, such as the ATP/NPAT Hypersonic and Subsonic test facility studies that will be finished in FY 2010, to complete the Capability Reliance Framework.

ATP Test Technology investments develop and implement new technologies that will increase aeronautics test capability, improve productivity and efficiency, and improve data quality. In FY 2011, the National Force Measurement Technology Capability will shift to full cost recovery and away from ATP funding. Also in FY 2011 and through the NPAT, ATP will lead a national test technology strategy involving the Arnold Engineering Development Center, Air Force Research Lab, and programs within the ARMD. The objective will be to make strategic investments based on customer requirements and the priorities set by ATP's Facility Capability and Reliability Framework as outlined in ATP's Strategic Plan.

Project Descriptions and Explanation of Changes

Aero Ground Test Facilities

The aeronautics ground test facilities are different classes of facilities including low speed wind tunnels, transonic wind tunnels, supersonic wind tunnels, and hypersonic wind tunnels. The four primary efforts to support the long term viability of the facilities and to continually improve on the efficiency and effectiveness of operations are:

- Facility operations support, which provides a portion of the fixed costs for ground test facilities to ensure facility and staff availability and user price stability.
- Facility maintenance and upgrades, which provides funding for maintenance and the upgrades that correct known deficiencies in facility safety, reliability, and productivity and enable the facilities to meet near-term and future testing requirements. These activities will result in improved facility productivity and reduced operational cost.
- Facility test technology, which provides funding to develop and implement new technologies that increase test capability, improve productivity and efficiency, and improve data quality.
- Facility related research, whose activities are competed openly with a strong desire to involve universities with experimental work in major facilities. It is anticipated that one or more ATP assets will be utilized to develop technologies that will support either the facility operation or other ARMD research programs.

Flight Operations and Test Infrastructure

The flight operations and test infrastructure consists of an integrated set of elements including the Western Aeronautical Test Range (WATR), support aircraft maintenance and operations, and the testbed aircraft that provide the resources required for research flight and mission support projects. The goal is to provide up to 100 percent of the facility fixed costs for these flight facilities to ensure facility and staff availability and user price stability.

The activity also includes the simulation and flight loads laboratories, a suite of ground based laboratories that support research flight and mission operations. The goal is to provide up to 20 percent of the fixed costs for labs to ensure facility and staff availability and user price stability.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2012, deliver at least 90% of on-time availability for operations and research facilities	Aeronautics Test	Same

Program Management

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/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aeronautics Test	Program Director	ARC, DFRC, GRC, and LaRC	DoD and Boeing

Acquisition Strategy

Acquisitions supporting ATP activity will be performed at each of the test sites consistent with the Federal Acquisition Regulation (FAR) and the NASA FAR Supplement (NFS). Each Center will be responsible for coordinating major acquisitions supporting ATP activities through the ATP Office as required by the ATP Director. Acquisitions that support the ATP facilities are usually less than $0.5 million and are initiated as early as possible in the fiscal year.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Expert Panel	07/2009	Periodic reviews are carried out by the NASA Advisory Council (NAC) and the U.S. users of ATP facilities. The last ATP review was carried out by the Aeronautics Committee of the NAC in July 2009; no major findings were reported. The last major community outreach meeting was held in September 2008 with NASA, DoD and U.S. aerospace industry users at the Ohio Institute of Aerospace. The next meeting is planned for April 2010.	03/2010
Performance	Expert Panel	12/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Recommendations will be addressed and a response will be developed no later than the next quarterly review.	12/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	0.0	60.0	113.1	115.1	111.7	107.4	107.4
Green Aviation	0.0	60.0	83.1	85.1	81.7	77.4	77.4
UAS Integration in the NAS	0.0	0.0	30.0	30.0	30.0	30.0	30.0
FY 2010 President's Budget Request	0.0	62.4	64.4	67.1	64.4	60.5	--
Green Aviation	0.0	62.4	64.4	67.1	64.4	60.5	--
Changes from FY 2010 Request	0.0	-2.4	48.7	48.0	47.3	46.9	--

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Program Overview

The Integrated Systems Research Program (ISRP) will conduct integrated system-level research on promising concepts and technologies and explore, assess or demonstrate their benefits in a relevant environment. The research in this program will be coordinated with on-going long-term, foundational research within the three other research programs, as well as efforts within other government agencies. ISRP will explore new vehicle concepts and enabling technologies through system-level experimentation and will focus specifically on maturing and integrating technologies in major vehicle systems/subsystems for accelerated transition to practical application. As the NextGen evolves to meet the projected growth in demand for air transportation, researchers must address the national challenges of mobility, capacity, safety, and energy and the environment to meet the expected growth in air traffic.

The number of flight operations at many of the nation's largest airports is projected to increase in the future. Environmental concerns over noise and emissions will limit the growth capacity of those airports, and therefore limit the capacity of the entire system. Recently, there have been several mandates, directives and recommendations issued to NASA by the National Research Council, Congress, the Executive Office of the President, and the NASA Advisory Council. These recommendations cite the need for NASA to develop a "green aircraft initiative" and advance the development of technologies and operational procedures to decrease the significant environmental impacts of the aviation system. These mandates and recommendations clearly point out the need for NASA to take the initiative to conduct system research and experiments of promising vehicle concepts and technologies that will simultaneously reduce fuel burn, noise and emissions.

NASA will also initiate a research and development effort to understand how advanced environmental technologies can best work in an integrated vehicle/aviation operations system. NASA will engage the external research community by beneficially including traditional and non-traditional research partners. NASA will initiate research activities to expand our current role in aviation alternate and bio-fuels research and will perform activities to determine if, and how, advances in air traffic management technologies can be used to limit aviation's effect on the environment.

In addition, ISRP will focus on delivering validated data and technology which could enable routine operations for Unmanned Aircraft Systems (UAS) of all sizes and capabilities in the National Airspace System (NAS) and NextGen. Requirements will be developed and validated for all sizes and classes of airports and improvised locations necessary to support UAS operations.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Plans For FY 2011

Researchers working on environmentally responsible aviation technologies will develop a hot jet test technique, will complete acoustic upgrades to the Langley 14x22 Subsonic Wind Tunnel, will begin the low speed performance assessment of a Hybrid Wing Body (HWB) aircraft, and will begin to test the ability of the aircraft architecture to shield aircraft engine noise during simulated takeoff and approach conditions. The program will develop combustor concepts that offer the potential of reducing NOx emissions levels below those attainable with current technologies, and will partner with industry to conduct flametube tests to evaluate fuel injector designs for advanced Low NOx combustor concepts, and will design and fabricate combustor sector hardware to enable emissions testing at realistic engine conditions in FY 2012. Test hardware of a full-scale, multi-bay, pressurized, noncircular fuselage section utilizing an advanced lightweight stitched composite concepts will be fabricated and delivered for evaluation in FY 2012. In addition, flight tests will begin on a drag reduction approach using distributed roughness elements (DRE). The flight test will be conducted by using an experimental aircraft with DREs on a specially designed glove. Finally, near term work in propulsor technology will be conducted on an ultra high bypass (UHB) geared turbofan. The experiments will establish performance and acoustic characteristics.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Project Descriptions and Explanation of Changes

Green Aviation

The goal of the green aviation research is to explore and assess new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions and thus reduce the impact of aviation on the environment. The program will mature the concepts and technologies and evaluate their performance at the system and sub-system level in a relevant environment, as well as identify and assess issues relative to safety. Through system-level analysis, promising N+2 vehicle and propulsion concepts and technologies will be down-selected based on their potential benefit towards the stated national goals. These concepts and technologies will then be matured and their performance will be evaluated at the system and sub-system level in relevant environments. Among the technologies to be explored are the following:

- Non-conventional aircraft architectures that enable reduced drag and shielding of propulsion system noise,
- Drag reduction through laminar flow,
- Advanced composite structural concepts for weight reduction,
- Low NOx combustors, and
- Propulsion/airframe integration for noise reduction and fuel burn improvements.

The program will expand the well-informed design trade space for these types of technologies, and will transfer knowledge outward to the aeronautics community so that aircraft and propulsion system manufacturers can confidently transition these technologies into new products. The program also has the potential to transfer knowledge back into to the Fundamental Aeronautics Program so that concepts and technologies which do not yield predicted performance benefits can be further investigated and developed at a foundational level. This would occur only after an evaluation of such concepts and technologies indicates that further fundamental research is warranted.

UAS Integration in the NAS

Addressing the challenges associated with all UAS sizes and capabilities will be formidable. With the removal of the pilot, UAS can become significantly smaller than existing aircraft and thus operate in flight regimes far different than aircraft do today. Issues associated with how the human interacts with such systems, reliability, spectrum management, separation assurance, and pilot qualifications are among the major issues requiring attention. Addressing these issues could also have a direct benefit to the safety of piloted aircraft through advances in technology and procedures.

Initial program milestones will be scoped for public UAS access as a confidence builder on the path to enabling routine civil UAS access to NextGen. Because public UAS can be self-certified by the public agency, they do not need to wait for formal rules to be established by the FAA, which can take several years. The validated data and technologies delivered by this program would be a key enabler, and dramatically reduce the time required for the rule making process.

This work will be conducted in close coordination with efforts underway in the UAS Executive Committee (ExCom), comprised of senior executives from the FAA, DOD, NASA, and DHS, to ensure the products of this work are transitioned in to application.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By FY 2012, conduct tests to validate low-noise characteristics of energy efficient unconventional aircraft concepts	Integrated Systems Research	New
By FY 2012, demonstrate a low-weight, damage-tolerant stitched composite structural concept on a large scale structure in a combined loads test facility	Integrated Systems Research	New

Program Management

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/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Integrated Systems Research	Program Director	ARC, DFRC, GRC, and LaRC	Boeing R&T, GE Aviation, Pratt & Whitney, AFRL

Acquisition Strategy

The Integrated Systems Research Program will develop and further mature 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.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Integrated Systems Research Program will award approximately $10.5 million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Subject Matter Experts	05/2009	The National Research Council of the National Academies is convening a meeting of experts to review NASA's plans for system-level research in Environmentally Responsible Aviation. The purpose of the review is for NASA to collect comments and observations from subject matter experts in the areas of aviation operations, vehicles and environmental impact. NASA will consider the comments and observations it receives in future refinement of its plans.	N/A
Relevance	Expert Review	09/2009	The Formulation Review is an internal and external review. The external component serves as a formal independent peer review. Experts from other government agencies give a recommendation to the ARMD Associate Administrator on whether or not the technical plans address relevant challenges and can achieve the stated objectives and schedule within the allocated resources. This recommendation decides whether or not the program and project are ready to move from formulation into implementation.	N/A
Performance	Review Panel	N/A	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010

Overview

NASA's Space Technology Program builds upon the success of its Innovative Partnerships Program and responds to input from the NRC in establishing an advanced space systems concepts and enabling technology development activity. The Space Technology program will advance multi-purpose technology, in some cases to flight-ready status. The Space Technology Program will complement the mission-focused technology development activities in NASA's Mission Directorates, delivering solutions to NASA's needs for new technologies in support of future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry in a manner similar to the way National Advisory Committee for Aeronautics aided the early aeronautics industry. The Space Technology Program will enable new approaches to NASA's current mission set and allow NASA to pursue entirely new missions.

In contrast to the mission-focused technology development activities in the NASA Mission Directorates, there shall be multiple customers for Space Technology program products. Potential customers include any of the NASA mission directorates, other government agencies, and the Nation's space industry. The Space Technology program will employ a portfolio approach to innovation that ensures opportunities for technology investment and maturation over the entire Technology Readiness Level (TRL) spectrum (see http://www.hq.nasa.gov/office/codeq/trl/trl.pdf for TRL definitions). The Space Technology program will sponsor research in academia, industry, and NASA Centers based on the quality of research proposed at those institutions and in a manner that supports competition and balance.

The FY 2011 budget request for Space Technology is $572.2 million, and $4,925.9 million is included in the five-year budget plan. While fostering and stimulating an innovative research and development culture at the NASA Centers, this initiative will expand NASA's technology and innovation portfolio through three major Program elements that span the TRL spectrum: open competitions that stimulate highly innovative early-stage space system concepts and ideas, development of game-changing technologies that can address NASA and national needs, and development of crosscutting capability demonstrations that permit infusion of new technological solutions into future spaceflight missions. While many visionary space systems concepts will be initiated by the Space Technology Program through early stage innovation awards and some of these concepts will progress through all three major program elements to achieve flight readiness status, it is important to note that the program also welcomes existing but immature technologies (TRL<6) from a wide range of sources for further development.

The Space Technology Program's space systems research and technology development activities leverage partnerships with the NASA field Centers, other Government agencies, academia, small businesses, and the emerging commercial space industry, while building the capabilities for tomorrow's space missions today. NASA's space technology investments are closely coordinated with the mission-focused technology investments of the NASA mission directorates, align with the Agency's Strategic Plan, and respond to both the President's space agenda and the Administration's research and development priorities.

The Space Technology Program is managed by NASA's new Office of the Chief Technologist, which reports directly to the NASA Administrator, outside the existing mission directorates. NASA will establish a deliberative panel of internal and external stakeholders - including stakeholders from industry and other government agencies - to review and advise on technology development priorities for the Space Technology Program through a transparent and balanced process. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are integrated into Space Technology.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**0.0**	**572.2**	**1,012.2**	**1,059.7**	**1,063.9**	**1,217.9**
Space Technology	0.0	0.0	572.2	1,012.2	1,059.7	1,063.9	1,217.9
Total Change from FY 2010 President's Budget Request	**0.0**	**0.0**	**572.2**	**1,012.2**	**1,059.7**	**1,063.9**	**--**

Mission Directorate:	Space Technology
Theme:	Space Technology

Theme Overview

The Space Technology Program consists of three major program elements and an Agency partnership development and strategic integration function. Through the three major elements of this program (Early Stage Innovation, Game Changing Technology, and Crosscutting Capability Demonstrations), a broad array of participants including NASA Centers, other Government agencies, academia and industry are engaged through competitive awards. These three program elements have been established based on past successful approaches to technology development using the TRL scale to organize the program content and on a desire to balance the funding distribution against NASA's future mission needs. Strategic integration of NASA's technology portfolio - working with the Mission Directorates and NASA Centers to develop an Agency technology roadmap and measure the significance and performance of the Agency's technology investments is also performed within this Program. By enhancing the function of NASA's Innovative Partnerships Program, the Space Technology Program also provides a single Agency entry point for technology transfer and commercialization, interagency coordination and joint activities, intellectual property management and partnership opportunities, providing additional value to external innovators, including a wide range of small businesses and the commercial space industry.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**0.0**	**572.2**	**1,012.2**	**1,059.7**	**1,063.9**	**1,217.9**
Early Stage Innovation	0.0	0.0	298.6	304.4	300.4	305.1	314.7
Game Changing Technology	0.0	0.0	129.6	359.3	349.1	349.1	424.2
Crosscutting Capability Demonstrations	0.0	0.0	102.0	302.0	362.0	362.0	424.0
Partnership Development and Strategic Integration	0.0	0.0	42.0	46.5	48.2	47.7	55.0
Total Change from FY 2010 Request	**0.0**	**0.0**	**572.2**	**1,012.2**	**1,059.7**	**1,063.9**	**--**

Mission Directorate:	Space Technology
Theme:	Space Technology

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The need for additional space capabilities is increasing as NASA leads our nation in envisioning missions of increasing complexity to explore and understand the Earth, our solar system, and the universe. Technology and innovation are critical to successfully accomplishing these missions. The Space Technology Program will improve the Nation's leadership in key research areas, enable far-term capabilities, and spawn game-changing innovations to make space travel more affordable and sustainable. Many positive outcomes are likely from a long-term, broad NASA advanced space concepts and technology development program. Chief among these are a more exciting space science and exploration future than our country has today, and a more robust national capability for space activities that will improve our competitive posture in the international marketplace, enable new industries and contribute to economic growth. Space Technology Program efforts will also serve as a spark to innovation that can be applied broadly in a more robust technology-based economy, an international symbol of our country's scientific innovation, engineering creativity and technological skill, and a component of the remedy to our nation's scientific and mathematics literacy challenges.

Major breakthroughs are needed to address our society's energy, health, transportation, and environment challenges. While NASA investments alone will not solve these grand challenges, NASA has proven to have a unique ability to attract and motivate many of the country's best young minds into educational programs and careers in science, technology, engineering and mathematics. A suite of game-changing space systems discoveries are within our nation's grasp. With a stronger focus on technology development, the intellectual capital at NASA's field centers will be utilized to deliver solutions to some of our nation's grand technological challenges.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Early Stage Innovation

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**0.0**	**298.6**	**304.4**	**300.4**	**305.1**	**314.7**
Space Technology Research Grants	**0.0**	**0.0**	**70.0**	**70.0**	**70.0**	**70.0**	**70.0**
NIAC Phase I and Phase II	**0.0**	**0.0**	**3.0**	**6.0**	**7.0**	**7.0**	**8.0**
Center Innovations Fund	**0.0**	**0.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**
SBIR/STTR	**0.0**	**0.0**	**165.6**	**168.4**	**163.4**	**168.1**	**176.7**
Centennial Challenges	**0.0**	**0.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
Changes from FY 2010 Request	**0.0**	**0.0**	**298.6**	**304.4**	**300.4**	**305.1**	**--**

Note: SBIR/STTR totals will change as amounts are calculated in accordance with current SBIR/STTR authorization.

Program Overview

The Early-Stage Innovation program element sponsors a wide range of low TRL advanced space system concept and initial technology development efforts across academia, industry and at the NASA field Centers. This program element includes: (a) the Space Technology Research Grant program (analogous to the Fundamental Aeronautics program within NASA's Aeronautics Research Mission Directorate) that focuses on foundational research in advanced space systems and space technology, (b) re-establishment of a NIAC-like Program to engage innovators within and external to the Agency in accordance with the recommendations of the NRC's Fostering Visions of the Future report, (c) enhancement of the Innovative Partnership Programs Seed Fund into a Center Innovations Fund to stimulate aerospace creativity and innovation at the NASA field Centers, (d) NASA's SBIR/STTR program to engage small businesses, and (e) the Centennial Challenges Prize Program to address key technology needs with new sources of innovation outside the traditional aerospace community. All selections within this low TRL program element are performed competitively. The FY 2011 budget request for the Early Stage Innovation program element within Space Technology is $298.6 million, and $1,523.2 million is included in the five-year budget plan. This program element incorporates two initiatives from NASA's Innovative Partnerships Program: $165.6 million in FY 2011 and $842.2 million in the five-year budget for the NASA SBIR/STTR program, and $10 million in FY 2011 and $50 million in the five-year budget for the NASA Centennial Challenges program.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Early Stage Innovation

Project Descriptions and Explanation of Changes

Space Technology Research Grants

Space Technology Research Grant Projects will meet future space science and exploration needs of NASA, other government agencies, and the commercial space sector through technological innovation. This low TRL technology portfolio focuses on foundational research in advanced space systems and space technology performed primarily through collaborative efforts between academia and NASA field Centers, with the option of including small business and industry partners. Integration and assessment of emerging technologies and advances in related disciplines to change the state-of-the-art in space systems design, hardware and modeling will be conducted. This thrust will provide idea maturation at the discipline and subsystem level prior to major R&D investment. This project will also provide innovations in space systems to help make space exploration more affordable. Project competition guidelines include a maximum award of $400k/yr for one year, with at most a one-year extension following technical evaluation of a renewal proposal. Examples of the types of foundational space system research that may be performed through this project include:Computational Materials Design, Nanotube Based Structural Materials, High Bandwidth Communications, Lightweight Low Transit Volume Space Structures, Non-Chemical In-Space Propulsion, Coatings and Adhesives, Flexible Power Arrays, Microwave/Laser Power Transmission, Energy Storage Systems, Space Robotic Assembly and Fabrication, Formation Flying Spacecraft Systems (Swarm Operations), Orbital Debris Removal, Planetary Protection Techniques, Nonconventional Access to Space, Print Manufacturing and Rapid 3D Prototyping, Extreme Environment (Temperature/Radiation) Sensors and Mechanisms, Climate Sensors, Planetary Entry Decelerators, Reliable and Affordable Exploration Systems, Advanced Radiation Shielding Materials(Techniques and Systems), Safe Despin/Detumble Approaches for Large Non-operational Spacecraft, Material/Structural Concepts to Mitigate Impact of Small Debris, and Precision Timing and Navigation Using Only Celestial Objects.

A significant aspect of this project is the competitive selection of U.S. citizen graduate student research that shows significant promise for future application toward NASA missions and strategic goals. The Space Technology Grant Project will train the next generation of aerospace engineers and scientists by funding NASA-related graduate student research performed on campus during the academic year and research performed at a NASA Center during the summer months, gaining hands-on experience. Each student in this project will be matched to a technically relevant and engaged NASA researcher who will serve as the student's NASA advisor. Through this experience, students will advance their STEM education, gain NASA experience and learn the research process. Innovative projects with high risk/high payoff will be encouraged. This project thrust will provide the Nation a new pipeline of engineers and scientists to improve the nation's technological competitiveness and serve NASA by providing a steady stream of new talent for potential hiring opportunities. Project guidelines include selection of as many as 500 graduate students per year for a two-year fellowship during their graduate studies, with at most a one-time extension following technical evaluation of a renewal proposal for two additional years. Funding will include tuition remission, a research stipend, fringe, and summer travel expenses. A small amount of funding for both the student's university advisor and NASA advisor will also be provided. Students will be selected based on demonstrated performance (GPA and GRE scores) and recommendations letters. Selected students are required to spend at least one summer, preferably two, at the host NASA center. The host Center will be provided resources for laboratory work and mentoring workforce.

NIAC Phase I and Phase II

Responsive the NRC report, Fostering Visions for the Future: A Review of the NASA Institute for Advanced Concepts (2009), the NASA Institute of Advanced Concepts (NIAC) will be re-established as a project within the Early Stage Innovation Program. The project is formulated as a two-phase, low TRL activity, focused upon conceptual studies of visionary approaches addressing long-term NASA strategic goals. The first phase of NIAC will fund a competed set of conceptual studies and systems analyses that investigate how technology innovations will enable NASA's future missions and extend its goals. Second Phase NIAC proposals will further develop successful Phase I proposals and work to transition the key technical advances into projects within the Game Changing Technology Program.

NIAC will serve as an incubator for bringing new technologies into future aerospace endeavors. By supporting innovative and visionary concepts aimed a decade or more into the future, NIAC-funded research significantly impacts the Agency's future missions as well as its roadmaps for future science, discovery and exploration. As a low-TRL early phase activity, NIAC will serve as a visible and recognized entry point for innovators and researchers who will enable future NASA missions and goals.

While the NIAC seeks concepts that stretch the imagination, these concepts must be based on sound scientific principles. In the context of the NIAC requirements, successful proposals for advanced concepts or studies will be: (a) innovative, visionary and new; not incremental, evolutionary or duplicative of concepts previously studied by NASA, (b) an architecture, system, mission strategy or approach to meeting an aeronautics and/or space goal; not narrowly focused at the component or sub-system level, (c) described in an aeronautics and/or space mission context, (d) adequately substantiated with a description of the scientific principles that form the basis for the concept, and (e) focused on a technology that is either, newly emerging, a unique combination of emerging technologies, or a technology that is developed as an integral part of the proposal.

The NIAC Phase I Program will competitively select low TRL (1-2) conceptual studies and systems analyses that examine the impacts of visionary changes. Phase I studies will examine the overall technical viability of the technology or concept, as well as how the change will impact or enable future architectures, missions or goals. Successful Phase I study proposals will examine changes in technologies that will occur 10 or more years into the future, have a maximum duration of 1 year, and a maximum budget of $100K. Proposals will be accepted from NASA researchers, academia, other Government Agencies, industry and partnerships. Phase II NIAC proposals will be competitively selected from the set of highly successful Phase I awards and will have a maximum duration of two years and a maximum budget of $500K. Phase II awards will study the major feasibility issues associated with cost, performance, development time and key issues with the technology, concept or approach. The Phase NIAC II study will also examine the transition path for potentially infusing the concept, technology or approach into a future Game Changing Technology project. Both Phase I and Phase II awards will be competitively selected based upon independent peer reviews. Participation in these studies is open to all categories of U.S. individuals and organizations. To encourage external innovators, NASA organizations, including the Jet Propulsion Laboratory, would be limited to receiving no more than 30% of the total NIAC project budget line in any given year.

Center Innovations Fund

The Center Innovations Fund will be distributed among the ten NASA centers to provide seed funding for new ideas and idea generation activities. These funds will allow Centers to support low TRL innovative technology initiatives that leverage Center talent and capability. It is envisioned that the most promising ideas that emerge from the Center Innovation Funds will compete subsequently for funding from other parts of the Space Technology Program or other NASA technology development programs. By placing the competition for these funds at the Center level, the Space Technology Program aims to stimulate and encourage creativity and innovation from within the NASA Centers. Activities supported with these funds must fall within the scope of space technology, dual-use technology, or be a technology that addresses a significant national need. All Center Innovations Fund awards must demonstrate scientific/technical merit and feasibility, relevance and value to NASA, capability and strength of the team, and the potential for leveraging of resources.

Through the Center Chief Technologist, Centers will conduct competitions on 6-month cycles to select ideas and provide appropriate oversight. Detailed feedback on these activities will be required before the end of each FY. Feedback describing the innovation pursued, criteria for selection, its relevance to the stated goals of the Center Innovation Funds, and the final results of the effort will be collected and measured. Centers may choose to highlight some projects by having the individual or team present their results directly to the Office of the Chief Technologist. An end-of-year report will be generated at each Center describing the successes and failures of the funded ideas, with an emphasis on the creativity involved. Proposals that would have been selected if more funds had been available to that Center may also be described in an Appendix of the report. These annual Center Innovation and Creativity Reports will be reviewed and scored by the Space Technology Program for creativity of the investment portfolio (independent of their success or failure) and on the future promise of any individual project successes. This scoring will feed directly into the process of allocating funds for the following year's Innovation Funds so that both creativity and success are rewarded.

Building on the demonstrated success of the Innovative Partnerships Program Seed Fund, a significant portion of the Center Innovations Fund will be used to leverage technology development partnerships. Partners will be sought out by the Centers for the pursuit of innovation that is of common interest, as demonstrated by the willingness of partners to contribute with technologies, resources, and expertise. Partners will include private sector firms both large and small, universities, other government agencies and FFRDCs.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Early Stage Innovation

SBIR/STTR

The Small Business Innovation Research (SBIR) Program was established by Congress in 1982 to increase research and development opportunities for small businesses with 500 or fewer employees, to increase employment, and to improve U.S. competitiveness. The program's specific objectives are to stimulate U.S. technological innovation, employ small businesses to meet federal research and development needs, increase private-sector commercialization of innovations derived from federal research and development, and encourage and facilitate participation by socially disadvantaged businesses. NASA, as a mission driven agency, seeks small, high-technology companies to participate in government-sponsored research and development efforts in technology areas critical to NASA's missions. NASA will implement the SBIR program consistent with pending reauthorization. Current authorization provides for SBIR funding at 2.5 percent of NASA's extramural research and development expenditures.

The Small Business Technology Transfer Research (STTR) Program awards contracts to small business concerns for cooperative research and development with a non-profit research institution, such as a university. NASA's STTR program has the primary objective of facilitating the transfer of technology developed by a research institution through the entrepreneurship of a small business, resulting in technology to meet NASA's needs. The small business and its partnering institution are required to sign an intellectual property agreement. Modeled after the SBIR Program, STTR is a separately funded activity. STTR is smaller than SBIR, with funding set at 0.3 percent of the extramural research and development budget, approximately one-eighth of the amount for SBIR.

Beginning in FY 2011, SBIR and STTR activities associated with the Innovative Partnerships Program are transferred to Space Technology. The Space Technology Program implements NASA's SBIR and STTR programs with the dual objectives of providing the high technology small business sector with an opportunity to develop technology for NASA, and commercializing that technology to spur economic growth. NASA tracks the maturity of technologies funded by SBIR/STTR through use of Technology Readiness Levels (TRLs)(see http://www.hq.nasa.gov/office/codeq/trl/trl.pdf for TRL definitions). This is important for understanding when technologies will be ready for infusion into NASA's programs and projects as well as their readiness for commercial use. Tracking TRLs also provides insight into the progress that technologies are making, and over time, the performance of different firms for successful maturing technologies. Included in this request, in addition to the 2.8% of extramural R&D for contract awards, are funds for SBIR/STTR Program Support to cover the administrative costs of running the program with operations at all ten NASA field centers, as well as the outreach efforts needed to increase participation in SBIR/STTR by the small business community. The percentage of new firms participating in NASA's SBIR/STTR programs each year has been in the 30-50% range, yielding new applicants each year. New participants have submitted between 20-35% of the total number of proposals in any given year.

Technologies funded by SBIR/STTR have made important contributions to numerous NASA programs and projects and have also been commercial successes that are bringing important benefits to society. The Agency is actively working to increase the number of NASA-funded SBIR/STTR technologies used in NASA's missions and projects. Some of NASA's high-profile programs directly benefiting from SBIR technologies include the Space Shuttle, ISS, Mars Exploration Rovers, and the Phoenix lander.

Centennial Challenges

The Centennial Challenges program seeks innovative solutions to technical problems that can drive progress in aerospace technology of value to NASA's missions in space operations, science, exploration and aeronautics. Beginning in FY 2011, Centennial Challenge activities associated with the Innovative Partnerships Program are transferred to the Space Technology Program. Centennial Challenges encourage the participation of independent teams, individual inventors, student groups and private companies of all sizes in aerospace research and development, and seek to find the most innovative solutions to technical challenges through competition and cooperation. NASA's original seven prize challenges have been successful in encouraging broad participation by innovators across our nation and across generations. Many of these technical challenges also have direct relevance to national and global needs such as energy and transportation.

Prize programs encourage diverse participation and multiple solution paths. A measure of diversity is seen in the geographic distribution of participants (from Hawaii to Maine) that reaches far beyond the locales of the NASA Centers and major aerospace industries. The participating teams have included individual inventors, small startup companies, and university students and professors. An example of multiple solution paths was seen in the 2009 Regolith Excavation Challenge. NASA can typically afford one or two working prototypes in a development program but at this Challenge event, over twenty different working prototypes were demonstrated for the NASA technologists. All of these prototypes were developed at no cost to the government. For three years of competitions with dozens of teams investing tens of thousands of hours, NASA spent only $750,000 in prize money.

The return on investment with prizes is exceptionally high as NASA expends no funds unless the accomplishment is demonstrated. NASA provides only the prize money and the administration of the competitions is done at no cost to NASA by non-profit allied organizations. For the Lunar Lander Challenge, twelve private teams spent nearly 70,000 hours and the equivalent of $12 million trying to win $2 million in prize money. Prizes also focus public attention on NASA programs and generate interest in science and engineering. Live webcasts of Centennial Challenge competitions attract thousands of viewers across the nation and around the world. The 2009 Power Beaming completion resulted in over 100 news articles and web features. Prizes also create new businesses and new partners for NASA. The winner of the 2007 Astronaut Glove Challenge started a new business to manufacture pressure suit gloves. Armadillo Aerospace began a partnership with NASA related to the reusable rocket engine that they developed for the Lunar Lander Challenge, and they also sell the engine commercially.

In selecting topics for prize competitions, NASA consults widely within and outside of the Federal Government. The $10 million per year FY 2011 request for Centennial Challenges will allow NASA to pursue new and more ambitious prize competitions. Topics for future challenges that are under consideration include revolutionary energy storage systems, solar and other renewable energy technologies, laser communications, demonstrating near-Earth object survey and deflection strategies, innovative approaches to improving the safety and efficiency of aviation systems including Next Generation Aeronautics efforts, closed-loop life support and other resource recycling techniques, and low-cost access to space. Annual funding for Centennial Challenges allows new prizes to be announced, addressing additional technology challenges that can benefit from the innovation of the Citizen inventor.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Game Changing Technology

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**0.0**	**129.6**	**359.3**	**349.1**	**349.1**	**424.2**
Game-Changing Developments	**0.0**	**0.0**	**123.6**	**329.3**	**319.1**	**319.1**	**394.2**
Small Satellite Subsystem Technologies	**0.0**	**0.0**	**6.0**	**30.0**	**30.0**	**30.0**	**30.0**
Changes from FY 2010 Request	**0.0**	**0.0**	**129.6**	**359.3**	**349.1**	**349.1**	**--**

Program Overview

The Game Changing Technology Program element focuses on maturing advanced space technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs. Responsive to the NRC report: America's Future in Space: Aligning the Civil Space Program with National Needs (2009), this program element demonstrates the feasibility of novel, early-stage ideas that have the potential to revolutionize future space missions through a significant ground-based test and/or laboratory experimentation program. Fixed duration awards are made to PI-led teams comprised of government, academia and industry partners. These high-risk awards are evaluated annually for progress against baseline milestones with the objective of maturing technologies to a TRL of 4, and in some cases TRL 5/6, through ground-based testing and laboratory experimentation (see http://www.hq.nasa.gov/office/codeq/trl/trl.pdf for TRL definitions). NASA intends to collaborate with DARPA and other government agencies in this program element to create and implement collaborative game-changing space technology initiatives, and share program management lessons learned. In this program element, more than 70% of the funds are competitively awarded.

New technologies considered may include advanced lightweight structures and materials, advanced in-space propulsion, nano-propellants, large aperture antennas and telescopes, power generation/transmission, surface robotic construction, energy storage, high bandwidth communications, and small satellite subsystem technology. With a focus on game-changing technologies, success is not expected with each investment; however, on the whole, and over time, dramatic advances in space technology that enable entirely new NASA missions and potential solutions for a wide variety of our society's grand technological challenges are expected and will be measured. The FY 2011 budget request for the Game Changing Technology program element within Space Technology is $129.6 million, and $1,611.3 million is included in the five-year budget plan.

Project Descriptions and Explanation of Changes

Game Changing Developments

The Game Changing Developments element will use a DARPA-like "end-game" approach. Research teams will be provided a list of challenge goals with top level requirements for the desired capability. The PI team then defines solution approaches and the anticipated technology needs. The PI is held accountable for ensuring that discoveries will move rapidly from the laboratory to application. Game Changing Development projects are intended to be capability-oriented and differ from traditional R&D methods that advance discipline or core knowledge. Instead of lengthy proposals, Heilmeier's Catechism is employed whereby seven key questions must be answered by the PI for each proposed effort:

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What's new in your approach and why do you think it will be successful?
- Who cares? If you're successful, what difference will it make?
- What are the risks and the payoffs?
- How much will it cost? How long will it take?
- What are the midterm and final "exams" to check for success?

New capabilities considered may include advanced in-space propulsion, large aperture antennas and telescopes, power generation/transmission, robotic construction systems, energy storage and high bandwidth communications.

An annual call for proposals will be made for game changing, "push" technologies that will be demonstrated at the subsystem or system level. In some cases, multiple technology advances may be required to achieve the stated capability. Awards will be made to PI-led teams comprised of government, academia and industry partners for high risk/ high payoff capabilities. Failure to achieve the stated capability goals within the schedule will necessarily result in termination. Review gates may also determine early cessation of an activity. Each high-risk activity will be made for a two-year duration to mature from TRL 3 to TRL of 4 or greater. These efforts will generally include the design, build and test of technology development units. Project success is measured both through technology advancement and demonstration of clear advantages enabling new NASA missions or dramatic improvements in their viability. A third optional year may be awarded to achieve TRL 5/6 if technically possible without the cost of orbital flight testing. Flight experiments will be conducted in the Crosscutting Capability Demonstration Program element; however, in some cases, ground testing or low cost (e.g. sub-orbital) flight testing may be used to raise the TRL (5/6) during the third year under the Game Changing Program element. Two year awards must be less than $45M. If an optional third year is awarded to achieve TRL 5/6, the total 3 year award cannot exceed $75M. Project selection guidelines include the establishment of PI-led teams willing to serve as communities of change-state advocates. Non-NASA PI's selected for participation may be offered an assignment to NASA for no more than three years, through an Intergovernmental Personnel Act (IPA) or NEX position.

Small Satellite Subsystem Technologies

Technologies that enable small satellites to provide game changing capabilities for the government and commercial sectors will be supported under a competed Small Satellite Subsystem Technologies project. These "push" technologies may include formation flying, long life power systems, miniaturized remote sensors, deployable apertures, autonomous swarm operations, and other technology enablers. Architectures, proximity operations, robotics, space-to-space power transmission and other system interoperability such as that being developed for standardization in the cubesat class of spacecraft will also be considered for TRL advancement from 3 to 4. In this project, ground testing of promising transformational small satellite capabilities are sought. Activities will have a two-year timeframe to mature to TRL 4. In some cases, based on performance and technology objectives, a third optional year may be granted to achieve TRL 5/6. However, technologies and capabilities that require flight testing must be submitted to the Crosscutting Capability Demonstration Program element. Annual review gates may determine early cessation of an activity. Two year funding must be less than $12M. If an optional third year is granted to achieve TRL 5/6, the total 3 year amount cannot exceed $18M. This small satellite subsystem technology development project will provide subsystem advances for the Edison Small Satellite Demonstration Missions and other small satellite missions.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Crosscutting Capability Demonstrations

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	0.0	0.0	102.0	302.0	362.0	362.0	424.0
Technology Demonstration Missions	0.0	0.0	75.0	265.0	325.0	325.0	387.0
Edison Small Satellite Demonstration Missions	0.0	0.0	10.0	20.0	20.0	20.0	20.0
Flight Opportunities	0.0	0.0	17.0	17.0	17.0	17.0	17.0
Changes from FY 2010 Request	0.0	0.0	102.0	302.0	362.0	362.0	--

Program Overview

One of the greatest challenges that NASA faces in incorporating advanced technologies into future missions is bridging the mid-TRL (3-6) gap between early conceptual studies and infusion of a new technology onto the critical path of a science or exploration mission. While the Game Changing Technology Program element will address an aspect of this gap, maturing a space technology to flight readiness status through relevant environment testing is a significant challenge from both a cost and risk perspective. Flight demonstration of a technology that has the potential for enormous economic savings in the long run is often considered too risky for a mission program or too costly for a technology program.

The Crosscutting Capability Demonstration program element matures a small number of technologies that are of benefit to multiple customers to flight readiness status, TRL 6. In this program element, more than 70% of the funds are competitively awarded. Technical risk, technology maturity, mission risk, customer interest, and proposed cost are discriminators used in the selection process. For infusion purposes, NASA-industry teams are required to have a sponsor (or sponsors) willing to cost share a minimum of 25% of the proposed development effort. With objectives analogous to the former New Millennium program, NASA will pursue flight demonstrations not only as standalone missions, but also as missions of opportunity using planned NASA missions as well as international and commercial partner space platforms through this program element. Examples of type of technologies that may be considered for this flight test program component include optical communications, and supersonic and hypersonic inflatable aerodynamic decelerators.

The Crosscutting Capability Demonstration Program element also includes the Commercial Reuseable Suborbital Research Program (which provides suborbital flight opportunities for technology demonstrations, scientific research and education), the Facilitated Access to the Space environment for Technology (FAST) project (which focuses on testing technologies on parabolic aircraft flights that can simulate microgravity and reduced gravity environments) and the the Edison Small Satellite Demonstration project (which develops and operates small satellite missions in partnership with academia). The FY 2011 budget request for the Crosscutting Capability Demonstration program element within Space Technology is $102 million, and $1552 million is included in the five-year budget plan.

Project Descriptions and Explanation of Changes

Technology Demonstration Missions

The most significant portion of the Crosscutting Capability Demonstration program element is the Technology Demonstration project. A key requirement for eligibility in this project is that the technology under consideration must be crosscutting (defined as a technology with potential to benefit to multiple NASA mission directorates, other government agencies or the space industry). Performing these flight demonstrations will advance the technology readiness of the selected systems, provide tangible products from the NASA innovation and technology program and capture significant public interest and awareness. Furthermore, executing these engaging and technically challenging space flight demonstrations, including designing the flight test program, building the flight hardware and performing/operating the mission is an outstanding means for developing the current NASA and industry workforce to handle more challenging space missions in the future.

This project will perform yearly calls for proposed flight test demonstrators. It is anticipated that between 3 and 8 openly competed proposals will be selected each year. Flight test projects that can be completed within a maximum of three years are sought. The Space Technology Program funding contribution to a given flight test demonstration is limited to a total of $150 M. The funding cap includes all elements of the flight test demonstration including test planning, flight hardware, launch costs, ground ops and post testing assessment/reporting.

In addition to the above criteria, for selection as a Crosscutting Capability Demonstration project, the candidate technology must be relatively mature (TRL of 4 or above), and if successful must raise the TRL of the candidate technology to a TRL of 6 or higher, such that it may be infused into the critical path for future NASA missions. Competed flight test demonstration opportunities are open to teams involving NASA centers, industry, other Government agencies and academia. All participants must be U.S. entities.

Edison Small Satellite Demonstration Missions

The Edison Small Satellite Demonstration project will develop and operate a series of NASA-focused small satellite demonstration missions. Science objectives for these missions will focus on the life and physical sciences, including fundamental biology. Technology objectives could include formation flying, autonomous operations, collaborative observations, and approaches enabling payload recovery. NASA will pursue these missions in collaboration with academia and small business in close coordination with relevant successful programs under development at AFRL and the Operationally Responsive Space Office. NASA-university collaborative efforts will be explored to enable university students to gain hands-on experience within these project activities. In addition, this project seeks to serve the small satellite community by improving the affordability of small payload launch through secondary payload process improvements and other development efforts.

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Crosscutting Capability Demonstrations

Flight Opportunities

Through the Commercial Reusable Suborbital Research (CRuSR) project and the Facilitated Access to the Space environment for Technology (FAST) project, NASA provides flight opportunities for science, technology development and education efforts to reduced-gravity environments, brief periods of weightlessness, and high-altitude atmospheric research. Beginning in FY 2011, these two activities associated with the Innovative Partnerships Program are transferred to the Space Technology Program.

CRuSR will also help foster the development of the commercial reusable suborbital transportation industry, an important step in the longer-term path that envisions suborbital RLVs evolving to provide the Nation with much lower-cost and much more reliable access to orbital space. CRuSR establishes a series of suborbital flights that will yield many benefits to NASA by providing access to 3-4 minutes of microgravity for experimentation, discovery and testing. Results are expected to reduce the risk for use of new technologies in future missions by demonstrating application in the space environment, providing for routine recovery of payloads and frequent flights. As commercial suborbital capabilities become available, the CRuSR program will competitively secure flight services for experiment payloads supporting NASA's objectives in science, technology and education.

The FAST project also provides opportunities for emerging technologies to be tested in the space environment thereby increasing their maturity and the potential for their use in NASA programs and in commercial applications. FAST focuses on testing technologies on parabolic aircraft flights that can simulate microgravity and the reduced gravity environments of the Moon or Mars. The FAST project promotes the growth of emerging commercial space services by employing competitively selected private reduced gravity flight services. In 2008, an initial set of FAST reduced gravity flights were accomplished with five SBIR companies. In 2009, 19 FAST-sponsored technology projects were flown during a flight week with two days of microgravity and two days of lunar gravity. The projects came from private companies, universities, government laboratories and partnerships among those entities. In 2011, NASA expects to fund up to four flight weeks for technology demonstration and research, allowing many more projects to benefit from the use of reduced gravity aircraft flights. A measure of FAST program success will be the extent to which it can infuse new technologies into NASA programs while encouraging the development of commercial space services by enlarging the customer base for this emerging industry.

Mission Directorate: Space Technology
Theme: Space Technology
Program: Partnership Development and Strategic Integration

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	0.0	0.0	42.0	46.5	48.2	47.7	55.0
Partnership Development and Strategic Integration	0.0	0.0	42.0	46.5	48.2	47.7	55.0
Changes from FY 2010 Request	0.0	0.0	42.0	46.5	48.2	47.7	--

Mission Directorate:	Space Technology
Theme:	Space Technology
Program:	Partnership Development and Strategic Integration

Program Overview

Partnerships are an integral part of NASA's strategy for reinvigorating technology and innovation. Building upon the success of the Innovative Partnerships Program, we will pursue partnerships with U.S. industry, academia, other Government agencies, and international partners. Partnerships provide rich sources of innovation to help address NASA's technical challenges, and also yield other applications of NASA-developed technologies that will benefit the public and contribute to economic growth. In addition, this program element will continue to build partnerships that facilitate the transfer of the NASA's Aeronautics research to American industry and government users. The Space Technology Program will work with entrepreneurs across the aerospace industry to enable new capabilities that will spur growth in commercial space activities in a manner similar to the way NACA aided the early aeronautics industry. NASA will also leverage the technology investments of other government agencies, engage universities, especially in early stage innovation and work with its partners to create inspiration in STEM education.

One of the key partnership development functions is managing NASA's intellectual property and facilitating the transfer of NASA-derived technology for commercial application and other national benefit. In FY 2009, NASA documented more than 1,400 New Technology Reports on NASA-funded technology that could lead to patenting and transfer. 90 patent applications were filed and 188 patents were awarded in FY 2009. NASA has continued its initiative to generate licenses for NASA technologies through an auctioning intermediary at no cost to NASA - a groundbreaking innovation previously unprecedented in government. NASA continues to document the top 40-50 recent successes in its "Spinoff" publication with over 1,600 examples of successful technology transfer having been documented. One of the ways NASA communicates these benefits is through NASA@Home/City, which helps the public identify how space technology is making positive contributions to their daily lives (http://www.nasa.gov/city).

Strategic integration of NASA's technology portfolio is a significant responsibility within the Space Technology Program. This function centers on working with the Mission Directorates and NASA Centers to develop an Agency technology roadmap and measure the significance and performance of the Agency's technology investments. Technology roadmapping activities are driven by the Agency's strategic goals, are consistent with the NASA Strategic Plan and coordinated with the technology development activities of our partners in industry, academia and other government agencies. An integrated assessment of the Agency's technology portfolio is developed through the Mission Directorate Technology Council, chaired by the Agency's Chief Technologist with participation from the Mission Directorates and Office of the Chief Engineer. This council meets biweekly to track the status of technology plans within the Mission Directorates and the Space Technology Program. The Agency's overall technology investment content is reviewed quarterly and identified content gaps or redundancies are managed. In addition, annual assessments of the Agency's technology investment portfolio, program performance, and technology plans are performed. Space Technology Program managers gain insight into the Mission Directorate technology programs through these council meetings, daily interactions with their colleagues in the Mission Directorates, and at senior leadership team decision meetings where the Chief Technologist is present.

The FY 2011 budget request for Space Technology Program Partnership Development and Strategic Integration functions is $42 million, and $239.4 million is included in the five-year budget plan.

Overview

The President's FY 2011 Budget request outlines an innovative new path for human space exploration and strengthens the capability to extend human presence throughout the solar system. NASA is taking a new approach to this long-term goal; by laying the ground work that will enable humans to safely reach multiple potential destinations, including the Moon, asteroids, Lagrange points, and Mars and its environs. The research and technology investments described in this budget describe the many near-term steps NASA will be taking to create the new knowledge and capabilities required for humans to venture beyond low Earth orbit to stay. This strategic approach is designed to more efficiently further and sustain the course of human exploration.

The Exploration Systems Mission Directorate (ESMD) will lead the Nation on a course of discovery and innovation that will provide the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. Investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore our solar system. In order to allow NASA to focus on the space frontier, the Agency will also invest aggressively in the commercial sector so that they will, in the near-term, develop the capability to transport people and supplies to and from the International Space Station. This approach will strengthen America's space industry, and could provide a catalyst for future business ventures to capitalize on affordable access to space. It will also leverage a broader range of American ingenuity to keep our nation on the leading edge of human space exploration capabilities.

The transformational technologies highlighted in this budget for development and demonstration address critical capabilities for sending crews to a variety of exciting destinations beyond low Earth orbit. By allowing for flight demonstrations, some at a flagship caliber, this ESMD budget resolves the achievement gap between lab demonstration and flight testing that might otherwise prevent NASA from implementing exciting new technologies. Prior to baselining them for crewed missions, these demonstrations will validate new technologies that are not yet fully developed, but are essential for mission success, such as automated and autonomous rendezvous and docking, in situ resource utilization, aero capture, large mass entry descent and landing, highly efficient in-space propulsion, precision landing and hazard avoidance, cryogenics storage and transfer, lightweight/inflatable modules, and others. And before sending humans on extended missions beyond low Earth orbit, accelerated biomedical research will help us to ensure crew health and safety.

A major thrust of this research and development activity will be related to space launch propulsion technologies. This effort will include first stage engine development, in-space engine demonstrations, and foundational propulsion research in areas such as new or largely untested propellants that can result in more capable and less expensive future rockets, including heavy-lift rockets. In addition, NASA will provide $25 million annually to fund commercial, university, and other non-governmental research organizations to conduct foundational propulsion research.

The technology investments outlined in this budget are just one component needed to enable sustained and affordable human exploration endeavors. An additional key contributor to a robust exploration program will be the acquisition of critical knowledge gained through the pursuit of exploration precursor robotic missions. These missions will provide vital information—from soil chemistry to radiation dose levels to landing site scouting to resource identification—necessary to plan, design and operate future human missions. These missions will help us determine the next step for crews beyond low Earth orbit, answering such questions as: Is a particular asteroid a viable target for crewed mission? Do the resources at the lunar poles have the potential for crew utilization? Is Mars dust toxic?

The intent of this exploration portfolio is not only to significantly improve capability, performance, and flexibility relative to current human space flight capabilities, but also to demonstrate that the resulting mature systems meet NASA's goals in terms of cost effectiveness, risk reduction, and operability. As part of this new direction, ESMD will provide technology maturation analysis, which will focus on the life cycle cost perspective and risk mitigation strategies. ESMD will also develop multi-mission operational concepts for future human space flight campaigns to such targets as the Moon, asteroids, Martian moons, and Mars itself, ensuring that the investments made today will have maximum utility in decision support for future missions into the solar system. ESMD will develop design reference missions (DRMs) for human exploration, setting priorities based upon the needs and requirements of the various DRMs. These DRMs will evolve as enabling technologies are defined, developed, and demonstrated, and as data from exploration precursor robotic missions are analyzed.

Depending on the investment, implementation responsibility for new projects may be directed to in-house civil servants or competed within industry and academia. For example, a given flagship technology demonstration mission may be designated to a human space flight center in order to benefit from the unique skills of NASA civil servants who will be well-positioned to develop a productive, near-term mission with high relevance to future human spaceflight. In such a case, however, ESMD would expect to compete segments of the payloads and data analysis teams. Similarly, portions of the engine technology development effort may be competed within industry, where significant launch vehicle experience can augment NASA expertise.

These programs present many opportunities for government-private sector-academic teams to collaborate and bring the best expertise from across the Nation to bear on future human space exploration needs. To tackle difficult design issues, ESMD will be responsive to innovations from outside NASA's purview, whether from the academic community, industry, international sources or the defense/security sector. The additional emphasis on technology and human research will result in increased demonstration and research efforts on the ISS and an increased launch and mission tempo to support those efforts. Exploration robotic precursor efforts will benefit from collaboration with scientific and international communities, while smaller scale technology demonstrations could benefit from university-developed satellites. This greater diversity of missions and increased tempo will enhance opportunities for engineers and scientists to work on projects from end-to-end, gaining invaluable experience and learning from mistakes on demonstration efforts, not full-scale operational development programs where risk has not yet been adequately retired for key components and technologies. At the same time, technology will be able to evolve at a more rapid pace, as new techniques can be tested on successive demonstrations. Using a variety of contributors and platforms, ESMD will show significant results from this investment portfolio within a 5-year horizon. And to more fully engage the public in these efforts, NASA will establish a Participatory Exploration Office, funded at $5 million a year, with the goal of making NASA missions more participatory and even more collaborative.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**3,905.5**	**3,779.8**	**4,263.4**	**4,577.4**	**4,718.9**	**4,923.3**	**5,179.3**
Exploration Research and Development			1,551.4	2,577.4	3,318.9	3,623.3	3,979.3
Exploration Technology and Demonstrations			652.4	1,262.4	1,807.9	2,013.3	2,087.3
Heavy Lift and Propulsion Technology			559.0	594.0	597.0	598.0	754.0
Exploration Precursor Robotic Missions			125.0	506.0	699.0	797.0	923.0
Human Research			215.0	215.0	215.0	215.0	215.0
Commercial Spaceflight			812.0	1,400.0	1,400.0	1,300.0	1,200.0
Commercial Cargo			312.0				
Commercial Crew			500.0	1,400.0	1,400.0	1,300.0	1,200.0
Constellation Transition			1,900.0	600.0	0.0	0.0	0.0
Constellation Systems	3,433.2	3,325.8					
Constellation Systems	3,190.1	3,286.7					
Commercial Crew and Cargo	243.0	39.1					
Advanced Capabilities	472.3	454.0					
Human Research Program	151.9	151.5					
Exploration Technology Development Program	264.1	283.4					
Lunar Precursor Robotic Program	56.3	19.1					
FY 2010 President's Budget Request	**3,905.5**	**3,963.1**	**6,076.6**	**6,028.5**	**5,966.5**	**6,195.3**	**-**
Constellation Systems	3,433.2	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6	-
Advanced Capabilities	472.3	457.7	533.3	556.5	558.9	592.7	-
Total Change from FY 2010 President's Budget Request		**-183.3**	**-1,813.2**	**-1,451.1**	**-1,247.6**	**-1,272.0**	

Mission Directorate: Exploration Systems
Theme: Exploration Research and Development

Theme Overview

The Exploration Research and Development Theme is focused on investment in expanding fundamental knowledge key to human space exploration, launching robotic pathfinders, and demonstrating technology trailblazers that will enable humans of all nations to explore space in a significantly more sustainable and affordable way than current capabilities allow. In addition to a significant boost in ongoing Human Research, three new programs will drive these efforts to provide the building blocks for a more capable, forward-looking approach to human exploration of space.

Mission Directorate: Exploration Systems
Theme: Exploration Research and Development
Program: Exploration Technology and Demonstrations

Program Overview

Activities within ESMD's Technology Demonstration Program will be aimed at advancing technologies needed to expand our human exploration opportunities, reduce mission costs, and contribute NASA innovation to broader national challenges and applications. This will be accomplished through investment in demonstration of flagship technology projects, as well as enabling technology development and demonstration. NASA will provide an assessment of the highest leverage technologies and demonstrations.

Flagship Technology Demonstrations

Projects selected as in-space, flagship demonstrations will be significant in scale, and offer high potential to demonstrate new capability and reduce the cost of future exploration missions. These missions will demonstrate such critical technologies as in-orbit propellant transfer and storage, inflatable modules, automated/autonomous rendezvous and docking, closed-loop life support systems, and other next generation capabilities key to sustainably exploring deep space.

In FY 2011, NASA will initiate several Flagship Technology Demonstrators, each with an expected lifecycle cost in the $400 million to $1 billion range, over a lifetime of five years or less, with the first flying no later than 2014. In pursuit of these goals, international, commercial, and other government agency partners will be actively pursued as integrated team members where appropriate. NASA will not give responsibility for all demonstrations to any single NASA center but rather looks forward to engaging with the expertise of various centers to accomplish these objectives. Specific architecture and approach for missions to demonstrate key capabilities will be developed for initiation in FY2011. Technologies targeted for demonstration will likely include:

In-Orbit Propellant Transfer and Storage: The capability to transfer and store propellant—particularly cryogenic propellants—in orbit can significantly increase the Nation's ability to conduct complex and extended exploration missions beyond Earth's orbit. It could also potentially be used to extend the lifetime of future government and commercial spacecraft in Earth orbit. This technology demonstration, building on previous ESMD technology investments and prior demonstrations such as Orbital Express, could test technologies and processes such as long-term storage of cryogenic propellant, automated physical connections between fuel lines in orbit, and verification of fuel acquisition, fuel withdrawal, and fuel transfer.

Lightweight/Inflatable Modules: Inflatable modules can be larger, lighter, and potentially less expensive for future use than the rigid modules currently used by the International Space Station (ISS). Working closely with industry and international partners who have already demonstrated a number of capabilities and interest in this arena, and building on previous ESMD investments, NASA will pursue a demonstration of lightweight/inflatable modules for eventual in-space habitation, transportation, or even surface habitation needs. The demonstration could involve tests of a variety of systems, including closed-loop life support, radiation shielding, thermal control, communications, and interfaces between the module and external systems. Use of the ISS as the testbed for this technology is an option being considered to potentially benefit both programs.

Automated/Autonomous Rendezvous and Docking: The ability of two spacecraft to rendezvous, operating independently from human controllers and without other back-up, requires advances in sensors, software, and real-time on-orbit positioning and flight control, among other challenges. This technology is critical to the ultimate success of capabilities such as in-orbit propellant storage and refueling, complex operations in assembling mission components for challenging destinations, in-space construction, and exploration operations far from Earth where the communications delay does not allow for effective human involvement.

NASA will also begin work in 2011 on an additional Flagship Technology Demonstrator mission to be selected within the Agency, and map out a sequence of Flagship missions to be initiated in 2012 and later. Potential candidates include but are not limited to:

Closed–loop life support system demonstration at the ISS: This would validate the feasibility of human survival beyond Earth based on recycled materials with minimal logistics supply. A follow-on demonstration could involve an integrated inflatable module/closed-loop life support system demonstration.

Aerocapture, and/or entry, descent and landing (EDL) technology: This could involve the development and demonstration of systems technologies for: precision landing of payloads on “high-g” and “low-g” planetary bodies; returning humans or collected samples to Earth; and enabling orbital insertion in various atmospheric conditions. Demonstrations could be ground-based or flight experiments.

Enabling Technology Development and Demonstration

Smaller scale development and testing of key, long-range exploration technologies will be pursued as part of the Enabling Technology effort. Projects will range from laboratory experiments to Earth-based field tests and in-space demonstrations and will be aimed at transitioning relevant technologies from lower to higher technology readiness levels. Although some work may be assigned to specific centers or other work groups in this program, we expect the majority of projects developing long-range, enabling technologies to be selected through full and open competition, including NASA centers, industry, academia, and international partners. International, commercial, and other government agency partners will also be actively pursued as integrated team members as appropriate;

In some cases, once technologies have been matured, the NASA centers will manage their integration into prototype systems for demonstration of advanced capabilities. These projects will be designed to take full advantage of available assets such as wind tunnels, ground-based analogs, flight test aircraft, suborbital sounding rockets, commercial reusable suborbital vehicles, robotic spacecraft, ISS, and other test platforms.

In FY 2011, NASA will initiate demonstration projects in the areas of in situ resource utilization (ISRU), autonomous precision landing and hazard avoidance, and advanced in-space propulsion, leading to demonstrations on either robotic precursor or flagship missions.

In Situ Resource Utilization: NASA will fund research in a variety of ISRU activities aimed at using lunar, asteroidal, and Martian materials to produce oxygen and extract water from ice reservoirs. A flight experiment to demonstrate lunar resource prospecting, characterization, and extraction will be considered for testing on a future Flagship Technology Demonstration or robotic precursor exploration mission. Concepts to produce fuel, oxygen, and water from the Martian atmosphere and from subsurface ice will also be explored.

Autonomous Precision Landing: In FY 2011, NASA will initiate development of a flight experiment to demonstrate an autonomous precision landing and hazard avoidance system. NASA will pursue use of this system on the first robotic precursor exploration mission to the Moon or other planetary body.

Advanced In-Space Propulsion: NASA will work with partners in industry as appropriate, to conduct foundational research to study the requirements and potential designs for advanced high-energy in-space propulsion systems to support deep-space human exploration, and to reduce travel time between Earth’s orbit and future destinations for human activity. These technologies could include nuclear thermal propulsion, solar and nuclear electric propulsion, plasma propulsion, and other high-energy and/or high-efficiency propulsion concepts. One or more concepts may mature to the level of a demonstration on a robotic precursor or Flagship mission.

In addition, the enabling technology projects line will consider a broad range of other technology development and demonstration projects in areas including:

Closed-loop life support systems: NASA will demonstrate technologies for recycling air, water, and solid waste on the ISS to validate the feasibility of human survival beyond Earth on long-duration missions with minimal logistics supply. A follow-on demonstration could involve an integrated inflatable module/closed-loop life support project. Combined with ISRU, mastering this capability will enable extended exploration missions that are more fully and effectively based on a self-reliant, “live off the land” approach proven essential during centuries of terrestrial exploration.

Extravehicular Activity Demonstrations: Building on current EVA technology projects, NASA will work with industry and academia to develop advanced spacesuits to improve the ability of astronauts to assemble and service in-space systems, and to explore the surfaces of the Moon, Mars, and small bodies. Spacesuit technologies such as life support systems, thermal control, power systems, and improved fabric materials will be demonstrated in EVA operations in space, including from the ISS.

Radiation Shielding Technology: NASA will test the feasibility of existing concepts, and also develop new concepts, to protect astronaut crews from the harmful effects of radiation, both in low Earth orbit and while conducting long-term missions away from Earth. This is one of the most critical areas for technology investment and demonstration in support of long-duration human missions beyond Earth.

Human-Robotic Interactive Systems Demonstrations: NASA will advance the state of the art in areas like tele-operation, autonomy, human-robot interaction, robotic assistance, and other advanced robotic concepts aimed at significantly increasing human and robotic efficiency and productivity in space.

High-Efficiency Space Power Systems: NASA will develop technologies to provide low-cost, abundant power for deep-space missions, including advanced batteries and regenerative fuel cells for energy storage, power management and distribution, wireless power transmission, thermoelectric and Stirling power conversion, solar (photovoltaic and solar-dynamic systems), and nuclear power systems. A major focus will be on the demonstration of dual-use technologies for clean and renewable energy for terrestrial applications.

Entry, Descent, and Landing (EDL) Technology: NASA will develop and test concepts for large aeroshells and advanced thermal protection system materials to enable aero-capture and atmospheric entry of heavy payloads. These technologies will enable the demonstration of EDL capabilities on future robotic precursor and flagship missions.

High-Performance Materials and Structures: NASA will develop high-temperature materials for propulsion and power systems, nano-structured materials to increase strength-to-weight fabric materials for spacesuits, and super-lightweight composite structures for exploration vehicles and crew habitats. New materials and structures will be tested in the space environment as components of other system-level flight experiments.

Also within this budget line, NASA will establish a Participatory Exploration Office funded at $5 million a year, charged with encouraging public involvement and interaction in the experience of discovery. NASA understands that a primary goal of participatory exploration is making the Agency’s research, development and related discoveries more open and transparent so that the general public can understand why NASA is important to their everyday lives. We recognize that participatory exploration covers a spectrum of activities and audiences ranging from directed hand-on activities with students building flight hardware, to collaborating on interpretation of data and discoveries.

This activity will focus on maximizing the strong efforts NASA already places on reaching various audiences, as well as leveraging open Government initiatives for public engagement, tying the two together for the maximum benefit of the public. Each year, NASA sponsors hundreds of programs, activities, events and resources, including award-winning educational Web sites, major exhibitions in museums and science centers, partnerships with minority universities, and research projects that allow the public to participate in NASA missions. NASA recognizes that when we do a better job at explaining the excitement and relevance of our missions to our stakeholders and to the public, they will want to be a part of those missions.

Mission Directorate: Exploration Systems
Theme: Exploration Research and Development
Program: Heavy Lift and Propulsion Technology

Program Overview

ESMD will lead research and development (R&D) activities related to space launch propulsion technologies. This propulsion R&D effort will include development of a U.S. first-stage hydrocarbon engine for potential use in future heavy lift (and other) launch systems, as well as basic research in areas such as new propellants, advanced propulsion materials manufacturing techniques, combustion processes, and engine health monitoring. In support of this initiative, NASA will explore cooperative efforts with the Department of Defense (DOD) and also develop a competitive process for allocating a small portion of these funds to universities and other non-governmental organizations.

First-Stage Launch Propulsion: NASA's efforts in this area will focus on development of a U.S. core stage hydrocarbon engine that would be suitable for use in a future heavy-lift rocket or as the first stage of a future launch vehicle. A strong candidate would be a hydrocarbon (liquid oxygen/kerosene) engine, capable of generating high levels of thrust approximately equal to or exceeding the performance of the Russian-built RD-180 engine. Other key target characteristics for this new capability include improvements in overall engine robustness and efficiency, health monitoring, affordability, and operability. In every aspect of the design, NASA will seek to incorporate features that will reduce manufacturing and operating costs for this engine, once it achieves nominal production status. The level of funding for this project is intended to result in a fully operational engine by the end of this decade or perhaps sooner if a DOD partnership is established.

In-Space Engine Demonstration: NASA will initiate development and in-space testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and potentially also low-cost liquid oxygen/liquid hydrogen engines. This work will build from NASA's recent R&D experience in this area, and the test articles will be viewed as a potential prototype for a subsequent operational engine that would be restartable and capable of high acceleration and reliability. Where appropriate, NASA will seek to leverage technologies that are under development in industry.

Foundational Propulsion Research: As noted in a recent OSTP assessment of the state of the U.S. launch propulsion industry base (as well as other related reports); there has been a significant downturn in U.S. industry and governmental investment in foundational R&D regarding space launch propulsion technologies. This has led to concerns about sustaining U.S. expertise in this area and the related potential to identify potential breakthrough propulsion technologies for reducing the costs and improving the performance of future systems. Accordingly, NASA will allocate funds to performing foundational research in chemical propulsion technologies in areas such as new or largely untested propellants, advanced propulsion materials and manufacturing techniques, combustion processes, and engine health monitoring and safety.

In support of this research initiative, NASA will also establish a transparent and equitable process for distributing $25 million in funds annually to commercial, university, and other non-governmental research organizations for foundational research in this area, with the goal of encouraging a broad range of innovative approaches and helping to develop the next generation of scientists and engineers in the space launch propulsion arena. This research effort will be coordinated to the extent possible with the broader Agency technology initiative led by the Chief Technology Officer in an effort to identify and leverage potential synergies between these programs.

Mission Directorate:	Exploration Systems
Theme:	Exploration Research and Development
Program:	Exploration Precursor Robotic Missions

Program Overview

Led by ESMD, NASA will send precursor robotic missions to candidate destinations for human exploration such as the Moon, Mars and its moons, Lagrange points, and nearby asteroids to scout targets for future human activities, and identify hazards and resources that will determine the future course of expanding human civilization into space. Projects will make critical observations, test approaches and operations concepts, and identify specific target destinations directly beneficial to future human space activities. Instruments, destinations and missions will be prioritized based on their utility to future human activities. These will be evaluated in a study of potential demonstrations. While there may be some synergies between this program and the Planetary Science theme within SMD, care will be taken to avoid unnecessary duplication. Dedicated precursor exploration missions are planned to remain below $800 million in total cost, and most will be considerably less expensive.

The Exploration Precursor Robotic Missions will springboard from the successes of the Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS), ESMD's first two robotic missions. Key programmatic and technical management lessons learned will be applied to future robotic precursors. While mission, spacecraft, and instrument selection processes will be derived from those used on LRO/LCROSS, mission objectives will be derived from the priorities of the Exploration Community internal and external to NASA, to assure relevancy and high value. Risk Management approaches developed on LCROSS to achieve mission goals under-budget will be applied to precursor robotic missions.

ESMD will join with other NASA Directorates and international partners to fly precursor instruments aboard partner spacecraft as missions of opportunity, and provide opportunities for partners to fly instruments on ESMD's exploration precursor missions. ESMD is already contributing to the Mars Science Laboratory mission with surface radiation measurement and entry instrumentation for atmospheric data collection. Similarly, ESMD and SMD will coordinate objectives for missions with similar destinations, such as the lunar South Pole and future Mars missions. This inter-directorate coordination will assure non-duplication of effort where appropriate, and the enhancement of robust common data sets elsewhere. However, the exploration precursor robotic missions will be unique—designed and developed to be relevant to the needs of future human exploration as the primary rationale.

NASA will begin funding at least two dedicated precursor missions in 2011. One will likely be a lunar mission to demonstrate tele-operation capability from Earth and potentially from the International Space Station, including the ability to transmit near-live video to Earth. This will also result in investigations for validating the availability of resources for extraction. NASA will provide opportunities to participate in the payloads and observation teams, and potentially portions of the spacecraft, through open competition.

NASA will also select at least one additional robotic precursor mission to initiate in 2011, and identify potential future missions to begin in 2012 and/or 2013. Potential missions may include:

Landing on asteroids or the moons of Mars rather than orbiting these bodies would allow us to better determine whether they pose safety hazards to astronauts or contain materials useful for future explorers. Landing can also test technologies that could help future human missions.

Landing a facility to test processing technologies for transforming lunar or asteroid materials for fuel could eventually allow astronauts to partially "live off the land."

These precursor exploration missions will cooperate closely with ESMD's Technology and Demonstrations Program, potentially serving as test-beds for new technologies. Additionally, the Exploration Precursor Robotic Missions will leverage its experience from the successfully co-manifested LRO and LCROSS missions to seek other co-manifesting opportunities in an effort to save launch vehicle costs and to encourage collaboration.

Program formulation will define processes and criteria for implementation. Leveraging LRO and LCROSS experience, formulation activities will define processes for destination and mission selection, methodology for risk and project management, acquisition strategies, and metrics against which program and project success will be defined. The Exploration Precursor Robotic Missions will foster open competition in procurements, accommodation for partnerships, and actively engage the public in coordination with Participatory Exploration efforts.

Additionally, a new portfolio of explorer scouts will execute small, rapid turn-around, highly competitive missions to exploration destinations. Generally budgeted at between $100M and $200M lifecycle cost, these missions will allow NASA to test new and innovative ways of doing robotic exploration of destinations of interest to future human exploration. Selected projects may provide multiple small scouting spacecraft to investigate multiple possible landing sites, or provide means of rapid-prototyping new spacecraft approaches. These missions will be fully and openly competed in a Principal Investigator mode.

Mission Directorate:	Exploration Systems
Theme:	Exploration Research and Development
Program:	Human Research Program

Program Overview

This budget increases Human Research funding to $215 million per year to support effort focused on solving the long-term problems that need to be addressed for humans to safely live and work at various locations in the inner solar system (e.g., Earth orbit, Mars transfer orbit, lunar surface).

The Human Research Program conducts research, develops countermeasures, and undertakes technology development to inform and support compliance with NASA's health, medical, human performance, and environmental standards. The Program will continue to address human health and performance risks endorsed by the National Research Council and Institute of Medicine within the existing portfolio elements structure:

- Human Health Countermeasures
- Space Radiation
- Space Habitability and Human Factors
- Behavioral Health and Performance
- Exploration Medical Capabilities
- ISS Medical Project

These risks address space radiation health concerns, behavioral health and team cohesion challenges associated with confinement and isolation, inadequate human-machine interfaces, emergency medical care issues, and effects of microgravity on the human body. Microgravity health effects include rapid muscle atrophy, bone loss, neurovestibular system changes that produce motion sickness, and significant fluid shifts that affect intracranial pressure, cardiovascular function, blood volume, and cause orthostatic intolerance.

This funding will enhance current HRP work and enable creation of more robust exploration-enabling projects, with an increased focus on the following areas:

Space radiation research to expand the knowledge base and reduce the uncertainty inherent in current radiation exposure limits for astronauts, leading to the development of radiation countermeasures. This work will be in coordination with space radiation protection demonstration projects by providing the latest progress on human vulnerabilities to the space environment.

Biomedical technology research and development that supports long-duration human spaceflight (and may also have applicability to public health care needs) in areas like advanced medical care technology and bioinformatics.

Research into human behavioral factors and psychological implications of long-duration spaceflight, and development of countermeasures to mitigate the risks of degraded human performance.

In addition, the funding will enable:

- Development of research and technology projects that fully utilize ISS as a space biomedical laboratory
- Enhancement of STEM education and projects that return Earth benefits
- Enhanced National Space Biomedical Research Institute leveraging of their U.S. National biomedical research infrastructure to address space related health risks
- Additional collaborations involving other National (NIH, DOE, DOD for example) and International agencies (ESA, JAXA, DLR, CNES, CSA, ASI for example)
- Additional National research solicitations to openly and competitively solicit, review, and select new research content

Theme Overview

NASA’s newly established Commercial Spaceflight Theme represents more than a $6 billion investment increase in America’s space industry. Building on established partnerships with the emerging commercial space sector through the Commercial Orbital Transportation Services (COTS) effort, the Agency will expand the market to include a range of both cargo and crew vehicles.

One of NASA's strategic goals is to encourage the pursuit of appropriate partnerships with the emerging commercial space sector. The Agency's major activity in this area is the COTS effort, overseen by the Commercial Crew and Cargo Program. This Program is aimed at encouraging the development of commercial space transportation services and an associated market, with multiple suppliers and customers. NASA would be one of these customers, purchasing transportation services on the open market.

COTS is being executed in two phases. The first is a period of private industry development and demonstration of the various space transportation capabilities to and from low Earth orbit determined to be most desirable for government and other customers. During this phase, NASA is providing $500 million of seed capital and technical assistance to promising space firms via funded and unfunded Space Act Agreements (SAA) to stimulate the commercial space transportation market. These COTS partners are to demonstrate capabilities that can be used for ISS resupply: Capability A, delivery of unpressurized cargo; Capability B, delivery of pressurized cargo; and Capability C, delivery and return of cargo to and from orbit. The second phase is a competitive procurement of orbital transportation services to supply ISS, and is the responsibility of the Space Operations Mission Directorate (SOMD). In addition, with Recovery act funding in FY 2009, NASA initiated development activities under the Commercial Crew Development (CCDev) effort to enable future commercial crew launches to the ISS. Space Act Agreements were awarded to five companies in February 2010 to demonstrate various technologies and capabilities necessary to reduce the risk of flying crew on commercial vehicles, with completion milestones in the November/December 2010 timeframe.

The SAAs NASA has in place with the COTS partners are written to maximize the flexibility of private development efforts. Partners are paid when the Agency certifies that they have passed a series of discrete developmental milestones; if they fail to make progress, they are not paid. Government requirements are kept to a minimum, and are only concerned with assuring safe interaction with the ISS. The partners are not required to follow the standard NASA Program and Project Management Processes and Requirements, NPR 7120.5. Rather, the relationship is intended to encourage innovation and allow partners to use alternatives to the standard NASA program management approaches, while still being held accountable for safety and ISS visiting vehicle requirements that NASA would impose were that partner being utilized for commercial transportation services.

In addition to providing a conduit for funding, the Commercial Crew and Cargo Program coordinates the COTS Advisory Team, made up of over 100 technical experts located throughout NASA. Funded and unfunded partners can utilize these experts as necessary; if a partner requires extensive assistance, NASA helps arrange reimbursable agreements with NASA centers to acquire the expertise they need. Commercial crew activities build upon the COTS and CRS successes, realizing that transporting cargo is different than transporting crew. NASA is in the process of developing an acquisition strategy that accounts for the additional insight and oversight necessary, allowing commercial companies to benefit from the vast experience NASA has amassed over fifty years of human spaceflight, without placing undue burden on the commercial partners. NASA will also work with the commercial partners to clearly articulate human rating processes and requirements that will contribute to the safe flight and safe return of NASA crew members on commercial space vehicles.

Mission Directorate:	Exploration Systems
Theme:	Commercial Spaceflight
Program:	Commercial Cargo

Program Overview

This budget allocates $312.0 million in FY 2011 for incentivizing NASA's current commercial cargo program to improve the chance of mission success by adding or accelerating the achievement of already-planned milestones, adding additional capabilities, or tests that may ultimately expedite the pace of development of cargo flights to the ISS. Risk reduction activities may include adding milestones to complete the Probabilistic Risk Assessment (PRA) to identify early risks. Accelerating enhanced capabilities may include adding milestones for early development of items such as the high energy engine for Orbital's Taurus II upper stage, and Block 2 engine upgrades SpaceX's Falcon 9; a demonstration flight may be added to validate the upgrades. NASA will continue to evaluate the Cargo Resupply Services (CRS) contract to determine if funds can be used to accelerate hardware fabrication and assembly of the CRS vehicles.

Commercial Orbital Transportation Services (COTS)

The Commercial Orbital Transportation Services (COTS) partner agreements are not projects by the standard NASA definition of the term, but individual firms that have entered into Space Act Agreements with the Agency. "Funded partners" are those receiving progress payments and technical assistance from NASA, while "unfunded partners" receive technical assistance, but are not paid. NASA has unfunded agreements with PlanetSpace of Chicago, IL and SpaceDev of Poway, CA, while our funded COTS partners are SpaceX, of Hawthorne CA, and Orbital Sciences Corporation of Dulles, VA.

SpaceX is developing new launch vehicles with the goal of providing reliable, globally cost competitive U.S. space transportation capabilities. Their Falcon 9 launch vehicle is an evolution of their clean sheet design of the Falcon 1 launch vehicle. Their "Dragon" spacecraft and launch vehicle are being designed for either cargo or crew transport. Both launch vehicle and spacecraft offer flexible configurations based on mission requirements, and are currently planned to be recoverable for refurbishment and reuse. SpaceX has chosen Cape Canaveral's launch complex 40 as the site for their launches, with the first ISS demonstration flight planned for completion by February 2011. For Phase 1, SpaceX will demonstrate cargo transportation Capabilities A-C. Additionally, SpaceX currently has an unfunded SAA option to demonstrate Capability D.

Orbital Sciences Corporation is developing a launch system concept comprised of a Taurus II launch vehicle, a new medium class booster using two Aerojet AJ-26 engines and an ATK Castor 30 second stage. Taking advantage of heritage systems, Orbital will use a standard service module derived from the STAR and Dawn spacecraft for all missions and the pressurized cargo module will be based on the ISS multi-purpose logistics module. The Wallops Flight Facility will serve as Orbital's launch site for an ISS demonstration flight, currently scheduled for March 2011. For Phase 1, Orbital will demonstrate cargo transportation Capability B.

Mission Directorate:	Exploration Systems
Theme:	Commercial Spaceflight
Program:	Commercial Crew

Program Overview

The Commercial Crew Program will provide $6 billion over the next five years to support the development of commercial crew transportation providers to whom NASA could competitively award a crew transportation services contract analogous to the Cargo Resupply Services contract for ISS.

These funds will be competed through COTS-like, fixed-price, milestone-based Space Act Agreements that support the development, testing, and demonstration of multiple commercial crew systems. As with the COTS cargo program, some amount of private investment capital will be included as part of any Space Act Agreement and NASA will use this funding to support a range of higher- and lower-programmatic risk systems. Unlike the COTS program, which exclusively funded entirely new and integrated systems (launch vehicles plus capsules), this program will also be open to a broad range of commercial proposals including, but not limited to: human-rating existing launch vehicles, developing spacecraft for delivering crew to the ISS that can be launched on multiple launch vehicles, or developing new high-reliability rocket systems.

NASA will leverage existing COTS and Commercial Crew Development (CCDev) activities to engage a broad spectrum of private industry, from emerging to established companies, with a full and open competition for commercial development activities at the conclusion of the CCDev activities. The competition will result in a targeted portfolio of up to four companies with a mixed risk balance consisting of launch vehicles, crew capsules, and supporting technologies, similar to the Commercial Crew Development awards from Recovery Act funds announced on February 2, 2010. The number of awardees will be based on such factors as technical competency and available funds. Firm-fixed-price awards will be issued for production of crew services after a key progress review of the down-selected commercial companies as necessary, within the available budget.

At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. NASA has unique expertise and history in this area, and a clearly demonstrated record of success. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. In that regard, NASA agrees with the Aerospace Safety Advisory Panel, which stated, “it is crucial that NASA focus on establishing the certification requirements, a certification process for orbital transportation vehicles, and a process for validating compliance. The performance and safety requirements must be stated promptly and clearly to enable NASA and non-NASA entities to proceed in the most productive and effective manner possible.” NASA will work to complete an agency and industry-coordinated human rating draft by the end of 2010.

Mission Directorate: Exploration Systems
Theme: Constellation Transition

Theme Overview

All funding within this theme provides for transition and closeout activities for the Constellation Program. This cancellation effort represents a fundamental strategic shift from a large, contract oversight and mission operations program to a more diverse development, demonstration, and precursor focus that will require significant realignment across the Agency. Constellation closeout will involve a comprehensive planning effort for the termination and resolution of existing contracts; safing, disposition and reallocation of facilities; workforce assessment and skills cross-mapping; and cataloguing and disposition of real and personal property.

In addition to direct Constellation Program closeout activities, the transition and retirement plans for Space Shuttle assumed Constellation would receive and utilize assets that will no longer be required. Also, some Shuttle capabilities that Constellation was not going to use may be used by new programs, such as the Space Launch Complex Modernization effort. Although the total amount of Agency facilities to be retired and dispositioned will likely be increased versus the plan to date, existing Shuttle transition and retirement processes and planning will be leveraged for maximum efficiency and cost effectiveness. The $600 million provided to enable the Shuttle to fly into the first quarter of FY 2011 if necessary may also become available to aid in transition if the Shuttle completes its manifest on time.

The funds allocated to Constellation closeout in FY11 and FY12 will be applied to such activities as:

- Termination and liability for existing contracts (including severance pay)
- Closeout costs of content and property disposition
- Costs to safe facilities no longer in use, mothballed, or targeted for demolition
- Potential remediation of Agency direct and support contractor facilities no longer in use
- Coverage for transitional civil servants as new programs are being initiated

NASA will work with Congress to initiate and complete these transition activities as quickly as possible.
To that end, the Agency has established a Constellation Transition Team, leveraging expertise from across the Agency to develop a rapid and cost effective ramp down plan that will free the resources required for new programs. As part of the early characterization and integrated planning effort, this team has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other government agency interface issues. The transition plan will outline three phases as part of an action plan for initial deliverables:

- Near term actions
- Primary termination of Constellation
- Transition of assets/resources to new Exploration focus areas, where appropriate

The study team will initiate this planning effort and prepare for transfer to a Constellation Transition and Closeout Project. As planning matures, new focus area requirements will be iteratively applied to Transition Study Team efforts to refine workforce, facilities, infrastructure, and property assessments, and their associated budget and transfer schedules.

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Overview

NASA's Space Operations Mission Directorate (SOMD) is responsible for providing space exploration services to both NASA customers and to other partners in the United States and throughout the world. SOMD manages the safe flyout of the Space Shuttle Program (SSP), oversees the operation of the system and payloads on the International Space Station (ISS), provides safe and reliable access to space through the Launch Services Program (LSP) and world-class rocket testing capabilities through the Rocket Propulsion Test (RPT) Program, maintains secure and dependable communications to ground stations and between platforms across the solar system through the Space Communication and Navigation (SCaN) Program; and provides the necessary training and supports the health and safety of our Nation's astronauts through the Human Space Flight Operations (HSFO) Program.

The International Space Station is a unique multinational orbital outpost for learning how to live and work in space as well as carrying out the scientific and engineering research needed for prolonged stays in space, including on the Moon, Mars and other bodies. To enhance benefits, NASA has secured partnerships with other United States Government agencies and private firms to utilize a portion of the ISS as a National Laboratory. For over a decade, the Space Shuttle and International Space Station programs have worked closely together to safely complete this critical element of our Nation's space infrastructure. Completing assembly of the International Space Station will be the crowning achievement of the Space Shuttle's forty year history. Once this historic task is complete after four more flights, estimated by the end of fiscal year 2010, the Space Shuttle will be retired so that NASA can focus on new challenges of a 21st century space agency. The FY 2011 budget for Space Shuttle Program continues to support the planning, optimized utilization, and responsive disposition of processes, personnel, resources, and real and personal property. We will embark on extended and enhanced International Space Station utilization, focusing on basic scientific research and technology demonstration that will prepare us for future exploration and benefit life on Earth. We will invest in the Space Station facility itself by initiating new activities to increase functionality. The activities are intended to support ISS upgrade efforts while proving new space technologies.

In addition to these high-profile programs, SOMD also is responsible for ensuring that the critical infrastructure to access and use space is available to meet the needs of NASA's internal and external customers. The Space and Flight Support Theme (SFS) is comprised of multiple programs that provide Agency-level enabling capabilities that play a critical role in the success of NASA missions and goals. The Space Communication and Navigation Program operates NASA's extensive network of terrestrial and orbiting communications nodes, as well as all of the associated hardware and software needed to pull down the terabytes of data generated by NASA's fleet of crewed vehicles and robotic spacecraft. The Launch Services Program facilitates access to space by providing leadership, expertise and cost-effective Expendable Launch Vehicle services for NASA's missions. The Rocket Propulsion Test Program maintains NASA's wide variety of test facilities for use by NASA, other agencies and commercial partners. The Human Space Flight Operations Program ensures that NASA's astronauts are fully prepared for current and future missions. Funding also is being provided to establish a 21st Century Space Launch Complex Program at the Kennedy Space Center (KSC). This effort is intended to benefit not only NASA's current and future operations at the KSC including commercial activities, but also to enhance the capabilities of the Florida launch range for the benefit of future NASA launches.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**5,764.7**	**6,180.6**	**4,887.8**	**4,290.2**	**4,253.3**	**4,362.6**	**4,130.5**
Space Shuttle	2,979.5	3,139.4	989.1	86.1	0.0	0.0	0.0
International Space Station	2,060.2	2,317.0	2,779.8	2,983.6	3,129.4	3,221.9	3,182.8
Space and Flight Support (SFS)	725.0	724.2	1,119.0	1,220.6	1,123.9	1,140.7	947.7
FY 2010 President's Budget Request	**5,764.7**	**6,175.6**	**3,663.8**	**3,485.3**	**3,318.6**	**3,154.8**	**--**
Space Shuttle	2,981.7	3,157.1	382.8	87.8	0.0	0.0	--
International Space Station	2,060.2	2,267.0	2,548.2	2,651.6	2,568.9	2,405.9	--
Space and Flight Support (SFS)	722.8	751.5	732.7	745.9	749.7	748.9	--
Total Change from FY 2010 President's Budget Request	**0.0**	**5.0**	**1,224.0**	**804.9**	**934.7**	**1,207.8**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Space Operations

Space Shuttle

New Initiatives:

None.

Major Changes:

The FY 2011 budget includes an increase in FY 2011 to allow for flying the Space Shuttle through December 31, 2010, if necessary, to safely execute the remaining manifest.

Major Highlights for FY 2011

NASA has manifested the last six Space Shuttle missions for FY 2010 including the STS-129 mission that was flown in November 2009. As of February 2010, NASA has four remaining missions to launch. NASA's focus has been and will continue to be on the safe execution of these flights. Once these flights are flown, the Space Shuttle will be retired.

International Space Station

New Initiatives:

We will invest in the Space Station facility itself by initiating new activities to increase functionality. The activities are intended to support ISS upgrade efforts while proving new space technologies. Potential objectives include reducing demands on crew time, lowering ground-based costs, mitigating capabilities lost when the Shuttle retires, improving ISS capabilities, improving ISS safety, and supporting activities benefiting future human spaceflight programs.

The ISS will also be used as a platform for developing and testing technologies and capabilities that are funded and operated within both the Exploration Technology and Space Technology programs. The Exploration Systems Mission Directorate (ESMD) has budgeted $6 billion over the next five years to develop U.S. commercial crew transportation which will ultimately be utilized by ISS

Major Changes:

The FY 2011 budget provides $2.5 billion in additional funding over five years to extend ISS, likely through 2020 or beyond, to enable full utilization of ISS, and to initiate activities to increase ISS functionality and maximize operations. The budget also includes a $250 million increase over five years for science and engineering research, intended to augment current basic research on ISS and supports some transportation of these experiments.

Major Highlights for FY 2011

Following assembly completion in FY 2010, the ISS will serve as a fully functional and permanently crewed research laboratory and technology test bed providing a critical stepping stone for exploration and future international cooperation. The Commercial Resupply Services (CRS) contracts awarded to Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation (OSC) will provide commercial resupply flights beginning in FY 2011. Cargo transportation to ISS will also be supplemented by the Japanese HII Transfer Vehicle (HTV), European Automated Transfer Vehicle (ATV) and Russian Progress flights. Crew transportation and rescue will be provided by the Russian Soyuz vehicle until domestic commercial services are available.

Space and Flight Support (SFS)

New Initiatives:

Funding is being provided to establish a 21st Century Space Launch Complex Program at the Kennedy Space Center and the Florida launch range to transform KSC and Cape Canaveral area into modern facilities poised to play a key role in 21st century space exploration. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial crew and cargo providers, consolidating and disposing of unused or underutilized facilites, and performing environmental work to improve the surrounding area. With this large, multi-year investment, this effort will benefit NASA's current and future operations at KSC and Cape Canaveral by targeting increased efficiency and safer operations.

Major Changes:

In FY 2011, changes are proposed to the SCaN Program and the HSFO Program within the SFS Theme. The Optical Communication System (OCS) was deleted from SCaN beginning in FY 2011, but is being considered for funding in the new Space Technology portfolio. The initial demonstration of OCS, the Lunar Atmosphere and Dust Environment Explorer (LADEE) will occur and is fully funded through FY 2010. Core crew health and medical services, which had been funded within ISS and CxP in FY 2010 are consolidated into a single budget line under Crew Health and Safety (CHS) and transferred to HSFO. The activities that will be included under HSFO in the future will be those deemed to be discrete multi-program functions that support the Agency's human space flight operations required regardless of vehicle supported.

Major Highlights for FY 2011

In FY 2011, the SCaN Program will begin procurement of a 34m antenna as part of the effort to improve the robustness of the Deep Space Network and replace the aging 70m antenna capability. SCaN will conduct a System Requirements Review (SRR) of the Space Network Ground Segment Sustainment (SGSS) Project in the third quarter of FY 2011 and will also complete the Critical Design Review (CDR) for the Tracking and Data Relay Satellite (TDRS) K&L. The Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) will be installed on ISS during FY 2011.

The LSP program has six planned NASA launches in FY 2011 including Glory, Aquarius, Juno, Nuclear Spectroscopic Telescope Array (NuSTAR), NPOESS Preparatory Project (NPP) and the Gravity Recovery and Interior Laboratory (GRAIL) mission. In addition to processing, mission analysis, spacecraft integration and launch services, LSP will continue to provide support for the development and certification of emerging launch services.

The RPT Program will continue to provide test facility management, and provide maintenance, sustaining engineering, operations, and facility modernization projects necessary to keep the test-related facilities in the appropriate state of operational readiness.

The HSFO Program includes CHS and Space Flight Crew Operations (SFCO). SFCO will provide trained crew for the manifested Shuttle requirements as well as four ISS long-duration crew rotation missions and crew expertise for development of future vehicles. CHS will identify necessary medical capabilities and identify and leverage the development of clinical care capabilities. NASA will also enlist the National Research Council (NRC) to conduct an independent study of the activities funded within NASA's Human Space Flight Operations program office to focus on the requirements post-Shuttle retirement, including the role and size of the astronaut corps, crew related facility requirements, and the most cost effective means to support NASA's new human spaceflight program.

Mission Directorate:	Space Operations
Theme:	Space Shuttle

Theme Overview

Thirty-eight years ago, NASA was charged with developing the world's first reusable space transportation system, a vehicle capable of astonishing power and versatility that would revolutionize humanity's ability to operate regularly in near-Earth space. With these last flights on the Space Shuttle manifest, the assembly and outfitting of the ISS, an extraordinary period in the history of space exploration will come to a close. As NASA retires the Space Shuttle, the Agency is transitioning key workforce, technology, facilities, and operational experience to a new generation of human spaceflight exploration activities. For more information, please visit www.nasa.gov/shuttle.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**2,979.5**	**3,139.4**	**989.1**	**86.1**	**0.0**	**0.0**	**0.0**
Space Shuttle Program	2,979.5	3,139.4	989.1	86.1	0.0	0.0	0.0
FY 2010 President's Budget Request	**2,981.7**	**3,157.1**	**382.8**	**87.8**	**0.0**	**0.0**	**--**
Space Shuttle Program	2,981.7	3,157.1	382.8	87.8	0.0	0.0	--
Total Change from FY 2010 Request	**-2.2**	**-17.7**	**606.2**	**-1.7**	**0.0**	**0.0**	**--**

Plans for FY 2011

Space Shuttle Program

NASA has manifested the last six Space Shuttle missions for FY 2010, including the STS-129 mission that was flown in November 2009 and the STS-130 mission in February 2010. The final six flights of the Space Shuttle are dedicated to completing assembly of the International Space Station (ISS), delivering and installing the Alpha Magnetic Spectrometer (AMS) to the ISS, and prepositioning equipment so that the ISS can achieve its full research potential. NASA will continue its priority to safely complete the remaining Space Shuttle manifest.

The FY 2011 budget includes funds to support an additional three months of operations, if necessary, to safely complete the existing manifest by the end of the calendar year 2010. NASA's focus has been and will continue to be on the safe execution of these flights. While NASA remains confident that these last missions can be safely and successfully completed in FY 2010, the FY 2011 budget for the Space Shuttle Program will retain the capability to accommodate a slip of one or two of these flights into FY 2011, if that should prove necessary to finish the manifest. Once these flights are flown, the Space Shuttle will be retired. If retirement occurs earlier than December 2010, NASA will work with the Administration and Congress to determine the highest priority use of FY 2011 funds. FY 2011 is also the first year of major T&R activities. T&R plans will be in place for all SSP hardware elements as well as primary supporting Centers and all organizations with a substantial role in ensuring a safe and efficient phase-out of SSP capabilities.

Mission Directorate:	Space Operations
Theme:	Space Shuttle

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's mission is to pioneer the future in space exploration, scientific discovery, and aeronautics research. With the completion of ISS assembly and the retirement of the Space Shuttle, the program's next step is to only transfer the Space Shuttle program's assets that will support the next generation of human space exploration activities while safeguarding the long-term viability of key technical capabilities. Capabilities that are no longer needed or are obsolete will be retired.

Relevance to education and public benefits:

For twenty-nine years, the Space Shuttle has carried more people (over 320) and more cargo (almost four million pounds) on more (and more different types of) missions than any other launch system in history. For the past twelve years, the full capabilities of the Space Shuttle have been applied to the mission for which the system was originally conceived and uniquely designed: assembly of a large, advanced research station in low-Earth orbit, one which can serve as a critical international research technology test bed to learn how humans can live in space and to prepare for further missions out to the Moon, to Mars, and beyond. The Space Shuttle's final series of missions are essential to the completion of the ISS, a facility with potential for addressing national priorities including education, international cooperation, and economic competitiveness.

Performance Achievement Highlights:

The Space Shuttle safely and successfully completed or exceeded every mission objective, including 4 crew rotations, for all five flights in FY 2009. This was accomplished on budget while overcoming several significant technical problems. Flight STS-126, launched in November 2008, delivered a Multi-Purpose Logistics Module loaded with hardware and supplies to support expansion of the ISS crew size from three to six. STS-126 also repaired the ISS's port Solar Alpha Rotary Joint (SARJ). The 10-foot-wide, wagon-wheel-shaped SARJ allows the electricity-generating solar arrays to track the sun and generate power for the Station. STS-119 launched in March 2009 and focused on the installation of the S-6 starboard truss, the last truss and solar array assembly for the ISS. STS-125 launched in May 2009 to perform the final servicing mission to the Hubble Space Telescope. In this mission, the crew successfully repaired two of Hubble's primary scientific instruments, replaced two other instruments with more advanced capabilities (including the new Wide Field Camera 3 and Cosmic Origins Spectrometer), attached a soft capture mechanism to facilitate eventual de-orbiting of the telescope, and refurbished the telescope's batteries, gyroscopes, guidance sensors, and thermal blankets. STS-127 launched in July 2009 to deliver and install the final pieces of the Japan Aerospace Exploration Agency's (JAXA) Kibo laboratory to provide a way to expose science experiments to the extreme environment of space. Although the Japanese provided this capability and will use it, the facility is available for use by NASA. A payload flown for NASA provided by the Naval Research laboratory is now collecting data from the exposed facility. STS-128 launched in August 2009 to deliver hardware and logistics in support of future ISS assembly and research support.

NASA continues to prepare for the retirement of the Space Shuttle once the Shuttle's role in assembling the ISS is complete. In FY 2009, the Space Shuttle program issued a request for information for final placement of the Space Shuttle Orbiters and Space Shuttle Main Engines after retirement. The program completed the final Space Shuttle Main Engine test at the Stennis Space Center, completed production of the final Main Engine, and continued production work on the last External Tank. The SSP released two Workforce Transition Strategy reports in FY 2009, and continues actively managing workforce reductions consistent with the reduction of Space Shuttle production capabilities.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	NASA Advisory Council	10/2009	Provides independent guidance for the NASA Administrator. No recommendations were provided to SSP at this time.	02/2010
Other	ASAP	10/2009	Provides independent assessments of safety to the NASA Administrator. In their 2008 Annual Report, the Aerospace Safety Advisory Panel (ASAP) stated that they "strongly endorse the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS". NASA will fly the Space Shuttle to complete the International Space Station and then retire the Shuttle.	TBD

Mission Directorate:	Space Operations
Theme:	Space Shuttle
Program:	Space Shuttle Program

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	2,979.5	3,139.4	989.1	86.1	0.0	0.0	0.0
Program Integration	458.5	678.1	284.8	25.1	0.0	0.0	0.0
Flight and Ground Operations	1,037.4	1,035.1	373.2	28.6	0.0	0.0	0.0
Flight Hardware	1,483.6	1,426.2	331.1	32.3	0.0	0.0	0.0
FY 2010 President's Budget Request	2,981.7	3,157.1	382.8	87.8	0.0	0.0	--
Program Integration	489.6	678.1	152.0	22.7	0.0	0.0	--
Flight and Ground Operations	1,031.2	1,035.1	109.5	49.1	0.0	0.0	--
Flight Hardware	1,460.9	1,443.9	121.3	16.0	0.0	0.0	--
Changes from FY 2010 Request	-2.2	-17.7	606.2	-1.7	0.0	0.0	--

Note: NASA will work with the Administration and Congress to determine the highest priority use of the FY 2011 funds if they are not required to fly the Shuttle in the first quarter of FY 2011.

Project Descriptions and Explanation of Changes

Program Integration

The Program Integration budget for mission execution in FY 2011 is focused on maintaining workforce needed to extend operations into the first quarter of the fiscal year, if necessary, to safely complete the existing manifest. The Program Integration budget includes the following: funds for flight software; system engineering, flight operations, and management integration; safety and mission assurance; business management; propulsion system integration; safety and sustainability; payload integration into the Space Shuttle; and systems integration of the Flight Hardware elements through all phases of flight. It provides for the engineering analysis needed to ensure that payloads are safe and meet Space Shuttle interface requirements. Finally, Program Integration includes the necessary mechanical, aerodynamic and avionics engineering tasks to ensure that the launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance and descend to a safe landing through the last Shuttle flight.

The Program Integration budget for transition and retirement (T&R) in FY 2011 is focused on retirement of the Space Shuttle Program (SSP) and the efficient transition of assets to other uses, as applicable to future exploration programs, once they are no longer needed for safe SSP mission execution. It includes the funds needed to ensure the overall safety and efficiency of SSP T&R activities. Similar to mission execution, Program Integration T&R provides for software support, systems engineering, business management, and overall support to the T&R process. Program Integration T&R funding also covers severance and retention costs associated with managing the drawdown of the Space Shuttle workforce.

Flight and Ground Operations

The Flight Operations budget for mission execution in FY 2011 is focused on maintaining workforce needed to extend operations into the first quarter of the fiscal year, if necessary to safely complete the existing manifest. The Flight Operations budget will provide the resources needed to ensure the successful accomplishment of pre-flight planning, mission training, operations control activities, and life sciences operations support for each mission. Flight operations funding also provides for the operation and maintenance of critical mission support facilities including the Mission Control Center, Integrated Training Facility, Integrated Planning System, and the Software Production Facility. The Ground Operations budget provides resources for final integration and checkout of all hardware elements for launch. It also includes coordination with other government agencies and foreign entities for Shuttle landing capabilities. The major launch site operational facilities at the Kennedy Space Center include three Orbiter Processing Facilities, two launch pads, the Vehicle Assembly Building, the Launch Control Center and three Mobile Launcher Platforms (MLP). Ground Operations support capabilities include launch countdown and landing for Space Shuttle missions. Ground support for Shuttle landing includes both the Kennedy Space Center and Edwards Air Force Base runways and multiple contingency landing sites in the United States and other countries. Ground Operations also includes the maintenance and operations of ground infrastructure to support launch and landing through the last Shuttle flight.

The Flight and Ground Operations budget for T&R includes resources needed to identify, process, safe, and transfer flight and ground assets once they are no longer needed for safe SSP mission execution. The T&R budget includes funds needed for assets such as the Mission Control Center, the launch pads, the Vehicle Assembly Building, and the Launch Control Center to prepare these assets for modification, and use for future needs, or transferred to other users or disposed if appropriate.. For assets such as the Mobile Launch Platforms, the Orbiter Processing Facilities, and landing site hardware that NASA no longer needs after Space Shuttle retires, Flight and Ground Operations T&R funding is used to ensure that the property is safed of hazardous materials and ready for either transfer to other Federal government users or disposition.

Flight Hardware

The Flight Hardware budget for mission execution in FY 2011 is focused on maintaining workforce needed to extend operations into the first quarter of the fiscal year, if necessary, to safely complete the manifest. By the end of FY 2010, production of all flight elements required to support the manifest will be completed and only sustaining engineering and mission execution support may be required in the first quarter FY 2011.

The Flight Hardware budget for T&R includes resources needed to identify, process, safe, and transfer flight hardware assets once they are no longer needed for safe SSP mission execution. For Orbiter, these costs include safing the vehicles of hazardous materials. For the main engines, these costs also include safing and transportation preparation activities for components from both the current fleet of flight engines as well as older engines that are no longer used for flight but would be available for use or display. The flight hardware T&R budget also covers the costs of dispositioning Orbiter, Space Shuttle Main Engine, External Tank, and Reusable Solid Rocket Motor production tooling that NASA no longer needs once the Space Shuttle fleet is retired.

Mission Directorate:	Space Operations
Theme:	Space Shuttle
Program:	Space Shuttle Program

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Safely complete manifest by the end of FY2010, but fly into FY2011 if necessary to complete manifest.	The Space Shuttle Program	Added an additional 3 months of operations funding so the program can be safely and affordably completed by the end of CY 2010 if necessary.

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
Program Integration (Planned end date is September 2010, but funding is requested to fly through December 2010 if necessary.)																	Tech		
																	Form		
																	Dev		
																	Ops	Dec-04	Dec-10
																	Res		
Flight and Ground Operations (Planned end date is September 2010, but funding is requested to fly through December 2010 if necessary.)																	Tech		
																	Form		
																	Dev		
																	Ops	Dec-04	Dec-10
																	Res		
Flight Hardware (Planned end date is September 2010, but funding is requested to fly through December 2010 if necessary.)																	Tech		
																	Form		
																	Dev		
																	Ops	Dec-04	Dec-10
																	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Space Operations
Theme:	Space Shuttle
Program:	Space Shuttle Program

Program Management

The Space Shuttle Program Manager reports to the Associate Administrator for Space Operations at NASA Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Program Integration	Johnson Space Center	Johnson Space Center	N/A
Flight and Ground Operations	Kennedy Space Center	Kennedy Space Center and Johnson Space Center	N/A
Flight Hardware	Johnson Space Center	Johnson Space Center and Marshall Space Flight Center	N/A

Acquisition Strategy

The Space Program Operations Contract (SPOC) prime contractor is United Space Alliance. Other prime contractors providing flight hardware are ATK Thiokol (Reusable Solid Rocket Motor), Lockheed Martin (External Tank), and Pratt & Whitney Rocketdyne (Space Shuttle Main Engines).

Mission Directorate:	Space Operations
Theme:	International Space Station

Theme Overview

The ISS orbits the Earth 16 times a day at an altitude that ranges from 230 to 286 miles and at a speed of 17,500 miles per hour. The ISS is a research and development (R&D) test bed. It is an experiment in the design, development, and assembly of an orbital space facility. It serves as a habitat for its crew, a command post for orbital operations, and a port for the rendezvous and berthing of smaller orbiting vehicles. It functions as an orbital microgravity and life sciences laboratory, a test bed for new technologies in areas like life support and robotics, a platform for astronomical and Earth observations, and a market and destination for the burgeoning commercial crew and cargo transportation industry. ISS has been continuously crewed since November 2000. Through CY 2009, there have been 93 United States and International Partner flights to the ISS, including flights for assembly, crew rotation, and logistical support. At assembly complete, the ISS will be composed of approximately 1,000,000 pounds of hardware brought to orbit in approximately 40 separate launches over the course of more than a decade. The ISS is the largest human-made object ever to orbit Earth.

The ISS Program represents an unprecedented level of international cooperation. The ISS international partnership is composed of NASA, the Russian Federal Space Agency (Roscosmos), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the Japanese Aerospace Exploration Agency (JAXA). International participation in the program has significantly enhanced the capabilities of the ISS.

ISS will be extended beyond 2016, likely through 2020 or beyond, to fully utilize the orbiting facility as a basic research facility, a testbed for exploration technology development and demonstrations, and a market/destination for commercial crew and cargo transportation services. The FY 2011 budget provides $2.5 billion in additional funding to support these robust efforts, and to initiate activities to increase ISS functionality.

NASA has secured partnerships with other United States Government agencies and private firms to utilize a portion of the ISS as a National Laboratory, as designated by the NASA Authorization Act of 2005. NASA's plan for the ISS National Laboratory, the National Lab Report, was submitted to Congress in May 2007. Approximately 50 percent of planned U.S. utilization resources and accommodations on ISS could be available for non-NASA use. Firm interest in ISS use has been demonstrated in the areas of education, human, plant and animal biotechnologies, aerospace technologies, and defense sciences research. NASA has signed Memoranda of Understanding (MOUs) for use of the ISS with the National Institutes of Health and the Department of Agriculture, and has pre-existing agreements with the Department of Energy, the Department of Defense and the National Science Foundation. In addition, NASA re-issued an announcement of "Opportunity for Use of the ISS by Non-Government Entities for Research and Development and Industrial Processing Purposes" in August 2009. To date, NASA has entered into Space Act Agreements (SAA) with 4 private firms and a university. Additional MOUs and SAAs are in various stages of discussion. In addition, current basic research on ISS has been augmented by providing funding within ISS for basic science and engineering research.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**2,060.2**	**2,317.0**	**2,779.8**	**2,983.6**	**3,129.4**	**3,221.9**	**3,182.8**
International Space Station Program	2,060.2	2,317.0	2,779.8	2,983.6	3,129.4	3,221.9	3,182.8
FY 2010 President's Budget Request	**2,060.2**	**2,267.0**	**2,548.2**	**2,651.6**	**2,568.9**	**2,405.9**	**--**
International Space Station Program	2,060.2	2,267.0	2,548.2	2,651.6	2,568.9	2,405.9	--
Total Change from FY 2010 Request	**0.0**	**50.0**	**231.5**	**332.0**	**560.5**	**816.0**	**--**

Plans for FY 2011

International Space Station Program

Post assembly complete, having fulfilled its international partner agreements to launch and outfit their modules, NASA will focus on increasing research, continuing safe operations, and utilizing space station to its full capacity as a testbed for exploration technology demonstrations and development. These efforts are intended to revitalize, enhance, and augment the ISS program and are discussed below.

Section 206 of the National Aeronautics and Space Administration Authorization Act of 2008 states "The Administrator shall take all necessary steps to ensure that the International Space Station remains a viable and productive facility capable of potential United States utilization through at least 2020 and shall take no steps that would preclude its continued operation and utilization by the United States after 2015." The FY 2011 budget request provides funding for work required to extend and maximize utilization of ISS, likely through at least 2020.

NASA will invest in the Space Station facility itself by initiating new activities to revitalize ISS and increase functionality. The activities are intended to support ISS upgrade efforts while proving new space technologies, reducing costs, and increasing functionality. Potential objectives include reducing demands on crew time, lowering ground-based costs, mitigating capabilities lost when the Shuttle retires, improving ISS capabilities, improving ISS safety, and supporting activities benefiting future human spaceflight programs.

The Commercial Resupply Service (CRS) contracts awarded to Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation (OSC) will provide commercial resupply flights beginning in FY 2011. The Exploration Systems Mission Directorate has budgeted $312 million for additional incentives for NASA's current domestic commercial cargo service providers. Cargo transportation to ISS will also be supplemented by the Japanese HII Transfer Vehicle (HTV), European Automated Transfer Vehicle (ATV) and Russian Progress flights. Crew transportation and rescue will be provided by the Russian Soyuz vehicle until domestic transportation providers are available. The Exploration budget includes $6 billion over five years to support this effort.

As we embark on the full utilization phase, the ISS will be utilized to conduct multidisciplinary research and technology development and operate as an outpost for human exploration. In FY 2011, NASA will begin operations on new external unpressurized payloads including the Alpha Magnetic Spectrometer (AMS) particle physics detector, a communications navigation and networking demonstration, and an advanced materials technology testbed.

Additionally, internal pressurized payloads will include ongoing studies to support NASA's human research program for exploration. NASA will continue National Laboratory collaborations with the National Institutes of Health (NIH), Department of Defense (DoD), Department of Energy (DOE), National Science Foundation (NSF); private industry collaborations with Astrogenetix, Inc. and Ad Astra Rocket Company; collaborations with academic institutions University of Colorado-Bioserve; and interagency collaborations on Science, Technology, Engineering, and Mathematics (STEM) education.

The ISS will be used as a major asset for demonstrating technologies and capabilities that are funded and operated within both the Space Technology Office and the Exploration Systems Mission Directorate. The goal is to enhance the Nation's ability to operate future human spaceflight activities and make space exploration more affordable and effective. In addition to the ISS research funding in other programs, beginning in FY 2011, ISS Operations will have funding to assist in National Laboratory research and fund engineering research consistent with Agency overall research objectives.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's mission is to pioneer the future in space exploration, scientific discovery, and aeronautics research. The ISS objective is to support scientific research and the development of new technologies and capabilities for human space exploration and other activities requiring the unique attributes of humans in space. Consistent with NASA's objectives, ISS research is focused on science and technology development that will prepare human explorers and spacecraft to travel beyond low-Earth orbit (LEO). Research aboard the ISS is critical to understand the effects of space environments on the human body and develop mitigation techniques, minimize the logistical burden of supporting humans far from Earth, address remote medical emergencies, and demonstrate enabling technologies for human exploration. NASA and the International Partners are applying the information learned to plan for future human and robotic missions. Techniques demonstrated in robotics, assembly, and maintainability on the ISS will guide development of next-generation space vehicles that will fly farther, faster, and for longer duration.

Research conducted on ISS in its role as a National Laboratory by other U.S. government agencies, private firms and universities will yield important new data applicable to their respective missions in human health, energy and the environment. The ISS also promotes the commercial space transportation industry by providing a market for crew and cargo transportation. The ISS partnership also provides a successful example of peaceful and constructive international cooperation that provides tangible benefits here on earth.

The FY 2011 budget revitalizes and strengthens the ISS program by ensuring increased functionality that will allow ISS to meet its full potential, and by augmenting the program to pursue additional basic and applied research.

Relevance to education and public benefits:

The benefits of ISS research cross all areas of American life, including public health, energy, environment, education, and promoting international cooperation. Specific examples include: new uses of ultrasound technology; embedded Web technology to allow remote monitoring and control of devices through a computer and Web browser; and, work to help researchers understand and mitigate muscle, balance, and bone problems.

Research performed on the ISS will contribute to a broader understanding of injury and disease in support of Earth-based medical applications. For example, a new vaccine for salmonella-induced infectious disease has been identified through ISS research and an investigational new drug (IND) classification will be applied for under Food and Drug Administration (FDA) approval. Ongoing investigations are being focused on a vaccine for methicillin-resistant staphylococcus aureas (MRSA), which has been responsible for over 19,000 deaths per year in the U.S. according to the Centers for Disease Control.

The ISS, an exploration research and technology test bed, will be used to develop and demonstrate, among other things, closed loop life support systems and remote medical care capabilities. Both technologies can be used to benefit people here on Earth. For example, water recycling technology is being used to provide potable water to places devastated by natural disasters. NASA will also demonstrate technologies on the ISS necessary for future space systems such as thermal control, environmental control, and power generation. As an earth observing platform, the onboard crew utilizes the ISS as a low-cost platform to monitor and record natural and human-driven changes and events on earth.

Performance Achievement Highlights:

November 2, 2008 represented completion of the eighth year of continuous human presence in space on the ISS. The ISS celebrated the 10th anniversary of the first element on orbit, Zarya, on November 20, 2008. In November 2008, ULF2 was launched delivering a galley, Crew Quarters, Waste and Hygiene Compartment, and Water Recovery System (WRS) among other equipment necessary to increase ISS crew size to six. The Water Recovery System recycles urine and condensate into drinking and coolant water, and helps reduce water upmass requirements after Shuttle retirement. As part of the Regenerative Environmental Control and Life Support System, WRS takes an important step toward the self sustaining crew support systems needed for long duration spaceflight beyond low Earth orbit. First drink of reprocessed water occurred on May 20, 2009. In March 2009, Flight15A added the S6 Truss and solar array completing assembly of the ISS power system. ISS six crew operations began with the docking of Soyuz 19S on May 29, 2009.

In July 2009, Flight 2J/A delivered the final JAXA segment, the Kibo Exposed Facility (EF) completing assembly of International Partner laboratories. Flight 17A, in August 2009, delivered about 15,500 pounds of pressurized cargo including three racks of research equipment, and additional crew habitation and environmental control equipment. This flight also delivered the Combined Operational Load Bearing External Resistance Treadmill (COLBERT).

JAXA launched the first H-II Transfer Vehicle (HTV) in September 2009 which was successfully captured and berthed to the ISS. HTV will contribute to the effort of resupplying the ISS when the Space Shuttle retires.

The ISS program continued processing activities, ground testing, and integration of flight hardware for future missions, while operating and monitoring the health of the vehicle systems and conducting operations. One hundred and six research experiments were conducted on ISS in FY 2009. During this period ISS crews were supported by re-supply and crew rotation using the Space Shuttle, the HTV and four Russian Progress and four Russian Soyuz vehicles. Ground training is ongoing for future flight crews, and ISS is continuing to conduct ISS-based Extravehicular Activities (EVAs) for ISS maintenance, science, and assembly. More detailed information may be found at http://www.nasa.gov/mission_pages/station/main/index.html."

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	ISS Advisory Committee	10/2009	Assess ISS operational readiness to support new crew, assess Russian flight team preparedness to accommodate the Expedition 15 mission, and assess health and flight readiness of Expedition 15 crew.	Ongoing
Other	NASA Advisory Council (NAC)	10/2009	Provides independent guidance for the NASA Administrator. The NAC was briefed by the JSC Safety and Mission Assurance Office on NASA Lessons Learned program. The Space Operations committee made two recommendations on NASA utilization of known Lessons Learned, including expanding the teaching aspect.	02/2010
Other	ASAP	10/2009	Provides independent assessments of safety to the NASA Administrator. No recommendations nor inquiries issued relating to the ISS.	02/2010
Other	Program Implementation Review	08/2008	Provides an independent review of ongoing ISS and SSP operations. The report cited concerns on budget resources which have been addressed in this budget and in cargo transportation availability post Shuttle.	2010

Mission Directorate:	Space Operations
Theme:	International Space Station
Program:	International Space Station Program

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**2,060.2**	**2,317.0**	**2,779.8**	**2,983.6**	**3,129.4**	**3,221.9**	**3,182.8**
ISS Operations	**1,594.9**	**1,689.0**	**1,923.0**	**1,797.8**	**1,903.9**	**1,934.2**	**1,971.2**
ISS Cargo Crew Services	**465.2**	**628.0**	**856.8**	**1,185.7**	**1,225.5**	**1,287.6**	**1,211.6**
FY 2010 President's Budget Request	**2,060.2**	**2,267.0**	**2,548.2**	**2,651.6**	**2,568.9**	**2,405.9**	**--**
ISS Operations	**1,755.4**	**1,639.0**	**1,717.3**	**1,513.9**	**1,437.8**	**1,449.0**	**--**
ISS Cargo Crew Services	**304.8**	**628.0**	**830.9**	**1,137.7**	**1,131.1**	**956.9**	**--**
Changes from FY 2010 Request	**0.0**	**50.0**	**231.5**	**332.0**	**560.5**	**816.0**	**--**

Project Descriptions and Explanation of Changes

Operations

The ISS Program brings together international flight crews; globally distributed launch, operations, training, engineering, and development facilities; communications networks; and the international scientific research community. Operating ISS is often more complicated than other space flight endeavors because of its many international partner components. Each ISS partner has the primary responsibility to manage and run the hardware it provides, but the various elements provided by the partners are not independent and they must be operated by NASA as an integrated system. The FY 2011 budget provides funds for work required to extend ISS Operations and support full utilization, likely through at least CY 2020 including: recertification of ISS structures; purchase of additional spares and consumables; extension of baseline operational services; enabling services for National Laboratory partnerships; and initiation of activities to increase functionality intended to support ISS upgrade efforts while proving new space technologies, reducing costs, and increasing available research capacity. ISS Operations encompasses several key functions necessary to plan, control and execute the ISS Program. The ISS Systems Engineering, Analysis and Integration function entails optimization of the system architecture, integrated system performance and verification analyses, tracking of vehicle configuration, interface requirements, and mission design. The Spacecraft function is responsible for maintaining the ISS on orbit in a fully crewed and mission-ready mode. The Safety & Mission Assurance function implements safety, reliability, maintainability, and quality assurance requirements to ensure that all significant risks are reviewed, tracked, and mitigated so that ISS is safe, reliable, and fully operational.

Having completed assembly, all of U.S. and International Partner elements and established six-person crew capability, the ISS Program focus will turn to utilization beginning in FY 2011. Current basic research on ISS has been augmented by providing funding within ISS for science and engineering research, including some funding to cover additional transportation costs for non-NASA users. Plans will be finalized to establish an independent organization with responsibility to further develop national uses of the ISS through partnerships with other U.S. government agencies, private firms and non-profit institutions. Research opportunities will then be expanded to conduct research in life sciences, material sciences, biotechnologies, condensed matter physics and thermal sciences (fluid mechanics, thermodynamics, heat transfer and combustion). The ISS Program will also continue pursuit of its primary research objective to serve as a test bed for the development and demonstration of technology for future space exploration missions. The Multi-User Systems Support (MUSS) function is responsible for projecting available utilization resources and accommodations, tactical planning and execution of the day-today ISS integrated research plan. This function manages all payload physical, analytical and operations integration activities.

During FY 2011, ISS Operations will establish an independent organization to further develop and facilitate national uses of the ISS, as well as to assist users and integrate the overall U.S. utilization strategy. The goals of this organization will be to act as a single entry point to allow users to interface efficiently with the Space Station; assist researchers in developing experiments, in meeting safety and integration rules, and in acting as an ombudsman on researchers' behalf; perform outreach to draw in researchers and to disseminate the results of ISS research activities; and further develop online ISS information materials to provide easy access to details about laboratory facilities, available research hardware, resource constraints, etc.

Mission Directorate:	Space Operations
Theme:	International Space Station
Program:	International Space Station Program

ISS Cargo Crew Services

The ISS Cargo Crew Services budget supports cargo and crew transportation to and from ISS. It funds services provided by International Partners and commercial purchases. NASA has contracted with Roscosmos to purchase cargo transportation through CY 2011 and crew transportation through CY 2012. The ISS Program plans to purchase crew transportation services from Russia as needed until a domestic capability is available. NASA has also contracted with domestic companies to provide cargo supply and cargo return services beginning in CY 2011 via the Commercial Resupply Services (CRS) contract. NASA does not plan to purchase any cargo services from Russia after CY 2011. The FY 2011 budget provides for the acquisition of cargo transportation through CY 2020, including cargo transportation for National Laboratory research payloads.   In addition, the Exploration Systems Mission Directorate (ESMD) has budgeted $6 billion over the next five years to develop U.S. commercial crew transportation which will ultimately be utilized by ISS.

Operations (Continued)

Other key operational activities include Mission Integration and Operations, Medical Support, and Launch Site processing.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
ISS Assembly complete by 2010	International Space Station (ISS)	Same

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
ISS (extend beyond 2016, likely to 2020 or beyond)																	Tech		
																	Form		
																	Dev	Oct-93	Sep-07
																	Ops	Oct-07	Sep-20
																	Res	Oct-11	Sep-20

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The ISS Program Manager reports to the Associate Administrator for Space Operations at NASA Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
On-orbit assembly and operations	NASA Johnson Space Center	NASA Johnson Space Center	Russian Federal Space Agency, European Space Agency, Japan Aerospace Exploration Agency, Canadian Space Agency, and Italian Space Agency (ASI).

Mission Directorate:	Space Operations
Theme:	International Space Station
Program:	International Space Station Program

Acquisition Strategy

NASA extended the Boeing U.S. On-Orbit Segment (USOS) contract until September 30, 2010; a follow-on extension is currently in process. NASA has also exercised the final options under the Cargo Mission Contract (CMC) and the Mission Integration Contract (MIC) for ongoing services through September 2010 and is in the process of re-competing these services. The Program Integration Contract (PIC) was awarded earlier this year for services beginning in October, 2009 and continuing for up to five years.

NASA awarded commercial cargo transportation services to Space Exploration Technologies Corporation (Space X) and Orbital Sciences Corporation through the CRS contracts on December 23, 2008. Initial activities have begun for cargo services beginning as early as CY 2011, with services available until early 2016. NASA has also extended its contract with Roscosmos to purchase crew launches through CY 2012 and crew rescue and return through mid 2013 and plans to continue to purchase Russian crew transportation services until a domestic capability is available. The Exploration Systems Mission Directorate (ESMD) has budgeted $312 million for additional incentives for NASA's current domestic commercial cargo service providers, and $6 billion over five years to develop commercial crew transportation.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)

Theme Overview

As explorers, pioneers and innovators, NASA boldly expands frontiers to inspire and serve America and to benefit the quality of life on Earth. Space and Flight Support (SFS) provides multiple Agency-level capabilities that enable exploration and science.

The Space Communications and Navigation (SCaN) Program is a vital element of the underlying support structure needed to conduct exploration and science. SCaN manages multiple space communication networks including the Deep Space Network, the Space Network, the Near Earth Network and also provides the support functions to regulate, maintain, and grow NASA's space communication and navigation capabilities in support of all NASA's space missions. Whether NASA missions are providing data about our home planet, focusing science instruments on cosmic phenomena or exploring far regions in space, reliable communication with Earth-based control centers is critical to mission success. As new spacecraft with different objectives and advanced technology are launched, the communication needs change. In response, NASA modifies and evolves its space communications capabilities to ensure Agency mission needs are fulfilled.

NASA has assigned responsibility for understanding the full range of civil space launch needs to the Launch Services Program (LSP). LSP works closely with other government agencies and the launch industry, seeking to ensure that safe, reliable, on-time and cost-effective launch opportunities are available on a wide range of launch systems.

The 21st Century Space Launch Complex Program at the Kennedy Space Center (KSC) is being established in the SFS Theme to transform KSC and Cape Canaveral Air Force Station into modern facilities poised to play a key role in 21st century space exploration. Focused on benefiting NASA's current and future operations at KSC, these operations will include NASA test flights, commercial cargo flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads, and robotic precursor missions. These upgrades will additionally help to improve KSC launch operations for future and current non NASA users of the range. It will also include consolidating and disposing of unused or underutilized facilites, and performing environmental work to improve the surrounding area.

The Rocket Propulsion Test (RPT) Program reviews, approves and provides direction on rocket propulsion test assignments, capital asset improvements, test facility modernization and refurbishments, integration for multi-site test activities, identification and protection of core capabilities and the advancement and development of test technologies.

The Human Space Flight Operations (HSFO) Program provides multi-program capabilities that support all current SOMD programs and future exploration activities. HSFO is comprised of the Space Flight Crew Operations (SFCO) and Crew Health and Safety (CHS). SFCO provides trained crew members for all NASA human space flight endeavors and is responsible for all JSC aircraft operations including aircrew training. The care of the Astronaut Corps is the responsibility of space medical operations at the Johnson Space Center. A portion of these responsibilities are managed within CHS which is realigned to HSFO beginning in FY 2011. CHS enables healthy and productive crew during all phases of space flight missions; implementation of a comprehensive health care program for astronauts; and the prevention and mitigation of negative long-term health consequences of spaceflight. NASA will also enlist the National Research Council (NRC) to conduct an independent study of the activities funded within NASA's Human Space Flight Operations program office to focus on the requirements, post-Shuttle retirement, including the role and size of the astronaut corps, crew related facility requirements, and the most cost effective means to support NASA's new human spaceflight program.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**725.0**	**724.2**	**1,119.0**	**1,220.6**	**1,123.9**	**1,140.7**	**947.7**
21st Century Space Launch Complex	0.0	0.0	428.6	500.0	400.0	400.0	200.0
Space Communications and Navigation	582.9	485.3	452.9	478.0	479.5	488.4	489.6
Human Space Flight Operations	0.0	102.3	114.4	115.8	117.7	118.1	121.0
Launch Services	91.7	83.8	78.9	82.6	82.5	86.0	87.9
Rocket Propulsion Test	41.8	44.3	44.3	44.2	44.2	48.2	49.2
Crew Health & Safety	8.6	8.6	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**722.8**	**751.5**	**732.7**	**745.9**	**749.7**	**748.9**	**--**
Space Communications and Navigation	582.9	496.6	506.9	520.3	524.0	524.0	--
Human Space Flight Operations	0.0	114.7	88.5	88.6	88.7	89.0	--
Launch Services	89.6	85.9	84.1	83.9	83.9	82.8	--
Rocket Propulsion Test	41.8	45.8	44.6	44.5	44.5	44.5	--
Crew Health & Safety	8.6	8.6	8.5	8.5	8.5	8.5	--
Total Change from FY 2010 Request	**2.2**	**-27.3**	**386.2**	**474.6**	**374.2**	**391.8**	**--**

Plans for FY 2011

21st Century Space Launch Complex

Efforts for the 21st Century Space Launch Complex Program are intended to benefit NASA's current and future operations at the KSC, but also to enhance the capabilities for non NASA users of the range. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, and transforming KSC into a modern facility that is well positioned to support the next century of space exploration. Areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities; relocating the KSC perimeter to facilitate certain private sector activities and operations; environmental remediation; and supporting the modernization of the launch range capabilities.

Space Communications and Navigation

In FY 2011, the SCaN Program will continue to successfully provide space communications and navigation capabilities to all missions and continue to define future communications requirements. SCaN will also continue to advance cross support opportunities with foreign space agencies through the definition and adoption of common standards and protocols, as well as proceed with the implementation of infrastructure upgrades and continue the development of enabling capabilities and technologies. Milestones to be completed in FY 2011 include completion of the SRR for the Space Network Ground Segment Sustainment Project, completion of the CDR for the Tracking and Data Relay Satellite (TDRS) K&L, completion of the CDR for the Optical Communication System payload Lunar Laser Communication Demonstration (LLCD), installation of the Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) on ISS and begin procurement of a 34m antenna to increase the robustness of the Deep Space Network.

Human Space Flight Operations

HSFO is comprised of SFCO and CHS. For FY 2011, SFCO will provide crew expertise for future vehicle development and will support the manifested Shuttle Program requirements as well as four ISS long-duration crew rotation missions by providing and maintaining an adequate number of astronauts with appropriate skills and experience. This will be accomplished by maintaining safe and effective aircraft operation, supporting human space flight program activities such as boards, and technical evaluations that require operational input and expertise, and representing NASA to the public directly and through media. Also under HSFO, CHS will work to identify necessary medical capabilities including the identification and development of cost efficient clinical care capabilities. NASA will enlist the National Research Council (NRC) to conduct an independent study of the activities funded within NASA's Human Space Flight Operations program. The study will focus on the role and size of the human spaceflight office in the post Space Shuttle retirement and Space Station assembly environment; the crew-related facility, aircraft and training requirements to support the astronaut corps' for the requirements of NASA's new human spaceflight program, and the more cost-effective means of meeting these requirements. Initiation of the study will commence as soon as possible.

Launch Services

The LSP program has six planned NASA launches including: 1) Glory, which will be launched on a Taurus XL; 2) Aquarius on a Delta II;3) Juno on an Atlas V; 4) Nuclear Spectroscopic Telescope Array (NuSTAR) on a Pegasus XL; 5) NPOESS Preparatory Project (NPP) on a Delta II and 6) the Gravity Recovery and Interior Laboratory (GRAIL) mission, the last mission to be launched on a Delta II. In addition to processing, mission analysis, spacecraft integration and launch services of the above missions, LSP will continue to provide support for the development and certification of emerging launch services.

Rocket Propulsion Test

RPT will continue to provide test facility management, and provide maintenance, sustaining engineering, operations, and facility modernization projects necessary to keep the test-related facilities in the appropriate state of operational readiness. RPT continues to use the established testing requirements from all of the RPT customers to identify excess and "at-risk" test facilities and will support decisions relative to test asset consolidation initiatives.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The SFS theme provides the enabling capabilities required to advance space exploration and expand scientific knowledge of Earth and the universe. Without these capabilities NASA could not perform any of its missions.

The SCaN Program provides able and dependable space communications and navigation capabilities vital to successfully conduct human and robotic space missions.

The LSP enables access to space for NASA and other select government missions. The LSP provides safe, reliable, cost-effective, and on-time commercial launch services for NASA and NASA-sponsored payloads using expendable launch vehicles.

The RPT capabilities continue to support safe operation of the Space Shuttle through retirement, and provide test facilities for use by other DOD and commercial programs.

SFCO provides trained crew members for all NASA human space flight endeavors, brings expertise to resolve operational or development issues and plays a major role in the public advocacy of human space flight. CHS provides enhancements to the health care provision environment both in space and on the ground for the Astronaut Corps. CHS contributes to the medical and health certification of astronauts before flight and the provision of care throughout their careers.

Relevance to education and public benefits:

The benefits of SFS to education and the public includes the return of scientific and educational data from space to Earth; the safe launching of expendable launch vehicles necessary for research; the assurance that rocket systems have been adequately tested; and the testing and implementation of various human health and illness prevention measures. A space program properly supported by this Theme will produce research data that can be used to generate new scientific knowledge through the study of heliophysics, astrophysics, solar system exploration, Earth science, biological and physical research, and more.

SFCO provides support to the NASA Education Outreach program by assigning astronauts for requested appearances and supplying the accompanying presentation materials. Astronauts support numerous public appearances with a variety of groups to disseminate information to the general public regarding current and future space missions. These appearances had a major impact on the spread of information about the space program and the development of critical relationships that help NASA programs.

Performance Achievement Highlights:

SCaN has successfully provided space communications services to over 80 NASA and non-NASA missions meeting or exceeding the SCaN proficiency metric despite aging network infrastructure and hardware obsolescence. SCaN successfully completed the PDR, the Non-Advocate Review (NAR) and the Sub-System PDR for TDRS K & L. In September 2009, SCaN initiated a request for proposal (RFP) for the Space Network Ground Segment Sustainment (SGSS) contract and plans to award the contract by June 2010. The SGSS will replace aging and obsolete infrastructure and move the network into an integrated architecture thus reducing operational costs. Studies have also been completed for the Deep Space Network 70-meter antenna replacement effort and plans for the 34-meter phased array antenna system are being initiated. SCaN successfully completed the CoNNeCT PDR in September 2009, This test bed will become NASA's orbiting Space Communications and Navigation National Laboratory on ISS and will be used to validate new flexible technology enabling greater spacecraft productivity.

In calendar year 2009, there were seven successful NASA/LSP launches including; NOAA-N, Kepler, STSS ATRR, LRO/LCROSS, STSS DEMO and WISE and one unsuccessful launch of the OCO satellite. NASA/LSP also served in an advisory role for the GOES-O mission.   Also in FY 2009, the ISS Program Commercial Resupply Services (CRS) contract was issued. Contract terms and deliverables are included for the LSP evaluation of the launch vehicles to be used to resupply the space station. The LSP has begun initial technical exchanges with SpaceX under the CRS contract. Furthermore, two Space Act Agreements (SAAs) have been established by LSP, one is for Taurus II, and the second with ATK for their SLV A and B small launch vehicles. Technical exchanges between LSP and ATK have been initiated in FY 2009 as a result of this SAA.

The Rocket Propulsion Test Program (RPT) continued to maintain the Agency's ability to safely test rocket propulsion systems by evaluating requirements and focusing resources to complete those requirements. To assure the accuracy of requirements, RPT has maintained close coordination with NASA and the Department of Defense (DOD) programs.

SFCO provided trained crew members to successfully complete five Space Shuttle missions. SFCO also provided trained crew members to successfully complete three long-duration crew rotation missions on the ISS and provided space flight readiness training in support of future Space Shuttle and ISS long-duration flights on the space flight manifest. Lastly, SFCO completed over 460 appearances to the public on behalf of the Agency in support of public outreach. CHS further enhanced the Longitudinal Study of Astronaut Health (LSAH) and implemented a system to enable flight surgeons easy access to analysis of medical requirements. CHS has also continued to identify and leverage the development of clinical care capabilities such as ultrasound units and is developing new technologies such as the Lightweight Trauma Module for hazardous and/or extreme environments ranging from the battlefield to space exploration use.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	21st Century Space Launch Complex

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**0.0**	**428.6**	**500.0**	**400.0**	**400.0**	**200.0**
21st Century Space Launch Complex	**0.0**	**0.0**	**428.6**	**500.0**	**400.0**	**400.0**	**200.0**
Changes from FY 2010 Request	**0.0**	**0.0**	**428.6**	**500.0**	**400.0**	**400.0**	**--**

Program Overview

This funding establishes a 21st Century Space Launch Complex Program at Kennedy Space Center (KSC) and the Florida launch range. This effort will benefit both NASA's current and future operations at the KSC, as well as help to improve KSC launch operations for future and current non NASA users of the range. Working with other users of the Florida launch range, the goal is to transform KSC into a modern facility poised to play a key role in 21st century space exploration. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, such as commercial cargo flights and future commercial crew flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads and robotic precursor missions. Additional areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities through capacity increases, improvement, and modernization, in addition to potentially relocating the KSC perimeter where appropriate and feasible, to enable certain existing private sector facilities to lie outside the security perimeter, thus making it far more convenient to use those facilities; environmental remediation to reduce the impact on the surrounding areas; and supporting the modernization of the launch range capabilities.

Plans For FY 2011

Efforts for the 21st Century Space Launch Complex Program are intended to benefit NASA's current and future operations at the KSC, but also to enhance the capabilities for non NASA users of the range. Working closely with other users of the range, this new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, and transforming KSC into a modern facility. Areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities; relocating the KSC perimeter to facilitate certain private sector activities and operations; environmental remediation; and supporting the modernization of the launch range capabilities. Implementation will be targeted to achieve increased operational efficiency and reduced launch costs not only for NASA, but also for other users of these facilities. The program will encompass overall launch and processing operations. We will be working closely with the KSC, the USAF, FAA, and the space user community to develop a plan that includes specific requirements, as well as a list of ongoing or future projects to which NASA may contribute and build upon.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	582.9	485.3	452.9	478.0	479.5	488.4	489.6
Space Communications Networks	342.2	372.8	371.2	404.7	412.3	429.2	436.1
Space Communications Support	86.7	86.6	62.6	50.7	53.8	59.2	53.5
TDRS Replenishment	154.0	26.0	19.0	22.6	13.4	0.0	0.0
FY 2010 President's Budget Request	582.9	496.6	506.9	520.3	524.0	524.0	--
Space Communications Networks	363.5	427.2	423.0	440.8	431.1	444.3	--
Space Communications Support	65.4	43.4	64.9	56.9	79.5	79.7	--
TDRS Replenishment	154.0	26.0	19.0	22.6	13.4	0.0	--
Changes from FY 2010 Request	0.0	-11.3	-54.0	-42.3	-44.5	-35.6	--

Note: The FY 2011 President's Budget request numbers in the FY 2010 column reflects the Initial Operating Plan budget numbers to be submitted to Congress.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation

Program Overview

Today's spacecraft are increasingly more powerful, complex, and capable of acquiring increasing amounts of mission data. They can also employ artificial intelligence enabling autonomous decisions. However complex and sophisticated these machines have become, two key functions have not changed: the need to communicate with Earth and to navigate in space. A failure of space communications and navigation on the spacecraft or on Earth could result in a complete loss of a mission. Hence, space communications and navigation is a fundamental capability of missions that depends on a high quality of hardware and software present on the spacecraft and the ground.

NASA's space communications and navigation capabilities rely on ground-based and space-based assets that enable near Earth and deep space missions, as well as those of the other U.S. agencies and of our international partners. These national assets are managed as dedicated projects within the Space Communications and Navigation (SCaN) program. The SCaN program manages these assets for the Agency and provides a cost efficient approach to effectively meeting all missions' needs throughout all stages of their life.

SCaN is also responsible for all Spectrum Management and Data Standards policy, oversight and management for the Agency. It represents NASA before all domestic and international regulatory or technical bodies dealing with Spectrum and/or Data Standards, thus providing NASA with an integrated approach to promoting and safeguarding its SCaN equities and interests. Additionally, SCaN leads all NASA activities associated with present and future navigation technology and capabilities such as supporting spacecraft tracking and position determination.

These seemingly disparate functions, sustainment of existing assets, technology development, spectrum management, and international standards, are integrated through a robust System Engineering and Integration (SE&I) activity to assure uninterrupted SCaN capabilities and to avoid loss of or any impact to science or exploration missions. In addition, SE&I also conducts long-range planning based on projected mission needs and identifies technical performance targets for new technologies such as Disruption Tolerant Networking (DTN), Optical Communications, and Software Defined Radio.

By planning, developing, operating, and maintaining space and ground networks of tracking and data systems, SCaN services the Nation's space missions, both crewed and robotic, from low Earth orbit to the fringes of the solar system.

For more information, please see https://www.spacecomm.nasa.gov/spacecomm/.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation

Plans For FY 2011

The SCaN Program will award the contract for the Space Network Ground Segment Sustainment (SGSS) by June 2010 and will conduct the System Requirement Review for this project. The implementation of the SGSS will be in full swing in FY 2011 with an expected completion by FY 2015. The SGSS will introduce a concept of operations and new technology that will enable integration of all NASA assets into a unified and integrated network with robust capabilities critical to meeting evolving NASA mission needs in science and exploration, through the next decade and beyond. SCan will continue to work towards the demonstration of Disruption Tolerant Networking (DTN) on ISS and Extrasolar Planet Observatory and Deep Impact Extended Investigation (EPOXI). SCaN will complete the Critical Design Review (CDR) for both the Tracking and Data Relay Satellite (TDRS) K &L and for the Optical Communications Systems payload Lunar Laser Communications Demonstration (LLCD) manifested on the Lunar Atmosphere and Dust Environment Explorer (LADEE) and their implementation will be well underway in FY 2011. SCaN will also have begun the procurement of 34m antennas to replace the aging Deep Space Network (DSN) 70m antennas in a scalable array configuration designed to provide maximum flexibility and robustness as well as substantial increase of capabilities and support to DSN users. The Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) will be installed on ISS during FY 2011.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation

Project Descriptions and Explanation of Changes

Space Communications Networks

Deep Space Network (DSN): The DSN consists of three facilities spaced approximately 120 degrees apart on the globe to enable continuous communications to spacecraft as the Earth rotates. The facilities are located in Spain, Australia, and California. DSN stations are NASA-owned assets managed by the DSN Project Office at the Jet Propulsion Laboratory. To maintain facility assets, SCaN utilizes Construction of Facilities (CoF) funding to provide minor revitalization of the three DSN facilities. A list of the total COF projects are included in the Construction and ECR section of this document.

Near Earth Network (NEN): The NEN consists of globally distributed tracking stations that are strategically located to maximize the communications service coverage provided to flight missions. The stations are located in Norway and Alaska, with additional antennas located at Wallops Island, VA and Merritt Island, FL. The NEN Project Office at GSFC manages the network, which includes both commercially owned assets and NASA facilities. The NEN provides communications services to a variety of missions in certain orbital and suborbital locations, including Low Earth Orbit (LEO), Geosynchronous Earth Orbit (GEO), lunar, and highly elliptical orbits. SCaN is presently looking into implementing higher data rate capability in the Ka-Band to meet the evolving needs of future NASA missions such as DesDNyl and reduce the mission load on the X-Band that is limited in capacity.

Space Network (SN): The SN is a combination of the Tracking and Data Relay Satellite System (TDRSS) and a set of supporting Space-to-Ground Link Terminals (SGLT) located at White Sands, NM and Guam. The ground terminals transmit signals to and from the TDRSS, which in turn relays those signals to and from flight missions. The SN predominantly supports LEO missions with global coverage, but it can also support launch vehicles and provide communications services to researchers in remote locations on Earth, such as the South Pole. The SN has demonstrated to be an effective National Asset meeting critical NASA and U.S. needs that cannot be supported by commercial providers or any other U.S. assets.

SN Ground Segment Sustainment (SGSS): SGSS is responsible for replacing outdated equipment and standardizing systems at all SN ground locations. The ground locations are White Sands, NM and the Guam Remote Ground Terminal (GRGT). After replacement, the SGLT equipment at each SN ground station will be capable of supporting any spacecraft in the TDRSS fleet. A key objective of SGSS is to establish the capabilities required to support future space exploration vehicles.

NASA Integrated Services Network (NISN): This network has commercial service backbones providing point-to-point terrestrial signal transport services and routing network services. The Office of Chief Information Officer has management responsibility for this project.

Space Communications Support

Space Communications Support manages cross-cutting communication functions, which are responsible for defining and protecting the integrity of the overall SCaN architecture, including identifying, assessing, and establishing policy or response to external policies. These functions include Spectrum Management, Systems Planning, and advanced concept enabling technology such as Optical Communications and the Disruption Tolerant Networking (DTN).

Spectrum Management ensures the availability and allocation of radio frequency (RF) spectrum for all Agency programs to support the operation of navigation systems, space and ground based radio transmission, and mission active and passive remote sensing requirements.

Systems Planning develops the communications and navigation architecture to support Exploration and Science Programs through FY 2030. This includes Space Data Standards, which pursues the implementation of national and international space data standards with the aim of improved interoperability; Technology, which aims to predict the needs of future communications missions in a manner that will yield initiatives with performance enhancements with reduced costs; and Systems Engineering, which coordinates all SCaN systems engineering activities and manages the requirements that enable NASA to fulfill its space communications and navigation needs for future missions.

An important part of the SCaN Technology Program is Optical Communications technology development and demonstration. The first NASA demonstration of this technology will be during the LADEE mission, which is fully funded through FY 2010 and schedule to launch in June 2012. The optical communication capability would provide NASA with a high rate communication technique for deep space mission data with an objective of at least a 10-fold data rate increase over that achievable with RF technology. This revolutionary technology will provide higher data rates for less space, weight, and power burden compared to RF technology. Higher data rates will allow more science spacecraft to share the same Earth-based optical receivers, and enable greater science return over spacecraft life, thus gaining higher mission utilization. Funding for additional Optical Communications technology demonstrations is currently under consideration within the Space Technology portfolio.

Another SCaN Technology Program effort currently in the demonstration phase is DTN. Two DTN nodes have been installed on ISS and initial demonstration results indicate significant productivity gains through automation of data transfers in the ISS's disruptive communications environment. DTN has also been demonstrated in a deep space environment during FY 2009 aboard the EPOXI spacecraft and a more rigorous second demonstration is planned for FY 2010 that will show that data transport efficiency can be improved 100%. International standardization of the DTN protocols will be moved forward by the SCaN Standards Program along with other communication data standards that provide a sound base for interoperability of NASA missions with other International space agencies.

In addition, SCaN provides subject matter expertise to the NASA Deputy Administrator for the Deputy Secretary-level Positioning, Navigation, and Timing (PNT) Executive Committee that manages the U.S. Global Positioning System (GPS). GPS is a critical infrastructure component for NASA human spaceflight and science, and enables greater autonomous navigation of spacecraft while reducing the operational and cost burdens of traditional two-way ranging and tracking.

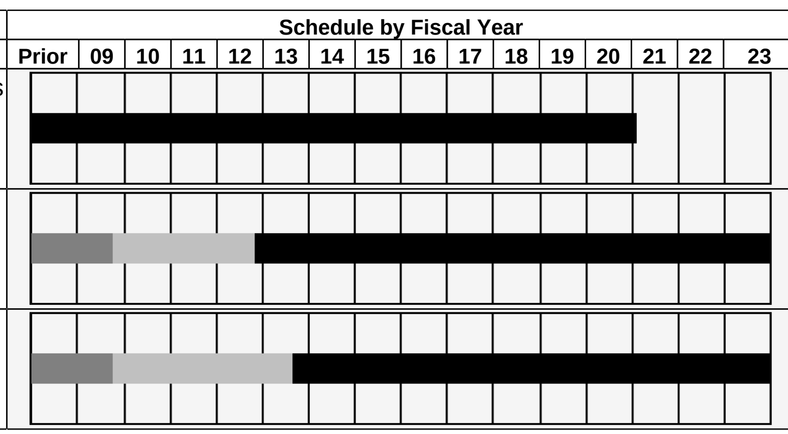
Tracking and Data Relay Satellite (TDRS) Replenishment

The TDRS Replenishment Project is responsible for the acquisition of two new Tracking and Data Relay Satellites, TDRS-K and TDRS-L, to replenish the aging fleet of communications spacecraft in the SN. The TDRS K and L Project Office at the Goddard Space Flight Center is managing the procurement, which includes on-orbit delivery, and acceptance of two spacecraft: TDRS-K to be launched in December 2012, followed by launch of TDRS-L in December 2013. Modifications of the SGLT equipment at the White Sands Complex (WSC) are included. In July 2009, the TDRS Replenishment Project completed Key Decision Point (KDP) - C, and the development documentation was approved. The SN is an effective National Asset meeting critical NASA and U.S. needs that cannot be supported by commercial providers or any other U.S. assets. The mission load on the SN has grown substantially potentially requiring additional TDRS spacecrafts. In light of the recent decommissioning of TDRS-1 and the emerging battery problem with the older generation spacecraft, SCaN is presently using the TDRS reliability model to assess future requirements for the TDRS Constellation.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Achieve less than 3% of lost operating time on NISN available services.	NASA Integrated Services Network, NISN	Same
Achieve at least 98% Network proficiency for delivery of Space Communications services.	Space Network, Deep Space Network, and Near Earth Network	Same

Implementation Schedule



Project	Phase	Beg	End
Space Communications and Navigation Operations	Tech		
	Form		
	Dev		
	Ops	Oct-05	Oct-20
	Res		
TDRS Replenishment - TDRS K	Tech		
	Form	Oct-07	Jul-09
	Dev	Jul-09	Jul-12
	Ops	Aug-12	Aug-27
	Res		
TDRS Replenishment - TDRS L	Tech		
	Form	Oct-07	Jul-09
	Dev	Jul-09	May-13
	Ops	Jun-13	Jun-28
	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation

Program Management

The Deputy Associate Administrator for Space Communications and Navigation (SCaN) reports to the Associate Administrator for Space Operations at NASA Headquarters. SCaN projects are managed from NASA Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Deep Space Network	Space Communications and Navigation Program Office - NASA Headquarters	Jet Propulsion Laboratory	N/A
Near Earth Network	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center	N/A
SN Ground Segment Sustainment	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center	Other Government Agencies
Network Integration and Engineering	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center, Glenn Research Center, Jet Propulsion Laboratory	N/A
Space Network	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center	Other Government Agencies
Space Communications Support	Space Communications Program Office - NASA Headquarters	Glenn Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Johnson Space Center	N/A
Optical Communications	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center, Jet Propulsion Laboratory	Other Government Agencies
NASA Integrated Services Network	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center, Marshall Space Flight Center	N/A
TDRS Replenishment	Space Communications and Navigation Program Office - NASA Headquarters	Goddard Space Flight Center, Kennedy Space Center	Other Government Agencies

Acquisition Strategy

NASA owns a large, established base of space communications assets located nationally, internationally, and in orbit near Earth and Mars. The SCaN Program conducts acquisition planning with the objective of preserving the governments past investments, and altering capability or capacity in response to mission needs and NASA SCaN architecture goals.

NASA conducts major SCaN acquisitions on a competitive basis. To meet mission support objectives and achieve best value for NASA, mission suitability and cost criteria are appropriately weighted and evaluated for competitively awarded acquisitions. When feasible, NASA pursues commercially available space communications services and products in preference to developing NASA-owned systems. NASA may also consider unique technical capabilities and maintenance of core competency in the NASA work force during the "make versus buy" decision process. To further achieve best value for NASA and the U.S. Government, the Agency may place task orders on Government Wide Acquisition Contracts (GWAC).

To support future Agency SCaN requirements, flight systems and associated ground terminals will be required at several locations in the Solar System. The type of contract depends upon the maturity of the technology and the associated mission risk. In general, lower risk radio frequency relay spacecraft near the Earth are acquired under "fixed price" terms with delivery on-orbit. Relay satellites at distant locations or acquisitions involving new technology, such as optical space communications, may be acquired under "cost plus award fee" terms.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	NASA Advisory Committee	09/2009	SCaN was reviewed by the NASA Advisory Committee with the report delivered by 09/30/2009. The report recommended that an independent study to review the aging infrastructure that will need to be upgraded or replaced to support the science and operational space missions be conducted. The improved infrastructure will support the human and robotic exploration of the moon, the solar system and the universe.	10/2011

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation
Project In Development:	TDRS Replenishment

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**215.0**	**154.0**	**26.0**	**19.0**	**22.6**	**13.4**	**0.0**	**0.0**	**0.0**	**450.0**
Formulation	215.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	240.6
Development / Implementation	0.0	128.4	26.0	19.0	22.6	13.4	0.0	0.0	0.0	209.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
FY 2010 President's Budget Request	**150.0**	**154.0**	**26.0**	**19.0**	**22.6**	**13.4**	**0.0**	**--**	**0.0**	**385.0**
Formulation	150.0	25.6	0.0	0.0	0.0	0.0	0.0	--	0.0	175.6
Development / Implementation	0.0	128.4	26.0	19.0	22.6	13.4	0.0	--	0.0	209.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Changes from FY 2010 Request	**65.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**--**	**0.0**	**65.0**
Formulation	65.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	65.0
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation
Project In Development:	TDRS Replenishment

Project Purpose

The existing fleet of the Tracking and Data Relay Satellite System (TDRSS) supports tracking, data, voice, and video services to the International Space Station (ISS), Space and Earth science missions, as well as other government agency users. The total mission load is predicted to increase, which will require additional satellites to be added to the fleet. The existing fleet is aging and reliability analyses predicts a shortage of flight assets to support NASA missions and the user community by FY 2011. As a result, NASA began in FY 2007 the acquisition of two additional spacecraft, TDRS-K and TDRS-L, to be launched in December 2012 and December 2013 respectively. By adding these two spacecraft to the TDRSS fleet, continuity of service will be insured for NASA and other government agency user missions through approximately FY 2016. The TDRS Replenishment Project supports future Agency requirements and technology initiatives consistent with the approved baseline of the SCaN architecture.

Project Parameters

The TDRS system consists of in-orbit telecommunications satellites stationed at a geosynchronous altitude with associated ground stations located at White Sands, NM and Guam. This system of satellites and ground stations is the Space Network (SN) which provides services for near earth user satellites and orbiting resources. The SN supports spacecraft that depend on it for reliable services to continue their missions. The TDRSS constellation includes the first-generation satellites (TDRS 1-6), the replacement satellite (TDRS 7), and the second-generation satellites (TDRS 8, 9, and 10).

Project Commitments

The TDRS-K and TDRS-L spacecraft will be fully compatible and capable of functioning as a part of the existing TDRS System operated by the White Sands Complex (WSC) and Guam ground terminals. Contract requirements are design, development, fabrication, integration, test, on-orbit delivery, and launch vehicle and services. Launch dates for TDRS-K and TDRS-L are in December 2012 and December 2013 respectively. The spacecraft are required to have an operational life of 11 years. The basic requirement will also include modification of the WSC Space-to-Ground Link Terminals (SGLT) to provide compatibility with the new spacecraft.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
TDRS Replenishment	NASA	Aging hardware replacement	Same	Same

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation
Project In Development:	TDRS Replenishment

Schedule Commitments

The Tracking and Data Relay Satellite (TDRS) Replenishment project was approved for entry into Phase C, Development in July 2009. The launch vehicle and payload are to be delivered to the Kennedy Space Center for processing to meet the TDRS-K and TDRS-L launch dates in December 2012 and December 2013 respectively.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
TDRS System Critical Design Review (CDR)	January 2010	N/A	Same
TDRS Systems Integration Review (SIR)	January 2011	N/A	Same
TDRS Flight Readiness Review (FRR)	November 2012	N/A	Same
TDRS K Launch Readiness Date (LRD)	December 2012	N/A	Same
TDRS L Launch Readiness Date (LRD)	December 2013	N/A	Same

Development Cost and Schedule Summary

The TDRS Replenishment LRD represents the completion of both TDRS K and L launches.

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
TDRS Replenishment	2010	209.4	2010	209.4	0	LRD	12/2013	12/2013	0

Development Cost Details

There are no changes to between the base year and current year cost estimates.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**209.4**	**209.4**	**0.0**
Aircraft/Spacecraft	56.7	56.7	0.0
Ground Systems	53.7	53.7	0.0
Other Direct Project Cost	99.0	99.0	0.0

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Space Communications and Navigation
Project In Development:	TDRS Replenishment

Project Management

The Deputy Associate Administrator for Space Communications and Navigation reports to the Associate Administrator for Space Operations at NASA Headquarters.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
TDRS Replenishment	Space Communications and Navigation (SCAN) Office	Headquarters SCaN Program Office	GSFC, KSC, and Non-NASA Agencies

Acquisition Strategy

The Acquisition Strategy for this procurement uses a Firm Fixed Price with Incentive Fee contract.

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
TDRS-K and TDRS-L Obsolescence Risk Management	Aging spacecraft requires replacement hardware by FY 2013. The mission load is predicted to exceed current capacity and will need additional spacecraft to provide enough capacity.	The project has awarded a Firm Fixed Price with Incentive Fee contract as of December 2007 to Boeing Satellite Systems, Inc. Spacecraft will launch in December 2012 and December 2013, respectively.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Human Space Flight Operations

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	0.0	102.3	114.4	115.8	117.7	118.1	121.0
Human Space Flight Operations	0.0	102.3	114.4	115.8	117.7	118.1	121.0
FY 2010 President's Budget Request	0.0	114.7	88.5	88.6	88.7	89.0	--
Space Flight Crew Operations	0.0	114.7	88.5	88.6	88.7	89.0	--
Changes from FY 2010 Request	0.0	-12.4	25.8	27.2	29.0	29.1	--

Program Overview

As the Space Shuttle program (SSP) completes the International Space Station (ISS) in 2010, there are a number of unique human spaceflight capabilities and facilities that have primarily supported the Space Shuttle and ISS assembly that NASA may wish to preserve. These capabilities are required for continued support of the ISS and future support of human space exploration activities. In FY 2011, Human Space Flight Operations (HSFO) includes Space Flight Crew Operations (SFCO) and the realignment of Crew Health and Safety (CHS). NASA will continue to assess and define projects requiring crew to provide program support, including technical input, via boards and panels; requirements, concept and design support; hardware development and testing support; mission support; and essential training.

Plans For FY 2011

SFCO provides trained astronauts for all of NASA human space flight endeavors. For FY 2011, the SFCO will support four ISS long-duration crew rotation missions, which will include the support of the first commercial delivery of cargo to the ISS under the contract with Space Exploration Technologies. If necessary to complete the existing manifest, SFCO will also support Space Shuttle flight into FY2011.

NASA will enlist the National Research Council (NRC) to conduct an independent study of the activities funded within NASA's Human Space Flight Operations program. The study will focus on the role and size of the human spaceflight office in the post Space Shuttle retirement and Space Station assembly environment; the crew-related facility, aircraft and training requirements to support the astronaut corps' for the requirements of NASA's new human spaceflight program, and the more cost-effective means of meeting these requirements. Initiation of the study will commence as soon as possible, with the goal of being completed in time to inform the FY 2013 budget process. The SFCO will also provide support and training for astronauts preparing for future flights to the ISS as well as provide technical and safety panel support to development of future human space systems.

CHS will enable healthy and productive crew during all phases of space flight missions; implementation of a comprehensive health care program for astronauts; and the prevention and mitigation of negative long-term health consequences of spaceflight. CHS will continue to collect, maintain, and mine health data related to the long term affects of space flight in order to enable the mitigation of those affects. This data will be useful to ongoing operations and assist human space exploration activities in defining requirements for the assuring safe human space operations for future systems. CHS will also work to implement technologies for monitoring health status before, during, and after flight and assure that medical personnel and crew members are trained to best use those technologies.

Project Descriptions and Explanation of Changes

Human Space Flight Operations

In FY 2011, SFCO and CHS are funded under the HSFO Program. SFCO provides trained astronauts for all of NASA human space flight endeavors and brings astronaut expertise to help resolve operations or development issues within the human space flight programs. SFCO is responsible for all JSC aircraft operations including aircrew training. CHS will continue to help develop and refine a standardized battery of clinical and physiological tests for all crew members. The Crew Health Surveillance will focus on developing and refining medical standards that are critical to meet the needs that will facilitate human space exploration activities. Similarly, real-time mission evaluation will continue to help define and deliver medical operations hardware for current programs and meet the needs of known architectures.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Human Space Flight Operations

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
SFCO will provide trained astronauts for all U.S. human space flight endeavors and bring experienced astronauts expertise to help resolve operations or development issues.	HSFO/SFCO	Transfer flight crew operations engineering support from ISS.
CHS will provide the full suite of medical capabilities necessary for the health and safety of the astronauts, and to assure they are mission ready from a health perspective.	HSFO/CHS	Realignment of Crew Health and Safety to HSFO.

Program Management

The SFCO and CHS managers report to the Associate Administrator for Space Operations at NASA Headquarters.

Acquisition Strategy

The contracts supporting SFCO are the Aircraft Maintenance and Modification Program (AMMP) provided by the Computer Services Corp. and the Aircraft Simulation Pro (ASP) contract with Lockheed Martin. The contract supporting CHS Bioastronautics is provided by Wyle Labs.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NASA Advisory Council	10/2009	Provides independent guidance for the NASA Administrator. No recommendations were provided to SFCO at this time.	02/2010
Performance	ASAP	10/2009	Provides independent assessments of safety to the NASA Administrator. In their 2008 Annual Report, the Aerospace Safety Advisory Panel (ASAP) stated that they "strongly endorse the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS". NASA will fly the Space Shuttle to complete the International Space Station and then retire the Shuttle.	TBD
Performance	Institute of Medicine	03/2007	At the request of NASA, the Institute of Medicine established a committee and issued this report. The committee was charged with examining the process by which NASA establishes space flight health standards for human performance. It assured the transparency of the current process, as well as considering its validity and integrity, particularly related to ensuring worker safety and integrating stakeholder input.	TBD
Performance	Institute of Medicine	04/2009	This report examines NASA's plans to assemble the available evidence on human health risks of spaceflight and to move forward in identifying and addressing gaps in research. The committee provided recommendations to strengthen the content, composition, and dissemination of the evidence books.	TBD

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Launch Services

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**91.7**	**83.8**	**78.9**	**82.6**	**82.5**	**86.0**	**87.9**
Launch Services	**91.7**	**83.8**	**78.9**	**82.6**	**82.5**	**86.0**	**87.9**
FY 2010 President's Budget Request	**89.6**	**85.9**	**84.1**	**83.9**	**83.9**	**82.8**	**--**
Launch Services	**89.6**	**85.9**	**84.1**	**83.9**	**83.9**	**82.8**	**--**
Changes from FY 2010 Request	**2.2**	**-2.1**	**-5.3**	**-1.3**	**-1.4**	**3.2**	**--**

Program Overview

Assuring reliable and cost-effective access to space for missions is critical to achieving NASA's goals. NASA has assigned responsibility for understanding the full range of civil space launch needs to the Space Operations Mission Directorate's Launch Services Program (LSP). The LSP, which works closely with other government agencies and the launch industry, seeks to ensure that the most safe, reliable, on-time, cost-effective commercial launch opportunities are available on a wide range of launch systems. The program works with customers from universities, industry, government agencies, and international partners from the earliest phase of a mission. A key challenge for the program is matching the launch capabilities to the needs of the different customers. Through various scientific missions, these customers seek to: understand the origins, evolution, and destiny of the universe; the nature of life in the universe and what kinds of life may exist beyond Earth's orbit; the solar system, both scientifically and in preparation for human exploration; and the Sun and Earth and the consequences of the Earth-Sun relationship for life on Earth. Customers further seek to provide integrated space communications, navigation and data system services that enable mission success in addition to providing missile technologies for improved National Security. The program purchases fixed-price launch services from domestic suppliers and provides oversight to ensure that these valuable, one-of-a-kind missions safely leave Earth to explore this planet and the universe beyond. The funding provides the capability for NASA to maintain critical skills that provide technical management of launch services on the full fleet of existing and new launch systems. For more information, please see http://www.nasa.gov/centers/kennedy/launchingrockets/index.html.

The LSP budget also supports integration activities for the Alpha Magnetic Spectrometer particle physics and astrophysics experiment planned for the ISS that will look for dark matter, anti-matter, and strange matter. This experiment is sponsored by the Department of Energy and funded largely by International Partners.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Launch Services

Plans For FY 2011

The LSP program has six planned NASA launches including: 1) Glory, which will be launched on a Taurus XL; 2) Aquarius on a Delta II; 3) Juno on an Atlas V; 4) Nuclear Spectroscopic Telescope Array (NuSTAR) on a Pegasus XL; 5) NPOESS Preparatory Project (NPP) on a Delta II; and 6) the Gravity Recovery and Interior Laboratory (GRAIL) mission, the last mission to be launched on a Delta II. In addition to processing, mission analysis, spacecraft integration and launch services of the above missions, LSP will continue to provide support for the development and certification of emerging launch providers that will be critical to supporting NASA programs.

Project Descriptions and Explanation of Changes

Launch Services Program

The primary elements of the LSP are described below. The LSP provides the acquisition and program management of Expendable Launch Vehicle (ELV) missions using primarily domestic launch vehicles and associated standard services with mission unique options. These services are contracted through LSP at the Kennedy Space Center. The LSP provides all program-related services including program-level financial management and the integration and insight of the launch services tasks across multiple Centers as well as management of all program resource requirements. The LSP provides the Contracting Officer Technical Representative function for launch service contracts, and support services contracts, ensuring consistency and best practices. The LSP assures that NASA retains the technical, management, and acquisition skills necessary to meet Agency and customer needs.

The LSP provides mission integration, technical, and launch management functions. Manifesting and scheduling of payload launches are accomplished through the auspices of the Flight Planning Board. Through this process all space access requirements and priorities are assessed to develop flight planning manifests that best meet customer requirements. The LSP acquires launch services to meet the full range of requirements, ranging from finding space for small payloads as secondary payloads to the launch of dedicated payloads on a range of launch vehicles. The LSP also provides technical management of the launch service, including planning, execution, and support for flight project customer requirements. This element of the program provides for planning and implementation of mission-specific integration activities, coordination and approval of mission-unique launch vehicle hardware/software development, and provision of payload-processing accommodations. Additionally, LSP offers management of the launch campaign/countdown including coordination with other government agencies and the commercial sector.

The LSP provides engineering services and analysis for launch vehicle certification at levels of detail commensurate with the mission risk tolerance. The program maximizes the mission success of commercially developed expendable launch services by employing a technical oversight approach that includes a combination of specified approvals and targeted insight. This element also provides for the coordination of mission-specific and fleet-wide launch vehicle analyses, hardware changes, and production oversight, assessments, and out-of-family anomaly resolution.

The LSP Construction of Facility (COF) projects support repairs and modifications to existing buildings and launch pads on the East and West Coasts, which sustain the processing, operations, and launch of NASA spacecrafts. A list of the total COF projects are included in the Construction and ECR section of this document.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Launch Services

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
The Launch Services Program is planning for 11 Missions by FY 2014 and is providing an advisory role for 6 additional missions.	SMD - 9 Missions, and SOMD - 2 Missions	Updated number of missions

Program Management

The Launch Services Program Manager reports to the Assistant Associate Administrator for Launch Services, Space Operations Mission Directorate at NASA Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Launch Services Acquisition and Management	LSP, Kennedy Space Center	Kennedy Space Center	Air Force, National Reconnaissance Office
Engine Assembly and Test	LSP, Kennedy Space Center	Stennis Space Center	Air Force, National Reconnaissance Office
Mission Planning and Integration	LSP, Kennedy Space Center	Kennedy Space Center	Science Mission Directorate, Exploration Systems Mission Directorate, Space Operations Mission Directorate, Missile Defense Agency, NOAA
Vehicle Production Insight	LSP, Kennedy Space Center	Marshall Space Flight Center	Air Force, National Reconnaissance Office

Acquisition Strategy

Under the NASA Launch Services (NLS) contracts with United Launch Alliance, Orbital Sciences Corporation (OSC), and Space Exploration Technologies, Inc. (SpaceX), the program acquires services associated with launches of Delta, Atlas, Pegasus, Taurus, and Falcon launch vehicles. Services are provided on a Firm-Fixed-Price / Indefinite-Delivery-Indefinite-Quantity (IDIQ) basis, and missions can be ordered under these contracts through June 2010. Missions not presently under contract are competed among existing NLS contractors through use of a Launch Service Task Order mechanism. In addition to the NLS contracts, Glory is the only active mission remaining under the Small Expendable Launch Vehicle Services contract with OSC. Award of the NLS II follow-on contract is anticipated by the end of June 2010.

The NLS solicitation contains a provision that permits technology infusion or improvements. New offerors may seek an NLS contract during open seasons that occur each year in February and August. The NLS contracts enable ordering of standard and non-standard services, as well as special studies and mission-unique modifications.

Integrated launch services are provided by the Analex Corporation through a hybrid fixed-price/cost contract which contains options to continue performance through September 2011. Payload processing for East Coast missions is provided by Astrotech Space Operations. West Coast payload processing is provided after a competitive selection by either Astrotech or Spaceport Systems International.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO Assessment	08/2009	This was a Non-Advocate Review (NAR) of LSP to present information to Agency decision-making councils. The IPAO Review Team found that LSP is a highly successful program compliant with Agency direction, policy and directives. The review, completed before the OCO launch failure, further illustrated that LSP's 100 percent launch success record, together with sound cost management, and demonstrates exceptional performance.	2012

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Rocket Propulsion Test

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	41.8	44.3	44.3	44.2	44.2	48.2	49.2
Rocket Propulsion Testing	41.8	44.3	44.3	44.2	44.2	48.2	49.2
FY 2010 President's Budget Request	41.8	45.8	44.6	44.5	44.5	44.5	--
Rocket Propulsion Testing	41.8	45.8	44.6	44.5	44.5	44.5	--
Changes from FY 2010 Request	0.0	-1.5	-0.4	-0.4	-0.3	3.6	--

Program Overview

As the principal implementing authority for NASA's rocket propulsion testing, the Rocket Propulsion Test (RPT) Program reviews, approves, and provides direction on rocket propulsion test assignments, capital asset improvements, test facility modernizations and refurbishments, integration for multi-site test activities, identification and protection of core capabilities, and the advancement and development of test technologies.

RPT employs a collaborative approach to ensure rocket propulsion test activities are conducted in a manner that reduces cost, enhances safety, provides credible schedules, achieves technical objectives, and leverages the lessons learned. RPT reduces propulsion test costs through the safe and efficient utilization of rocket propulsion test facilities in support of NASA programs, commercial partners, and the Department of Defense, while eliminating unwarranted duplication. RPT sustains and improves Agency-wide rocket propulsion test core capabilities (both infrastructure and critical skills) and ensures appropriate levels of capability and competency are maintained.

The program strategy is to fund and maintain a core competency of skilled test and engineering crews and test stand facilities; consolidate and streamline NASA's rocket test infrastructure; establish and maintain world-class test facilities; modernize test facility equipment; provide non-project specific equipment and supplies; and develop effective facility/infrastructure maintenance strategies and performance. RPT provides critical institutional and program capabilities to support NASA's missions.

Further information on the RPT Program can be found at http://rockettest.nasa.gov/.

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Rocket Propulsion Test

Plans For FY 2011

Test facility management, maintenance, sustaining engineering, operations, and facility modernization projects required to keep the test-related facilities in the appropriate state of operational readiness will continue to be funded. Established testing requirements for the Agency's exploration program will be used to identify excess and "at-risk" test facilities and will support decisions relative to test asset consolidation initiatives. RPT's inventory of 32 test locations, ranging from active to mothballed facilities, will continue to be maintained at various states of operational readiness as required. Propulsion test technology development will also be continued.
By working with Exploration and the new Heavy Lift and propulsion technology development projects, RPT will continue to identify new technologies to improve the efficiency and reliability of the propulsion test infrastructure.

The RPT Program will also continue to assist in the rocket propulsion testing requirements definition for low Earth orbit and in-space propulsion systems and related technologies.

Project Descriptions and Explanation of Changes

RPT

RPT represents the single point interface for NASA's rocket propulsion test facilities located at: Stennis Space Center (SSC), Marshall Space Flight Center (MSFC), Johnson Space Center-White Sands Test Facility (JSC-WSTF), and Glenn Research Center-Plum Brook Station (GRC-PBS). These facilities have a replacement value of greater than $2 billion. The RPT sustains and improves Agency-wide rocket propulsion test core competencies (both infrastructure and critical skills), ensures appropriate levels of capability and competency are maintained, and eliminates unwarranted duplication. The program strategy is to fund and maintain core competencies of skilled test and engineering crews and test stand facilities; consolidate and streamline NASA's rocket test infrastructure; establish and maintain world-class test facilities; modernize test facility equipment; provide non-project specific equipment and supplies; and develop effective facility/infrastructure maintenance strategies and performance. The RPT budget does not include resources to support the marginal costs of testing (e.g., direct labor, propellants, materials, program-unique facility modifications, etc.) since these activities are funded by programs as a direct cost when they utilize the RPT test stands. When NASA, DoD, and commercial partners use the RPT-supported test stands, they are responsible for program-specific facility modifications in addition to the active testing of the program-specific test article.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Support continued commercial testing of RS-68 engine	Pratt Whitney Rocketdyne/Air Force	Same

Mission Directorate:	Space Operations
Theme:	Space and Flight Support (SFS)
Program:	Rocket Propulsion Test

Program Management

The Rocket Propulsion Testing Program Manager reports to the Assistant Associate Administrator for Launch Services, Space Operations Mission Directorate at NASA Headquarters.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Technical Services and Support	Stennis Space Center	Jacobs-Sverdrup, Mississippi Space Services, Plum Brook Operations Support Group	Rocket Propulsion Test Management Board Members: Stennis Space Center, Marshall Space Flight Center, Johnson Space Center, White Sands Test Facility, Glenn Research Center's Plum Brook Station, Kennedy Space Center (associate member), and Glenn Research Center (associate member). National Rocket Propulsion Test Management Board Department of Defense Members: Air Force Research Lab, Arnold Engineering Development Center, Redstone Technical Test Center, and Naval Air Warfare Center.

Acquisition Strategy

The Test Operations Contract (TOC) will be completing its final option contract period in September 2010. A 3-month extension to December 2010 is in negotiation. A new contract will be openly competed at that time.

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Mission Directorate: Education

Overview

"The nation that out-educates us today will out-compete us tomorrow", said President Barack Obama in an April 27, 2009 speech to the National Academy of Science. NASA performs a leading role in assuring that the U.S. is not out-educated by inspiring the next generation of explorers in the disciplines of science, technology, engineering, and mathematics (STEM). The FY 2011 President's Budget provides a 14% increase to NASA's Education budget, which will enable NASA to continue to capitalize on the excitement of NASA's mission to inspire innovative solutions, approaches, and tools that inspire student and educator interest and proficiency in STEM disciplines and pursue new innovative approaches to reaching students. NASA will continue to capitalize on the excitement of NASA's mission to inspire innovative solutions, approaches, and tools that inspire student and educator interest and proficiency in STEM disciplines. This strategy will increase the distribution and impact of NASA's progressive opportunities for elementary and secondary teachers, university faculty, students of all ages, and the public.

NASA is a leader among Federal Research and Development agencies in promoting STEM education opportunities, and NASA has recently established an Agency High Priority Performance Goal related to education and future workforce development. NASA partners with academic institutions, professional education associations, industry, and other Government agencies to provide teachers and faculty with the experiences that capitalize on the excitement of NASA's discoveries to spark their students interest and involvement. Strategies include offering professional development experiences, lessons, and classroom materials; using emerging communications and education technologies; and providing research opportunities, and hands-on science and engineering activities that draw on NASA's unique missions. NASA resources and opportunities are available to a diverse audience of educators and students, including women, minorities, and persons with disabilities. Special projects within the NASA portfolio of investments ensure that a diverse audience is actively engaged in NASA STEM education. In FY 2011, NASA will pursue the following education priorities:

Support the Administration's STEM education teaching and learning improvement education efforts, including Race to the Top and Educate to Innovate;
- NASA will support the Summer of Innovation project by partnering with internal and external stakeholders, and other education organizations to leverage the excitement of NASA's missions.
- Continue efforts to incorporate NASA content into STEM education efforts of other federal agencies.

Engage the Nation's universities, colleges, students and faculty;
- Stimulate competitive NASA-themed STEM research, through NASA Research Announcements and Announcements of Opportunity offered to targeted states, universities, and other educational institutions. In order to prepare institutions for future competitions, benefit NASA, and prepare students for future employment (at NASA, in aerospace industry, or academia), research and engineering activities will be directly tied to NASA missions and research objectives (e.g. Mars Exploration; global climate change; aeronautics).
- Collaborate with the Office of Human Capital Management to recruit participants in NASA's scholarship, internship and fellowship projects into cooperative-education (co-op) and Federal Career Intern Program (FCIP) positions at NASA.
- Broaden community college participation in NASA research and STEM workforce development.

Inspire and engage the Nation's K-12 students and educators;
- Pursue innovative approaches that enable additional student launch initiatives and other hands-on payload development and engineering opportunities for NASA missions. Through partnerships with NASA centers, universities, and industry, students will gain research experiences and hands-on engineering experience on a variety of real-world platforms that may include high altitude balloons, sounding rockets, aircraft, space satellites, and the International Space Station (ISS). High school students will intern under mentorship of NASA scientists and engineers, and university students will participate in ongoing space and aeronautics research missions. Many will contribute to original research and support designing hardware to fly on future NASA missions.
- Expand teacher pre-service, professional development and training opportunities that are based on education research and reflect current and future NASA science and exploration missions.
- Prepare pre-college students for undergraduate study through "transitional" experiences that blend NASA research and engineering experiences with classroom study and near-peer/NASA mentoring.
- Immerse students and educators in current NASA science and technology, with an increasing emphasis on e-Education and cyber-learning opportunities.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**169.2**	**183.8**	**145.8**	**145.8**	**145.7**	**145.7**	**146.8**
Education	169.2	183.8	145.8	145.8	145.7	145.7	146.8
FY 2010 President's Budget Request	**169.2**	**126.1**	**123.8**	**123.8**	**123.8**	**125.5**	**--**
Education	169.2	126.1	123.8	123.8	123.8	125.5	--
Total Change from FY 2010 President's Budget Request	**0.0**	**57.7**	**22.0**	**22.0**	**21.9**	**20.2**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Education

Education

New Initiatives:

In FY 2011, NASA will implement the Summer of Innovation initiative to provide an intensive STEM teaching and learning experiences during the summer. It is targeted at the middle school level and complements school year curricula. Summer camps, Saturday-programs, and other forms of intensive NASA and STEM-focused experiences, will be offered in the summer and beyond. These strategies are designed to help STEM underperformers catch up to, and perhaps surpass, standard expectations of STEM performance for their grade level. A significant outcome of the program will be to expand the pool of students - particularly females, those from low-income and underserved/underrepresented populations, and those underperforming in STEM - who consider and pursue STEM professions. STEM learning experiences provided by the Summer of Innovation will engage at least 100,000+ middle school students and 5,000+ teachers (program-wide, not per state) with the ultimate goal of increasing the number of future scientists, mathematicians, and engineers in the U.S.

Major Changes:

In FY 2011, NASA will explore innovative ways to reach university level students and improve STEM retention; engage younger K-12 students through authentic hands-on STEM learning; and capture the public's attention by an innovative approach to imparting informal education in the Nation's science centers, museums, community groups, and other organizations. These new innovative projects will include:

The Innovation in Higher Education STEM Education and Innovations in Global Change Education, projects within the Higher Education STEM Education Program, will focus on innovative ways to reach undergraduate and graduate student, improve student retention in STEM disciplines, leverage the research platform of the ISS, and better engage community colleges and minority institutions.

The Innovation in K-12 STEM Education, a project within the K-12 STEM Education program, will provide competitive opportunities for NASA partners to engage students through authentic hands-on learning opportunities that build STEM knowledge and skills. The Summer of Innovation initiative will fall under this project.

The NASA Informal Education Opportunities, a project within the Informal STEM Education program, will seek innovative approaches to conducting informal education in the Nation's science centers, museums, community groups, and other organizations. NASA Informal STEM Education will continue to support both the NASA Field Center requests from local, state, and other informal education providers who use NASA content to engage their audiences in STEM experiences that inspire STEM achievement and increase public understanding and awareness of NASA's mission achievements.

NASA does not request FY 2011 funding for the Global Climate Change Education, the K-12 Competitive Educational Grant Program, Science Museums and Planetarium Grants, or NASA Visitors Centers. NASA will be able to achieve the intended outcomes of these Congressional-directed initiatives (in FY 2008 and FY 2009), as well as NASA's stated education goals, through the programs for which the Agency is requesting funding.

Major Highlights for FY 2011

In FY 2011, NASA will continue its investment in STEM education and proposes to:

-Continue the Summer of Innovation pilot project, encouraging participation from additional states and education organizations. The FY 2011 Summer of Innovation will provide intensive Summer STEM experiences for middle school students.

-Expand Innovations in STEM Higher Education to build on pilot projects initiated in FY 2010 and to align to the innovation agenda of the Agency.

-Support more than 30,000 undergraduate and graduate students participating in NASA education opportunities.

-Expand collaborations with the more than 850 college, university and industry partners in the National Space Grant College and Fellowship Program to engage students in student launch activities, research and engineering grants, and courses based upon NASA science and engineering.

-Refocus the Graduate Student Research Program (GSRP) to a Graduate Student STEM Education (GSE) to include support of graduate studies in STEM education and education administration.

-Provide over $20M in grants to universities to support NASA-related research and to enhance their capacity to compete for new Federal research dollars.

-Fully realize and execute new infrastructures to improve higher education student recruitment, application processes, and mentoring through the One Stop Shopping Initiative and Virtual Student Ambassadors.

-Work with the Office of Human Capital Management and other internal and external stakeholders to improve the conversion of NASA Higher Education student participants into full time employment with NASA, aerospace industry, and STEM education organizations. This reflects the Agency's High Priority Performance Goal related to education and future workforce development.

-Engage 1,000,000 elementary and secondary student participants in NASA instructional and enrichment activities. Authentic hand-on experiences leverage NASA's education technologies and other communication tools. Student design competitions will be tied to NASA's ongoing priorities, allowing teachers to engage students in real-time, cutting edge science and engineering problems. NASA will make extensive use of telepresence technologies, from web disseminated information and remote control of science instruments, to learning in virtual worlds.

-Engage 75,000 formal and informal educators in NASA's education programs by providing NASA-related STEM education resources and opportunities.

-Actively engage 350 science centers, museums and planetariums, and community-based informal education providers in sharing the excitement of NASA's mission with the American public.

Mission Directorate:	Education
Theme:	Education

Theme Overview

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**169.2**	**183.8**	**145.8**	**145.8**	**145.7**	**145.7**	**146.8**
Higher Ed. STEM Education	107.7	121.2	81.0	81.0	81.0	81.0	81.0
K-12 STEM Education	47.5	46.5	62.8	62.8	62.7	62.7	63.8
Informal STEM Education	14.0	16.1	2.0	2.0	2.0	2.0	2.0
FY 2010 President's Budget Request	**169.2**	**126.1**	**123.8**	**123.8**	**123.8**	**125.5**	**--**
Higher Ed. STEM Education	107.7	80.6	80.6	80.6	80.7	80.7	--
K-12 STEM Education	47.5	43.3	41.0	41.0	41.0	42.7	--
Informal STEM Education	14.0	2.1	2.1	2.1	2.1	2.1	--
Total Change from FY 2010 Request	**0.0**	**57.7**	**22.0**	**22.0**	**21.9**	**20.2**	**--**

Relevance

Relevance to national priorities, relevant fields, and customer needs:

The Obama Administration has identified STEM education as a high priority and is calling on federal agencies to help "improve the performance and participation of American students in STEM". A strong U.S. economy is founded on the abilities, interests and innovations of its citizens, yet performance of American students on international assessments of STEM ability is "middle of the pack" and falling (as identified in the Third International Mathematics & Science Study). NASA will partner with K-12 schools and districts, other federal agencies, industries, colleges and universities, and other education institutions.

NASA's Education programs are fully supportive of national STEM priorities (e.g. Race to the Top) that focus on state-based education and student performance. NASA Education specialists, scientists and engineers work collaboratively with school/district administrators, universities, science centers and industry partners to offer hands-on learning, mentoring and participatory exploration. Programs are based on STEM research and best practices. Investments are evaluated and assessed for impact and performance. NASA provides practical experience and skills development for the future workforce through internships, fellowships and student research related to NASA missions. NASA is uniquely qualified to attract students to STEM study and careers as it is able to engage these future workers in inspiring NASA missions, foster relationships with the current workforce, offer opportunities to work in "out of this world" facilities, and capitalize on the innovative perspectives and problem-solving approaches offered by student researchers. Hands-on challenges with expert mentors increase the likelihood of undergraduate STEM study and increase the number of students who seek employment in a STEM or related field. It also fosters pursuit of graduate study aligned to NASA's missions.

Relevance to education and public benefits:

NASA Education projects (such as Space Grant and MUREP) increase the number of students who are proficient in, who choose to major in, and who pursue careers in STEM fields. Improving STEM ability, increasing public scientific literacy, increasing the talent pool of future STEM workers, and developing the STEM skills of the future workforce are imperatives for a nation to remain globally competitive and sustain a strong economy. To effect STEM improvement, it is simply not enough to offer a grant or provide materials to educators and students. NASA actively works through mutually beneficial relationships with 500+ colleges and universities, hundreds of K-12 schools/districts, and 350+ museums and science centers to provide education experiences so that all students can learn deeply and think critically in STEM disciplines. Such relationships enable NASA to reach tens of thousands of collegians, a million K-12 students and innumerable members of the public.

NASA is a supporter of STEM education efforts that engage a broad range of students and educators, providing access to personnel, research, technology and access to facilities that allow participation in NASA's missions. NASA supports cutting-edge student research that contributes to NASA missions while training the next generation of scientists, engineers and innovators. NASA works with state and community leaders to offer professional development opportunities needed by teachers, better preparing pre-service and in-service educators to teach STEM topics. NASA pursues collaborative partnerships that improve STEM teaching and learning. NASA targets recruitment and retention of underserved and underrepresented students, including women and girls, drawing on a rich and underutilized for education opportunities and developing our future workforce.

Performance Achievement Highlights:

NASA provided opportunities to help students and educators gain hands-on experiences in STEM through internships, fellowships and research. NASA reached more than 24,000 higher education students, of which more than 4,500 received substantial research/fellowship awards. This included 550 intensive study opportunities for underserved students, teachers and faculties. Of students participating in undergraduate programs, 41 percent continued to pursue advanced degrees; 57 percent entering the workforce pursued NASA-related careers, including work for NASA, aerospace industry and STEM education.

NASA awarded 43 institutional research awards, worth more than $32M, to targeted colleges and universities. This NASA-related research, will better enable these institutions to compete for funding from sources other than NASA's Office of Education.

NASA increased its commitment to high quality professional development projects targeted to pre- and in-service educators. Education research shows that in-depth and sustained experiences increase the impact of training and improve STEM teaching practices. NASA launched the first year of the Endeavor Science Teacher Certificate Project, reaching 40 educators through intensive professional development that will culminate in a NASA STEM teaching certificate. NASA also supported teachers through short experiences offered by the Digital Learning Network (reached 13,000 educators), Education Flight Project (reached 13,000 educators), Aerospace Education Services (reached 8,000 educators) and other projects. NASA is increasing use of technology to provide "virtual" workshops and other experiences to educators and students.

NASA attracted and retained students in STEM disciplines by: engaging over 1300 high school interns in NASA STEM activities through the Interdisciplinary National Science Program Incorporating Research & Education that targets underserved students; leveraging partner distribution infrastructures to reach more than 7 million on-line viewers (e.g. Channel One); and supported Science, Engineering, Mathematics, and Aerospace Academy activities that actively engaged over 40,000 students. According to the National Research Council, NASA has had a unique role in inspiring, engaging, and educating students about STEM and STEM careers.

Partnerships through the NASA Museum Alliance, the Space Place Network, Smithsonian, Visitor Centers and others engage and inform the public. The NASA Museum Alliance provided programming at 400 science centers and museums across the U.S.. Museums were able to share features and education materials related to STS-119 and the flight of two Educator Astronauts. Coverage/exhibits on a number of aeronautics and space activities, materials and experts were provided to institutions during the International Year of Astronomy.

NASA awarded 22 innovative grants through the Global Climate Change Education initiative, and awarded 11 grants to public schools and nonprofit organizations through the K-12 Competitive Educational Grant Program, Science Museums and Planetarium Grants, and NASA Visitor Centers as directed by Congress in FY 2008 and 2009. NASA's FY 2009 Performance and Accountability Report provides further discussion and detail regarding the performance of NASA's Education Program. The report can be found at http://www.nasa.gov/budget.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	Abt Associates, Cambridge, MA	FY 2008	An external independent evaluation of the SEMAA project, (including RCT), is assessing the effectiveness and determining how intended goals are being implemented. Evaluation will consider the overall effort, provide data on how differences in effectiveness are associated with site-site variations, and offer explanations for observed outcomes. Abt is to provide results in Q2 2010.	FY 2013
All	Abt Associates, Cambridge, MA	FY 2009	The external evaluation contractor is initiating the planning phase for reviewing selected projects in the Higher Education program. Abt is to provide results at the end of Q1 2011	FY 2010
All	NRC - National Academies	FY 2008	The recommendations for the NASA K-12 Education Program, provided by the NRC review, reinforced the important complementary role of NASA STEM education. Improvement areas include: (1) the nature of NASA's role in K -12 STEM education, (2) continuous improvement of projects, (3) partnerships and expertise in education, and (4) information and communications technology; for details go to http://www.nap.edu/catalog/12081.html.	FY 2010-12
All	Abt Associates, Cambridge, MA	FY 2010	The external evaluation contractor is initiating the planning phase for the Informal Education program. Abt is to provide results at the end of Q4 2010	FY 2010
All	Booz-Allen Hamilton	FY 2009	An external independent evaluation of the NES project was conducted by Booz-Allen Hamilton (BAH), per Congressional Direction. The evaluation included review of previous assessments and the NES redesign model. Results were received by NASA in FY 2009. BAH identified several structural elements that limited the NES project's ability to scale up to a level that would support significantly greater numbers of schools, students and educators. A redesign of the project is underway.	FY 2010-12

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	107.7	121.2	81.0	81.0	81.0	81.0	81.0
STEM Opportunities (Higher Education)	9.5	12.4	16.9	16.9	16.9	16.9	16.9
NASA Space Grant	40.0	45.5	27.7	27.7	27.7	27.7	27.7
Experimental Program to Stimulate Competetive Research	20.0	24.9	9.3	9.3	9.3	9.3	9.3
Minority University Research & Education Program	28.2	28.4	27.2	27.2	27.2	27.2	27.2
Global Climate Change Education	10.0	10.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	107.7	80.6	80.6	80.6	80.7	80.7	--
STEM Opportunities (Higher Education)	9.5	11.6	11.6	11.6	11.6	11.6	--
NASA Space Grant	40.0	28.4	28.4	28.4	28.4	28.4	--
Experimental Program to Stimulate Competetive Research	20.0	10.0	10.0	10.0	10.0	10.0	--
Minority University Research & Education Program	28.2	30.7	30.7	30.7	30.7	30.7	--
Global Climate Change Education	10.0	0.0	0.0	0.0	0.0	0.0	--
Changes from FY 2010 Request	0.0	40.6	0.4	0.4	0.4	0.4	--

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

Project Descriptions and Explanation of Changes

STEM Opportunities (Higher Education)

STEM Opportunities focuses on strengthening the research capabilities of the Nation's colleges and universities, and providing opportunities that attract and prepare increasing numbers of students for NASA-related careers. The research conducted by these institutions contributes to the research needs of NASA's Mission Directorates and furthers the Nation's scientific and technology innovation agendas. The student projects serve as a major link in the pipeline for addressing NASA's Human Capital Strategies. The projects 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's workforce.

STEM Opportunities consist of the Undergraduate Student Researchers Project (USRP), the Graduate Student Education (GSE) project, and the Innovations in Higher Education STEM Education project. USRP attracts undergraduate students from a wide array of backgrounds, who are representative of America's racial, economic, ethnic, and cultural diversity. It provides them with hands-on, challenging research experiences that stimulate continued student interest in the fields/disciplines aligned with NASA's research and development mission.

The GSE project awards research fellowships for graduate study leading to masters or doctoral degrees in the fields of science, mathematics, and engineering related to NASA research and development, and education, thereby cultivating research ties to the academic community and helping meet the continuing needs of the Nation's aeronautics, space research, and STEM education efforts. GSE increases the number of highly trained scientists and engineers in aeronautics and space-related disciplines, broadens the base of students pursuing advanced degrees in science, mathematics, and engineering; and supports graduate level education in STEM education and education administration.

The Innovation in Higher Education STEM Education project enables NASA to seek out and support innovative and replicable approaches to improve STEM learning and instruction, and opportunities for student and faculty to participate in NASA related research and launch/payload development activities. These activities include working with the ISS Program Office to reach students and faculty in developing new ISS hardware, conducting experiments, and identifying new strategies for utilizing ISS data in classroom activities.

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

National Space Grant

NASA initiated the National Space Grant College and Fellowship Program (Space Grant) in FY 1989. Space Grant is now composed of 52 consortia in 50 states, the District of Columbia and the Commonwealth of Puerto Rico. The Space Grant national network includes over 850 affiliates from universities, colleges (including minority-serving institutions), community colleges, industry, museums, science centers, and state and local government agencies. These institutions support a national network that expands opportunities for Americans to understand and participate in NASA's aeronautics and space projects. Space Grant institutions leverage the resources of the members, state and local aerospace industries to support and enhance science and engineering education, research, and public outreach efforts in higher education, elementary and secondary education, and informal education.

The Space Grant consortia fund fellowships and scholarships for students pursuing NASA-related STEM careers, and fund curriculum enhancement and faculty development. Between FY 2003 and FY 2009, Space Grant awarded almost 20,000 scholarships and fellowships, over 700 research infrastructure development grants, 850 higher education program grants, and conducted over 400 public service/engagement program awards, reaching hundreds of thousands of students across the U.S. In recent years, scholarship and fellowship recipients included 21% underrepresented minorities and 42% women, well above other non-targeted and/or STEM-directed programs. In FY 2009, Space Grant programs reached over 21,000 higher education participants, including 3,400 individuals receiving significant education and research support. Longitudinal tracking of students indicates that typically 90% of Space Grant award recipients become employed in STEM fields after graduation or matriculate into an advanced STEM degree program.

In FY 2011, increased funding for Space Grant will enable NASA to increase the depth and breadth of collaborations with lead institutions, affiliates and previously unengaged institutions. Specific goals are to increase the active participation of community colleges and underserved/underrepresented students.

Experimental Program to Stimulate Competitive Research

The Experimental Program to Stimulate Competitive Research (EPSCoR) strives to develop academic research enterprises that are long term, self-sustaining, and nationally competitive by supporting states with modest research infrastructure to become more competitive in attracting research funding. Funding is awarded to lead academic institutions in twenty-eight eligible states (designated by NSF each year) to foster a STEM relationship with industries for research and development opportunities. NASA actively seeks to integrate the research conducted by EPSCoR jurisdictions and the aerospace and exploration agenda being pursued by the Agency.

Representatives from each of NASA's Mission Directorates work closely with EPSCoR program 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 Field 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 the annual progress report. Additional involvement may occur, depending upon the nature of the collaboration already established or desired. This includes, but is not limited to, integrating the EPSCoR research into ongoing activities or research efforts, and increasing the Principal Investigator and his/her team's awareness of other related or relevant research in NASA.

Minority University Research and Education Program

In FY 2011, Minority University Research and Education Program (MUREP) will add one project and phase out another. Innovations in Global Climate Change Education, a new project in FY 2011, will seek innovative approaches to providing opportunities for students and teachers to engage in research, use of technological tools, and access NASA data sets to improve teaching and learning in the area of global climate change. The NASA Administrator's Fellowship Project will be phased out in FY 2011.

MUREP engages underserved and underrepresented populations in two ways: 1) multiyear grants awarded to assist minority institutions, faculty, and students in research pertinent to NASA missions; and 2) recruitment and retention of underserved and underrepresented students. Methods by which these are achieved are by providing scholarships, fellowships, internships; mentoring & tutoring; ensuring their completion of undergraduate and graduate degrees; and supporting their entry into the scientific and technical workforce. The program is composed of Research Clusters, University Research Centers and Minority Institution Collaborations.

Research Clusters is composed of five research activities. Motivating Undergraduates in Science and Technology (MUST) provides partial scholarships to underserved undergraduate students to support up to 50% of tuition and fees. Students also participate in a NASA Center internship. Curriculum Improvement Partnership Award for the Integration of Research (CIPAIR) is a 3-year undergraduate STEM curriculum improvement effort, using NASA related content, for minority institutions (MI), including Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), Tribal Colleges and Universities (TCUs), and others. NASA Science and Technology Institute for Minority Institutions (NSTI-MI) provides research opportunities for faculty and students from MIs that contribute to NASA's astrobiology, biotechnology, IT, and nanotechnology research agenda. Faculty and students collaborate with scientists at NASA, industry, academia and nonprofit organizations to research technologies enabling future exploration. Jenkins Pre-doctoral Fellowship Project (JPFP) provides support for underrepresented students (women, minorities, and persons with disabilities) in STEM disciplines who seek advanced degrees and opportunities in NASA-related disciplines, thereby increasing the number of skilled workers. The JPFP provides its participants with access to NASA mentors, NASA research opportunities, and the ability to network and collaborate with the aerospace professionals.

University Research Centers provide a broad-based, competitive NASA-related research capability among the Nation's MIs to foster new aerospace science and technology concepts; expand the Nation's base for aerospace R&D; develop mechanisms for increased participation by faculty and students of MI in mainstream research; and increase the number of underserved students obtaining advanced degrees in STEM disciplines.

Minority Institutions Collaborations is a project made up of two activities. Tribal, HSI, and HBCU Collaborations Project enables NASA to partner with these minority institutions to increase student and faculty involvement in space exploration and cutting-edge technology, improve competitiveness for Federal grants and resources, and provide high-quality educational opportunities to traditionally underserved students and faculty. MUREP Small Projects support a variety of opportunities for students, teachers, faculty and researchers from underrepresented and underserved communities in NASA related STEM fields.

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Provide undergraduates and graduate students opportunities to engage in research and engineering supporting NASA missions.	Higher Education STEM Education Program/ STEM Opportunities	Same
Promote a nationwide network of state-based consortia to engage students and faculty in NASA research and other opportunities;enhance capabilities of eligible states and institutions to compete for NASA-sponsored research and technology opportunities	Higher Education STEM Education Program/ Space Grant, EPSCoR	Same
Target underserved and under-represented students with opportunities to engage in research and engineering supporting NASA missions. Enhance capabilities of minority serving institutions to compete for NASA-sponsored work.	Higher Education STEM Education Program/ MUREP (Research Clusters, URC, MI Collaborations)	Same

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

Program Management

The Assistant Administrator for Education is responsible to the NASA Administrator for NASA's education portfolio, reports to the NASA Administrator, serves as NASA Education Officer, and manages all education responsibilities.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Undergraduate Student Research Program (USRP)	Johnson Space Center (JSC)	All NASA Centers	None
Graduate Student Research Program (GSRP)	Jet Propulsion Lab (JPL)	All NASA Centers	None
Innovation in STEM Education	NASA Headquarters Office of Education	All NASA Centers	None
National Space Grant College and Fellowship Project (Space Grant)	NASA Headquarters Office of Education	All NASA Centers	Fifty-two (52) state (including Puerto Rico and District of Columbia) consortia provide required cost sharing. In FY 2009 it is anticipated that the average ratio of cost sharing to award will be $0.82 to $1.00; as reported in FY 2008.
Experimental Project to Stimulate Competitive Research (EPSCoR)	Kennedy Space Center (KSC)	All NASA Centers	Twenty-seven EPSCoR eligible states provided required cost sharing funds. In FY 2009 it is anticipated that the average ratio of cost sharing to award for EPSCoR research awards will be $0.81 to $1.00 and EPSCoR RID awards will average to approximately $1.04 to $1.00 cost sharing, as reported in FY 2008.
MUREP: Research Cluster	Ames Res Center (ARC), Glenn Res Center (GRC), Jet Prop Lab (JPL), Marshal Space Flight Center(MSFC	All NASA Centers	None
MUREP: University Research Centers (URC)	Dryden Research Flight Center (DRFC)	All NASA Centers	None
MUREP: Minority Institutions Collaborations	NASA Headquarters Office of Education	All NASA Centers	None
MUREP: Innovations in Global Climate Change Education	Langley Research Center (LaRC)	All NASA Centers	None

Mission Directorate:	Education
Theme:	Education
Program:	Higher Ed. STEM Education

Acquisition Strategy

NASA solicits new and innovative education products, tools, and services from qualified external 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 encourages participation of new or less experienced organizations and awards education grants and contracts through full and open competition. NASA includes feedback from staff, subject matter experts, and public in developing solicitations, including the requirements, expected outcomes, schedules, proposal instructions, and evaluation approaches. NASA solicits comments on perceived programmatic risk issues associated with performance of the work. Procurement offices at NASA review all solicitations.

NASA awards all major grants and cooperative agreements based on reviews by external panels of peers for educational merit; NASA and external scientists and engineers for content, merit, feasibility, and alignment to education goals; and Mission Directorates for alignment with NASA's research and development interests. Indications of a clear competitive process are an integral part of reviews. NASA makes awards only after qualified assessments of merit. While competition may sometimes be restricted by legislation to designated participants, such as defined EPSCoR states, grant awards and selection of participating institutions are still determined competitively. When designated participants are identified, all proposals are reviewed for merit, and each award must be justified and deemed worthy of funding.

Mission Directorate:	Education
Theme:	Education
Program:	K-12 STEM Education

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	47.5	46.5	62.8	62.8	62.7	62.7	63.8
STEM Student Opportunities (K-12)	15.2	17.2	46.1	46.1	46.1	46.1	46.1
STEM Teacher Development (K-12)	16.3	14.3	16.7	16.7	16.6	16.6	17.7
K-12 Competitive Educational Grant Program	16.0	15.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	47.5	43.3	41.0	41.0	41.0	42.7	--
STEM Student Opportunities (K-12)	10.5	14.5	14.5	14.5	14.5	14.5	--
STEM Teacher Development (K-12)	21.0	28.9	26.5	26.5	26.5	28.2	--
K-12 Competitive Educational Grant Program	16.0	0.0	0.0	0.0	0.0	0.0	--
Changes from FY 2010 Request	0.0	3.2	21.7	21.7	21.6	19.9	--

Mission Directorate:	Education
Theme:	Education
Program:	K-12 STEM Education

Project Descriptions and Explanation of Changes

STEM Student Opportunities (K-12)

STEM Student Opportunities focus on engaging and retaining students in STEM education programs to encourage pursuit of NASA's future engineering, scientific, and technical missions through flight opportunities, hands on research and engineering experiences, and increased knowledge of NASA science and technology content. STEM Student Opportunities is adding Innovations in K-12 STEM Education as a new project in FY 2011. Innovations in K-12 STEM Education will support the Administration's national STEM education efforts by seeking, piloting, and fostering innovative approaches that provide authentic hands-on opportunities for students and teachers to engage in NASA science, engineering, and exploration missions, improving teaching proficiency, student ability, and student interest in STEM. This project will include the Summer of Innovation (SOI) initiative. SOI will provide an intensive Summer learning experience to middle school students. This effort is designed to enable, underperforming and at-risk students to make gains in STEM skills and knowledge during summer breaks.

The STEM Student Opportunities portfolio also includes the following projects. Education Flight Projects provide hands-on experiences through participation in NASA research applications, in order to inspire and motivate students to pursue studies and careers in STEM. Activities include ISS Earth Knowledge Acquired by Middle School Students (EarthKAM), Amateur Radio on the International Space Station (ARISS), ISS In-flight Education Downlinks, and On-orbit Education Activities.

The Interdisciplinary National Science Project Incorporating Research and Education Experience (INSPIRE) is designed to maximize student participation and involvement in NASA and STEM, and enhance the STEM pipeline from high school (grades 9-12) into the undergraduate level.

The Science Engineering Mathematics and Aerospace Academy (SEMAA) reaches K-12 minority and underserved students that are traditionally underrepresented in careers involving STEM. Students meet during school, after school, or on Saturday mornings during the school year, as well as during the summer, to engage in NASA-based hands-on, interactive learning sessions that are specifically designed for each grade level.

The NASA Explorer Schools (NES) project will fully implement its new secondary education model. The NES project will be open to all interested secondary schools and will utilize current technologies in the delivery of opportunities and experiences to meet the needs of today's learning and learners.

The Learning Technologies Project (LTP) develops and refines cutting-edge technologies that are in use within NASA missions and/or projects to enhance the teaching and learning of scientific concepts. Technologies funded under LTP are developed, evaluated, and leveraged with strategic partners throughout the federal government in order to extend their reach into educational and commercial applications.

Mission Directorate:	Education
Theme:	Education
Program:	K-12 STEM Education

STEM Teacher Development (K-12)

STEM Teacher Development uses NASA's unique content and resources to provide pre-service and classroom teachers with learning experiences that build critical instructional STEM skills and enable teachers to better motivate students to achieve academic excellence and pursue STEM careers. The following are projects included in the STEM Teacher Development portfolio.

Aerospace Education Services (AES) has shifted its focus to providing sustained training to in-service and pre-service teachers. AES provides appropriate classroom resources and demonstrations to support classroom instruction.

The Endeavor Science Teacher Certificate Program (ESTCP) provides workshops to in-service and alternate route teachers, as well as faculty at colleges of education who are preparing future STEM educators. Participants receive assistance in delivering NASA content through on-line methods and practicum courses. The majority of the Endeavor fellows serve underrepresented student populations. ESTCP meets state requirements for certification, and enabling teachers to reach a "highly-qualified" STEM teaching status.

NASA Educational Technologies Services (NETS) is responsible for maintaining educational content on NASA Portal, managing operations of the Office of Education web site and other e-based dissemination/publishing networks. Additional web support is provided to the education video file (education programming) on the NASA TV Public Services channel and NASA TV Education Services channel.

The Learning Environments and Research Network (LEARN) encompasses 3 major activities: NASA -sponsored Classroom of the Future, Digital Learning Network (DLN), and electronic professional development network infrastructure (ePDN). The intent of LEARN is to conduct empirical educational research that is the basis for development and testing of off-the-shelf and new educational technologies, enabling NASA to better meet the needs of its educational audiences. LEARN will incorporate research findings on cognition, effective application of technology to educational settings, integration of NASA content, and delivery through videoconferencing, Internet multimedia, handheld devices, and dissemination infrastructures available to the Agency.

e-Education Small Projects develop infrastructure and deploy research-based technology applications, products, and services to enhance the educational process for formal and informal education. The project emphasis is implementation of educational product development, review, and meta-tagging processes and final distribution through approved media, electronic, and/or site-based channels. Another aspect of e-Education Small Projects is the Central Operations for Resources for Educators (CORE). CORE is a national distribution center for NASA's audiovisual educational materials.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Provide experiences, tools, & opportunities to educators & students, to engage in missions & learning experiences, & ability to teach/learn in STEM disciplines, & increased use of leveraged multimedia-rich products & technology infrastructures.	K-12 STEM Education/STEM Student Opportunities, STEM Teacher Development	Same

Mission Directorate:	Education
Theme:	Education
Program:	K-12 STEM Education

Program Management

The Assistant Administrator for Education is responsible to the NASA Administrator for NASA's education portfolio, reports to the NASA Administrator, serves as NASA Education Officer, and manages all education responsibilities.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Flight Projects (STEM Student Opportunities)	Johnson Space Center (JSC)	All NASA Centers	None
Interdisciplinary Nat Sci Prog Inc Res & Ed Exper (INSPIRE) (STEM Student Opportunity)	Kennedy Space Center (KSC)	All NASA Centers	None
Science, Engin. Math & Aerospace Acad.(SEMAA) (STEM Student Opportunity)	Glenn Research Center (GRC)	All NASA Centers	Fourteen implementation sites are required to develop local partnerships for cost and resource sharing
NASA Learning Technologies Project (LTP) (STEM Student Opportunity)	Goddard Space Flight Center (GSFC)	All NASA Centers	Project Whitecard, Information in Place and Virtual Heroes (competitively selected) will provide in-kind labor and product development costs for an educational game.
Aerospace Education Services Program (AESP) (STEM Teacher Development)	Langley Research Center (LaRC)	All NASA Centers	None
NASA Explorer Schools (NES) (STEM Student Opportunities)	Glenn Research Center (GRC)	All NASA Centers	None
Endeavour Teacher Science Certificate Project (STEM Teacher Development)	Goddard Space Flight Center (GSFC)	All NASA Centers	None
NASA Education Technology Services (NETS) (STEM Teacher Development)	Marshall Space Flight Center (MSFC)	All NASA Centers	None
Learning Environment and Research Network (LEARN) (STEM Teacher Development)	Langley Research Center (LaRC)	All NASA Centers	None
eEducation Small Projects (STEM Teacher Development)	Marshall Space Flight Center (MSFC)	All NASA Centers	None
Innovation in K-12 STEM Education (STEM Student Opportunities)	Goddard Space Flight Center (GSFC)	All NASA Centers	None
Summer of Innovation (STEM Student Opportunities)	NASA Headquarters (HQ)	All NASA Centers	None

Mission Directorate:	Education
Theme:	Education
Program:	K-12 STEM Education

Acquisition Strategy

NASA solicits new and innovative education products, tools, and services from qualified external 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 encourages participation of new or less experienced organizations and awards education grants and contracts through full and open competition. NASA includes feedback from staff, subject matter experts, and public in developing solicitations, including the requirements, expected outcomes, schedules, proposal instructions, and evaluation approaches. NASA solicits comments on perceived programmatic risk issues associated with performance of the work. Procurement offices at NASA review all solicitations.

NASA awards all major grants and cooperative agreements based on reviews by external panels of peers for educational merit; NASA and external scientists and engineers for content, merit, feasibility, and alignment to education goals; and Mission Directorates for alignment with NASA's research and development interests. Indications of a clear competitive process are an integral part of reviews. NASA makes awards only after qualified assessments of merit. While competition may sometimes be restricted by legislation to designated participants, such as defined EPSCoR states, grant awards and selection of participating institutions are still determined competitively. When designated participants are identified, all proposals are reviewed for merit, and each award must be justified and deemed worthy of funding.

Mission Directorate:	Education
Theme:	Education
Program:	Informal STEM Education

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	14.0	16.1	2.0	2.0	2.0	2.0	2.0
Science Museums and Planetarium Grants	7.0	7.0	0.0	0.0	0.0	0.0	0.0
NASA Visitor Centers	7.0	6.4	0.0	0.0	0.0	0.0	0.0
NASA Informal Education Opportunities	0.0	2.7	2.0	2.0	2.0	2.0	2.0
FY 2010 President's Budget Request	14.0	2.1	2.1	2.1	2.1	2.1	--
Science Museums and Planetarium Grants	7.0	0.0	0.0	0.0	0.0	0.0	--
NASA Visitor Centers	7.0	0.0	0.0	0.0	0.0	0.0	--
NASA Informal Education Opportunities	0.0	2.1	2.1	2.1	2.1	2.1	--
Changes from FY 2010 Request	0.0	14.0	-0.1	-0.1	-0.1	-0.1	--

Project Descriptions and Explanation of Changes

NASA Informal Education Opportunities (NIEO)

The NASA Informal Education Opportunities (NIEO) project supports the needs of the informal education community. Through informal education experts at NASA centers, NASA provides technical assistance to museums, planetariums, community-based organizations, and other informal education partners in all 50 states. NIEO-funded innovations at NASA Centers, NASA Visitor Centers and elsewhere respond to state, local or national needs, while sharing NASA's mission with students, educators and the public. NIEO significantly invests in support of the NASA Museum Alliance, a free-of-charge, nation-wide online-community of science centers, museums and planetariums hosted by JPL. NIEO at NASA's nine field centers includes mini-grants, cooperative agreements, contracts or other types of assistance to museums, science centers, planetariums, libraries, other institutions of informal education or individuals who seek to partner with NASA to provide STEM education activities, including exhibits or special events, to diverse audiences.

Mission Directorate:	Education
Theme:	Education
Program:	Informal STEM Education

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Provide educators and students with tools, experiences and opportunities to engage in NASA missions and learning experiences, improving their knowledge of, and ability to teach/learn in STEM disciplines.	Informal STEM Education Program/ NASA Informal Education Opportunities (NIEO)	Same

Program Management

The Assistant Administrator for Education is responsible to the NASA Administrator for NASA's education portfolio, reports to the NASA Administrator, serves as NASA Education Officer, and manages all education responsibilities.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
NASA Informal Education Opportunities (NIEO)	NASA Headquarters Office of Education	All NASA Centers	None

Acquisition Strategy

NASA solicits new and innovative education products, tools, and services from qualified external 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 encourages participation of new or less experienced organizations and awards education grants and contracts through full and open competition. NASA includes feedback from staff, subject matter experts, and public in developing solicitations, including the requirements, expected outcomes, schedules, proposal instructions, and evaluation approaches. NASA solicits comments on perceived programmatic risk issues associated with performance of the work. Procurement offices at NASA review all solicitations.

NASA awards all major grants and cooperative agreements based on reviews by external panels of peers for educational merit; NASA and external scientists and engineers for content, merit, feasibility, and alignment to education goals; and Mission Directorates for alignment with NASA's research and development interests. Indications of a clear competitive process are an integral part of reviews. NASA makes awards only after qualified assessments of merit. While competition may sometimes be restricted by legislation to designated participants, such as defined EPSCoR states, grant awards and selection of participating institutions are still determined competitively. When designated participants are identified, all proposals are reviewed for merit, and each award must be justified and deemed worthy of funding.

Cross-Agency Support

Overview

NASA's Cross-Agency Support (CAS) provides critical mission support activities that are necessary to ensure the efficient and effective operation and administration of the Agency but cannot be directly aligned to a specific program or project requirement. These functions align and sustain institutional and program capabilities for the purpose of supporting NASA's mission portfolio by leveraging resources to meet mission needs, establishing Agency-wide capabilities, and providing institutional checks and balances. NASA's CAS includes two themes: Center Management and Operations and Agency Management and Operations. CAS institutional and program capabilities ensure core services are ready and available for performing NASA Mission roles and responsibilities. CAS institutional capabilities ensure agency operations are effective and efficient and activities are conducted in accordance with all statutory, regulatory, and fiduciary responsibilities. CAS program capabilities ensure vital skills and assets are ready and available to meet technical milestones for programs and projects; missions and research are technically and scientifically sound; and that Agency practices adhere to standards and processes that provide safety and reliability through proper management of risk.

Center Management and Operations directly supports Agency programs and projects that are hosted and executed at NASA Centers. This theme provides for the care of institutional assets, for establishing and maintaining the staff and their competencies, and for the facilities required by current and future programs and projects at nine field Centers. Center Institutional Capabilities provides resources, oversees the assignment of workforce and facilities, and manages Center operations. Center Program Capabilities sustains the technical facilities, workforce expertise and skills, equipment, tools, and other resources required to facilitate program and project execution.

NASA's Agency Management and Operations activities provide policy and oversight to assure compliance with external and internal requirements, assure safety and mission success, and sustain Agency-wide critical capabilities. These activities provide management of human capital, acquisitions, financial performance, information technology, and performance improvement, including additional funding to improve the capability and capacity of the Agency's acquisition workforce. Agency Management and Operations provides for near and long-term alignment of its human capital policy and a corporate approach to managing its unique or highly-specialized facilities. It maintains a core complement of civil service professionals to resolve its financial, acquisition, and business challenges.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**3,356.4**	**3,095.1**	**3,111.4**	**3,189.6**	**3,276.8**	**3,366.5**	**3,462.2**
Center Management and Operations	2,024.3	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3
Agency Management and Operations	921.2	941.7	841.2	842.2	849.1	856.8	867.9
Institutional Investments	343.7	23.4	0.0	0.0	0.0	0.0	0.0
Congressionally Directed Items	67.2	63.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	**3,356.4**	**3,400.6**	**3,468.4**	**3,525.7**	**3,561.4**	**3,621.4**	**--**
Center Management and Operations	2,024.0	2,084.0	2,119.2	2,142.5	2,166.1	2,189.9	--
Agency Management and Operations	921.2	961.2	956.9	964.5	972.3	981.5	--
Institutional Investments	343.7	355.4	392.3	418.7	423.0	450.0	--
Congressionally Directed Items	67.5	0.0	0.0	0.0	0.0	0.0	--
Total Change from FY 2010 President's Budget Request	**0.0**	**-305.5**	**-357.1**	**-336.2**	**-284.6**	**-254.9**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column. The Institution Investments (II) budget has transferred to the new Construction and Environmental Compliance and Restoration (CECR) appropriation for FY 2010 and beyond. The remaining FY 2010 enacted funding includes labor and travel to support CECR activities. The II labor and travel budget will transfer to Center Management and Operations in FY 2011. The Innovative Partnerships Program (IPP) has transferred to the new Aeronautics and Space Research and Technology appropriation.

Plans for FY 2011

Cross-Agency Support

Center Management and Operations

New Initiatives:

None

Major Changes:

Labor to support the construction and environmental activities of the Construction and Environmental Compliance and Restoration account was transferred to Center Management and Operation from Institutional Investments.

Major Highlights for FY 2011

Center Management and Operations provides for continuing operations of nine field Centers, including four major component facilities, in ten separate states in support of NASA's mission portfolio. It ensures that Centers can provide the basic support required to meet internal and external requirements; effectively manage its human capital, information technology, and facility assets; responsibly execute its financial management and acquisition responsibilities; ensure independent technical oversight of NASA's programs and projects in support of safety and mission success; and provide a safe, secure, and environmentally sustainable workplace. These center capabilities provide the services and products required by the programs and projects; enable technology innovation for NASA and the broader science and engineering communities; and serve as unique national capabilities to industry, academia, and government.

Agency Management and Operations

New Initiatives:

None

Major Changes:

The Agency Management and Operations (AMO) FY 2011 budget request includes increased funding for two new requirements. The first requirement is for a new government-wide initiative to improve the capability and capacity of our acquisition workforce. An additional $3.6M is designated for training, recruiting, retention, and hiring of the agency's acquisition workforce as well as for information technology and management solutions to improve the agency's acquisition management. The second requirement is for the Independent Verification and Validation (IVV) activities that are increased by $10.0M to increase the software analysis activities on NASA's critical software systems.

A funding augmentation of $5.1M is designated to Agency Management to complete electrical metering of all appropriate Center buildings as required by Executive Order 13423. An addition of $3.0M is designated to fund natural gas metering effort at the NASA Centers in FY 2011.

This FY 2011 request includes three zero-sum transfers of content and budget into Agency Management and Operations all pertaining to the Agency Information Technology Services (AITS) activities.

To improve Information Technology (IT) security and efficiency, NASA is implementing new Agency-wide IT service contracts that consolidate or replace Agency and Center specific contracts. Currently, there are multiple approaches in place for funding for IT services across the NASA Centers making it difficult to efficiently execute critical IT services. This budget request includes a zero-sum transfer of content and budget from program budgets to Cross Agency Support to replace these multiple approaches with common, consolidated approach. As a result, the Agency Management and Operations includes an increase of $18.3M due to the transfer of common enterprise IT activities, such as integrated email, calendaring, instant messaging, and directory services into Agency IT Services (AITS).

In addition, $11.8M was transferred to Agency IT Services (AITS) for transformation and renewal of the NASA IT network infrastructure at the NASA Centers. This IT initiative will mitigate IT security threats and vulnerabilities through network security zones and provide enterprise-wide benefits of consolidated network management and monitoring, coupled with sufficient capacity and reliability to support increasing mission-related data transfer requirements.

To achieve cost savings and efficiencies, NASA will also retire the NASA Data Center (NDC) mainframe six months following the last planned shuttle flight. To facilitate this, $8.5M was transferred from the program and center budgets into AITS to transition the legacy NASA Supply Management System application from the NASA Data Center mainframe to the NASA's Enterprise Resource Planning suite.

Major Highlights for FY 2011

The Agency Management and Operations programs deliver policies, controls, and oversight across a range of functional and administrative management service areas including procurement, finance, human capital, real property and infrastructure, security, diversity, equal opportunity, and small business. For FY 2011 and beyond, the Innovative Partnerships Program has transferred to the new Aeronautics and Space Research and Technology appropriation.

The Safety and Mission Success program will continue to administer and refine policies, procedural requirements, and technical standards. Safety and Mission Success program activities are a key component of the 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. The plans for FY 2011 provide for an effective NASA Engineering and Safety Center, NASA Safety Center, and Independent Verification and Validation Facility as established and recognized components of a comprehensive remedial response to lessons learned from NASA's greatest tragedies. The plans include the required support for independent research, audit, and assessment of NASA activities that have risk for loss or failure.

NASA will complete deployment of several initiatives to improve security, efficiency and integration of information and systems. The NASA CIO will consolidate several IT contracts and implement centralized management of the IT infrastructure, which is expected to yield efficiencies and improved security of networks, end-user devices, and data center services. The NASA Communications Improvement (NCI) project will reconfigure border routers, gateways and circuits to better control and secure the network perimeter, enabling implementation of Trusted Internet Connections. The Center Zoned Architecture Project (CZAP) will establish network security zones to enable secure collaboration across NASA Centers and programs, while still allowing necessary connectivity with external partners and universities for research. Finally, the use of Smart Cards for logical access to many NASA systems will complete testing and undergo initial implementation.

Strategic Capabilities Assets Program (SCAP) will continue to provide strategic management and funding for critical facilities. The current portfolio consists of thermal vacuum chambers which provide for the thermal testing of spacecraft, flight simulators which provide for simulation of air and space vehicle flight characteristics, and an arc jet facility for critical testing of re-entry materials.

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Mission Directorate:	Cross-Agency Support
Theme:	Center Management and Operations

Theme Overview

NASA's Center Management and Operations (CMO) budget request funds the ongoing management, operations, and maintenance of nine NASA field Centers, including four major component facilities, in ten separate states across the Country. It provides Center Institutional and Program Capabilities to satisfy program requirements and schedules. The Center Management and Operations budget request enables execution of NASA's mission at the Centers by providing the resources required to effectively oversee the assignment of workforce and facilities and manage Center operations to facilitate program and project execution while ensuring that statutory, regulatory, and fiduciary compliance requirements are met.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**2,024.3**	**2,067.0**	**2,270.2**	**2,347.4**	**2,427.7**	**2,509.7**	**2,594.3**
Center Management and Operations	2,024.3	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3
FY 2010 President's Budget Request	**2,024.0**	**2,084.0**	**2,119.2**	**2,142.5**	**2,166.1**	**2,189.9**	**--**
Center Management and Operations	2,024.0	2,084.0	2,119.2	2,142.5	2,166.1	2,189.9	--
Total Change from FY 2010 Request	**0.3**	**-17.0**	**151.0**	**204.9**	**261.6**	**319.8**	**--**

Plans for FY 2011

Center Management and Operations

Activities funded within the CMO budget request include a wide variety of essential operations:

Security, environmental management, and safety services to ensure that Centers meet basic workplace standards for the public and for the NASA workforce;

Facility maintenance and operations, including utility funding, to support the Agency's infrastructure, including support to more than 5,500 facilities with a Current Replacement Value of over $23B;

Information Technology services to provide video, voice, network, data center, and desktop computer support at the Centers;

Program Capability support required to ensure that the Agency's Science, Engineering, and Technical Authority staff have the resources, services, and laboratory support required to achieve the Agency's technical mission;

Training, logistics, occupational health, and human resources services required to support the Agency's 16,600 Center civil servants;

Senior management, legal, Equal Employment Opportunity, and public affairs support at the Centers;

Procurement and Financial services supporting contract and financial management; and

Labor for the civil servants and on-site contractors that provide the above essential services at the Centers.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

Center program capability support to NASA's mission contributes to the development of advances in U.S. leadership in human space exploration,aeronautics, space and earth sciences, advancement of technical partnerships in the commercial space sector, and development of innovative technologies that benefit society.

Relevance to education and public benefits:

Strategic communications and education activities at the Centers keep stakeholders and the public informed in a way that helps them understand our policies, programs, and plans. It also fulfills the mandate of the National Aeronautics and Space Act of 1958 "[to] provide for the widest practicable and appropriate dissemination of information concerning its activities and results thereof."

Performance Achievement Highlights:

NASA Centers continued to provide high quality support for the execution of Programs and Projects. NASA faces the challenge of providing adequate levels of institutional support to the current programs while absorbing labor and utility cost increases and new requirements such as inititatives to reduce Green House Gas emissions.

To partially offset these increasing costs, NASA has implemented energy savings initiatives, consolidated activities, and reduced or deferred some Center Management and Operations activities, particularly in the area of facility maintenance.

To support energy savings, NASA updated its facilities maintenance and operations practices to strengthen the commitment to and use of sustainable procedures and methods within existing facilities as outlined by the U.S. Green Building Council LEED re-commissioning guidelines. NASA continued implementing its plans to provide electrical service metering and monitoring for facilities, installing metering, as appropriate, in most facilities. This enables a reduction in electrical power use by monitoring real-time usage to identify and resolve inefficient practices. NASA conducted water conservation assessments at many of its sites to enable progress towards its goal of reducing water usage 15% by FY 2015.

Mission Directorate:	Cross-Agency Support
Theme:	Center Management and Operations
Program:	Center Management and Operations

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	2,024.3	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3
Center Institutional Capabilities	1,542.1	1,591.7	1,776.1	1,830.5	1,890.9	1,956.3	2,021.8
Center Programmatic Capabilities	482.2	475.3	494.0	516.8	536.8	553.4	572.5
FY 2010 President's Budget Request	2,024.0	2,084.0	2,119.2	2,142.5	2,166.1	2,189.9	--
Center Institutional Capabilities	1,579.0	1,608.6	1,626.1	1,631.7	1,637.2	1,644.5	--
Center Programmatic Capabilities	445.0	475.4	493.1	510.8	528.9	545.4	--
Changes from FY 2010 Request	0.3	-17.0	151.0	204.9	261.6	319.8	--

Mission Directorate:	Cross-Agency Support
Theme:	Center Management and Operations
Program:	Center Management and Operations

Project Descriptions and Explanation of Changes

Center Institutional Capability

NASA's Center Institutional Capability encompasses a diverse set of activities including financial and human capital management; acquisition services; facility maintenance; utilities; information technology; and safety and security. This capability manages and sustains the Center staff, facilities and operations required for program and project execution and provides for the ongoing operations of nine NASA field Centers, including four major component facilities to maintain a safe, healthy, and environmentally responsible workplace. Center institutionally-sustained services are the most efficient approach to providing services and products required by programs to implement their assigned missions as well as to preserve unique national capabilities relied upon by industry, academia and government.

Center Institutional Capability is critical to the successful execution of the programs and projects executed at NASA Centers. For years, center facility maintenance and operations has been underfunded as labor, utility, and operations costs continue to grow at a higher rate than the budget. The impact of this under-funding is most evident in aging and deteriorating buildings and other infrastructure. In FY 2009, total CMO costs were $2127M, funded with FY 2009 and prior year unobligated funds. This FY 2011 request funds Center Institutional Capability at FY 2009 levels plus 4% inflation to cover increases in utilities and labor. Without this increase Centers will be forced to reduce services, increasing deferred maintenance and the risk of costly unplanned repairs, unscheduled outages and disruption to program activities.

Additionally, this request includes three zero-sum transfers of content and budget into Center Institutional Capability:

To improve Information Technology (IT) security and efficiency, NASA is implementing new Agency-wide IT service contracts that consolidate or replace Agency and Center specific contracts. Currently, there are multiple approaches in place for funding IT services across the NASA Centers making it difficult to efficiently execute critical IT services. This budget request includes a zero-sum transfer of content and budget from program budgets to Cross-Agency Support to replace these multiple approaches with a common, consolidated approach. As a result, the Center Institutional Capability request includes an increase of $17M due to the transfer of IT activities into Center Institutional Capability.

This request reflects an increase of $4.4M above the FY 10 level due to a transfer of facility support at Kennedy Space Center from program budgets to CMO. This zero-sum transfer of content and budget better aligns the Kennedy facility services CMO content with that of the rest of the Agency to improve efficiency, consistency and clarity.

$29.5M for labor to support the construction and environmental activities of the Construction and Environmental Compliance and Restoration account was transferred to Center Institutional Capability from Institutional Investments.

Mission Directorate:	Cross-Agency Support
Theme:	Center Management and Operations
Program:	Center Management and Operations

Center Program Capability

NASA's Center Program Capability supports the scientific and engineering staff across the Agency tasked with 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; enabling efficient execution of the programs and projects hosted at the Centers. A key component of NASA's overall system of checks and balances is provided within Technical Capabilities through formally delegated Technical Authorities. The Technical Authorities at NASA's nine Centers number 800 civil servant FTE who provide independent oversight and review of programs and projects in support of safety and mission success. This is to assure that NASA's activities are safely implemented in accordance with accepted standards of professional practice and applicable NASA requirements.

Center Management and Operations Technical Authority

SMA Technical Authority	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total $M	**$51.6**	**$55.6**	**$57.6**	**$59.9**	**$62.0**	**$64.2**
Ames Research Center	$3.4	$3.8	$3.9	$4.1	$4.2	$4.4
Dryden Flight Research Center	$4.6	$4.9	$5.0	$5.2	$5.4	$5.6
Glenn Research Center	$2.1	$2.2	$2.3	$2.4	$2.5	$2.6
Goddard Space Flight Center	$12.6	$14.5	$15.1	$15.8	$16.4	$17.1
Johnson Space Center	$6.8	$6.6	$6.8	$7.1	$7.3	$7.6
Kennedy Space Center	$9.3	$10.7	$11.0	$11.3	$11.6	$11.9
Langley Research Center	$3.1	$3.2	$3.3	$3.4	$3.6	$3.7
Marshall Space Flight Center	$8.2	$8.5	$8.8	$9.2	$9.4	$9.8

Engineering Technical Authority	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total $M	**$124.3**	**$130.7**	**$135.6**	**$140.9**	**$145.9**	**$151.2**
Ames Research Center	$2.3	$3.3	$3.5	$3.6	$3.8	$3.9
Dryden Flight Research Center	$6.9	$7.1	$7.4	$7.6	$7.9	$8.2
Glenn Research Center	$13.8	$14.4	$15.0	$15.7	$16.4	$17.1
Goddard Space Flight Center	$11.6	$12.4	$12.9	$13.6	$14.3	$15.0
Johnson Space Center	$21.4	$22.4	$23.2	$24.0	$24.8	$25.7
Kennedy Space Center	$12.2	$12.8	$13.2	$13.6	$14.0	$14.5
Langley Research Center	$16.0	$16.7	$17.4	$18.2	$18.9	$19.7
Marshall Space Flight Center	$37.1	$38.4	$39.7	$41.2	$42.3	$43.7
Stennis Space Center	$3.1	$3.2	$3.3	$3.4	$3.5	$3.5

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations

Theme Overview

Agency Management and Operations provides for the management and oversight of Agency missions, programs, functions and performance of NASA-wide activities. Agency Management and Operations activities at NASA Headquarters ensure that 1) core services are ready and available Agency-wide for performing our Mission roles and responsibilities, 2) the Agency operations are effective and efficient, and 3) our activities are conducted in accordance with all statutory, regulatory, and fiduciary responsibilities. NASA Headquarters develops policy and guidance for the Centers and provides strategic planning and leadership on the issues concerning availability, readiness, and sustainability. They also establish programs and initiatives to maximize individual and organizational capabilities. NASA 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 Agency capacity, and scale assets accordingly.

Agency Management and Operations includes the Headquarters management of all essential corporate functions such as human capital, finance, information technology, infrastructure, procurement, chief counsel, protective services, occupational health and safety, equal opportunity and diversity, small business programs, external relations, and strategic communications. This theme is divided into the following four programs: Agency Management, Safety and Mission Success, Agency Information Technology Services, and Strategic Capabilities Assets Program. Beginning in this FY 2011 budget request, Innovative Partnerships Program has been transferred from Agency Management and Operations to Space Technology.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**921.2**	**941.7**	**841.2**	**842.2**	**849.1**	**856.8**	**867.9**
Agency Management	389.3	398.9	432.0	451.1	455.8	460.6	467.0
Safety and Mission Success	179.8	192.9	201.6	203.8	205.8	206.6	208.7
Agency IT Services (AITS)	163.9	145.3	177.8	157.5	157.7	159.5	161.7
Innovative Partnerships Program	160.2	175.2	0.0	0.0	0.0	0.0	0.0
Strategic Capabilities Assets Program	28.0	29.4	29.8	29.8	29.8	30.1	30.5
FY 2010 President's Budget Request	**921.2**	**961.2**	**956.9**	**964.5**	**972.3**	**981.5**	**--**
Agency Management	390.0	412.7	417.4	422.0	426.6	431.3	--
Safety and Mission Success	179.1	183.9	186.1	188.6	190.9	193.0	--
Agency IT Services (AITS)	163.9	150.4	138.3	138.0	138.3	139.7	--
Innovative Partnerships Program	160.2	184.8	184.9	185.7	186.3	187.0	--
Strategic Capabilities Assets Program	28.0	29.4	30.2	30.2	30.2	30.5	--
Total Change from FY 2010 Request	**0.0**	**-19.5**	**-115.7**	**-122.3**	**-123.2**	**-124.7**	**--**

Plans for FY 2011

Agency Management

The Agency Management program will continue to deliver policies, controls, and oversight across a range of functional and administrative management service areas including procurement, finance, human capital, real property and infrastructure, protective services, diversity, equal opportunity, and small business. The Agency Management program will continue to provide infrastructure support and facility operations for NASA Headquarters.

Safety and Mission Success

The Safety and Mission Success program will continue to administer and refine the pertinent policies, procedural requirements, and technical standards. The program will 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. The plans for FY 2011 provide for an effective NASA Engineering and Safety Center, NASA Safety Center, and Independent Verification and Validation Facility as established and recognized components of a comprehensive remedial response to lessons learned from NASA's greatest tragedies. These organizations form a basis for a disciplined execution of safety, reliability, quality and system engineering needed for the successful pursuit of NASA's missions.

Agency IT Services (AITS)

NASA will continue operations for essential Agency IT services such as the Agency business applications, the NASA Scientific and Technical Information (STI) program, NASA Public Web portal, NASA Enterprise Architecture, and E-Government in FY 2011. The NASA Information Resources Management Strategic Plan focuses on four goals in this budget year associated with the Agency IT Services program. The four goals are: 1) improve the management of information and information technology, 2) improve the security of NASA information and information technology, 3) improve IT efficiency and collaboration capabilities, and 4) improve IT service delivery and visibility.

Strategic Capabilities Assets Program

Strategic Capabilities Assets Program (SCAP) will continue to provide management oversight and critical funding for our current portfolio of assets. These portfolios include thermal vacuum chambers which provide capability for thermally testing spacecraft, flight simulators which test air and space vehicles flight characteristics, and arc jet which provides capability for critical testing of re-entry materials.

Performance Achievement Highlights:

AMO supported on-going management and operations activities across the Agency and was responsible for operational efficiency gains in many mission support areas during this past year.

NASA implemented the initial phase of Security Operations Center (SOC) and initiated the second phase to improve incident management. The Agency re-architected NASA's identity, credentialing, and authentication management services to align with Federal Homeland Security Presidential Directive (HSPD-12) requirements. Several NASA Centers implemented a single directory service for managing desktops and laptops, enabling smartcard (HSPD-12 badges) access to desktops. As well, significant progress was achieved in implementation of Federal Desktop Core Configurations to strengthen Federal IT security by reducing opportunities for hackers to access and exploit government computer systems.

NASA finalized Requests for Proposals for new IT contracts that will consolidate and improve NASA's IT infrastructure. The Agency initiated development of an enterprise service desk and ordering system at the NASA Shared Services Center, which will effectively serve the entire Agency. NASA also completed design of a defense-in-depth network architecture and procured necessary hardware for a common border infrastructure at the network perimeter to improve network security.

NASA implemented Application Portfolio Management processes at all Centers, creating accurate application inventories and increased application visibility. The Agency established an enterprise licensing office at the NASA Shared Services Center (NSSC) that manages 375,000 licenses across eight product suites, resulting in $2.5M cost efficiencies and cost avoidance for the Agency.

NASA established a fully integrated state-of-the-art photo and ID/access control system in compliance with HSPD-12 requirements and deadlines. Currently, NASA has issued 100% of HSPD-12 compliant credentials/badges to NASA's eligible workforce. Noted counterintelligence accomplishments included conducting 17 full field investigations and producing Agency and Center-specific counterintelligence (CI) and counterterrorism (CT) threat assessments for all 9 centers and JPL.

The Agency established a solid baseline for the successful implementation of an Agency Safety Center in Cleveland, Ohio. Accomplishments include the 1) development of a technical qualification program for Agency Safety and mission assurance technical excellence, 2) trending of root causes and communication of lessons learned from Agency mishap investigations, and 3) continuation and improvement of the Agency safety and mission assurance review and audit program.

The NASA Engineering and Safety Center made progress resolving NASA's most critical mission success issues including the Shuttle Engine Cut-off Sensor reliability, Shuttle Wing Leading Edge reinforced carbon spallation, ISS rotary joint bearing life, and Orion seat landing loads attenuation, power system optimization, and acceleration options. The Agency developed a strategy for Agency-wide support of Product Data Management/Product Lifecycle Management standards and implementation.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency Management

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**389.3**	**398.9**	**432.0**	**451.1**	**455.8**	**460.6**	**467.0**
Agency Management	389.3	398.9	432.0	451.1	455.8	460.6	467.0
FY 2010 President's Budget Request	**390.0**	**412.7**	**417.4**	**422.0**	**426.6**	**431.3**	**--**
Agency Management	390.0	412.7	417.4	422.0	426.6	431.3	--
Changes from FY 2010 Request	**-0.8**	**-13.8**	**14.6**	**29.1**	**29.2**	**29.3**	**--**

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency Management

Program Overview

Agency Management provides governance and functional and administrative management oversight for the Agency and operational support for NASA Headquarters. Through Agency Management, policies, controls, and oversight are delivered across a range of functional and administrative management service areas. This program function primarily supports on-going operations. Agency Management support reflects the activities required for being in business in the federal sector and provides the capability to respond to legislated or other mandated services that the Agency must provide.

Agency Management activities are performed at NASA Headquarters with critical support provided by the NASA field centers. Distributed Agency Management activities are also performed at the NASA Management Office (NMO) at the Jet Propulsion Laboratory, Applied Physics Laboratory (APL), and the NASA Shared Services Center (NSSC) at Stennis Space Center. The Agency Management program supports over thirty-five discrete operations and mission support projects with over 210 separate activity line items.

Agency Management governance and oversight activities include the NASA Administrator and staff, finance, protective services, general counsel, public affairs, external relations, legislative affairs, training, human capital, procurement, real property and infrastructure, budget management, systems support, internal controls, diversity, equal opportunity, program analysis and evaluation, and small business programs.

The Agency Management program provides for the 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, and automated business systems implementation and operations costs including e-Government initiatives.

Agency Management provides for all the Headquarters civil service labor and related personnel costs (e.g. employee training, relocation allowances, workers' compensation) including the civil service labor for all the Mission Directorates. The program also covers the travel and business costs for over twenty mission support and staff offices of the Headquarters workforce.

The program is responsible for conducting independent technical assessments of Agency programs and delivers strategic planning services. Through Agency Management efforts, NASA program and mission performance are assessed and evaluated.

Plans For FY 2011

Agency Management will deliver policies, controls, and oversight across a range of functional and administrative management service areas, and provide independent technical assessments and strategic planning service, and direct the activities in procurement, finance, human capital, real property and infrastructure, protective services, diversity, equal opportunity, and small business.

Determination will be made in FY 2011 for the future housing of Headquarters office operations following the expiration of the current office building lease in July 2012. Award is tentatively scheduled for the summer of 2010. If any additional funding is required in FY 2011, it will be paid for by reallocations within the requested CAS funding level.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency Management

Project Descriptions and Explanation of Changes

Agency Management

The Agency Management budget includes Headquarters personnel salaries, benefits, travel, training, and operational costs such as rents, IT support, payroll information services, and facility services. Civil Service labor components include employee salaries and benefits and associated employee costs, such as, employee awards, promotions, lump sum retirement payments, worker's compensation, permanent change of station, recruit and retention allowances, transit subsidy program, student loan repayments and employee training. The FY 2011 labor budget supports 1,224 FTE.

HQ Operations elements include the lease costs for the rent of the HQ office building, and Inspector General leased space in New Jersey and California. Other significant operations activities include: IT and Communications infrastructure hardware and software acquisitions and maintenance, contracted IT support services, printing, graphics; facility operations support including physical security, custodial and maintenance services, equipment, expendable supplies, mail services, motor pool operations, logistics services, emergency preparedness, employee occupational health/fitness and medical services; human resources staffing, employee payroll and benefits processing, retirement services, grants awards, and employee training; costs of support provided by the Goddard Space Flight Center for accounting and procurement operations; costs of operations support, configuration maintenance, automated business and administrative systems; contract close-out services and payments to the Office of Naval Research for grants management ; equal opportunity alternate dispute resolution services, EEO complaint investigations and special emphasis diversity recognition program; and human resources.

Agency Management also provides the agency-wide management functions of finance, protective services, and program analysis. The Chief Financial Officer (CFO) is responsible for the financial leadership of NASA and its primary duty is to uphold strong financial management and accountability while providing timely, accurate, and reliable financial information and enhancing internal control. The Office of Protective Services (OPS) serves as the focal point for policy formulation, oversight, coordination and management of the Agency security, counter-intelligence (CI), counter-terrorism (CT), emergency preparedness planning, and continuity of operations functions. Independent Program and Cost Evaluation is an independent assessment organization that provides objective, transparent, and multidisciplinary analysis to support strategic decision making.

HEADQUARTERS BUDGET BY OFFICE

Agency Management Budget by Offiice ($ in miilions)	FY 2009 Funding	FY 2010 Enacted	FY 2011 Estimated	FY 2012 Estimated	FY 2013 Estimated	FY 2014 Estimated	FY 2015 Estimated
Total Agency Management	**389.3**	**398.9**	**432.0**	**451.1**	**455.8**	**460.6**	**467.0**
Missions	**60.9**	**67.5**	**71.2**	**74.0**	**75.5**	**78.4**	**80.2**
Science	23.7	26.2	27.6	28.7	29.3	30.4	31.1
Aeronautics Research	4.9	6.1	6.5	6.7	6.9	7.1	7.3
Space Technology (includes IPP)*	2.0	2.1	2.2	2.3	2.4	2.5	2.5
Exploration Systems	13.1	14.1	14.9	15.4	15.8	16.4	16.7
Space Operations	14.5	15.7	16.6	17.3	17.6	18.3	18.7
Education	2.7	3.2	3.4	3.5	3.6	3.7	3.8
Staff Offices	**121.3**	**124.4**	**129.2**	**132.3**	**132.6**	**136.6**	**138.9**
Office of the Administrator	3.3	4.2	4.3	4.5	4.6	4.7	4.8
Chief Engineer	4.0	4.6	4.9	5.0	5.1	5.3	5.5
Chief Financial Officer	27.4	27.8	29.1	29.9	30.2	31.3	31.6
Chief Health and Medical Officer	1.2	1.3	1.4	1.4	1.5	1.5	1.6
Chief Information Officer	5.1	6.7	7.1	7.3	7.5	7.8	8.0
Chief Scientist*							
Communications	17.4	14.5	10.8	10.7	10.6	10.9	11.2
Diversity and Equal Opportunity	5.7	4.5	4.6	4.6	4.7	4.8	4.9
General Counsel	9.0	8.9	9.4	9.7	9.8	10.1	10.3
Independent Program and Cost Evaluation	24.2	25.7	30.5	31.1	31.5	32.1	32.6
International and Inter-Agency Relations	11.8	13.0	13.5	13.9	13.3	13.6	13.9
Legislative and Intergovernmental Affairs	3.8	4.0	4.2	4.3	4.3	4.5	4.6
Safety and Mission Assurance	6.4	6.8	7.2	7.4	7.6	7.9	8.1
Small Business Programs	1.9	2.3	2.4	2.4	1.9	1.9	2.0
Mission Support	207.0	207.0	231.6	244.8	247.7	245.6	247.9
Budget Management and Systems Support	7.3	7.7	8.0	8.0	8.1	8.0	8.0
Human Capital Management	31.5	32.7	34.4	35.4	35.4	36.1	36.9
Headquarters Operations	115.9	114.0	124.3	123.0	126.1	122.1	122.6
Infrastructure	18.8	16.4	24.7	41.9	41.6	42.0	42.3
Internal Controls and Management Systems	2.4	2.4	2.5	2.6	2.6	2.7	2.7
Procurement	7.0	7.6	11.5	8.0	7.7	7.9	8.1
Program and Institutional Integration	10.5	10.6	11.2	10.8	10.9	11.1	11.2
Protective Services	13.7	15.7	15.1	15.2	15.4	15.7	16.0

*** Budget for the offices of the Chief Scientist and Technology Innovation have not yet been allocated**

HEADQUARTERS TRAVEL BUDGET BY OFFICE

Headquarters Travel Budget ($ in millions)	FY 2009 Actual	FY 2010 Current	FY 2011 Estimated
Total Headquarters Travel Budget	11.2	11.5	11.4
Missions	5.2	5.3	5.3
Science	1.3	1.2	1.2
Aeronautics Research	0.6	0.6	0.6
Space Technology (includes IPP)*	0.3	0.2	0.2
Exploration Systems	1.3	1.4	1.4
Space Operations	1.6	1.7	1.7
Education	0.2	0.2	0.2
Staff Offices	4.6	4.8	4.7
Office of the Administrator	0.4	0.4	0.4
Chief Engineer	0.5	0.5	0.5
Chief Financial Officer	0.4	0.6	0.6
Chief Health and Medical Officer	0.1	0.1	0.1
Chief Information Officer	0.4	0.4	0.3
Chief Scientist			
Communications	0.2	0.2	0.2
Diversity and Equal Opportunity	0.1	0.1	0.1
General Counsel	0.1	0.1	0.1
Independent Program and Cost Evaluation	0.9	1.1	1.2
International and Inter-Agency Relations	0.8	0.7	0.7
Legislative and Intergovernmental Affairs	0.1	0.1	0.1
Safety and Mission Assurance	0.3	0.3	0.3
Small Business Programs	0.1	0.1	0.1
Mission Support	1.4	1.4	1.4
Budget Management and Systems Support	0.0	0.0	0.0
Human Capital Management	0.1	0.1	0.1
Headquarters Operations	0.1	0.1	0.1
Infrastructure	0.4	0.4	0.4
Internal Controls and Management Systems	0.1	0.1	0.1
Procurement	0.2	0.2	0.2
Program and Institutional Integration	0.2	0.2	0.2
Protective Services	0.4	0.4	0.4

Headquarters FTE Assignments By Office

Headquarters	Total FTE FY 2009	SES FY 2009	Non-Career FY 2009	Contract WYE FY 2009	Total FTE FY 2010	SES FY 2010	Non-Career FY 2010	Contract WYE FY 2010	Total FTE FY 2011	SES FY 2011	Non-Career FY 2011	Contract WYE FY 2011
Total Agency Management	1179	128	11	729	1225	146	11	699	1225	146	11	666
Missions	374	40	0	213	393	48	0	171	393	48	0	138
Science	142	16	0	78	150	17	0	62	150	17	0	62
Aeronautics Research	31	5	0	12	36	9	0	7	36	9	0	7
Space Technology (includes IPP)*	12	1	0	1	12	1	0	1	12	1	0	1
Exploration Systems	81	6	0	44	84	8	0	14	84	8	0	14
Space Operations	91	9	0	62	93	10	0	71	93	10	0	38
Education	17	3	0	16	18	3	0	16	18	3	0	16
Staff Offices	472	63	11	171	490	71	11	163	490	71	11	164
Office of the Administrator	20	5	7	0	24	6	7	0	24	6	7	0
Chief Engineer	23	8	0	30	25	8	0	15	25	8	0	15
Chief Financial Officer	109	9	1	28	113	10	1	31	113	10	1	31
Chief Health and Medical Officer	8	1	0	3	8	1	0	3	8	1	0	4
Chief Information Officer	30	5	0	25	38	6	0	35	38	6	0	35
Chief Scientist												
Communications	51	5	1	26	48	6	1	26	48	6	1	26
Diversity and Equal Opportunity	20	3	0	13	20	3	0	5	20	3	0	5
General Counsel	44	5	0	0	43	6	0	0	43	6	0	0
Independent Program and Cost Evaluation	48	5	0	21	50	7	0	21	50	7	0	21
International and Inter-Agency Relations	51	7	0	12	53	7	0	6	53	7	0	6
Legislative and Intergovernmental Affairs	27	3	2	0	26	4	2	0	26	4	2	0
Safety and Mission Assurance	37	6	0	11	37	6	0	19	37	6	0	19
Small Business Programs	5	1	0	3	5	1	0	2	5	1	0	2
Mission Support	333	25	0	345	342	27	0	365	342	27	0	364
Budget Management and Systems Support	17	1	0	24	18	1	0	21	18	1	0	21
Human Capital Management	37	4	0	39	38	5	0	17	38	5	0	17
Headquarters Operations	91	3	0	273	96	4	0	302	96	4	0	302
Infrastructure	61	7	0	2	61	7	0	10	61	7	0	10
Internal Controls and Management Systems	11	1	0	1	11	1	0	1	11	1	0	1
Procurement	36	4	0	0	35	4	0	0	35	4	0	0
Program and Institutional Integration	34	3	0	3	35	3	0	5	35	3	0	4
Protective Services	46	2	0	5	49	2	0	9	49	2	0	9

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Safety and Mission Success

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**179.8**	**192.9**	**201.6**	**203.8**	**205.8**	**206.6**	**208.7**
Safety and Mission Assurance	44.3	48.2	49.0	49.5	49.9	50.5	51.2
Chief Engineer	87.0	101.1	103.6	105.2	106.8	106.9	108.4
Chief Health and Medical Officer	3.6	3.6	4.1	4.1	4.1	4.1	4.2
Independent Verification and Validation	45.0	40.0	45.0	45.0	45.0	45.0	45.0
FY 2010 President's Budget Request	**179.1**	**183.9**	**186.1**	**188.6**	**190.9**	**193.0**	**--**
Safety and Mission Assurance	42.9	48.3	48.8	49.3	49.7	50.4	--
Chief Engineer	87.0	102.2	103.6	105.3	106.8	107.0	--
Chief Health and Medical Officer	4.1	3.7	3.7	3.7	3.8	3.8	--
Independent Verification and Validation	45.0	29.7	30.0	30.3	30.6	31.9	--
Changes from FY 2010 Request	**0.8**	**9.0**	**15.5**	**15.2**	**14.9**	**13.6**	**--**

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Safety and Mission Success

Program Overview

The Safety and Mission Success (SMS) program includes the NASA Headquarters programs for technical excellence, mission assurance and technical authority. SMS includes the corporate work managed by the offices of the Chief, Safety and Mission Assurance (including the NASA Safety Center and the Independent Verification and Validation Facility), the Chief Engineer (including the NASA Engineering and Safety Center), and the Chief Health and Medical Officer. The elements of SMS reflect the recommendations of many studies, boards and panels including the direct recommendations from two major accident investigations resulting in the loss of 14 astronauts (Challenger, 1986 and Columbia, 2003). The features of 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. Aerospace technology advancement, because it is leading the edge of known capability, will always present a risk of catastrophe. SMS is the only resource that has the reduction of risk of failure as its exclusive focus.

SMS is responsible for developing policy and procedural requirements. The program provides advice to the Administrator, Mission Directorates, Program Managers and Center Directors who, due to their line management responsibilities, are ultimately accountable for the safety and mission success of all NASA programs, projects and operations and the safety and health of the associated workforce. In addition, 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 funding maintains and trains a competent technical workforce within the disciplines of system engineering (including system safety, reliability, and quality) and space medicine.

Resources provided by SMS are essential for judging the implications on safety and mission success, as well as the health and medical aspects of new requirements and departures from existing requirements. With this funding, discipline experts judge the criticality of the associated risk and evaluate the risk acceptability through an established process of independent review and assessment. The information and advice from these experts is critical for developing key decision information for the proper execution of the delegated technical authority applied at program and project decision forums.

Plans For FY 2011

For FY 2011, the individual plans for each element of the SMS align with and directly support the objectives of the Agency's Mission Directorates by helping to improve the likelihood of safety and mission success for all NASA programs, projects, and operations. SMS managers will continue to administer and refine the pertinent policies, procedural requirements, and technical standards. The managers will 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.

The plans for FY 2011 provide for an effective NASA Engineering and Safety Center, NASA Safety Center, and Independent Verification and Validation Facility as adjuncts and necessary to fulfilling the organization's assigned missions. This support assures that NASA civil service employees have, and continue to apply, the appropriate knowledge, skills, abilities, and tools for sound and well-informed decision-making on matters critical to safety and mission success. The plans will include prioritized development, maintenance, and conduct of training and education necessary for assuring the existence of a competent technical workforce. The plans include the required support for independent research, audit, and assessment of NASA activities that have risk for loss or failure.

These organizations charter independent reviews under SMS resources that judge the safety and likelihood of success of NASA activities and the health of those individuals exposed to risks that are not commonplace. The ability to author effective requirements, evaluate precisely the departures from conformance with existing requirements, and determine the criticality of the risk and evaluate and advise on its acceptability are totally reliant on the proper investment in SMS. This established process of independent review supports informed decision-making through the execution of delegated technical authority applied to program and project decisions. Without a robust application of these resources, the Agency strategy to challenge the validity of complex engineering and operational plans and proposals is flawed and subject to incuring unneccessary risks.

Due to the tremendous energies possessed by space debris, the collision between a piece of debris only a half-inch in diameter and an operational spacecraft has the potential for catastrophic consequences. The intentional destruction of the Chinese Fengyun-1C weather satellite in January of 2007 and the accidental collision of American and Russian spacecraft in February 2009 have increased the cataloged debris population by nearly 40 percent, in comparison with all the debris remaining from the first 50 years of the Space Age. For FY 2011, NASA, in connection with the U.S. Space Surveillance Network, will increase its effort in scientific studies to characterize the near-Earth space debris environment, to assess its potential hazards to current and future space operations, and to identify and to implement means of mitigating its growth. Enhancements to this space situational awareness data program during FY 2011, especially close approach predictions, offer the greatest near-term and lowest cost improvement to space safety.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Safety and Mission Success

Project Descriptions and Explanation of Changes

Safety and Mission Assurance

The SMS supports the Office of Safety and Mission Assurance (OSMA) by providing resources for independent evaluations of their approaches to improving mission success. OSMA is responsible for establishing and maintaining an acceptable level of technical excellence and competence in safety, reliability, maintainability and quality engineering within the Agency. OSMA assures that the risk presented by either a lack of safety requirement or from lack of compliance with a safety requirement is analyzed, assessed, communicated and used for proper decision-making and risk acceptance by the appropriate organizational leader.

Fundamental to these two responsibilities is the definition and execution of a robust and well understood methodology and process for the application of the disciplines of safety, reliability and quality (S, R and Q) in defining the level of risk. In addition, the organization conducts a schedule of review and assessments that focus on the life cycle decision milestones for crucial NASA programs and projects and S, R, and Q 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 (NSC) in Cleveland, OH assists OSMA in achieving its objectives in consolidating SMS efforts agency-wide in four key areas: safety and mission assurance (SMA) technical excellence, knowledge management, audits and assessments, and mishap investigation support. Since being established in FY 2007, the NSC has: (1) established a Technical Excellence initiative to improve and formalize training and qualification requirements for five SMA engineering disciplines (system safety; reliability and maintainability; quality; software assurance; and operational and aviation safety); (2) undertaken streamlined processes to increase and sustain domain knowledge within the SMA community through the facilitation, storage and retrieval of important documents and lessons learned; by providing data analysis and trending of mishap-related data; by rapidly disseminating mishap-related Agency Safety Alerts; and improving the Agency Incident Reporting Information System, a comprehensive, Agency-wide tool used for reporting mishaps and close calls; (3) continued to evaluate and streamline the conduct of facilities, programmatic and supplier audits; and (4) assembled and deployed a trained team of mishap investigators to support mishap investigations boards. The end result of these activities is to promote the highest level of safety and reliability for NASA's programs and projects. This increase in request is to make the NASA Safety Center in Cleveland, OH fully operational.

Chief Engineer

The SMS supports the Office of Chief Engineer (OCE) by providing the resources for independent and senior engineering expertise to enhance mission success. The OCE promulgates policy and requirements for program and project management, for the engineering excellence of the Agency, system engineering methodology, and for the Agency's system of engineering standards. The Office of Chief Engineer manages the NASA Engineering and Safety Center (NESC), which is responsible for rapid, cross-Agency response to mission-critical engineering issues and for improving the state of practice in critical engineering areas. OCE also sponsors the Academy of Program/Project and Engineering Leadership (APPEL) to develop Program and Project Management and Systems Engineering skills.

APPEL delivers the necessary program/project management and engineering competence learning through the application of learning strategies, methods, models and tools. APPEL provides professional development products and services for individual practitioners and program and project teams. This includes a formal training curriculum designed to address four career levels from recent college graduate to executive; direct support to project teams in the field through workshops, coaching, and technical experts; and conferences, forums and publications.

The NESC, established in FY 2003 in response to the Columbia accident, responds rapidly to cross-Agency mission-critical engineering issues and for improving the state of the practice in critical engineering areas. The NESC performs value-added independent testing and analyses and technical assessments of NASA's projects and technical activities to enhance safety and mission success. The NESC works proactively to help NASA avoid problem recurrence and to prevent future problems. SMS funding provides for the core NESC organization of senior engineering experts from across the Agency, including the NASA Technical Fellows and their Technical Discipline Teams composed of experts from NASA, industry, and academia.

Chief Health and Medical Officer

The Office of the Chief Health and Medical Officer (OCHMO) promulgates Agency health and medical policy, standards, and requirements, assuring the medical technical excellence of the Agency, assuring the physical and mental health and well being of the NASA workforce, and assuring the safe and ethical conduct of NASA-sponsored human and animal research. OCHMO exercises oversight of NASA medical and health related activities through audit processes, and monitors the implementation of health and medical related requirements and standards in all developmental human spaceflight programs through designated discipline experts at NASA Centers. OCHMO also provides oversight of medical and health related activities in operational human spaceflight through Center-based discipline experts and clinical boards. On-going medical and health discipline professionalism and licensure is supported through annual certified Continuing Medical Education (CME) activities, and flight surgeon education and clinical currency is provided through OCHMO-sponsored, university based physician training programs. NASA's biomedical research programs in support of human spaceflight are guided by OCHMO-developed health and medical standards. Center-based review boards under OCHMO sponsorship provide direct supervision of NASA-sponsored human and animal research safety and ethics, completing a comprehensive system of oversight to maintain robust health and medical support of NASA personnel at all levels.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Safety and Mission Success

Independent Verification and Validation

The NASA Independent Verification and Validation (IV&V) Project, as a part of the Agency's overall Safety and Mission Success Program, supports the Office of Safety and Mission Assurance (OSMA) by providing software expertise, services and resources 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. The NASA IV&V Project performs independent software analysis activities on NASA's most critical software systems as a "checks and balances" to assure safety and mission success of those systems.

The IV&V Project provides systems engineering activities that improve software safety, reliability, and quality of NASA programs and projects through effective applications of systems and software IV&V methods, practices, techniques, and tools. The NASA IV&V Facility applies software engineering best practices to evaluate the correctness and quality of critical and complex software systems throughout the project's System Development Life Cycle.

The IV&V Project provides resources and expertise to other OSMA elements in support of independent evaluations of software related approaches and processes, developing software related policy and procedural requirements, evaluating risks associated with new software requirements and/or departures from existing requirements, sustaining software technical excellence in the SMA community, sustaining software domain knowledge within the SMA organization, and in developing software development improvement recommendations to the Agency.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency IT Services (AITS)

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	163.9	145.3	177.8	157.5	157.7	159.5	161.7
IT Management	18.1	28.6	16.1	16.6	16.4	16.7	17.0
Applications	64.0	68.4	79.1	70.6	70.9	71.7	72.6
Infrastructure	81.8	48.3	82.6	70.4	70.4	71.1	72.1
FY 2010 President's Budget Request	163.9	150.4	138.3	138.0	138.3	139.7	--
IT Management	17.3	31.9	25.8	25.1	24.0	23.0	--
Applications	67.2	70.2	66.1	66.7	67.1	68.8	--
Infrastructure	79.4	48.3	46.4	46.2	47.2	47.9	--
Changes from FY 2010 Request	0.0	-5.1	39.5	19.5	19.4	19.8	--

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency IT Services (AITS)

Program Overview

The principles underlying the Agency IT Services (AITS) program are for NASA's information and information technology to enable the NASA mission, to provide for efficiencies and be efficiently delivered, and to be secure and integrated. Accordingly, the program provides for centrally-managed, consolidated enterprise-level services benefitting the entire Agency. The three following projects constitute the AITS program: IT Management, Applications, and IT Infrastructure (which includes IT security).

Within the IT Management project, NASA incorporates the necessary budget for the NASA Chief Information Officer to ensure effective management of the Agency's IT resources in accordance with federal laws and regulations, OMB guidance, and industry best practices. It enables the Agency to meet requirements in areas such as privacy, records management, information collections, and information quality, as well as value-added activities such as enterprise architecture, capital planning and investment control, and IT project management. Additionally, it incorporates payments to other Federal agencies for E-Government services.

Within the Applications project, NASA incorporates the development and sustaining support of Agency applications for mission support functions, such as financial management, supply management, procurement management, human capital management, etc. These services are provided by the NASA Enterprise Applications Competency Center in Huntsville, Alabama. It also includes enterprise licensing agreements and Scientific and Technical Information management on behalf of the Agency.

Within the IT Infrastructure project, NASA incorporates core IT and infrastructure services such as the NASA Public Web Portal, email, calendaring, directory services, enterprise license management, identity and credential management. Due to the close relationship between IT infrastructure and IT security, NASA incorporates IT security-related initiatives within the IT Infrastructure project. These initiatives include the NASA Security Operations Center, Agency penetration testing, vulnerability scanning, patch management and reporting, and other proactive measures to mitigate security threats.

Plans For FY 2011

For FY 2011, the AITS program will largely provide sustaining operations for essential Agency information management and IT needs under the IT Management project, Applications project and the IT Infrastructure project, with some development, modernization and enhancement (DME) planned.

The Applications project is planning significant DME activities for FY 2011 including the implementation of the SAP module for Supply Management, which will enable NASA to decommission the existing NASA Supply Management System (NSMS). NSMS currently runs on the only remaining mainframe computer at NASA, which NASA intends to decommission in concert with termination of the Space Shuttle program.

The IT Infrastructure and Security project is planning significant DME activities for FY 2011 including implementation of new contracts for for End-User Services, Integrated Communications Services (local and wide area networks), Consolidated Data Center Services, and Public Web Services. In addition, the Agency plans to implement an Enterprise Service Desk and Ordering System for Agency IT services beginning in FY 2011. The implementation of these new contracts and services will pave the way towards consolidation of NASA's networks and network management to gain efficiencies, improve security and enable cross Center data sharing required to effectively execute the NASA mission. In addition, it provides the means to consolidate data center capabilities in order to gain efficiencies and reduce related infrastructure on NASA Centers. Under the consolidated End User Services contract, NASA expects improved standardization of desktop and laptop configurations, as well as increased effectiveness in applying patches. In addition, NASA will invest in renewal of network infrastructure where necessary to mitigate risks of prolonged network outages, most notably by replacing obsolete routers on the mission network and replacing outdated wiring and electronics within some Center networks.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Agency IT Services (AITS)

Project Descriptions and Explanation of Changes

IT Management

The IT Management Project provides Agency level services for managing IT and meeting internal and external requirements relative to Agency CIO responsibilities. Included in this project are fees paid to E-Gov managing partners for the various E-Gov activities and Federal CIO Council Committees in which NASA participates. This project also constitutes the budget for the NASA Office of the CIO to meet OMB guidance, Executive Orders, laws and regulations relative to E-Government, Paperwork Reduction and Information Collection, the Federal Information Security Management Act, Records Management, Mail Management, Forms Management, Privacy, Capital Planning and Investment Control, and IT Budget Formulation under Circular A-11.

Applications

The Applications Project provides steady state operations of NASA's business and management systems developed under the Integrated Enterprise Management Program, such as, the Core Financial System (SAP), Integrated Asset Management System, the Human Capital Information Environment, and Aircraft Management Module. This project also provides Scientific and Technical Information (STI) services for the Agency. It also supports the implementation of E-Gov initiatives across the Agency, such as, E-Travel, Grants.gov and E-Training. Changes for FY 2011 include $8.45M to transition the existing NASA Supply Management System off of the mainframe computer, which is being decommissioned by NASA.

Infrastructure

The IT Infrastructure Project provides common core infrastructure services across the Agency, such as, the NASA Public Web portal, enterprise licensing, Personal Identification Verification (PIV) card systems required for identity and credential management for logical access control, and configuration control capabilities for networks, end-user services, and data centers. This project also provides IT security capabilities at the Agency level, such as the Security Operations Center (SOC), third party penetration testing, vulnerability scanning, and patch management. For FY 2011, an increase in funding will be applied to renew the aging IT network infrastructure including the mission network. Additionally, NASA has realigned IT funds within the Agency in order to implement a common funding model for IT services beginning in FY 2011. Under this model, email, calendaring, directory services, software management and other core Agency infrastructure services will be provided by the Agency End User Services contract and funded by the AITS IT Infrastructure project.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Strategic Capabilities Assets Program

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	28.0	29.4	29.8	29.8	29.8	30.1	30.5
Simulators	11.5	11.7	11.7	11.7	11.7	11.8	12.2
Thermal Vacuum Chambers	7.2	8.3	8.4	8.4	8.4	8.5	8.5
Arc Jets	9.3	9.4	9.7	9.7	9.7	9.8	9.8
FY 2010 President's Budget Request	28.0	29.4	30.2	30.2	30.2	30.5	--
Simulators	11.5	11.7	12.1	12.1	12.1	11.9	--
Thermal Vacuum Chambers	7.2	8.3	8.4	8.4	8.4	8.7	--
Arc Jets	9.3	9.4	9.7	9.7	9.7	9.9	--
Changes from FY 2010 Request	0.0	0.0	-0.4	-0.4	-0.4	-0.4	--

Program Overview

NASA's Strategic Capabilities Assets Program (SCAP) ensures that identified operational core assets and capabilities are available to support NASA's current and future missions. The SCAP establishes an alliance between all centers with like assets; makes decisions on disposition of capabilities no longer required; identifies re-investment/re-capitalization requirements within and among classes of assets; and implements changes. SCAP reviews the assets' capabilities each year to ensure the requirements continue to be valid.

SCAP ensures that essential test facilities are in a state of "ready to test". It maintains the skilled operational workforce and performs essential preventative maintenance to keep core facilities available to meet program requirements. The core capabilities supported within SCAP are Thermal Vacuum Chambers, Simulators, and Arc Jet facilities.

For additional information on SCAP, please see: http://oim.hq.nasa.gov/oia/scap/index.html.

Mission Directorate:	Cross-Agency Support
Theme:	Agency Management and Operations
Program:	Strategic Capabilities Assets Program

Plans For FY 2011

SCAP will sustain the strategic technical capabilities needed by NASA for successful missions. SCAP will institute consistency in reimbursable pricing policies, perform quarterly program performance reviews continually reassess the strategy and provide a forum for cooperation between all centers within asset classes.

SCAP will ensure maximum benefit across government by broadening its alliances outside of the Agency for capabilities, such as, thermal vacuum chambers. By initiating new organizations, such as, the Space Environments Simulation Facilities Alliance (SESFA) between NASA, DOD, and other entities. This year an arc jet alliance will be established to allow coordination between DOD and NASA in this test area. SCAP will examine and scrutinize new proposals for additional capabilities that are submitted as part of the FY 2011 budget process.

SCAP is committed to continue developing and implementing disposition plans for assets which are no longer required by the Agency.

Project Descriptions and Explanation of Changes

Simulators

SCAP sustains operations of simulators which are critical components of the success of NASA's Aeronautics Research in the areas of fundamental aeronautics and aviation safety. This capability includes an array of research and development manned flight simulator assets at ARC and LaRC which are in the operations phase. Principal assets include the Vertical Motion Simulator, a large motion system, and its supporting cabs, laboratories, and equipment at ARC which provides scientists and engineers with tools to explore, define, and resolve issues in both vehicle design and missions operations. The Cockpit Motion Facility and its supporting suite of simulators (the Differential Maneuvering Simulator and the Visual Motion Simulator) and other central support facilities at LaRC are designed to support aeronautics and spaceflight vehicle research studies in which motion cues are critical to the realism of the experiments being conducted.

Thermal Vacuum Chambers

SCAP sustains thermal-vacuum, vacuum, and acoustic chambers at NASA facilities (Glenn Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, and Plum Brook Station) that simulate conditions in the launch and space environments. These assets are large enough to accommodate a spacecraft with adequate space surrounding the structure for safe, easy access while inside the chamber. Chambers with minimum outline dimensions of 10 ft. by 10 ft. will generally meet this provision. These chambers have the capability of producing pressures of 1 X 10-2 torr or lower and thermal shrouds capable of liquid nitrogen temperatures or lower. Acoustic chambers are capable of generating approximately 150 dB at frequencies in the range of 25 to 1000 Hertz. These chambers perform significant risk mitigation for most of NASA payloads launched into space as well as many in other government agencies such as NOAA, and DOD. Almost all spacecraft launched into space must first be tested in one of NASA's thermal vacuum chambers.

Arc Jets

The NASA SCAP sustains arc-jet complexes located at Ames Research Center and the Johnson Space Center. An arc jet provides simulated high temperature, high velocity environments that support the design, development, test and evaluation (DDT&E) activities in thermal protection materials, vehicle structures, aerothermodynamics, and hypersonics. A gas (typically air) is heated and accelerated to supersonic/hypersonic speeds by a continuous electrical arc. This high-temperature gas passes over a test sample, producing an approximation of the surface temperature and pressure environments experienced by a vehicle on atmospheric entry. Arc jet testing has been critical in the safe return of Space Shuttles from orbit with tile damage. In addition, arc jet testing performed essential validation of materials for the Mars entry missions such as Mars Science Laboratory. NASA maintains two of the four arc jets in the United States providing a critical national capability.

Overview

Construction and Environmental Compliance and Restoration (CECR) provides for design and execution of programmatic and non-programmatic discrete and minor revitalization construction of facilities projects, facility demolition projects, and environmental compliance and restoration activities.

The Construction of Facilities (CoF) program ensures that the facilities critical to achieving NASA's space and aeronautics programs are the right size and type, and that they are safe, secure, environmentally sound, and operated efficiently and effectively. It also ensures that NASA installations conform to requirements and initiatives for the protection of the environment and human health. NASA facilities are essential to the Agency and facility revitalization is needed to maintain infrastructure that is safe and capable of supporting NASA's missions. The facilities being revitalized or constructed in this program are expected to remain active in the long term.

The purpose of NASA's Environmental Compliance and Restoration (ECR) program is to clean up chemicals released to the environment from past activities. Cleanups are prioritized to ensure that the highest priority liabilities are addressed first in order to protect human health and the environment and preserve natural resources for future missions.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**448.3**	**397.3**	**363.8**	**366.9**	**393.5**	**398.5**
Construction of Facilities	0.0	381.1	335.2	316.3	319.5	344.6	349.0
Environmental Compliance and Restoration	0.0	67.2	62.1	47.5	47.4	48.9	49.5
Total Change from FY 2010 President's Budget Request	**0.0**	**448.3**	**397.3**	**363.8**	**366.9**	**393.5**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Construction and Environmental Compliance and Restoration

Construction of Facilities

New Initiatives:

Further detailed in the Space Operations section of this document, NASA is initiating the development of the 21st Century Launch Complex at the Kennedy Space Center and the Florida launch range. The goal is to transform KSC and Cape Canaveral AFS into modern facilities poised to play a key role in 21st century space exploration. To do so, this new initiative focuses on upgrades to the Florida launch range, in cooperation with other interested users; expanding capabilities to support commercial launch providers, such as commercial cargo flights and future commercial crew flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads and robotic precursor missions. Other important work will include consolidating and disposing of unused or underutilized facilities, and performing environmental work to improve the surrounding area. With this large, multi-year investment, this effort will benefit NASA's current and future operations at KSC and Cape Canaveral by targeting increased efficiency and safer operations. Once details of this initiative have been established, NASA will work with Congress to ensure that appropriate funds are transferred to the construction account.

Major Changes:

All institutional and programmatic CoF budgets are consolidated in the new Construction and Environmental Restoration account established by Congress in the Consolidated Appropriation Act, 2010 (P.L. 111-117).

Major Highlights for FY 2011

FY 2011 funding will continue essential infrastructure repair and revitalization activities. Repair by replacement projects will provide sustainable and energy efficient infrastructure by replacing old, inefficient, deteriorated buildings with new efficient high performance buildings. NASA will reduce infrastructure by disposing of un-needed facilities.

Environmental Compliance and Restoration

New Initiatives:

None

Major Changes:

The Environmental Compliance and Restoration budget has been transferred to the new Construction and Environmental Restoration account established by Congress in the Consolidated Appropriation Act, 2010 (P.L. 111-117).

Major Highlights for FY 2011

FY 2011 funding should be sufficient to successfully complete the decommissioning of the Plum Brook Reactor Facility at NASA's Plum Brook Station in Ohio. Funding will also further NASA's goal of cleaning up the Santa Susana Field Laboratory in preparation for excessing the property.

Mission Directorate:	Construction and Environmental Compliance and Restoration
Theme:	Construction of Facilities

Theme Overview

Construction of Facilities (CoF) provides for design and execution of all programmatic and non-programmatic facilities projects including discrete, minor revitalization and construction, and demolition of facilities. The CoF programs are managed via NASA's Capital Facility Investment Program which includes institutional and programmatic facility investments. The construction planning process starts several years in advance, with design being funded two budget years prior to construction start. CoF requirements are developed through a process involving both internal and external stakeholders. Institutional CoF requirements from all the Centers are reviewed and prioritized annually to ensure that only the highest ranking priorities are funded. Programmatic facility requirements are identified as an integral part of the Mission Directorates program development process which ensures that only those programmatic CoF projects that are necessary for mission success are funded.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**381.1**	**335.2**	**316.3**	**319.5**	**344.6**	**349.0**
Science CoF	0.0	13.7	40.5	0.0	0.0	0.0	0.0
Exploration CoF	0.0	90.8	0.0	0.0	0.0	0.0	0.0
Space Operations CoF	0.0	27.3	14.0	0.0	0.0	0.0	0.0
Institutional CoF	0.0	249.3	280.8	316.3	319.5	344.6	349.0
Total Change from FY 2010 Request	**0.0**	**381.1**	**335.2**	**316.3**	**319.5**	**344.6**	**--**

Plans for FY 2011

Science CoF

The Science CoF Program continues the modification of the thermal vacuum Chamber A at the Johnson Space Center to achieve the required temperature and contamination control test conditions for hardware prior to flight. Renovation of the NASA Space Science Data Center at Goddard Space Flight Center will create a sustainable office facility in accordance with federal energy mandates, and in compliance with applicable codes and standards.

Exploration CoF

FY 2011 CoF requirements necessary to support the Exploration Mission are being considered in conjunction with the restructuring of the Exploration Programs and will be identified within the Program's total funding. The funds will be transferred to the Construction and Environmental Compliance and Restoration account upon enactment of the FY 2011 Budget.

Space Operations CoF

Space Operations CoF continues construction of the 24-Meter Beam Waveguide Antenna, DSS-35 at Canberra Aaustralia. It also provides for the revitalization of facilities utilized by the Launch Services Program and at Deep Space Network sites.

Institutional CoF

The Institutional CoF Program will make capital repairs to NASA's critical infrastructure and make improvements that will improve safety and security, protect NASA's infrastructure, and improve NASA's operating efficiency by reducing utility usage. The program will continue to right size the infrastructure by demolishing infrastructure that is no longer needed. Projects with initial cost estimates between $1.0 million and $10.0 million are included in the program as Minor Revitalization and Construction projects, and projects with initial cost estimates of $10.0 million or greater are budgeted as discrete projects. Projects with initial cost estimates of $1.0 million or less are accomplished by routine day-to-day facility maintenance and repair activities provided for in program and Center operating budgets. NASA will invest in projects that protect the agency's critical assets, improve mission assurance, reduce mission risk and support capabilities needed for mission. Investment in projects such as launch facility protection at Wallops Island will protect NASA's critical assets in the case of natural disasters. Fire protection system repairs and upgrades will improve worker safety and provide safer operations. NASA's repair by replacement program will provide sustainable and energy efficient infrastructure by replacing old, inefficient, deteriorated buildings with new efficient high performance buildings. In some cases, NASA will be able to refurbish existing facilities into sustainable buildings that will meet NASA's future technology needs by retaining only the structure and replacing the systems necessary for mission operations. When this approach is viable, the projects will save capital investment over wholesale replacement but still yield a good return on investment through reduced operating costs. By investing in demolition, NASA will be able to reduce un-needed infrastructure and avoid future expenses for maintaining this infrastructure. The FY 2011 program will demolish some of the first facilities that the agency has identified as un-necessary once the Space Shuttle is retired. This will allow the agency to shift some investment in Shuttle facilities to support new programs shortly after the Shuttle's last flight. More than 80% of NASA's infrastructure is beyond its design life. As NASA's facilities age beyond their useful life, the facilities become unreliable and put NASA's programs and operations at risk. To mitigate the increasing risk to NASA's missions from infrastructure failure, NASA must maintain its investment in infrastructure repair and refurbishment.

Mission Directorate:	Construction and Environmental Compliance and Restoration
Theme:	Construction of Facilities

Relevance

Relevance to national priorities, relevant fields, and customer needs:

Construction of Facilities funding ensures that NASA's facilities and field installations meet the Agency's infrastructure needs in a safe, secure, and environmentally sound manner. Activities implement sustainable design practices and support compliance with state and national environmental laws and initiatives outlined under the Energy Policy Act of 2005.

Performance Achievement Highlights:

NASA continued essential infrastructure repair and revitalization activities, completing $391 million of construction.

Additionally NASA continued reducing its infrastructure by disposing of 117 un-needed facilities. Assertive recycling strategies and sustainable demolition practices facilitated demolishing a large inactive Wind Tunnel.

PROJECT DESCRIPTIONS AND EXPLANATIONS OF CHANGES

SUMMARY OF FY 2011 COF PROJECTS

In Millions of Dollars	FY 2009 Actual	FY 2010 Enacted	FY 2011
SCIENCE	16.2	13.7	40.5
Restoration of Building 26 (GSFC)	---	---	14.0
Modify Thermal Vacuum Chamber A (JSC)	---	---	26.5
Improve Launch Pad Infrastructure, WFF (GSFC)	14.0	---	---
Minor Revitalization and Construction at Various Locations greater than $1M but less than $10M	2.2	12.6	---
Facility Planning and Design	---	1.1	---
EXPLORATION	89.8	90.8	---
Modify Space Power Facility, Plum Brook Station (GRC)	21.8	2.3	---
Modify Launch Complex 39B for ARES 1 Vehicles (KSC)	---	6.8	---
Modify Multi-Payload Processing Facility for Orion (KSC)	---	1.0	---
Modify Vehicle Assembly Building (KSC)	2.5	35.8	---
Modify Building 103 to Support Upper Stage Manufacturing, MAF (MSFC)	11.0	2.5	---
Construct A-3 Propulsion Test Facility (SSC)	---	16.8	---
Construct Vertical Assembly & Welding Highbay in Building 103, MAF (MSFC)	42.3	---	---
Modify A-1 Propulsion Test Facility (SSC)	0.9	---	---
Minor Revitalization and Construction at Various Locations greater than $1M but less than $10M	11.3	23.2	---
Facility Planning and Design	---	2.4	---
SPACE OPERATIONS	15.7	27.3	14.0
Construct 34-Meter Beam Waveguide Antenna, DSS-35, Canberra, Australia (JPL)	---	6.8	7.3
Minor Revitalization and Construction at Various Locations greater than $1M but less than $10M	15.7	20.0	6.7
Facility Planning and Design		0.5	
INSTITUTIONAL CoF PROJECTS	268.9	249.3	280.7
Construct Replacement Facilities Support Center (DFRC)	---	---	12.5
Launch Facilities Protection, WFF (GSFC)	---	7.0	13.0
Construct Integrated Services Building (LaRC)	---	---	30.4
Construct Replacement Engineering Office Building 4220 (MSFC)	---	---	40.0
Repair Hangar, Fire Protection and Electrical, Building 4820 (DFRC)	---	10.0	---
Repair Primary Electrical Distribution-Phase 6 (DFRC)	---	10.0	---
Construct Centralized Office Building (GRC)	---	25.3	---
Construct Shipping and Receiving Facility (GSFC)	---	12.5	---
Revitalize Administrative Support Building 12 (JSC)	---	22.0	---
Renovation of Operations & Checkout Building (KSC)	6.0	16.0	---
Revitalize High and Medium Voltage Electrical Distribution Systems (KSC)	---	19.0	---
Replace Asbestos Siding and Provide Energy/Safety Upgrades, Bldg 4707 (MSFC)	7.4	5.0	---

Construct Collaborative Support Facility, Building N232 (ARC)	29.0	---	---
Upgrade Electrical Supply for NASA Advanced Supercomputing Facility N258 (ARC)	11.5	---	---
Repair and Construct Consolidated Information Technology Center (DFRC)	10.8	---	---
Upgrade Auxiliary Chiller Plant (JSC)	8.3	---	---
Replace Propellant North Admin and Maintenance Facility (KSC)	4.5	---	---
Revitalize Electrical Maintenance Facility (KSC)	5.9	---	---
Repair of Hurricane Damage (JSC)	50.0	---	---
Minor Revitalization and Construction at Various Locations greater than $1M but less than $10M	81.6	84.5	137.2
Demolition of Facilities	15.0	15.0	19.9
Facility Planning and Design	38.9	23.0	27.7

DISCRETE PROJECTS

Science CoF

Project Title: Restoration of Building 26
Location: Goddard Space Flight Center, Greenbelt, MD
Mission Directorate: Science
FY 2011 Estimate: $14.0M

This project renovates the NASA Space Science Data Center, Building 26 to create a sustainable office facility in accordance with federal energy mandates, and in compliance with applicable codes and standards. Work will include replacing building system components including HVAC, plumbing, sprinklers, electrical lighting and power, doors and windows, finishes, roofing, elevator, fire alarm and removal of asbestos and lead paint. Most of the building components are original and over 40 years old. The HVAC system currently functions poorly requiring costly maintenance and is highly energy-inefficient. The steam system was installed in 1964 with the construction of the building, is in poor condition and failing. The building's electrical distribution system is original and replacement parts are discontinued. This project will improve overall facility condition of the building, extend the life of the building 25-40 years, and be LEED Silver certified.

Project Title: Modify Thermal Vacuum Chamber A
Location: Johnson Space Center, Houston, Texas
Mission Directorate: Science
FY 2011 Estimate: $26.5M

This project continues modifications to Chamber A to prepare for testing the James Webb Space Telescope (JWST) Optical Telescope Element and Integrated Science Instrument Module. Modifications include upgrade of LN2 Systems and upgrade of High vacuum systems which include installation of new gates valves and new cryo pumps, the installation of a Helium system (both refrigeration system and shroud), and installation of a new clean air system in the chamber. These modifications to the thermal vacuum Chamber A are necessary to achieve the required temperature and contamination control test conditions for flight hardware. This is the fourth of five increments for this project with the final increment planned for FY 2012. The total project cost is $73.9M.

Space Operations CoF

Project Title: Construct 34-Meter Beam Waveguide Antenna, DSS-35
Location: Canberra, Australia
Mission Directorate: Space Operations
FY 2011 Estimate: $7.3M

This project includes fabrication and installation of the antenna structure, panels, gearboxes, bearings, electric drives, encoders, beam waveguide mirrors, subreflector and subreflector positioner. It also includes the design and construction of the foundation and pedestal, as well as facilities in and around the Canberra Complex, antenna structure and pedestal, such as paved access road, trenches, drainage, flood control devices, water main and distribution system, antenna apron, security fence, HVAC, electrical power distribution, fire detection and suppression system, and surveillance system assembly. A Beam Waveguide antenna is needed to add resilience in the southern hemisphere for the Deep Space Network. This antenna is needed to support additional mission loading from projects currently under development and scheduled for launch during or after FY 2015. This is the second of three increments with a total estimated construction cost of $23.9 million with the last phase planned for FY 2012.

Institutional CoF

Project Title: Construct Replacement Facilities Support Center
Location: Dryden Flight Research Center, Kern County, CA
FY 2011 Estimate: $12.5M

This project constructs a new 20,000 square-foot Facilities Support Center (FSC) consolidating the functions of the Dryden Facilities Engineering & Asset Management Office along with the Safety, Health & Environmental Office as more than 100 people move into the new FSC. These functions are currently scattered in seven old buildings and 25 sheds and conex boxes. Many of these structures are 50-60 years old, inefficient and obsolete with high maintenance and energy costs. Most of these sites are alongside the hazardous, active aircraft flight line exposing employees to aircraft engine fumes and high noise levels. The functions need to be relocated to higher ground in the Support Services Zone. When the new FSC is complete, about 23,000 square feet of old, inefficient and obsolete structures will be demolished. The FSC will be designed to meet Leadership in Energy and Environmental Design (LEED) Silver rating fully conforming to current structural, life safety, and Americans with Disabilities Act (ADA) codes.

Project Title: Launch Facilities Protection
Location: Wallops Flight Facility, Wallops Island, Virginia
FY 2011 Estimate: $13.0M

This is the second of three increments for Wallops Island Launch Facilities Protection. The first increment extends the seawall south approximately 1500 feet to protect existing assets and repair the failing seawall based on results of a detailed inspection. This increment will begin the sand fill portion of the project. The goal of the completed beach fill segment is to provide a 70-foot wide dry beach in front of the seawall (~3M cubic yards) along its entire length (6,800 meters). Wallops Island has experienced erosion throughout the six decades that NASA has occupied the site. Since the 1990's, part of the island has been protected with a stone rubble-mound seawall. Although the seawall has temporarily limited the shoreline's erosion, the structure is being undermined and failing because there is little or no protective sand beach remaining and waves break directly on the sea wall. The south end of the island is currently unprotected and suffers continuous erosion. A 2006 Army Corps of Engineers study titled "Beach Erosion Mitigation and Sediment Management Alternatives at Wallops Island, VA" validates the need and outlines the requirements for protection. The Wallops Launch Range supports sounding rocket and NASA small satellites launches; Commercial Orbital Transportation Services (COTS) demonstration and re-supply the ISS; launches for other federal and commercial entities; and unmanned aerial vehicle (UAV) flights. The final increment is planned for FY 2012 with a total project cost of $37.6 million. The project will not provide a complete solution until final increment is executed.

Project Title: Construct Integrated Services Building
Location: Langley Research Center, Hampton, Virginia
FY 2011 Estimate: $30.4M

This project constructs a two-story integrated services building and provides related site improvements. The new 95,000 sq. ft building will house up to 125 administrative personnel and incorporate the media services center, main conference facilities, cafeteria, training classrooms, and many other services now scattered throughout Langley. The Integrated Services Building will be located very close to the center of the campus and will be energy efficient, designed to the United States Green Building Council Leadership in Energy and Environmental Design (LEED) certification requirements of silver as a minimum. Site improvements include upgrades to the existing pedestrian walkway, addition of a civic mall in the center of the campus, and expansion of surrounding parking lots. The project also includes demolition of six older buildings directly impacted by this project, removing 98,000 sq. ft of floor space and eliminating $37.8M in deferred maintenance. The buildings to be replaced by the new Integrated Services Building are over 60 years old. The fire protection systems in these older facilities are very inadequate. Most do not have sprinkler systems and many of the fire alarms, smoke detection systems, and fire exits are not code compliant. The majority of these older facilities have antiquated HVAC systems, which frequently break down and disrupt operations. The existing media services are located in four separate locations, causing this service to be very inefficient. These buildings have potential problems with hazardous materials such as asbestos; Polychlorinated biphenyls (PCBs) ballasts; mercury thermostats; and lead, chromium, and cadmium based paints. Half of the buildings are not ADA compliant. All of these facilities are run down, inefficient, and inadequate to perform their intended functions. Renovation of the existing facilities is not cost effective and eliminating these facilities reduces the risk of accidental injury or death from fire or other system failures. This is the first of two increments with a total estimated construction cost of $50.4 million. The final increment is planned for FY 2012. The project will not provide a complete and usable facility until completion of increment 2.

Project Title: Construct Replacement Engineering Office Building 4220
Location: Marshall Space Flight Center, Huntsville, Alabama
FY 2011 Estimate: $40.0M

This building is the first major replacement building in the Main Administrative Complex which comprises the northern end of the North Campus portion of the MSFC Master Plan. This project will replace Building 4202 , a deteriorated, high-maintenance, high operating cost building, with an energy and operationally efficient state-of-the art office building and will allow the efficient consolidation and co-location of a multi-discipline work force that has been widely dispersed throughout MSFC, improving functional efficiency and coordination between the various operations. The facility will meet "LEED Silver" criteria, as well as MSFC standard energy conservation requirements to ensure low operating costs for the life of the facility. This project will include the demolition of building 4202, totaling approximately 110,000 square feet and will eliminate over $4M of deferred maintenance. Building 4202 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 such as ADA compliance. Building 4220 is a cost effective solution that will provide significant operating and energy cost savings and will eliminate numerous code-compliance issues. Current HVAC inefficiencies in 4202 are significant due to the poor sealing of the windows on this six story curtain-wall structure.

MINOR REVITALIZATION & CONSTRUCTION OF FACILITIES (PROJECTS LESS THAN $10.0M EACH)

This request includes facility revitalization and construction needs with initial cost estimate greater than $1.0 million but less than $10.0 million per project. Projects with initial cost estimates of $1.0 million or less are normally accomplished by routine day-to-day facility maintenance and repair activities provided for in direct program and Center operating budgets. Proposed FY 2011 Institutional minor revitalization and construction projects total $137.3 million for components of the basic infrastructure and institutional facilities, funded in Institutional Investments, and $6.7 million for Program funded projects. These resources provide for revitalization and construction of facilities at NASA field installations and government-owned industrial plants supporting NASA activities. 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. It also includes major preventive measures that are normally accomplished on a cyclic schedule and those quickly needed out-of-cycle based on adverse condition information revealed during predictive testing and inspection efforts. 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 or increase its functional capability or so that it can meet new building, fire, and accessibility codes.

NASA's facilities are primarily from the Apollo era. Most of NASA's facilities are beyond their original design life, resulting in increased reliability problems and occasional impacts to NASA missions. Assessments of NASA's facilities indicate that the repair backlog has increased over recent years and the facilities continue to degrade. To reverse this trend, NASA has developed a long term strategy that includes increasing facility repair investments, replacing facilities when it makes economic sense and eliminating facilities that are no longer needed. The minor revitalization and construction projects that comprise this request are of the highest priority, based on relative urgency and expected return on investment. Work to be accomplished includes repair and upgrades of fire protection systems; utilities systems such as electrical distribution, water and waste water, and steam; heating, ventilating, and air-conditioning systems; roofs; roads and paved areas; and building exteriors/interiors. The amount requested addresses the most urgent repairs needed as well as component and system replacement to improve the reliability of NASA's facilities over time and reduce impacts to NASA's critical missions.

MINOR REVITALIZATION CENTER DISTRIBUTION

SPACE OPERATIONS

A. Jet Propulsion Laboratory (JPL), $2.7 million

B. Kennedy Space Center (KSC), $4.0 million

INSTITUTIONAL

A. Ames Research Center (ARC), $14.0 million

B. Dryden Flight Research Center (DFRC), $12.4 million

C. Glenn Research Center (GRC), $11.4 million

D. Goddard Space Flight Center (GSFC), $8.1 million

E. Jet Propulsion Laboratory (JPL), $5.3 million

F. Johnson Space Center (JSC), $23.7 million

G. Kennedy Space Center (KSC), $21.7 million

H. Langley Research Center (LaRC), $19.0 million

I. Marshall Space Flight Center (MSFC), $14.6 million

J. Stennis Space Center, $7.1 million

DEMOLITION OF FACILITIES

Cognizant Office: Office of Infrastructure
FY 2011 Estimate: $19.9M

The funds requested will be used to eliminate inactive and obsolete facilities that are no longer required for NASA's Mission. Abandoned facilities present eyesores on the Centers, and pose a potential safety and environmental liability. These abandoned facilities must still be maintained at minimal levels to prevent increasing safety and environmental hazards. These recurring maintenance costs exacerbate the limited maintenance dollars needed at the Centers. Demolishing these abandoned facilities will allow 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 potential facilities for the demolition program through special studies to determine if the facility is required for a current of future missions. Facilities that are no longer needed are included in a 5 year demolition plan that sets project schedules based on last need, annual costs avoided, potential liability, and project execution factors. Individual project schedules are sometimes adjusted in response to factors such as consultation with states on historic properties, changes in operational schedules, environmental remediation, funding profiles, local market forces, and cost of recycled materials. Proposed FY 2011 demolition projects will reduce facilities inventory current replacement value by roughly $188M.

FACILITY PLANNING AND DESIGN

Cognizant Office: Office of Infrastructure
FY 2011 Estimate: $27.7M

These funds are required to 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; and participation in facilities-related professional engineering associations and organizations. These resources provide for project planning and design activities associated with non-programmatic construction projects. Project planning and design activities for construction projects required to conduct specific programs or projects are included in the appropriate budget line item. Other activities funded include: 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.

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Theme Overview

NASA's Environmental Compliance and Restoration (ECR) Program primarily provides funding to complete the cleanup of hazardous materials and wastes that have been released to the surface or groundwater at NASA installations, NASA-owned industrial plants supporting NASA activities, and other current or former sites where NASA operations have contributed to environmental problems and where the agency is legally obligated to address these hazardous releases. Nearly $1 Billion worth of cleanup liabilities impacting all NASA centers are prioritized to ensure that the highest priority liabilities are addressed first in order to protect human health and the environment, and preserve natural resources for future missions. Specific program activities include projects, studies, assessments, investigations, plans, designs, related engineering, program support, sampling, monitoring, regulatory agency oversight costs, and any land acquisitions necessary to ensure operation of remedial treatment processes and sites as part of the remediation and cleanup measures. In an effort to respond to recent executive orders and address the increasing impacts of global climate change on NASA facilities and projects, the ECR program also provides for strategic investment in environmental methods and practices to ensure that NASA may continue to carry out its primary missions. Included are investments in 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 the mission project design phase. Additional information concerning NASA's ECR program can be found at http://oim.hq.nasa.gov/oia/emd/ecr.html

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**67.2**	**62.1**	**47.5**	**47.4**	**48.9**	**49.5**
Environmental Compliance and Restoration	0.0	67.2	62.1	47.5	47.4	48.9	49.5
Total Change from FY 2010 Request	**0.0**	**67.2**	**62.1**	**47.5**	**47.4**	**48.9**	**--**

Plans for FY 2011

Environmental Compliance and Restoration

The FY 2011 funding request represents a prioritized, risk-based approach for addressing a total of 136 cleanup projects remaining at all NASA centers and is based upon 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, it is expected that program priorities may change requiring revisions to planned activities. Major cleanups with the highest priority requirements planned for accomplishment in FY 2011 include the following:
1) Continue decommissioning and demolition of NASA's Plum Brook Reactor Facility. FY 2011 funding should allow NASA to terminate its Nuclear Regulatory Commission (NRC) license.
2) Address ground water and drinking water issues associated with contamination emanating from NASA's Jet Propulsion Laboratory;
3) Continue cleanup of ground water contamination at White Sands Test Facility; and
4) Accelerate cleanup of contamination at Santa Susana Field Laboratory to facilitate property transfer.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

ECR funding ensures that contaminated sites at NASA centers, several of which are listed on EPA's National Priorities List (Superfund) or have high congressional or public interest, are completed effectively and in accordance with existing federal, state, and local laws and regulations.

Relevance to education and public benefits:

The Environmental Compliance and Restoration program ensures that the public is not exposed to hazards and that impacted natural resources are restored for future use.

Performance Achievement Highlights:

In FY09, NASA continued to address high priority cleanups, completing 12 sites and continuing remediation operations at another 75 sites out of a total of 150 individual cleanups. Soil and groundwater remediation at the Santa Susana Field Laboratory continued in preparation for transferring this property as excess. At the Jet Propulsion Laboratory, NASA initiated construction of a groundwater treatment system to address offsite contamination. Additionally, concerns about releases to an offsite estuary were alleviated and final status survey work commenced at the Plum Brook Nuclear Reactor Facility.

Mission Directorate:	Construction and Environmental Compliance and Restoration
Theme:	Environmental Compliance and Restoration
Program:	Environmental Compliance and Restoration

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
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Changes from FY 2010 Request	0.0	67.2	62.1	47.5	47.4	48.9	--

Program Overview

NASA's Environmental Compliance and Restoration (ECR) Program primarily provides funding to complete the cleanup of hazardous materials and wastes that have been released to the surface or groundwater at NASA installations, NASA-owned industrial plants supporting NASA activities, and other current or former sites where NASA operations have contributed to environmental problems and where the agency is legally obligated to address these hazardous releases. Liquidating these liabilities is estimated to cost nearly one billion dollars with much of that work planned in the next decade. Specific program activities include projects, studies, assessments, investigations, plans, designs, related engineering, program support, sampling, monitoring, regulatory agency oversight costs, and any land acquisitions necessary to ensure operation of remedial treatment processes and sites as part of the remediation and cleanup measures. This program also invests in methodologies for sustainably reducing energy intensity and greenhouse gas emissions and supports operational activities by ensuring that advances in chemical risk management are incorporated early in the mission project design phase. Additional information concerning NASA's ECR program can be found at http://oim.hq.nasa.gov/oia/emd/ecr.html

Plans For FY 2011

The FY 2011 funding request represents a prioritized, risk-based approach for addressing a total of 136 cleanup projects remaining at all NASA centers and is based upon 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, it is expected that program priorities may change requiring revisions to planned activities. Major cleanups with the highest priority requirements planned for accomplishment in FY 2011 include the following:
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Mission Directorate:	Construction and Environmental Compliance and Restoration
Theme:	Environmental Compliance and Restoration
Program:	Environmental Compliance and Restoration

Program Management

Primary responsibility for managing the ECR program and determining program priorities resides within the Environmental Management Division at NASA HQ.

Acquisition Strategy

Services necessary for carrying out the ECR program are provided primarily through external contractors managed by in house environmental engineers at affected NASA centers.

Overview

The NASA Office of Inspector General (OIG) budget request for FY 2011 is $37.0 million. The NASA OIG consists of 192 auditors, analysts, specialists, investigators, and support staff at NASA Headquarters in Washington, DC, and NASA Centers throughout the United States. The FY 2011 request supports the OIG mission to prevent and detect crime, fraud, waste, abuse, and mismanagement while promoting economy, effectiveness, and efficiency within the Agency.

The OIG Office of Audits (OA) conducts independent, objective audits and reviews of NASA and NASA contractor programs and projects to improve NASA operations, as well as a broad range of professional audit and advisory services. It also comments on NASA policies and is responsible for the oversight of audits performed under contract. OA helps NASA accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the economy, efficiency, and effectiveness of NASA operations.

The OIG Office of Investigations (OI) identifies, investigates, and refers for prosecution cases of crime, waste, fraud, and abuse in NASA programs and operations. The OIG's federal law enforcement officers investigate false claims, false statements, conspiracy, theft, computer crimes, mail fraud, and violations of federal laws, such as the Procurement Integrity Act and the Anti-Kickback Act. Through its investigations, OI also seeks to prevent and deter crime at NASA.

NASA's FY 2011 OIG request is broken out as follows:

- $30.9M (83.5 percent) of the proposed budget is dedicated to personnel and related costs, including salaries, benefits, monetary awards, worker's compensation, permanent change of station costs, as well as the Government's contributions for Social Security, Medicare, health and life insurance, retirement accounts, and matching contributions to Thrift Savings Plan accounts. Salaries include the required additional 25 percent law enforcement availability pay for criminal investigators.

- $1.2M (3.3 percent) of the proposed budget is dedicated to 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.

- $1.7M (4.6 percent) of the proposed budget is dedicated to operations and includes funding for training, government vehicles, special equipment for criminal investigators, metro subsidies, and information technology equipment unique to the OIG.

- $3.2M (8.6 percent) of the proposed budget is funding for the Agency's annual financial audit.

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**35.6**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**	**40.5**
Inspector General	35.6	36.4	37.0	37.8	38.7	39.6	40.5
FY 2010 President's Budget Request	**35.6**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**	**--**
Inspector General	35.6	36.4	37.0	37.8	38.7	39.6	--
Total Change from FY 2010 President's Budget Request	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**--**

Note: In accordance with Public Law 110-409, Inspector General Reform Act of 2008, the Inspector General certifies that the $.4M for staff training and $.1M to support the Council of Inspectors General on Economy and Efficiency included in the budget request satisfy all known training requirements and planned contributions to the Council.

In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column. Budget shown is the same as the IG's original request to the Agency.

Plans for FY 2011

Inspector General

Inspector General

New Initiatives:

None

Major Changes:

None

Major Highlights for FY 2011

The FY 2011 budget estimates for the IG is a total of $37.0 million:
Personnel and related costs $30.9 million
Travel $1.2 million
Operations and Equipment $4.9 million

SUPPORTING DATA TABLE OF CONTENTS

CIVIL SERVICE FULL-TIME EQUIVALENT DISTRIBUTION BY CENTER

The workforce level proposed in the 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, educators, and students.

Average Agency FTE levels of nearly 18,300 are expected from FY 2010 through FY 2015. The workforce will demonstrate the relevance to society of its work, apply itself to contemporary problems, lead or participate in emergent technology opportunities, and communicate the results of Agency programs and activities.

The Agency will apply its capabilities to the range of mission, research and technology work while continuing workforce reshaping and realignment to adjust to emerging requirements. The Agency anticipates offering buyouts in selected surplus skill areas, and it expects to identify, recruit, and retain employees who possess essential/critical skills and competencies. To promote workforce revitalization and adaptability, the Agency has set a goal of having no more than 85% of all Civil Service Science and Engineering (S&E) employees employed as Full-Time Permanent (FTE) Employees. These strategies are making good use of the flexibilities granted to the Agency in the NASA Flexibility Act of 2004.

	Actuals[1]	FTE Estimates[2]					
	FY09	FY10	FY11	FY12	FY13	FY14	FY15
ARC	1,254	1,233	1,234	1,222	1,222	1,222	1,222
DFRC	556	553	555	551	547	547	547
GRC	1,607	1,659	1,662	1,652	1,642	1,634	1,634
GSFC	3,131	3,263	3,272	3,252	3,232	3,212	3,212
JSC	3,342	3,336	3,338	3,322	3,322	3,322	3,322
KSC	2,131	2,153	2,156	2,136	2,136	2,136	2,136
LaRC	1,895	1,945	1,946	1,927	1,927	1,927	1,927
MSFC	2,609	2,566	2,567	2,561	2,561	2,561	2,561
SSC	268	275	276	272	272	272	272
HQ	1,179	1,225	1,225	1,225	1,225	1,225	1,225
NSSC	128	146	146	146	146	146	146
TOTAL	**18,100**	**18,354**	**18,377**	**18,266**	**18,232**	**18,204**	**18,204**

[1] *Includes 250 student FTE* [2] *Includes 267 student FTE each FY*

BUDGET FOR FY 2011 BY OBJECT CLASS CODE

The following tables reflect projections of obligations for FY 2011 based on FY 2009 actual obligations. The tables and data are organized to reflect the Mission Directorate structure which began in the FY 2009 budget with the exception of the Construction and Environmental Compliance and Restoration mission which was initiated in FY 2010.

FY 2011 Total and Mission Directorate Estimates ($M)	**NASA**	**SCIENCE**	**AERONAUTICS AND SPACE RESEARCH AND TECHNOLOGY**	**EXPLORATION**	**SPACE OPERATIONS**	**EDUCATION**	**CROSS AGENCY SUPPORT**	**CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION**
Personnel compensation								
Full-time permanent	1,906	213	209	368	275	4	837	0
Other than full-time permanent	148	16	17	42	26	0	48	0
Other personnel compensation	52	1	2	3	3	0	43	0
Special personal service payments	1	0	0	0	0	0	1	0
Total Personnel compensation	**2,108**	**230**	**228**	**413**	**304**	**4**	**929**	**0**
Civilian personnel benefits	534	59	57	109	77	0	231	0
Benefits to former personnel	5	0	0	1	1	0	3	0
Travel & transportation of persons	85	16	8	20	15	1	25	0
Transportation of things	837	1	0	1	832	0	3	0
Rental payments to GSA	26	0	0	0	0	0	26	0
Rental payments to others	8	5	0	0	1	0	2	0
Communications, utilities & misc charges	126	6	8	7	26	0	79	0
Printing and reproduction	8	2	0	0	1	0	5	0
Advisory and assistance services	660	121	31	289	52	3	164	0
Other services	811	249	50	66	118	7	322	0
Other purchases of goods & services from Gov accounts	310	111	6	52	86	0	54	0
Operation and maintenance of facilities	2,059	20	45	187	1,144	1	279	382
Research & development contracts	8,594	3,488	490	2,475	1,822	7	312	0
Medical care	4	0	0	0	0	0	4	0
Operation and maintenance of equipment	625	63	21	50	175	2	315	0
Supplies and materials	155	24	21	41	39	0	30	0
Equipment	207	41	19	19	81	0	47	0
Land and structures	281	9	10	65	26	0	172	0
Grants, subsidies, and contributions	880	551	53	85	4	127	60	0
TOTAL DIRECT	**18,322**	**4,996**	**1,047**	**3,880**	**4,804**	**151**	**3,062**	**382**

Status of Unobligated Funds

The figures below represent actual unobligated balances within NASA's individual appropriation accounts as of September 30, 2009, and estimates for the disposition of those accounts at the future dates specified.

FY 2009 – FY 2011 Appropriations ($ in millions)	Unobligated Balances Sept. 30, 2009 [1]	Estimated Unobligated Balances Sept. 30, 2010	Estimated Unobligated Balances Sept. 30, 2011
Science	317	91	100
Aeronautics and Space Research & Technology	154	10	115
Exploration	229	47	430
Space Operations	12	63	147
Education	28	27	22
Cross-Agency Support	80	22	71
Construction and Environmental Compliance and Restoration		112	127
Inspector General	2	0	0
Total NASA	**822**	**372**	**1,012**

Prior Year Appropriations ($ in millions)	Unobligated Balances Sept. 30, 2009	Estimated Unobligated Balances Sept. 30, 2010	Estimated Unobligated Balances Sept. 30, 2011
Science, Exploration, & Aeronautics	27		
Exploration Capabilities	31		
Science			
Aeronautics			
Exploration			
Space Operations			
Education			
Cross-Agency Support			
CoF & ECR			
Total NASA	**58**	**0**	**0**

[1] FY 2009 Unobligated balances includes $608 million of 2009 Recovery Act funding

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 2011 estimate is based on historical data.

Budget Authority ($ in millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011
Cross Agency Support	1,351.4	1,717.2	1,700.0
Office of Inspector General	0.5	1.2	1.2
Total	**1,351.9**	**1,718.4**	**1,701.2**

ENHANCED USE LEASING

In 2003, NASA was authorized by Congress to demonstrate leasing authority and collections at two Centers. In 2007 and in 2008, that authority was amended by Congress 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% 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 EUL income. The table below depicts the estimated FY 2011 Enhanced Use Leasing (EUL) expenses and revenues. The amounts identified under Capital Asset Account Expenditures may be adjusted between projects listed based on actual contract award.

FY2011 EUL Expenses and Revenues ($K)	ARC	KSC	Agency	Total
Base Rent	$6,612.2	$57.9		$6,670.1
Institutional Support Income	$1,747.5	$14.4		$1,761.9
Total Rent Income	**$8,359.7**			**$8,359.7**
Institutional Support Costs	-$1,747.5	-$14.4		-$1,761.9
Lease Management and Administration	-$720.0			-$720.0
Tenant Building Maintenance and Repair	-$320.0			-$320.0
Total Cost Associated with Leases	**-$2,787.5**	**-$14.4**		**-$2,801.9**
Net Revenue from Lease Activity	**$5,572.2**	**$57.9**		**$5,630.1**
Beginning Balance, Capital Asset Account	**$0.0**	**$0.0**		**$0.0**
Net Revenue from Lease Activity	**$3,621.9**	**$37.6**	**$1,970.5**	**$5,630.0**
- Planned Maintenance, Various building (ARC)	$1,600.0			$1,600.0
- Life Safety and Seismic Repairs, Various Buildings (ARC)	$212.0			$212.0
- Replace Roofs, Various Building (ARC)	$1,750.9			$1,750.9
- Replace Roof on Building N231 ARC Jet Lab & Machine Shop (ARC)	$59.0			$59.0
- Energy and Sustainability Upgrades, Various Buildings (Various Centers)			$1,970.5	
Center Capital Asset Account Expenditures	**$3,621.9**	**$0.0**	**$1,970.5**	**$5,592.4**
Capital Asset Account Ending Balance	**$0.0**	**$37.6**	**$0.0**	**$37.6**
Additional Reimbursable Demand Services Requested by Leasees (including overhead)	$1,091.8			$1,091.8
Cost to Fulfill Reimbursable Demand Services (including overhead)	-$1,091.8			-$1,091.8
Net activity due to Reimbursable Demand Services	**$ -**	**$ -**		**$0.0**
In Kind	**$425.0**	**$ -**		**$425.0**

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 Jan 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 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. The figures shown in the table below do not include safety and mission assurance costs associated with lower level NASA projects. The out-year numbers are estimates.

$ In Millions	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Total Safety Oversight	**485.3**	**498.2**	**494.8**	**498.2**	**507.8**	**517.5**	**527.5**
Agency-wide Safety Oversight	**115.7**	**121.2**	**123.0**	**125.0**	**127.1**	**129.2**	**131.5**
Safety and Mission Assurance	44.3	48.3	48.8	49.3	49.8	50.4	51.0
Institutional Operational Safety	25.2	25.7	26.2	26.7	27.3	27.8	28.4
Technical Authority	23.4	23.9	24.3	24.8	25.3	25.8	26.4
Safety & Mission Assurance Spt.	22.8	23.3	23.7	24.2	24.7	25.2	25.7
Program Specific	**369.6**	**377.0**	**371.8**	**373.2**	**380.7**	**388.3**	**396.0**
Exploration	43.4	44.3	185.0	275.0	280.5	286.1	291.8
Science	69.0	70.4	71.8	73.2	74.7	76.2	77.7
Space Operations	257.2	262.3	115.0	25.0	25.5	26.0	26.5

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, the mishap prevention program including reporting and investigations, safety training, safety awareness, the safety management 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 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.

Supporting Data: Budget for Safety Oversight (continued)

Safety and Mission Assurance (S&MA) Technical Authority
The S&MA technical authority program includes labor and travel 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 requirement 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.

Safety & Mission Assurance Mission Support
S&MA 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 activities that support the safety and mission success needs of an individual project.

BUDGET FOR PUBLIC RELATIONS BY CENTER

The NASA budget for Public Affairs is not funded by programs. Instead, it is budgeted in two separate accounts under 1) Center Management and Operations (CMO) and 2) Agency Management and Operations (AMO). All the Installations listed below with the exception of Headquarters are in the CMO account. The Headquarters budget is in the AMO 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, nasa.gov portal and other multimedia support. Funding by installation is shown below.

Center ($ in millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Ames Research Center	1.0	1.5	1.6	1.7	1.7	1.8	1.9
Dryden Flight Research Center	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Glenn Research Center	1.9	2.6	2.7	2.8	2.9	3.1	3.2
Goddard Space Flight Center	3.6	4.3	4.4	4.6	4.8	5.0	5.2
Headquarters	7.9	3.8	3.8	3.8	3.8	3.8	3.8
Johnson Space Center	6.6	6.8	5.6	5.8	6.2	6.1	6.7
Kennedy Space Center	4.7	1.9	2.0	2.0	2.1	2.2	2.2
Langley Research Center	2.1	2.5	2.5	2.6	2.7	2.7	2.7
Marshall Space Flight Center	2.7	1.3	1.4	1.4	1.4	1.4	1.5
Stennis Space Center	1.4	11.1	8.6	8.5	8.7	9.1	9.2
Total	**32.6**	**36.5**	**33.3**	**34.0**	**35.1**	**36.0**	**37.2**

SUMMARY OF CONSULTING SERVICES

NASA uses paid experts and consultants to provide advice and expertise to or beyond that which is available from its in-house civil service workforce. Management controls are established which assure that before entering into a consultant or expert services arrangement with an individual that there is ample justification.

Most of the expert and consultant services are used by 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 are used to provide independent looks at technical and functional problems in order to give top management the widest possible range of views before making major decisions.

Expert / Consultants (Total NASA)	**FY 2009 Actual**	**FY 2010 Current**	**FY 2011 Estimate**
Number of Paid Experts and Consultants	46	40	40
Annual FTE Usage	6	5	5
Salaries	$0.5	$0.3	$0.3
Total Salary and Benefits Costs	$0.6	$0.4	$0.4
Travel Costs	$0.3	$0.3	$0.3
Total Costs	**$0.9**	**$0.7**	**$0.7**

Note: Definition of Consultants and Experts

A *consultant* is 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.

An *expert* is 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 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 to the Office of Personnel Management (OPM) annually.

E-GOV INITIATIVES AND BENEFITS

NASA is providing funding contributions in FY 2011 for each of the following E-Government Initiatives:

Initiative	2011 Contributions (Includes In-Kind)	2011 Service Fees *
E-Rulemaking 026-00-01-99-04-0060-24		$55,113
Grants.gov 026-00-01-99-04-0160-24	$208,424	
E-Training 026-00-01-99-04-1217-24		$700,000
Recruitment One-Stop		$96,791
EHRI 026-00-01-99-04-1219-24		$362,772
E-Payroll 026-00-01-99-04-1221-24		$3,825,650
E-Travel 026-00-01-99-04-0220-24		$1,552,396
Integrated Acquisition Environment 026-00-01-99-04-0230-24		$1,783,828
IAE-Loans and Grants 026-00-01-99-04-4300-24		$2,156
Financial Management LoB 026-00-01-99-04-1100-24	$75,000	
Human Resources Management LoB 026-00-01-99-04-1200-24	$65,217	
Grants Management LoB 026-00-01-99-04-1300-24	$59,316	
Geospatial LoB 026-00-01-99-04-3100-24	$15,000	
Budget Formulation and Execution LoB 026-00-01-99-04-3200-24	$105,000	
NASA Total	**$527,957**	**$8,378,706**

* Service Fees are estimates as provided by the E-Government Initiative Managing Partners

NASA's FY 2010 Exhibit 300 IT business cases will be posted at: www.nasa.gov/offices/ocio/reports/exhibit300.html within two weeks of the release of the President's Budget. NASA's Congressional Justification, which will be posted online, will include a link to the Exhibit 300s. Additional information about these NASA investments (along with other Federal IT investments) can be explored in more detail at 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 2011 are as follows:

E-Rulemaking (Managing Partner EPA) FY 2011 Benefits

NASA's benefits for the E-Rulemaking initiative are largely focused on public benefits. One-stop access to NASA and other Federal agency information on rulemakings and non-rulemaking activities is included in the more than 2 million documents posted on *Regulations.gov*. The rate at which the public uses *Regulations.gov* to submit comments (known as public submissions) is increasing rapidly. The public initially submitted about 1,000 comments per month during the first 18 months of the public site. Now, the public submits nearly 40,000 comments per month. The public has also visited *Regulations.gov* more than 200 million times, averaging 5 million hits per month in 2006, 6.2 million in 2007, and 12.5 million in 2008.

Regulations.gov site active is illustrated by the following statistics for FY 2009:

- Monthly average number of site hits is 10.5 million;
- Monthly average number of page views is 6.6 million;
- Approximately 39,000 documents added per month on average; and
- Nearly 2.2 million documents are available to the public on the site;

Since FY 2008, over thirty departments and independent agencies (constituting more than 90% of Federal rulemaking activity) have fully implemented the Federal Docket Management System (FDMS) and additional agencies continue to join the program each year. The E-Rulemaking program currently supports nearly 7,500 Federal agency users from more than 160 rulemaking entities.

In addition to the process benefits the E-Rulemaking 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 E-Rulemaking 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 E-Rulemaking Program to develop a Cost-Benefit Model.

NASA benefits in several ways through its participation and reliance on FDMS and *Regulations.gov*. NASA reaps substantial benefits by improving the transparency of its rulemaking actions as well as increasing public participation in the regulatory process. Direct budget cost savings and cost avoidance result from NASA's transition to FDMS 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 thousand over alternative options that would provide similar services.

Grants.gov (Managing Partner HHS) FY 2011 Benefits

The *Grants.gov* Initiative benefits NASA and its grant programs by providing a single location to publish grant (funding) opportunities and application packages, making the process easier for applicants to apply to multiple agencies. *Grants.gov* achieved tremendous growth during FY 2009 exceeding the previous Fiscal Year total of 202,366 submissions. *Grants.gov* received a total of 309,771 submissions in FY 2009 – a 53% increase.

All 26 major Federal grant making agencies posted 100% of their synopses for discretionary funding opportunity announcements on *Grants.gov*. 4,547 discretionary application packages were posted in FY 2009, 717 of those accompanying a matching synopsis. The remaining 3,830 approved exemptions included some fellowships and collaborative grants (government-wide processing is still in initial government-wide functional requirements phase with the agencies and *Grants.gov*), or were not discretionary applications but were requests for information (RFI), broad agency announcements (BAA), or by the nature of their business process had not been posted within the quarter that was being measured. By the end of FY 2009, 717 opportunities were available for electronic application through *Grants.gov*, representing an increase of more then 20% over FY 2008.

Additionally, 886 discretionary synopses were posted in FY 2009, with 12,927 posted since the launch of the *Grants.gov* website and 795,915 application submissions have being processed by *Grants.gov* since full processing was deployed in FY 2004. These submissions cover all agency and application populations – small to large, research to state and local governments, not-for-profit, etc.

Through the government-wide *Grants.gov* Memorandum of Understanding (MOU) and Service Level Agreement (SLA) with all 26 Federal agencies, *Grants.gov* provided contact center operations servicing on over 220,862 phone calls and 64,180 emails for a total of 285,042 contacts on behalf of the grant making agencies. The *Grants.gov* Program Management office serviced and trained over 8,500 people including Federal, state and local grant administrators, Congressional workshops, and grant organizations. Additionally, over 24,198 registration brochures were distributed during FY 2009. Grants.gov instituted quarterly satellite webcasts to provide outreach, status,technical and program management status and support servicing to the grant community.

The Grants.gov Initiative benefits NASA and its grant programs by providing broader exposure to a wider community who could potentially apply for NASA funding. 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 use of Grants.Gov by increasing data accuracy and reducing processing cycle times.

E-Training (Managing Partner OPM) FY 2011 Benefits

The E-Training Initiative provides a premier electronic training environment to support the 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 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 and other Federal workforce by reducing redundancies and achieving economies of scale in the purchase and/or development of E-Learning content and in purchase of learning technology infrastructure. In 2006, NASA streamlined its three separate online training systems into one centralized learning management system, SATERN. SATERN is a “one-stop” approach offering Web-based access to training and career development resources. This centralized approach has allowed NASA to reduce costs through the consolidation of multiple learning systems.

Through these consolidations in SATERN, employees can more comprehensively view required training, launch online content, view training history, and self-register for courses. In addition, the system allows NASA to identify offices that have not met training requirements and bring them in line with Federal mandates. SATERN also offers employees access to career planning tools, individual development plans, and competency management tools. Currently SATERN has more than 2,000 online courses and 10,000 online books in its catalog, and recently added new SkillSoft courses covering a wide variety of topics and subject areas for business, information technology, and engineering. SkillSoft and Books 24x7 are available through SATERN at anytime, so they can easily be accessed at the employee's convenience either at work or at home.

Recruitment One-Stop (Managing Partner OPM) FY 2011 Benefits

USAJOBS is the United States Government's official system and program for Federal jobs and employment information. The USAJOBS system delivers the service by which Federal agencies meet their legal obligation (5 USC 3327 and 5 USC 3330) to provide public notice of Federal employment opportunities to Federal employees and American citizens. USAJOBS receives revenue from other government agencies through a fee-for-service funding model. In FY 2010, USAJOBS expects to collect $9.780 million in revenue and incur expenses of $9.058 million.

Since the inception of the Recruitment One Stop (ROS) Initiative, Federal agencies have enjoyed the uninterrupted use of the USAJOBS System. In previous years, the Competitive Service Components bore the cost of maintaining the site and the functionality associated with the system. Beginning in FY 2008, all agencies using USAJOBS shared in the cost of operation. The FY 2009 fee assessment was lowered by 21% to return FY 2008 savings to agency stakeholders in a manner that allowed funds to be used for other HR programs in FY 2009.

The following program enhancements and major initiatives are scheduled during FY 2010:

- Billing and Collection of fees from agencies using a historically based "per-posting" model that mimics the private sector fee structure.
- Continuous Monitoring and Independent Verification and Validation program will be managed by the USAJOBS Program Office. All vendor systems entering through the Business Gateway (BGW) and connecting to USAJOBS must meet minimal connectivity standards prior to access being granted.
- Expiration of the current master technology contract and the re-compete for services contract.
- Intensified and targeted Marketing and Outreach Program

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 250,000 visitors per day (the online portal serviced over 50 million applications during FY 2008) and over 100,000 resumes are created monthly.

NASA adopted the USAJOBS resume as the basic application document for all NASA positions, except for Astronaut positions, with Phase II implementation completed in 2005. Although the Agency believes that implementation of ROS 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, numerous intangible benefits ROS 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 2011 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 that is 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 some other Federal and Local Governments with a total user population of more than 1.9.million The system will replace the existing manual HR 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. In FY 2009, EHRI increased the number of converted folders to more than 1.2 million for more than 30 agencies.

Specific EHRI/eOPF benefits to NASA include improved convenience in searching, better security and safety to electronic files, is more economical streamlined business processes, and enabled the ability to have a central repository of OPF records for the Agency. 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 action processing to the NASA Shared Service Center (NSSC).

E-Payroll (Managing Partner OPM) FY 2011 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. Now four providers furnish payroll services for the Executive Branch. In 2004, the Department of Interior (DOI) began serving as NASA's payroll provider, using their system called the Federal Personnel and Payroll System (FPPS), to process NASA's HR and Payroll transactions. 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 cost avoidance of duplicative capital system modernization activities. The initiative also promotes standardization of business processes and practices and a unified service delivery.

E-Travel (Managing Partner GSA) FY 2011 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 superior customer satisfaction. The ETS is commercially hosted to minimize technology development costs to the government and guarantee refreshed functionality for basic travel services included in the master contract. From travel planning and authorization to the review and approval of post-travel reimbursement, this end-to-end service streamlines travel management and enables the government to capture real-time visibility into the buying choices of travelers while assisting agencies in optimizing their travel budgets thus producing a savings to the taxpayer.

The benefits of the ETS include:

- Increased cost savings associated with overall reduction to 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. Prior to ETS, the estimated overall government-wide on-line adoption rate for travel reservations was approximately 6%. To date, in agencies using the ETS end-to-end, the on-line booking engine (OBE) adoption rate is over 76% resulting in dramatic cost savings as a result of lowering travel agent service fees.

NASA completed migration of its travel services to Electronic Data Systems Corporation (EDS), 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.

Integrated Acquisition Environment (Managing Partner GSA) FY 2011 Benefits

The Integrated Acquisition Environment (IAE) initiative is designed to streamline the process of reporting on subcontracting plans and to provide agencies with access to analytical data on subcontracting performance. Use of the IAE common functions and 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. Over 6.5 million hours were saved by the contributing agencies in completing over 14.4 million recorded acquisition business process transactions. Contributing agencies received estimated benefits of $341.6 million based upon the processes, personnel, roles, steps, and actions involved. Additionally, agencies realized an estimated cost avoidance of $5.8 million and estimated operational cost savings of $31.5 million.

The IAE services were greatly impacted by the passage of the American Recovery and Reinvestment Act of 2009 ("the Recovery Act"). In order to provide greater transparency and openness for Recovery Act opportunities, the FedBizOpps (FBO) team quickly took several actions to flag Recovery Act actions and simplify searches for Recovery actions. The Federal Procurement Data System (FPDS) team also was able to respond quickly to the demands for transparency related to Recovery Act expenditures by insertion of Treasury Account Symbols into FPDS and providing a report to track recovery spending.

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 were not allowed to use the IAE systems, they 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.

Integrated Acquisition Environment – Loans & Grants FY 2011 Benefits

All agencies participating in the posting and/or awarding of Federal Contracts, Grants and 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]

[1] More information on the development of this website can be found at: http://www.federalspending.gov.

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 FFATA statutory requirements, ahead of schedule. Since 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.

In addition to routine enhancements to improve usability and maintainability, USASpending.gov is focused on supporting implementation of sub-contract and sub-grant awards reporting.

Cross government cooperation with OMB's IAE 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 FFATA enhances transparency of Federal program performance information and funding.

The FY 2011 IAE Loans and Grants funding requirement 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 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 2011 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. Agencies will be able to improve financial management decision making and program performance.

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.

Benefits of these SSPs include:

- Cost Avoidance:
    - Agencies using SSPs will not have to configure, operate and maintain individual financial systems, whether customized or commercial off-the-shelf (COTS);
    - Share common costs for standard application management and IT support functions; and
    - Minimize costs of testing and evaluation for upgrades.
- Facilitate Best Practices:
    - Agency SSP customers leverage IT and financial processing expertise to provide shared services to multiple agencies, boards, and commissions;
    - Share consistent, reliable financial data that can be shared across agency business systems
    - Use standardized, government-wide financial codes and categorizations of financial transactions that improve financial reporting and accountability;
    - Increase efficiency of financial transactions through reengineered and stream-lined business processes; and
    - Minimize risks associated with financial system implementation by providing a uniform starting point for configuration

In October 2009, FMLoB released the standard business processes for Reporting and Reimbursable Management. Currently, FM LoB is creating tools that will offer agencies a boilerplate solicitation template and guidelines for completing an RFP or system migrations. FMLoB is also incorporating public feedback to draft core financial system requirements. Once the requirements have been updated, the certified core accounting software products will be tested and a federal configuration will be implemented to help agencies upgrade their existing financial management software or migrate to an SSP.

NASA implemented their core financial system the year preceding establishment of the FMLoB and has already invested and consolidated much of its financial transaction processing to a central Shared Services Center. NASA has expressed interest in becoming an FMLoB Shared Service Provider for the Federal government.

Human Resources Management LoB (Managing Partner OPM) FY 2011 Benefits

Through the HR LoB, OPM is using Enterprise Architecture (EA)based principles and best practices, proven through the E-Gov initiatives and Federal Enterprise Architecture (FEA), to identify common solutions for HR business processes and/or technology-based shared HR services to be made available to government agencies. Driven from a business perspective rather than a technology focus, the solutions will address distinct business improvements that enhance government's performance of HR services in support of agency missions delivering services to citizens. The end result of the HR LoB efforts will be to save taxpayer dollars, reduce administrative burdens, and significantly improve HR service delivery.

The revised HR LOB Cost Benefit Analysis (CBA) identified cost savings and avoidance to be realized by the Federal government as agencies migrate their HR and p ayroll systems to Shared Service Centers. Through FY 2015, the projected cost savings will exceed $1.3 billion with total lifecycle benefits of nearly $3 billion and total lifecycle costs of $1.6 billion. As the HR LOB continues to move forward with agency migrations to the approved Shared Service Centers (SSCs), significant cost savings and avoidance are achieved and other benefits such as improved management, operational efficiencies, and improved customer services are realized.

To date five U.S. government agencies have been designated as public sector SSCs: Department of Agriculture (USDA), Department of the Interior, Department of the Treasury, Department of Health and Human Services and Department of Defense (DoD). The four private sector SSCs are: Accenture National Security Services, Allied Technology Group, Inc., Carahsoft Technology Corporation, and IBM. In addition, four U.S. government agencies serve as payroll providers: DoD's Defense Finance and Accounting Service (DFAS), the General Services Administration (GSA), the Department of Interior's National Business Center (NBC) and the USDA's National Finance Center (NFC).

Selected HR LoB accomplishments from 2009 include:

- HR and Payroll Benchmarking
    - Performed the first-ever HR Benchmarking study of Shared Service Centers and agencies providing a snapshot of current HR operational performance and set a baseline of performance in 2009 against which to compare future progress. Updated the Payroll Benchmarking study, which continues to demonstrate the success of the four Federal E-Payroll providers when compared to industry benchmarks.

- Provider Assessment
    - Completed the design and development of an assessment process to appraise HR LOB Shared Service Centers and Payroll Providers on their ability to deliver services to their customers emphasizing compliance, transparency and modernization. The assessments are designed to deliver benefits to both providers and their customer agencies.

- Cost Benefit Analysis
    - Updated the HR LOB Cost Benefit Analysis and established a new baseline for measuring cost savings and cost avoidance associated with the initiative. The CBA calculates the cost savings and avoidance that will be realized across the government as a result of the HR LOB initiative and agency migration of core HR IT and payroll services to an HR LOB SSC or Payroll provider. By the end of FY 2015, the HR LOB is projected to generate over $1.3 billion in total cost savings and avoidance for the government. After FY 2015, the HR LOB is expected to generate over $200 million in cost savings annually.

- HR Systems Integration
    - Completed version 1.0 of the *Integration Support Project* which provides the first-ever end-to-end integration view of government-wide HR systems at OPM. Building on version 1.0 of the ISP, the HR LOB also launched an effort to address multiple feeds and redundant data, and enhance the user experience of OPM government-wide systems. In addition, the HR LOB established an E-Authentication workgroup to develop a standardized approach for implementing E-Authentication across agencies and government-wide systems.

- HR Enterprise Architecture
    - Mapped HR LOB Target Requirements to the Service Component Model to provide customers and providers a common understanding of HR services that can serve as a basis for negotiating service-delivery expectations.

In FY 2010 the HR LoB will conduct the following activities designed to achieve the initiative's goals:

- HR IT Transformation
    - Provide and manage a government-wide Human Resources Information Technology (HR IT) strategy that integrates Office of Personnel Management (OPM) systems to address multiple feeds and redundant data and enhance the end user experience; put into place the standards, guidelines, architectural specifications, and governance to achieve integration; and establish a government-wide vision for HR IT that enables HR transformation.
- Standards and Requirements
    - Monitor the evolution of the Federal Enterprise Architecture (FEA) and ensure HR IT innovation through updating the HR LOB FEA models and target requirements.
- SSC Oversight and Assessment
    - Oversee agency migrations to Shared Service Centers and implement the Provider Assessment program designed to assess SSC's ability to deliver services to their customer agencies with a focus on compliance, modernization, and transparency.
- SSC Performance Measurement and Agency HR Benchmarking
    - Work with agencies and SSCs to identify and pursue opportunities to become more efficient, customer service-oriented, cost effective, and more strategically focused. Conduct HR and payroll benchmarking studies and results to promote best practices.
- Strategy Formulation
    - Develop and execute the HR LOB strategy to achieve the initiative goals and objectives. Promote effective and efficient collaboration across partner agencies and other stakeholders through the HR LOB governance structure.

NASA works in partnership with one of the approved service providers, the Department of Interior's National Business Center (NBC). Through this partnership, NASA shares and receives "best-in-class" HR solutions. NBC 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 NBC. NASA achieves the benefits of "best-in-class" HR solutions through implementation and integration of NBC 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.

Grants Management LoB (Managing Partners HHS and NSF) FY 2011 Benefits

The Grants Management Line of Business (GMLoB) will ultimately offer the development of a government-wide solution to support end-to-end grants management activities promoting citizen access, customer service, and financial and technical stewardship for the Agency. The end result is intended to be a government-wide streamlined grant making process providing transparency and efficiency in the grant decision-making process. The benefits of GMLoB include increased service to citizens through standardized processes; cost savings for grant-making agencies through use of shared IT infrastructure; a reduction in the number of redundant grants management systems; and improved reporting on government-wide grant activities and results. The GMLoB adopted a “consortia-based” approach to implementation and developed a process for forming consortia and having agencies participate in consortia as members.

In FY07 NASA signed a Memorandum of Understanding (MOU) with its selected consortia partner, the National Science Foundation (NSF). In 2008 NASA implemented NSF’s new research-focused initiative, *Research.gov*, improving public access to detailed information about NASA awards. *Research.gov* is a collaborative partnership of Federal research-oriented agencies working together for the ultimate benefit of the research community. The Research Spending and Results Service lets Congress, the general public, and the broader research community easily search and find grant award information for NASA and NSF in one place. For 2010 and beyond, NASA and NSF are continuing to together to serve the research community and to provide access to information and services for both agencies in one location. NASA news and information is also now available in *Research.gov’s* Policy Library and Research Headlines. Moving forward, NASA will continue to collaborate with NSF to explore and implement future *Research.gov* service offerings based on NASA and research community needs.

Geospatial LoB (Managing Partner DOL) FY 2011 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 FGDC standards where these are appropriate. In FY 2008 and FY 2009, NASA signed MOUs with DOL to continue its participation in the Geospatial LOB.

Budget Formulation and Execution LOB (Managing Partner Education) FY 2011 Benefits

The Budget Formulation and Execution Line of Business (BFELoB) provides significant benefits to partner agencies by encouraging best practices crossing all aspects of Federal budgeting -- from budget formulation and execution to performance to collaboration to human capital needs. To benefit all agencies, BFELoB continues to support the idea of shared service budget systems. NASA procured a budget system prior to the establishment of the BFELoB. NASA is an active participant in the BFELoB's weekly and bi-weekly meetings.

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 has begun exploring the use of BFELoB's online meeting tool for NASA meetings. Currently, NASA has 536 active users in the community. NASA has been using the MAX Community site for the hosting of NASA emergency preparedness materials and as the launch pad for guidance and execution of the American Recovery and Reinvestment Act of 2009 activities, including, but not limited to, NASA internal audits.

The BFELoB released *MAX Collect* to facilitate the rapid collection and reporting of agency information. NASA expects to benefit from reduced errors, and reduced time spent manually consolidating and publishing data by using *MAX Collect*'s data collection capabilities. NASA is investigating the possible benefits of 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. NASA has already begun looking into the benefits from using MAX Analytics' data visualization tools.

In October, 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 look into the benefits of using it 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 in FY 2010. 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. BFELoB will continue to expand this framework in 2010. In addition, the BFELoB Human Capital work group offers multiple technical and developmental training opportunities throughout the year. NASA benefitted with half a dozen agency staff attending BFELoB sponsored trainings in FY 2009.

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Management and Performance

Overview

The Management and Performance section provides a comprehensive record of the past and planned performance for NASA's programs and projects. This section includes an update to the FY 2010 Performance Plan based on Congressional budget action; a summary of the cost and schedule performance of NASA's projects with estimated life cycle cost above $250 million; and progress on NASA's performance improvement initiatives. The NASA FY 2011 Performance Plan, typically included in this section, will instead accompany the NASA 2010 Strategic Plan later this spring, to be consistent with the Agency’s updated strategic goals.

NASA's planning and performance management processes are an essential part of the Agency's governance and strategic management system. The Agency has an integrated system to: plan strategy and implementation; monitor, assess, and evaluate performance toward commitments; identify issues; gauge programmatic and organizational health; and provide appropriate data and information to NASA decision-makers.

Through its strategic management system, NASA: identifies the Agency's long-term Strategic Goals, multi-year Outcomes, and other key performance measures; develops and implements plans to achieve these Goals; and continuously measures the Agency's progress toward these Goals. NASA managers use performance results as a basis for key investment decisions, and NASA performance data provides a foundation for both programmatic and institutional decision-making processes.

NASA's planning and performance management processes provide data to Agency management via: ongoing monthly and quarterly analysis and reviews; annual assessments in support of budget formulation (for budget guidance and issue identification, analysis, and disposition); annual reporting of performance, management issues, and financial position; periodic, in-depth program or special purpose assessments; and recurring or special assessment reports to internal and external organizations.

NASA's performance system is designed to align with the Agency's internally and externally imposed performance measurement and reporting requirements, tools, and practices, including the Government Performance and Results Act and Executive Order 13450, Improving Government Program Performance. Examples of recent activities are provided in the Performance Improvement narrative that follows.

NASA continues to use independent program assessments, which are listed in the theme and program sections of this document, and commits to improvement actions in response to the findings.

NASA strives to find new ways to use performance information to support decisions concerning strategy and budget. A continued focus for NASA in FY 2010 is to improve the metrics and analysis processes for life cycle cost and schedule performance monitoring and reporting. The Major Program Annual Reports discussed in this section is one of the reporting tools used to determine how NASA performs this task.

Performance Improvement

NASA's Mission demands high levels of performance from our diverse workforce, whose knowledge, skills, and dedication are the backbone of our achievements. NASA has aligned the Agency's performance systems, organizational structure, policies, and processes to ensure programmatic content, institutional capabilities, and other resources are focused on successfully completing the programs and projects tied to our Strategic Goals. The Agency governance councils have joint responsibility for sustaining this alignment through a set of clear, transparent, and repeatable processes that flow to all organizational elements and levels within the Agency. Aligning the entirety of NASA with our Strategic Goals is essential for organizational effectiveness and efficiency. NASA communicates priorities and directions for all components of the Agency through a planning and decision process based on prior year performance and future year objectives. This annual guidance is the benchmark for other processes, including feedback on internal control needs, risk concerns, and safety and mission assurance issues that ripple through our programmatic and institutional framework, ultimately influencing the allocation of resources for each budget year.

The Agency continues to find value in, and improve upon its monthly forum, the Baseline Performance Review. As an integrated review of institutional and program activities, inter-related issues that impact performance and program risk are highlighted and actions are assigned for resolution. In 2009 quarterly reviews for the topics of diversity, small business, and information technology were added. The Baseline Performance Review forum fosters communication across organizational boundaries to address mutual concerns and interests.

In FY 2009 a requirement to improve the agency's program management was met by NASA's Academy of Program/Project Engineering Leadership (APPEL). A comprehensive set of actions to integrate training and certification of program managers was implemented and over 70 project managers were certified (ahead of plan). In FY 2010 and beyond, certification will keep pace by training new managers as they are identified. APPEL will continue to enhance NASA's mission through learning opportunities for individuals, project teams, and the program and project management community. In FY 2010, APPEL's new knowledge-sharing initiative, "Pass the Torch," will share lessons learned from the Space Shuttle Program, and its Hands on Project Experience (HOPE), in partnership with the Science Mission Directorate, will build training opportunities for young engineers.

In FY 2010, NASA will begin tracking its four High Priority Performance Goals developed in response to a White House initiative for building a high-performing government. NASA's goals focus on research and operational activities in the areas of air transportation, climate change, "green government," and future workforce preparation.

In FY 2011, NASA will participate in an OMB pilot program for impact evaluations. NASA will participate as a way of assessing programs in NASA's portfolio that do not fall within the flight program management process, and to build additional internal capability for this type of assessment. The NASA evaluation pilot will begin efforts to examine the broader societal benefits of the Applied Sciences Program in facilitating use of NASA's Earth science data products by partner organizations in their decision making activities for areas such as resource allocation, early warning systems, general planning, and disaster response.

In FY 2011, NASA will continue to examine its policies and processes to enhance its performance management system and use of performance information in planning and decision-making.

2010 Major Program Annual Report Summary

The 2010 Major Program Annual Report (MPAR) is provided to meet the requirements of section 103 of the National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613; the Act). The 2010 MPAR consists of this summary along with the 2011 Budget Estimates *Project in Development* pages for the fourteen projects included in this year's report. The later documents constitute each project's annual report, or baseline report, if this is the first year for which it is in reporting. This summary also includes, for the first time, the confidence level information requested in the Conference Report accompanying the FY 2010 Consolidated Appropriations Act (P.L. 111-117).

Table 1 provides cost, schedule, and confidence level information for NASA projects currently in development with lifecycle cost (LCC) estimates of $250M or above.

Changes in MPAR Composition since the 2010 NASA Budget Estimates

One project, the Wide-field Infrared Survey Explorer (WISE) mission is no longer included in this report, since WISE successfully launched in December 2009 and is operational.

Four projects with estimated life cycle costs greater than $250M received authority to proceed into development since the 2009 MPAR was prepared for the 2010 NASA Budget Estimates, and are baselined in this report:

- Global Precipitation Measurement (GPM) mission;
- Landsat Data Continuity Mapper (LDCM) mission;
- Magnetospheric Multiscale (MMS) mission; and
- Tracking and Data Relay Satellite (TDRS-K/L) mission.

Updated cost and schedule estimates are provided for six projects baselined in previous MPAR reports:

- Aquarius mission;
- Glory mission;
- James Webb Space Telescope (JWST);
- National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP),
- Solar Dynamics Observatory (SDO), and
- Stratospheric Observatory for Infrared Astronomy (SOFIA).

The Mars Science Laboratory (MSL) project baseline has been re-established, as required by the Act when the development cost estimate for a project exceeds 30% of its original baseline. This new baseline reflects previously-reported cost and schedule growth associated with technical difficulties resulting in a change in launch date from the 2009 to the 2011 launch window.

Changes in Cost and Schedule Estimates from the 2009 MPAR

Two projects exceeded a cost or schedule threshold since the 2009 MPAR: the Glory and Aquarius missions.

Management and Performance

The Glory mission schedule has grown by 17 months and costs have grown by 31% since the project established a new baseline in 2008. This growth is due predominantly to testing failures of the spacecraft computer, that only became evident after a year of successful testing. After work on the existing computer was unable to correct the failures, NASA opted to replace the computer with another model. The cost and schedule estimates reported in Table 1 reflect the redesign, modification, and re-testing required as a result of this technical change, in addition to the cost of the computer equipment itself. The schedule estimate and associated costs also reflect the need to accommodate the Taurus corrective action plan following the Orbiting Carbon Observatory (OCO) launch failure, as both missions relied on the same launch vehicle.

The Aquarius project cost estimate has grown by 15 percent of its MPAR baseline cost, as established in the 2008 NASA Budget Estimates, due to additional delays by its international partner. NASA is providing additional support to this partner and has rephased its planned costs to reduce the overall impact of these schedule delays on project costs.

The Agency is completing the report required under the Act providing additional information on growth of the Glory mission, which includes the reasons for these changes in cost and schedule, alternatives assessed by the Agency, and the selected actions. A report will not be provided for Aquarius, as there had already been one produced when the original schedule breach occurred,

Confidence Levels

The Conference Report accompanying the FY 2010 Consolidated Appropriations Act requires "NASA to include in its annual budget justifications the reserve amount assumed by the agency to be necessary for the program and the amount actually proposed for each directorate, theme, program, project and activity, or if the proposed funding level is based on confidence level budgeting, the confidence level assumed in the proposed funding level."

NASA utilizes a confidence level approach to budgeting. This approach incorporates program and project risks directly into cost and budget estimates and, as such, is suited to NASA's complex, high-risk portfolio. This approach affords project managers the necessary flexibility to pro-actively manage and mitigate the large technical and other risks associated with NASA's missions. The likelihood of meeting any given estimate is referred to as the confidence level (CL). Implementation of this approach varies depending on the type of program, as described below. To fulfill the Congressional direction, per the 2010 Appropriations Conference Report, where applicable to the type of NASA project, the confidence level is reflected in table 1 below. NASA distinguishes between Space Flight and Ground System projects in development; projects in operations, and Research & Technology projects. All of the projects that are currently subject to MPAR reporting fall within the Space Flight category.

Space Flight Projects in Development. NASA's acquisition strategy policy (NPD 1000.5) requires space flight projects and programs to develop probabilistic cost estimates, which incorporate the likely cost impacts of project risks. NASA targets a confidence level of about 70 percent for most of its projects and programs.

NASA is in the process of transitioning its probabilistic cost estimation from consideration of cost risk only to a joint cost and schedule approach designed to increase the likelihood of project success at the specified funding level. The application of the this joint cost and schedule confidence level (JCL) approach is expected to increase insight into uncertainties and contingencies within an integrated technical, cost, schedule, and risk plan. Because this approach requires the employment of new tools and techniques, full implementation will take some time to deploy. NASA's space flight projects are in various states within this transition, hence not all have a JCL that has been produced, and many were grandfathered into MPAR reporting under past cost estimation techniques.

The confidence levels provided in Table 1 for three projects (LDCM, MMS, and MSL) represent a JCL. Two projects (SOFIA and JWST) have JCLs in progress. Two of the projects (NPP and SDO) were baselined prior to NASA's transition to probabilistic cost estimation, so do not have a CL to report. A confidence level for the re-baselined Glory project was not part of the project's continuation (rebaseline) review. Further details are provided in the footnotes to Table 1.

Space Flight Projects in Operations. The annual costs for operational programs are estimated based on the likely costs required to maintain required operational performance given identified risks to this performance. Reserves are not explicitly budgeted, but these risks are managed as liens against the program budget over the course of the operating year. As with space flight development programs, NASA does not budget for all known risks; as a result liens are often larger than available budget. Program Managers focus their mitigation and risk management efforts on the risks with the largest potential consequences or which have a high probability of occurring. The level of operational confidence reflected in each operational program's cost estimate varies depending on the consequences of a loss of performance and are provided in the Agency's Annual Performance Plan Update also found in this section.

Research and Technology Programs. Research and technology programs address technical and science challenges and outcomes. These programs do not include reserves or specific confidence levels within their estimated costs. Rather, they operate on a 'level of effort' basis; matching progress to available funding and using interim milestones to assess on-going progress towards key research or technology goals.

Table 1: MPAR Summary and Confidence Levels

Project	Base Year	Confidence Level[1]	Development Cost Est. ($M) Base	Development Cost Est. ($M) 2010	Cost Change (%)	Key Milestone[2]	Key Milestone Base	Key Milestone 2010	Schedule Change (months)	Cost Change > 15%[3]	Schedule Change > 6 Mo[3]	Factors Contributing to Breaches since 2009 MPAR: Internal	Factors Contributing to Breaches since 2009 MPAR: External
Aquarius	2007	75%[5]	$193	$223	16	LRD	Jul-09	Jan-11	18	**X**	X		Additional delays by international partner.
Glory	2009	N/A [6]	$259	$339	31	LRD	Jun-09	Nov-10	17	**X**	**X**	Current estimates reflect decision to replace spacecraft computer after failure.	
GPM	2010	70%	$555	$555	0	LRD	Jul-13	Jul-13	0				
GRAIL	2009	70%	$427	$427	0	LRD	Sep-11	Sep-11	0				
Juno	2009	70%	$742	$742	0	LRD	Aug-11	Aug-11	0				
JWST	2009	JCL in-process	$2,581	$2,710	5	LRD	Jun-14	Jun-14	0				
LDCM[4]	2010	70% (JCL)	$583	$583	0	LRD	Jun-13	Jun-13	0				
MMS[4]	2010	70% (JCL)	$857	$857	0	LRD	Mar-15	Mar-15	0				
MSL	2010	70% (JCL)	$1,720	$1,720	0	LRD	Nov-11	Nov-11	0				
NPP	2006	N/A[7]	$593	$725	22	LRD	Apr-08	Sep-11	41	X	X		
RBSP	2009	70%	$534	$534	0	LRD	May-12	May-12	0				
SDO	2006	N/A[7]	$624	$667	7	LRD	Aug-08	Feb-10	18		X		
SOFIA	2007	JCL in-process	$920	$1,097	19	FOC	Dec-13	Dec-14	12	X	X		
TDRS-K,L[4]	2010	75%	$209	$209	0	LRD	Dec-13	Dec-13	0				

[1]The confidence level estimates reported here reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Each estimate reflects the practices and policies at the time it was developed. For example, levels provided in Table 1 for three projects (LDCM, MMS, and MSL) represent a JCL. Two projects (SOFIA and JWST) have JCLs in progress. Estimates which include combined cost and schedule risks are denoted as Joint Confidence Level (JCL) estimates; all other Confidence Levels (CL) reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.
[2]Key Milestone LRD = Launch Readiness Date; and FOC = Full Operational Capability.
[3]Bolded "X" indicates new changes compared to 2009 MPAR
[4];The confidence level estimate addresses the full partnership; the developments cost reflect the NASA portion of project costs.
[5]CL estimate reflects NASA portion of project; the cost increases reflected here represent the impact of partnership delays.
[6]A confidence level for the re-baselined Glory project was not part of the project's continuation (rebaseline) review.
[7]Pre-dates use of probabilistic analysis.

National Aeronautics and Space Administration Proposed Appropriation 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, $5,005,600,000, to remain available until September 30, 2012.

AERONAUTICS AND SPACE RESEARCH AND TECHNOLOGY

For necessary expenses, not otherwise provided for, in the conduct and support of aeronautics and space 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, $1,151,800,000, to remain available until September 30, 2012; of which $579,600,000 shall be for aeronautics activities; and of which $572,200,000 shall be for space research and technology activities.

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; 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; 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, $4,263,400,000, to remain available until September 30, 2012: Provided, That when any activity has been initiated by the incurrence of obligations for construction of facilities or environmental compliance and restoration activities as authorized by law, such amount available for such activity shall remain available until September 30, 2016.

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; maintenance; 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; 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, $4,887,700,000, to remain available until September 30, 2012: Provided, That when any activity has been initiated by the incurrence of obligations for construction of facilities or environmental compliance and restoration activities as authorized by law, such amount available for such activity shall remain available until September 30, 2016.

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; program management; personnel and related costs, 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, $145,800,000, to remain available until September 30, 2012.

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 $120,000 for official reception and representation expenses; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, $3,111,400,000, to remain available until September 30, 2012.

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, $397,300,000, to remain available until September 30, 2016.

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General, in carrying out the Inspector General Act of 1978, $37,000,000.

ADMINISTRATIVE PROVISIONS
(INCLUDING TRANSFER OF FUNDS)

Funds for announced prizes otherwise authorized shall remain available, without fiscal year limitation, until the 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. 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.

The unexpired balances of previous accounts, for activities for which funds are provided under this Act, may be transferred to the new accounts established in this Act that provide such activity. Balances so transferred shall be merged with the funds in the newly established accounts, but shall be available under the same terms, conditions and period of time as previously appropriated.

Section 20 of the National Aeronautics and Space Administration Authorization Act of FY 1992 (Public Law 102–195, 42 U.S.C. 2467a) is amended by adding at the end thereof: "(d) Availability of Funds— The interest accruing from the National Aeronautics and Space Administration Endeavor Teacher Fellowship Trust Fund principal shall be available in FY 2011 and hereafter for the purpose of the Endeavor Science Teacher Certificate Program.".

Of funds provided under the headings "Science" and "Exploration" in this Act, up to $15,000,000, 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.

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AA	Associate Administrator
AAD	Aircraft Aging and Durability
ACCESS	Advanced Collaborative Connections for Earth System Science
ACE	Advanced Composition Explorer
ACRIMSat	Active Cavity Radiometer Irradiance Monitor Satellite
ADCAR	Astrophysics Data Curation and Archival Research
AEDC	Arnold Engineering Development Center
AESP	Aerospace Education Services Program
AFB	Air Force Base
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AISR	Applied Information Systems Research
AITS	Agency Information Technology Services
ALI	Advanced Land Imager
AMM	Aircraft Management Module
AMMOS	Advanced Multi-Mission Operations System
AMMP	craft Maintenance and Modification Program
AMO	Agency Management and Operations
AMS	Alpha Magnetic Spectrometer
AMSR-E	Advanced Microwave Scanning Radiometer for the Earth Observing System
AO	Announcement of Opportunity
APG	Annual Performance Goal
APL	Applied Physics Laboratory (Johns Hopkins University)
APPEL	Academy of Program/Project and Engineering Leadership
APR	Annual Performance Report
ARC	Ames Research Center
ARISS	Amateur Radio on the International Space Station
ARMD	Aeronautics Research Mission Directorate
AS&T	Aeronautics Science and Technology
ASAP	Aerospace Safety Advisory Panel
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ASP	Airspace Systems Program
ASPERA-3	Analyzer of Space Plasma and Energetic Atoms-3
ASR	Aviation Safety Report
ASRG	Advanced Stirling Radioisotope Generator
ASSP	Architecture for Survivable System Processing
AST	Advanced Subsonic Technology
ATLO	Assembly, Test and Launch Operations
ATM	Air Traffic Management
ATMS	Advanced Technology Microwave Sounder (NPOESS Preparatory Project instrument)
ATP	Aeronautics Test Program
ATV	Automated Transfer Vehicle
AU	Astronomical unit
AvSP	Aviation Safety Program
AvSa	Aviation Safety
BARREL	Balloon Array for Radiation-belt Relativistic Electron Losses
BATC	Ball Aerospace and Technology Corporation
BCP	Ball Commercial Platform
BE	Beyond Einstein
BEPAC	Beyond Einstein Program Assessment Committee
C&DH	Command and Data Handling
C3S	Command, Control, and Communication Segment
CAEP	Committee on Aviation Environmental Protection
CALIPSO	Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations
CAPTEM	Curation and Analysis Planning Team for Extraterrestrial Materials
CAS	Cross-Agency Support
CAST	Commercial Aviation Safety Team
CCD	Charge Coupled Device
CDC	Centers for Disease Control
CDI	Congressionally Directed Items
CDR	Critical Design Review
CERES	Clouds and the Earth's Radiant Energy System
CESR	Centre d'Etude Spatiale des Rayonnements
CFD	Computational Fluid Dynamics
CFO	Chief Financial Officer
ChemCam	Chemistry Camera
CheMin	Chemistry & Mineralogy Instrument
CHS	Crew Health and Safety
CI	Counter-intelligence
CINDI	Coupled Ion Neutral Dynamics Investigation
CIO	Chief Information Officer
CIPAIR	Curriculum Improvement Partnership Award for the Integration of Research
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CM&O	Center Management and Operations
CMB	Cosmic Microwave Background
CMC	Cargo Mission Contract
CME	Continuing Medical Education
CME	Coronal Mass Ejection
CMO	Center Management and Operations
CO	Carbon Monoxide
CO2	Carbon Dioxide
CoF	Construction of Facilities
CONAE	Argentina's National Committee of Space Activities
CoNNeCT	Communication Navigation and Networking Reconfigurable Testbed
CO-OP	Cooperative-Education

COTF	Classroom of the Future
COTR	Contracting Officer Technical Representative
COTS	Commercial Orbital Transportation Services
C/NOFS	Communication/Navigation Outage Forecast System
CRI	Center for Rotorcraft Innovation
CSA	Canadian Space Agency
CSAR	Cost and Schedule Analysis Report
CT	Counter-terrorism
CY	Calendar Year
CZAP	Center Zoned Architecture Project
DAAC	Distributed Active Archive Centers
DAN	Dynamic Albedo of Neutrons
DAP	Data Analysis Program
DCAA	Defense Contract Audit Agency
DCAS	Defense Contract Audit Service
DESDynl	Deformation, Ecosystem Structure, and Dynamics of Ice
DFRC	Dryden Flight Research Center
DLN	Digital Learning Network
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DRS	Disturbance Reduction System
DSN	Deep Space Network
DTN	Disruption Tolerant Networking
E&PO	Education and Public Outreach
EA	Enterprise Architecture
EarthKAM	Earth Knowledge Acquired by Middle School Students
ECLSS	nvironmental Control and Life Support System
ECR	Environmental Compliance and Restoration
ECT	Energetic Particle, Composition and Thermal Plasma
ED	Education
EDL	Entry, Descent, and Landing
EDMD	Exploration Technology Development Program
EEE	Evolution of EOSDIS Elements
EELV	Evolved Expendable Launch Vehicle
EEO	Equal Employment Opportunity
EFASC	Electric Field and Search Coil
EF	Exposed Facility
EFPO	Education Flight Projects
EFW	ic Field and Waves
EIS	Extreme Ultraviolet Imaging Spectrometer
EJSM	Europa Jupiter System Mission
ELV	Expendable Launch Vehicle
EMFISIS	Electric and Magnetic Field Instrument Suite and Integrated Science
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EPA	Environmental Protection Agency
EPN	Effective Perceived Noise
EPNdB	Effective Perceived Noise in Decibels
EPOCh	Extrasolar Planet Observations and Characterization
EPSCoR	Experimental Program to Stimulate Competitive Research
ERA	Environmentally Responsible Aviation
ESA	European Space Agency
ESD	Earth Science Division
ESDR	Earth System Data Records
ESM	Earth Systematic Missions
ESMD	Exploration Systems Mission Directorate
ESSP	Earth System Science Pathfinder
ESTO	Earth Science Technology Office
ESTP	Earth Science Technology Program
ET	External Tank
ETD	Exploration Technology Development
ETDP	Exploration Technology Development Program
ETM	Enhanced Thematic Mapper
EUV	Extreme-Ultraviolet
EXEP	Exoplanet Exploration Program
FA	Fundamental Aeronautics
FAA	Federal Aviation Administration
FAP	Fundamental Aeronautics Program
FAR	Federal Acquisition Regulation
FAST	Facilitated Access to the Space Environment for Technology Development and Training
FCIP	Federal Career Intern Program
FGS	Fine Guidance Sensor
FLITECAM	First Light Infrared Test Experiment Camera
FMI	Finnish Meteorological Institute
FOC	Full Operational Capability
FPA	Focal Plane Array
FPP	Focal Plane Package
FS	First Stage
FY	Fiscal Year
GALEX	Galaxy Evolution Explorer
GCCE	Global Climate Change Education
GCRP	Global Change Research Program
GEO	Geosynchronous Earth Orbit
GES DAAC	GSFC Earth Science Distributed Active Archive Center
GI	Guest Investigator
GISS	Goddard Institute for Space Studies
GLOBE	Global Learning and Observations to Benefit the Environment
GMAO	Global Modeling and Assimilation Office
GN	Ground Networks
GO	Ground Operations
GOES	Geostationary Operational Environmental Satellite
GPM	Global Precipitation Measurement

GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GRAIL	Gravity Recovery and Interior Laboratory
GRB	Gamma Ray Burst
GRC	Glenn Research Center
GRC-PBS	Glenn Research Center–Plum Brook Station
GREAT	German Receiver for Astronomy at Terahetz
GRGT	Guam Remote Ground Terminal
GS	Ground Support
GSFC	Goddard Space Flight Center
GWAC	Government Wide Acquisition Contracts
HBCU	Historically Black Colleges and Universities
HCIE	Human Capital Information Environment
HECC	High End Computing Capability
HgCdTe	Mercury-Cadmium-Telluride
HIPO	High-speed Imaging Photometer for Occultation
HIRES	High Resolution Echelle Spectrometer
HPS	Heliophysics Subcommittee
HQ	NASA Headquarters
HR	Human Resource
HRP	Human Research Program
HSB	Humidity Sounder for Brazil
HSFO	Human Space Flight Operations
HSPD	Homeland Security Presidential Directive
HSR	High-Speed Research
HST	Hubble Space Telescope
HTV	H-II Transfer Vehicle
HVAC	Heating, Ventilating and Air Conditioning
HWB	Hybrid Wing Body
I&T	Integration and test
IAM	Integrated Asset Management
IBEX	Interstellar Boundary Explorer
ICAO	International Civil Aviation Organization
ICESat	Ice, Cloud, and Land Elevation Satellite
IDIQ	Indefinite Delivery Indefinite Quantity
IDPS	Interface Data Processing Segment
IDS	Interdisciplinary Science
IEMP	Integrated Enterprise Management Program
IG	Inspector General
IIFD	Integrated Intelligent Flight Deck
ILN	International Lunar Network
INPE	Brazilian Institute for Space Research
INSPIRE	Interdisciplinary National Science Program Incorporating Research and Education Experiences
IOM	Institute of Medicine
IP	Intellectual Property
IPO	Integrated Program Office
IPP	Innovative Partnerships Program
IPS	Integrated Planning System
IR	Infrared
IRA	Institutional Research Awards
IRM	Information Resources Management
IRT	Independent Review Team
ISIM	Integrated Science Instrument Module
ISM	Interstellar Medium
ISRP	Integrated Systems Research Program
ISS	International Space Station
IT	Information Technology
ITF	Integrated Training Facility
IUVS	Imaging Ultraviolet Spectrometer
IVHM	Integrated Vehicle Health Management
IV&V	Independent Verification and Validation
IXO	International X-ray Observatory
JADE	Jovian Auroral Distributions Experiment
JAXA	Japan Aerospace Exploration Agency
JCAA	Joint Council on Aging Aircraft
JDAP	Jupiter Data Analysis Project
JDEM	Joint Dark Energy Mission
JEDI	Jupiter Energetic particle Detector Instrument
JHU-APL	Johns Hopkins University–Applied Physics Laboratory
JOI	Jupiter Orbit Insertion
JPDO	Joint Planning and Development Office
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
JSC-WSTF	Johnson Space Center–White Sands Test Facility
JWST	James Webb Space Telescope
KaPR	Ka-band Precipitation Radar
KI	Keck Interferometer
KNMI	Royal Netherlands Meteorological Institute
KSC	Kennedy Space Center
KuPR	Ku precipitation radar
LADEE	Lunar Atmosphere and Dust Environment Explorer
LANL	Los Alamos National Laboratory
LaRC	Langley Research Center
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
LCC	Launch Control Center
LCC	Life-Cycle-Cost
LDCM	Landsat Data Continuity Mission
LDEX	Lunar Dust EXperiment
LEARN	Learning Environments and Research Network
LEO	Low Earth Orbit
LISA	Laser Interferometer Space Antenna
LN2	Liquid Nitrogen
LQP	Lunar Quest Program
LRD	Launch Readiness Date
LRO	Lunar Reconnaissance Orbiter
LRR	Launch Readiness Review

LSAH	Longitudinal Study of Astronaut Health
LSP	Launch Services Program
LTP	Learning Technologies Project
LV	Launch Vehicle
LWS	Living with a Star
MA	Multiple Access
MAG	Magnetometer
MAVEN	Mars Atmosphere and Volatile EvolutioN
MCC	Mission Control Center
MCR	Mission Confirmation Review
MD	Mission Directorate
MDAO	Multidisciplinary Design Analysis and Optimization
MDR	Mission Design Review
MEaSUREs	Making Earth System data records for Use in Research Environments
MEP	Mars Exploration Program
METI	Ministry of Economy Trade and Industry (Japan)
MEX	Mars Express
MFMTC	National Force Measurement Technology Capability
MI	Minority Institutions
MIC	Mission Integration Contract
MIDEX	Medium-Class Explorer
MIs	Minority Institutions
MIT	Massachusetts Institute of Technology
MLP	Mobile Launch Platform
MLS	Microwave Limb Sounder
MMS	Magnetospheric Multiscale
MO	Missions of Opportunity
MO&DA	Mission Operations and Data Analysis
MOE	Mission Operations Element
MoO	Mission of Opportunity
MOPITT	Measurements of Pollution in the Troposphere
MPLM	Multi-Purpose Logistics Module
MRO	Mars Reconnaissance Orbiter
MSFC	Marshall Space Flight Center
MSG	Magnetic Spectrometer
MSL	Mars Science Laboratory
MSR	Mars Sample Return
MUREP	Minority University Research and Education Program
NAC	NASA Advisory Committee
NAS	National Airspace System
NCAR	National Center for Atmospheric Research
NCAS	NASA Contract Assurance Services
NCI	NASA Communications Improvement
NCSER	National Center for Space Exploration Research
NEAR	Near-Earth Asteroid Rendezvous
NEN	Near Earth Network
NEO	Near-Earth Object
NES	NASA Explorer School
NESC	NASA Engineering and Safety Center
NETS	NASA Educational Technology Services
NextGen	Next Generation Air Transportation System
NFS	NASA FAR Supplement
NG	Northrop Grumman
NGATS	Next Generation Air Transportation System
NGIMS	Neutral Gas and Ion Mass Spectrometer
NIP	New Investigator Program
NIRCam	Near-Infrared Camera
NIRSpec	Near-Infrared Spectrometer
NISN	NASA Integrated Services Network
NIVR	Netherlands Agency for Aerospace Programmees
NLS	NASA Launch Services
NLT	NASA Learning Technologies
NMO	NASA Management Office
NMP	New Millennium Program
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxide
NPOESS	National Polar–orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NPR	NASA Procedural Requirement
NRA	NASA Research Announcement
NRC	National Research Council
NRC	Nuclear Regulatory Commission
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office
NSC	NASA Safety Center
NSF	National Science Foundation
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
NSWPC	National Space Weather Program Council
NuSTAR	Nuclear Spectroscopic Telescope Array
NWP	Numerical Weather Prediction
OA	Office of Audits
OCE	Office of the Chief Engineer
OCHMO	Office of the Chief Health and Medical Officer
OCIO	Office of Chief Information Officer
OCO	Orbiting Carbon Observatory
OGAs	Other Government Agencies
OHCM	Office of Human Capital Management
OI	Office of Investigations
OIG	Office of Inspector General
OMI	Ozone Monitoring Instrument

ONERA	Office National d'Études et de Recherches Aérospatiales
ORR	Operations Readiness Review
OSC	Orbital Sciences Corporation
OSMA	Office of Safety and Mission Assurance
OSTM	Ocean Surface Topography Mission
OSTP	Office of Science and Technology Policy
OSTST	Ocean Surface Topography Science Team
OTE	Optical Telescope Element
OVWST	Ocean Vector Winds Science Team
PA&E	Program Analysis and Evaluation
PAR	Performance and Accountability Report
PAR	Program Acceptance Review
PB	President's Budget
PBR	President's Budget Request
PBS	President's Budget Submit
PCA	Program Commitment Agreement
PCOS	Physics of the Cosmos Program
PDR	Preliminary Design Review
PDS	Planetary Data System
P&F	Particles and Fields
PI	Principal Investigator
PIC	Program Integration Contract
PIR	Program Implementation Review
PIV	Personal Identification Verification
PMC	Program Management Council
PMCs	Polar Mesospheric Clouds
PNAR	Preliminary Non-Advocate Review
PNT	Positioning, Navigation, and Timing
PPS	Precipitation Processing System
PR	Precipitation Radar
PSBR	Proton Spectrometer Belt Research
QTR	Quarter
QuickSCAT	Quick Scatterometer
R&A	Research and Analysis
R&D	Research and Development
RBSP	Radiation Belt Storm Probes
REMS	Rover Environmental Monitoring System
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposal
RI	Research Institutions
RMB	Reimbursable
RMP	Risk Mitigation Phase
ROSES	Research Opportunities in Space and Earth Science
Roskomos	Russian Federal Space Agency
RPS	Radioisotope Power System
RPT	Rocket Propulsion Testing
RR	Readiness Review
RSDO	Rapid Spacecraft Development Office
RSP	Radioisotope Power Systems
RW	Reaction Wheel

S&MA	Safety and Mission Assurance
SA	Single Access
SAA	Space Act Agreement
SAC-D	Satellite de Aplicaciones Cientificas–D (Argentina)
SALMON	Stand Alone Missions of Opportunity
SAM	Sample Analysis at Mars
SAP	Core Financial System Software
SAR	Synthetic Aperture Radar
SBIR	Small Business Innovative Research
SCEM	Scientific Context for Exploration of the Moon
SCFO	Space Flight Crew Operations
SCP	Space Communications Program
SDLC	System Development Life Cycle
SDO	Solar Dynamics Observatory
SEC	Sun–Earth Connection
SE&I	System Engineering and Integration
SEMAA	Science Engineering Mathematics Aerospace Academy
SESFA	Space Environments Simulation Facilities Alliance
SFS	Space and Flight Support
SFW	Subsonic Fixed Wing
SGSS	Space Network Ground Segment Sustainment
SHERE	Shear History Extensional Rheology Experiment
SHFH	Space Human Factors and Habitability
SIM	Space Interferometry Mission
SIR	System Integration Review
SLI	Student Launch Initiative
SMA	Safety and Mission Assurance
SMAP	Soil Moisture Active and Passive
SMD	Science Mission Directorate
SMEX	Small Explorer
SMS	Safety and Mission Success
SN	Space Network
SNI	Simultaneous, non-interfering
SOC	Security Operations Center
SOC	Solar Orbiter Collaboration
SOFIA	Stratospheric Observatory for Infrared Astronomy
SOMD	Space Operations Mission Directorate
SORCE	Solar Radiation and Climate Experiment
SPF	Software Production Facility
SPOC	Space Program Operations Contract
SR	Senior Review
SRB	Standing Review Board
SRG	Stirling Radioisotope Generator
SRR	System Requirement Review
SRW	Subsonic Rotary Wing
SS	Steady State
SSC	Stennis Space Center

SSE	Solar System Exploration
SSME	Space Shuttle Main Engines
SSP	Space Shuttle Program
SSS	Sea Surface Salinity
SST	Solid State Telescope (Thermal Emission Imaging System instrument)
ST	Space Technology
STATIC	SupraThermal And Thermal Ion Composition
STaR	Shuttle Transition and Retirement
STEM	Science, Technology, Engineering, and Mathematics
STEREO	Solar Terrestrial Relations Observatory
STI	Scientific and Technical Information
STOL	Short take-off and landing
STP	Solar Terrestrial Probes
STS	Space Transportation System
STScI	Space Telescope Science Institute
SwRI	Southwest Research Institute
SXS	Soft X-ray Spectrometer
T2	Technology transfer
TA	Technical Authority
TBD	To Be Determined
TCU	Tribal Colleges and Universities
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TE	Technical Excellence
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIMED	Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics
TIMS	Thermal Infrared Multispectral Scanner
TIRS	Thermal Infrared Sensor
TMC	Technical, Management and Cost
TM	Technical Monitors
TMI	TRMM Microwave Imager
TOC	Test Operations Contract
TPS	Thermal Protection System
T&R	Transition and Retirement
TRL	Technology Readiness Level
TRMM	Tropical Rainfall Measuring Mission
TSDIS	TRMM Science Data and Information System
TVC	Thermal Vacuum Chambers
TWINS	Two Wide–angle Imaging Neutral–atom Spectrometers
UAS	Uninhabited Air Systems
UAV	Unmanned Aerial Vehicle
UAZ	University of Arizona
UCLA	University of California at Los Angeles
UI	University of Iowa
ULA	United Launch Alliance
URC	University Research Center
USA	United Space Alliance
USAF	United States Air Force
UTD	University of Texas at Dallas
UV	Ultraviolet
UVS	UV Spectrometer
VAB	Vehicle Assembly Building
VAO	Virtual Astronomical Observatory
VCL	Vegetation Canopy Lidar
WATR	Western Aeronautical Test Range
WISE	Wide-field Infrared Survey Explorer
WMAP	Wilkinson Microwave Anisotropy Probe
WRS	Water Recovery System
WSC	White Sands Complex
WSTF	White Sands Test Facility
XRT	X-Ray Telescope
XMM	X-ray Multi-mirror Mission (Newton Observatory)