EXPLORATION

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**3,821.2**	**3,712.8**	**3,932.8**	**4,076.5**	**4,076.5**	**4,076.5**	**4,076.5**
Exploration Systems Development	2,982.1	3,007.1	**2,769.4**	2,913.1	2,913.1	2,913.1	2,913.1
Commercial Spaceflight	606.8	406.0	**829.7**	829.7	829.7	829.7	829.7
Exploration Research and Development	232.3	299.7	**333.7**	333.7	333.7	333.7	333.7

EXPLORATION OVERVIEW ..... EXP- 2

EXPLORATION SYSTEMS DEVELOPMENT

Orion Multi-Purpose Crew Vehicle EXP- 7

Crew Vehicle Development EXP- 11

Space Launch System EXP- 20

Launch Vehicle Development EXP- 23

Exploration Ground Systems EXP- 32

COMMERCIAL SPACEFLIGHT

Commercial Crew EXP- 41

EXPLORATION RESEARCH AND DEVELOPMENT

Human Research Program EXP- 49

Advanced Exploration Systems EXP- 58

EXPLORATION

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**3,821.2**	**3,712.8**	**3,932.8**	**4,076.5**	**4,076.5**	**4,076.5**	**4,076.5**
Exploration Systems Development	2,982.1	3,007.1	**2,769.4**	2,913.1	2,913.1	2,913.1	2,913.1
Commercial Spaceflight	606.8	406.0	**829.7**	829.7	829.7	829.7	829.7
Exploration Research and Development	232.3	299.7	**333.7**	333.7	333.7	333.7	333.7
Change From FY 2012 Estimate	--	--	**220.0**				
Percent Change From FY 2012 Estimate	--	--	**5.9%**				

Note: *As directed by Congress, NASA is requesting all programmatic construction of facilities (CoF) for FY 2013 in the CECR account. For Exploration, NASA requests $140.4 million in programmatic CoF (see CECR account). In this table, the FY 2014 column is identical to what the FY 2013 column would be with Exploration-related programmatic CoF included.*

An artist's conception depicts a new era for human exploration.

The Exploration account is focused on developing the systems and capabilities required for human exploration of space beyond low Earth orbit, and for U.S. crew vehicle access to ISS. These systems and capabilities include launch and crew vehicles for missions beyond low Earth orbit, affordable commercial crew access to ISS, technologies and countermeasures to keep astronauts healthy and functional during deep space missions, and technologies to reduce launch mass and cost of deep space missions. NASA's exploration goals are consistent with the NASA Authorization Act of 2010, which calls for expanding permanent human presence beyond low Earth orbit to destinations such as near Earth asteroids, the Moon, and Mars, while maintaining uninterrupted U.S. human space flight capability in low Earth orbit and beyond.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

In September 2011, NASA released draft request for proposals for commercial crew transportation, inviting industry comments before final release by the end of CY 2011. However, based on the current budget environment, NASA has changed its planned acquisition strategy. Rather than moving forward with a firm-fixed price contract for integrated design, NASA will support the design and development of commercial crew transportation systems through the use of funded Space Act Agreements for the next

phase of the program. (See the Commercial Crew program section for an extended discussion of this issue.)

ACHIEVEMENTS IN FY 2011

In May 2011, NASA approved the Orion-based reference vehicle design, as outlined in NASA's January 2011 report to Congress, as the Agency's Multi-Purpose Crew Vehicle (MPCV). Orion maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010, and it was already being built to meet the requirements of a deep-space vehicle under a contractual partnership with Lockheed Martin Corporation.

On September 14, 2011, the Administrator selected the design of the new launch vehicle. The Space Launch System (SLS) design closely follows the requirements laid out in the NASA Authorization Act of 2010 and will take NASA's astronauts farther into space than ever before, create high-quality jobs here at home, and provide the cornerstone for America's future human deep space exploration efforts. The vehicle's early flights will be capable of lifting 70 metric tons before evolving to a lift capacity of 130 metric tons.

During FY 2011, NASA's Commercial Crew Development partners, Blue Origin, Boeing, Sierra Nevada Corporation, SpaceX, United Launch Alliance, and Alliant Techsystems Inc., successfully completed their milestones and are maturing their space vehicle designs and systems as part of the Commercial Crew Development second phase Space Act Agreements (CCDev 2).

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, the Orion MPCV will complete the Launch Abort System-Crew Module mating in preparation for Exploration Flight Test-1, planned for early FY 2014. The major elements of SLS will have Preliminary Design Reviews to evaluate the completeness of the program's preliminary design and to determine the program's readiness to proceed with the detailed design phase of the program. See program schedule in the SLS program section. In FY 2012, the Commercial Crew program plans to award additional Space Act Agreements, which will lead to significant progress toward the design of multiple crew transportation systems. NASA will use FY 2013 funds to reach more advanced milestones under the Space Act Agreements.

To keep astronauts healthy and functional during deep space missions, the Human Research program will deliver a number of technologies and countermeasures including the ISS treadmill kinematics study final report to improve exercise countermeasures for bone health and ISS VO_2max study final report to assess and address safety concerns in the event of an emergency during space flight.

EXPLORATION

Themes

EXPLORATION SYSTEMS DEVELOPMENT (ESD)*

ESD is developing three capabilities that will enable humans to explore beyond low Earth orbit. SLS, the Orion MPCV, and the Exploration Ground Systems (EGS) program (which will prepare and launch the SLS and Orion MPCV). NASA will managed SLS, Orion MPCV, and EGS as separate programs, working jointly to integrate and prepare for the first exploration mission test flight and beyond. Integration among programs at NASA Headquarters will streamline decision-making processes and better enable an affordable long-term human exploration program. The Exploration Systems under development are part of NASA's capability-driven approach to human exploration, as opposed to one focused on a specific destination and schedule. The capabilities SLS and Orion MPCV provide can be combined with later developed capabilities to go to asteroids, lunar, and other destinations. All of these destinations are scientifically compelling, rich in data that will provide continuous expansion of human knowledge of the universe, and inspire humankind. As designated by the President, NASA's initial destination for a human mission is to an asteroid by 2025, followed eventually by a human mission to Mars. This journey begins with SLS, Orion MPCV, and EGS as the first important core elements of the evolutionary exploration approach.

* Previously called Human Exploration Capabilities

BUDGET EXPLANATION

The FY 2013 request for ESD is $2,913.1 million, including $143.7 million of exploration-related CoF funding included in the CECR. This total request represents a $94.0 million decrease from the FY 2012 estimate ($3,007.1 million). The FY 2013 request includes:

- $1,028.2 million for the Orion MPCV, which will develop a spacecraft that will carry humans beyond low Earth orbit. This includes:
  - $968.5 million for Crew Vehicle Development;
  - $56.4 million for Orion MPCV Program Integration and Support; and
  - $3.3 million for programmatic CoF, included in the CECR request as directed by Congress.

- $1,884.9 million for SLS, which will develop a heavy-lift vehicle along with the ground infrastructure necessary to support NASA Exploration activities. This includes:
  - $1,304.1 million for Launch Vehicle Development;
  - $35.9 million for SLS Program Integration and Support;
  - $404.5 million for EGS, identified as a separate program in this request as directed by Congress; and
  - $140.4 million for programmatic CoF for SLS ($88.9 million) and EGS ($51.5 million), included in the CECR request as directed by Congress.

EXPLORATION

KEY ACHIEVEMENT IN FY 2011

In addition to the account achievements, above,

- Orion MPCV accomplishments include: initiating a series of tests to investigate various water landing scenarios, completing construction of ground test article vehicle, beginning vibroacoustic and modal testing to better understand the forces that will be transmitted to the inside of the spacecraft during a launch abort, and conducting a flawless flight test of the launch abort system;
- SLS accomplishments include: completing the first full-scale J-2X upper stage engine test, successfully firing the third five segment development motor; and
- EGS accomplishments include: completing a new mobile launcher structure that will be used to support, service, transport, and launch the heavy lift rocket being developed by the SLS program.

In addition, the programs engaged an outside consultant to perform an independent assessment of cost estimates, schedules, and risks. The independent cost assessment team concluded the estimate are reasonable and acceptable to serve as the basis for near-term, three to five-year, analysis of alternatives and program decisions, but are not sustainable beyond that timeframe. NASA is now in the process of implementing the findings of the independent cost assessment and is working on a plan to implement those recommendations that will provide benefit to the Agency. Among the findings, Independent Cost Assessment team observed that further analysis is needed by NASA in terms of full life cycle costs, programmatic cost risks, and planned reserve levels. This assessment was critical to Agency decisions to proceed to the next phases in the programs.

COMMERCIAL SPACEFLIGHT

In the area of commercial spaceflight, NASA has implemented a two-phased approach for developing and procuring transportation services to and from ISS. Responsibility for the development of commercial transportation systems to ISS is in the Exploration account, while the procurement of services is within the Space Operations account. While funding stops in FY 2012, the Commercial Orbital Transportation Services (COTS) program continues to develop and demonstrate commercial cargo transportation systems through agreements funded in FY 2011 and prior years. Following the retirement of the Space Shuttle, the Commercial Crew program is working with industry partners to develop crew transportation systems to enable American companies to transport our crews to the ISS by mid-decade. With COTS and Commercial Crew program, NASA is continuing to expand an opportunity for commercial access to space, thereby creating multiple means for NASA to access low Earth orbit.

BUDGET EXPLANATION

The FY 2013 request is $829.7 million. This represents a $423.7 million increase from the FY 2012 estimate ($406.0 million), and $20.3 million less than the FY 2012 request ($850 million).

EXPLORATION

EXPLORATION RESEARCH AND DEVELOPMENT (ERD)

The ERD effort will expand knowledge that is fundamental to human space exploration, and develop advanced exploration systems that will enable humans to explore space in a sustainable and affordable way. ERD is comprised of the Human Research Program (HRP) and the Advanced Exploration Systems (AES) program, which will provide the knowledge and advanced spaceflight capabilities required to implement the U.S. Space Exploration Policy.

BUDGET EXPLANATION

The FY 2013 request is $333.7 million. This represents a $22.9 million increase from the FY 2012 estimate ($310.8 million). The FY 2013 request includes:

- $164.7 million for the HRP, which will keep astronauts healthy and functional during deep space missions by researching and assessing technologies and countermeasures; and
- $169.0 million for the AES, which will address the highest-priority capabilities identified in human spaceflight architecture studies for exploration missions to near Earth asteroids, cis-lunar space, the Moon, and Mars and its moons.

KEY ACHIEVEMENT IN FY 2011

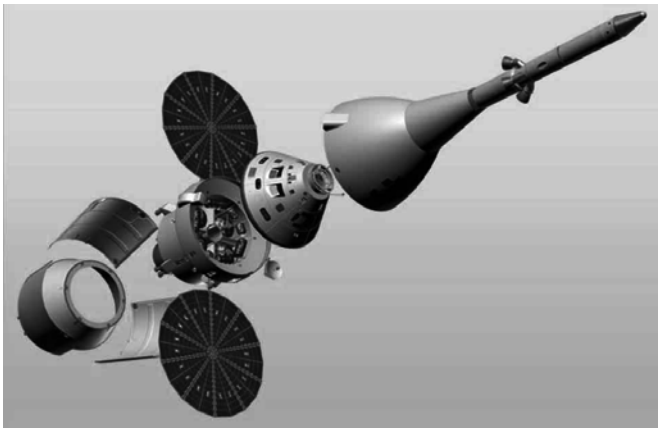
In 2011, NASA's HRP flew 11 major medical experiments and added new ISS biomedical capabilities including the second-generation ultrasound for medical imaging, the urine monitoring system, and the jointly developed ESA/NASA muscle atrophy research and exercise system.

While the AES program began in FY 2012, several projects continued efforts funded by the Exploration Technology Development and Demonstration (ETDD) program in FY 2011, such as a portable life support system for an advanced space suit and a radiation assessment detector for the Mars Science Laboratory mission.

ORION MULTI-PURPOSE CREW VEHICLE (ORION MPCV)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**1,196.0**	**1,200.0**	**1,024.9**	**1,028.2**	**1,028.2**	**1,028.2**	**1,028.2**
Crew Vehicle Development	1,086.0	1,142.9	**968.5**	975.8	980.2	984.2	983.7
MPCV Program Integration and Support	110.0	57.1	**56.4**	52.4	48.0	44.0	44.4
Change From FY 2012 Estimate	--	--	**-175.1**				
Percent Change From FY 2012 Estimate	--	--	**-14.6%**				



The Orion MPCV design divides critical functions among multiple modules to maximize the performance of the integrated spacecraft design.

The Orion MPCV design will meet the evolving needs of the Nation's beyond low Earth orbit space exploration program for decades to come and will transport astronauts on a variety of expeditions. The program features dozens of technology advancements and innovations that have been incorporated into the spacecraft's subsystems and component design. Orion MPCV includes both crew and service modules, a spacecraft adaptor, and a revolutionary launch abort system that will significantly increase crew safety. The program's unique life support, propulsion, thermal protection and avionics systems in combination with other deep space elements will enable extended duration deep space missions. These systems have been developed to facilitate integration of new technical innovations as they become available in the future.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

For FY 2013, there are no programmatic changes for Orion MPCV. The program is on a path of development consistent with the NASA Authorization Act of 2010, which directs NASA to develop an Orion MPCV that continues the advanced development of human safety features, designs, and systems in the Orion project.

In FY 2012, extra-vehicular activity (EVA) support to the Orion MPCV has been suspended pending further program review of baseline requirements; however, the EVA suit and portable life support system research continues under the Advanced Exploration Systems program.

ORION MULTI-PURPOSE CREW VEHICLE (ORION MPCV)

ACHIEVEMENTS IN FY 2011

On May 24, 2011, NASA announced its decision to accept the Orion-based reference vehicle design, as outlined in the Agency's January 2011 report to Congress, as the MPCV. From the outset, Orion was developed to meet the requirements of a deep space vehicle and the Orion design is consistent with the NASA Authorization Act of 2010.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

As part of its program objectives, NASA plans to conduct the exploration flight test 1 (EFT-1) in early 2014; final preparation and manufacturing milestones for the flight test will be completed in FY 2013. EFT-1 is an early flight test of critical Orion MPCV systems that address 10 of the 16 highest risks to crew survivability and exploration mission failure. This orbital flight will provide data critical to influencing design decisions and validating Orion MPCV systems in flight environments that cannot be duplicated on the ground. The planned flight conditions required for EFT-1 will demonstrate integrated vehicle performance for ascent, on-orbit flight, and a high energy re-entry profile of approximately 84 percent of the lunar entry velocity from beyond low Earth orbit. Conducting this test before the Orion MPCV critical design review will mitigate program cost and schedule risks by allowing actual flight data to influence the final design of critical spacecraft systems, thereby avoiding increased ground testing and costly redesign efforts prior to the planned unmanned launch in December 2017 aboard the SLS. Performing the EFT-1 flight test will also enable the program to refurbish and reuse the crew module test vehicle in AA-2 in 2016 prior to the first joint Orion-Orion MPCV/SLS mission in 2017.

BUDGET EXPLANATION

The FY 2013 request is $1,028.2 million (including $3.3 million of programmatic CoF included in the CECR account), a $171.8 million decrease from the FY 2012 estimate ($1,200.0 million). The FY 2013 request includes:

- $968.5 million for Crew Vehicle Development;
- $17.7 million for Mission Operations;
- $11.7 million for Exploration Systems Division MPCV Integration Support;
- $27.0 million for HEO MPCV Executive Administration; and
- $3.3 million for programmatic CoF, included in the CECR account.

ORION MULTI-PURPOSE CREW VEHICLE (ORION MPCV)

Projects

ORION MPCV PROGRAM INTEGRATION AND SUPPORT

Orion MPCV program integration and support includes mission operations, ESD MPCV integration support, and headquarters program support.

Mission operations integrates flight operations for all exploration vehicles. In FY 2011, the project successfully completed initial design of the mission operations facilities and integrated communications network for the initial flight test.

ESD MPCV integration support is responsible for verifying that the program office satisfies all technical, cost, and schedule requirements. It is also responsible for ensuring that Orion MPCV is fully integrated with the Space Launch Systems program at MSFC, and Ground Systems development and operations at the KSC.

The NASA Headquarters HEO MPCV Executive Administration function is responsible for allowing the Human Exploration and Operations Mission Directorate (HEOMD) to perform critical activities such as cross-program integration, which includes managing the interfaces between the various programs within the directorate. This ensures that necessary coordination and integration occurs on a timely basis, to avoid design and cost issues. This function also includes programmatic assessment of all HEOMD programs (including technical, cost, schedule, acquisition, legislative assessments) to ensure an integrated approach. Other activity includes strategic and feasibility studies, along with small scale research tasks to plan for future human exploration activities.

Program Schedule

See the Crew Vehicle Development project section.

Program Management and Commitments

JSC will manage the Orion MPCV program, with support from the four research centers, ARC, DFRC, GRC, and LaRC, MSFC, and KSC.

ORION MULTI-PURPOSE CREW VEHICLE (ORION MPCV)

Project Element	Provider
Crew Vehicle Development	Provider: JSC Project Management: JSC NASA Center: JSC Cost Share: JSC
Mission Operations	Provider: JSC Project Management: JSC NASA Center: JSC Cost Share: JSC
ESD MPCV Integration Support	Provider: HQ Project Management: HQ NASA Center: JSC, MSFC, ARC, KSC, HQ Cost Share: HQ
HQ Program Support	Provider: HQ Project Management: HQ NASA Center: HQ Cost Share: HQ

Acquisition Strategy

See the Crew Vehicle Development project section.

MAJOR CONTRACTS/AWARDS

See the Crew Vehicle Development project section.

INDEPENDENT REVIEWS

Independent reviews will be performed as required by NPR 7120.5. NASA has established a standing review board (SRB) to review the Orion MPCV program and crew vehicle project.

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

FY 2013 BUDGET

		Actual	Estimate		Notional			
Budget Authority (in $ millions)	**Prior**	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**0.0**	1,086.0	1,142.9	**968.5**	975.8	980.2	984.2	983.7
Change From FY 2012 Estimate		--	--	**-174.4**				
Percent Change From FY 2012 Estimate		--	--	**-15.3%**				

After six months of testing different water landing scenarios, an 18,000 pound Orion mockup took its final splash into the LaRC Hydro Impact Basin on January 6, 2012. This test represented a worst case landing for an abort scenario in rough seas. This scenario is not likely to occur during actual vehicle operation, but is essential for the validation of analytical models. As was the case with Apollo, the Orion MPCV flight design will feature an onboard up-righting system.

PROJECT PURPOSE

The Orion MPCV will transport astronauts on a variety of expeditions, meeting the evolving needs of the Nation's space exploration program beyond low Earth orbit for decades to come.

EXPLANATION OF PROJECT CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

Orion MPCV is made up of three separate components that will carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry from deep space return velocities.

The launch abort system is positioned on a tower atop the crew module, and activates within milliseconds to propel the crew module to safety in the event of an emergency during launch or climb to orbit. The system also protects the crew module from dangerous atmospheric loads and heating, then jettisons after the Orion MPCV is completes the initial mission phase of ascent to orbit.

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

The crew module is the transportation capsule that provides a safe habitat for the crew as well as storage for consumables and research instruments, and serves as the docking port for crew transfers. This module is the only part of the Orion MPCV that returns to Earth after each mission.

The service module supports the crew module from launch through separation prior to reentry. It provides in-space propulsion capability for orbital transfer, attitude control, and high altitude ascent aborts. When mated with the crew module, it provides the water, oxygen and nitrogen needed for a habitable environment; generates and stores electrical power while on-orbit; and maintains the temperature of the vehicle's systems and components. This module can also transport unpressurized cargo and scientific payloads.

ACHIEVEMENTS IN FY 2011

With the decision to use the Orion-based reference vehicle design for MPCV, the program began a series of landing tests at the LaRC hydro-impact basin in order to splash test the boilerplate test article vehicle to investigate various water landing scenarios. Orion MPCV also completed construction of its ground test article vehicle, which is the next higher-fidelity vehicle beyond the boilerplate test article. The ground test article was brought to the Orion Denver facility to begin the first campaign of vibroacoustic and modal testing to better understand the forces that will be transmitted to the inside of the spacecraft during a launch abort. NASA also flew a test of rendezvous and docking technology on Space Shuttle STS-134 in support of Orion MPCV test objectives, and a flawless flight test of the launch abort system was successfully conducted.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, work will be focused on preparation of the Orion structural test article production and system integration in support of the EFT-1. Set to launch in 2014 atop an expendable launch vehicle from Cape Canaveral Air Force Station, the mission will be a multi-hour, two-orbit test of the Orion command module featuring a high apogee on the second orbit and a high-energy reentry at around 20,000 miles per hour, which will test mission control interfaces and data recovery. The spacecraft will remain attached to the expendable launch vehicle’s upper stage until reentry begins, and will rely on internal batteries for power rather than photovoltaic arrays, which will not be installed. The spacecraft will splash down in the Pacific Ocean, where KSC landing recovery forces will be exercised. The test will address 10 of 16 of Orion’s top risks, high speed reentry, and reusability of the vehicle structure. Additionally, the flight will test various Orion systems, including avionics, heat shielding and parachutes prior to its debut launch aboard the Space Launch System, currently scheduled for late 2017.

In preparation for EFT-1, the crew module, service module, and launch abort system will be integrated and tested at the KSC during FY 2013. Orion MPCV will also begin testing the hardware components of the flight test article that will be flown in 2014.

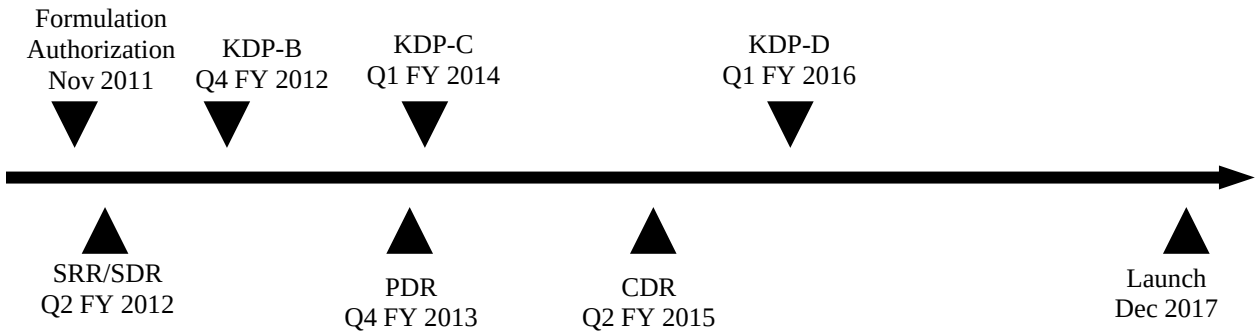
CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

ESTIMATED PROJECT SCHEDULE

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation Authorization	Nov-11	Nov-11
Systems Requirements/ Systems Definition Review (SRR/SDR)	Q2 FY 2012	Q2 FY 2012
Key Decision Point (KDP) B	Q4 FY 2012	Q4 FY 2012
Preliminary Design Review (PDR)	Q4 FY 2013	Q4 FY 2013
KDP-C	Q1 FY 2014	Q1 FY 2014
Critical Design Review (CDR)	Q2 FY 2015	Q2 FY 2015
KDP-D	Q1 FY 2016	Q1 FY 2016
Launch	Dec-17	Dec-17

Project Schedule



CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Project Management & Commitments

The Orion MPCV Crew Vehicle Development will be managed at JSC, with support from the four research centers, ARC, DFRC, GRC, and LaRC, as well as MSFC and KSC.

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Crew Module	Provider: JSC Project Management: JSC NASA Center: ARC, GRC, JSC, LaRC Cost Share: N/A	The crew module is the transportation capsule that provides a safe habitat for the crew as well as storage for consumables and research instruments, and serves as the docking port for crew transfers.	Same	Same
Service Module	Provider: JSC Project Management: JSC NASA Center: ARC, GRC, JSC, LaRC Cost Share: N/A	The service module supports the crew module from launch through separation prior to reentry.	Same	Same
Launch Abort System	Provider: JSC Project Management: LaRC NASA Center: JSC, LaRC, MSFC Cost Share: N/A	The launch abort system is used to propel the crew module to safety in the event of an emergency during launch or climb to orbit.	Same	Same

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The resources requested for Orion MPCV are not available at the levels and on the schedule requested, Then: The Orion MPCV will likely experience programmatic delays and increased costs.	The Orion MPCV program is taking a number of steps to ensure that the spacecraft can be developed within a flat budget with a first flight by December 2017. Cost and schedule are overriding considerations for the Orion MPCV program. The Orion MPCV architecture itself is evolvable, with near term development focused on those capabilities specifically required to execute the initial test flights. The evolved capability elements can be matured and introduced as resources permit The program is also focusing on affordability from development through operations. Cost, schedule, and technical targets are achievable within the budget request. Reductions or delays to providing the resources requested in this budget will likely result in delays that will impact the first launch in 2017 and/or the deferral of development work needed to field the evolved capability, as well as increased overall development cost.

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

As part of the Orion MPCV decision, the NASA Administrator determined that the Agency's current Orion contractual partnership with Lockheed Martin Corporation maps well to the scope of the Orion MPCV requirements for human exploration. Therefore, NASA will use the current contract for the development phase of the Orion MPCV. Principal merits of this option include building from a mature design currently in the design phase that meets requirements through the implementation of affordability measures to reduce development costs, while maximizing existing contracts and support infrastructure. The Orion MPCV government and industry team has assessed and initiated additional affordability initiatives that have reduced development costs and enabled schedule acceleration. These initiatives include but are not limited to:

- Furthering the incremental approach to building and testing vehicle capabilities;
- Streamlining government oversight and insight ;
- Reducing formal deliverables and simplifying processes while retaining adequate rigor;
- Using high fidelity engineering development units in lieu of flight equivalent hardware in test facilities and labs;
- Consolidating test labs and re-use of test articles; and
- Enhancing approach for spacecraft processing by re-using applicable Space Shuttle processes and certified Space Shuttle personnel.

Element	Vendor	Location
MPCV Design and Development	Lockheed Martin	Littleton, CO

INDEPENDENT REVIEWS

Independent reviews will be performed as required by NPR 7120.5. NASA established an SRB to review the Orion MPCV program and crew vehicle project.

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
SRR	SRB	Mar-07	To evaluate whether program functional and performance requirements are properly formulated and correlated with Agency and Mission Directorate strategic objectives; to assess the credibility of the program's estimated budget and schedule	N/A
SDR	SRB	Aug-07	To evaluate proposed program requirements and architecture and allocation of requirements to initial projects; to assess the adequacy of project pre-formulation efforts; to determine whether the maturity of the program's definition and associated plans are sufficient to begin implementation.	N/A
PDR	SRB	Aug-07	To evaluate completeness and consistency of the program's preliminary design, including its projects, in meeting all requirements with appropriate margins, acceptable risk and within cost and schedule constraints; and to determine the program's readiness to proceed with the detailed design phase of the program.	N/A

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Independent Cost Assessment	Booz Allen Hamilton	Aug-11	Provide an independent assessment of the Orion MPCV cost estimates, schedules, and risks. The assessment concluded that NASA's estimates for three to five year budget horizon were serviceable. The independent cost assessment conducted by Booz Allen Hamilton, was completed and delivered to NASA on August 14th of 2011. Cost estimates to design, develop, and operate this architecture, with associated preliminary schedules, were developed and deemed credible, consistent with this early planning phase of pre-formulation and within the constraints of the current fiscal environment. In the longer term, the assessment found that that the program estimates ssumed large, unsubstantiated futre cost efficiences, leading to the impression that they are optimistic.	N/A
Resynchronization Review	SRB	N/A	To resynchronize the program's preliminary design to the requirements of Exploration system development. NASA procedures allow that a program's management agreement may be changed in response to internal and external events. A significant divergence from must be accompanied by an amendment to the decision memorandum signed at the KDP subsequent to the preliminary design review.	Q2 FY 2012

CREW VEHICLE DEVELOPMENT

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Critical Design Review	SRB	N/A	To evaluate the integrity of the program integrated design, including its projects and ground systems, to meet mission requirements with appropriate margins and acceptable risk, within cost and schedule constraints; to determine if the integrated design is appropriately mature to continue with the final design and fabrication phase.	Q3 FY 2015

SPACE LAUNCH SYSTEM

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 13 Request in FY 12 Budget Structure	1,801.2	1,859.6	**1,884.9**	1,884.9	1,884.9	1,884.9	1,884.9
- Prog. CoF in CECR Account	*15.1*	*52.5*	***140.4***	*0.0*	*0.0*	*0.0*	*0.0*
- Exploration Ground Systems	*250.0*	*304.5*	***404.5***	*455.6*	*455.6*	*455.6*	*455.6*
FY 2013 President's Budget Request	**1,536.1**	**1,502.6**	**1,340.0**	**1,429.3**	**1,429.3**	**1,429.3**	**1,429.3**
Launch Vehicle Developments	1,313.8	1,456.1	**1,304.1**	1,399.1	1,397.9	1,393.4	1,364.4
SLS Program Integration and Support	222.3	46.4	**35.9**	30.2	31.4	35.9	64.9
Change From FY 2012 Estimate	--	--	**25.3**				
Percent Change From FY 2012 Estimate	--	--	**1.4%**				

Note: *As directed by Congress, Exploration Ground Systems is included as a separate program in the FY 13 request. Total funding for SLS ($1304.1 million), EGS ($404.5 million), and programmatic CoF ($140.4 million) is $1,884.9 million, $25.3 million higher than the FY 12 estimate (Calculation based in FY 12 Budget Structure).*

NASA is moving forward with development of the SLS, an advanced heavy-lift launch vehicle that will provide a new national capability for human exploration beyond Earth's orbit for the first time since the Saturn V took American astronauts to the moon over 40 years ago. With its superior lift capability, SLS will expand U.S. reach into the solar system and human enable exploration of cis-lunar space, near-Earth asteroids, Mars and its moons, and beyond. The new launch vehicle will be designed to carry the Orion MPCV, as well as important cargo, equipment and science experiments beyond Earth orbit to multiple destinations. SLS will provide a safe, affordable and sustainable means of opening up new discoveries from the unique vantage point of space.

SLS development cost and schedule benefit from the significant investments made in critical elements of the architecture: large-scale aluminum manufacturing at the Michoud Assembly Facility, an inventory of 15 Space Shuttle main engines, and large segmented solid rocket motors. The SLS architecture is incorporates a liquid hydrogen and liquid oxygen propulsion system, which will utilize the RS-25d from the Space Shuttle program for the core stage, the J-2X engine for the upper stage, and solid rocket boosters for initial development flights. Follow-on advanced boosters will be competed based on performance requirements and affordability considerations. The SLS will have an initial lift capacity of 70 metric tons, nearly three times the capability of any launch system currently in operation, then mature to 130 metric tons. The first SLS flight test is targeted for the end of 2017.

This evolvable approach allows NASA to address high-cost development activities early on in the program. The selected architecture also enables NASA to leverage existing capabilities and lower development costs by using liquid hydrogen and liquid oxygen for both the core and upper stages. While the baseline SLS concept is to continue operations at 130 metric tons lift capability, trade studies are underway to determine the feasibility using different core stage, upper stage, and first-stage booster combinations to achieve the most efficient launch vehicle for any given mission.

SPACE LAUNCH SYSTEM

An artist's conception shows the SLS ready to launch. The SLS will eventually have a lift capacity between 70 and 130 metric tons, but not every mission will require that much lift. The SLS modular architecture allows use of different core stage, upper stage, and first-stage booster combinations to match the mission requirements.

NASA's plans for implementing the SLS program include transition of relevant Space Shuttle assets and design and developmental activities of the Constellation program. A major element of this transition involves shifting design and developmental efforts from a closely coupled system (Ares I and Orion) to a more generic launch vehicle (SLS) and multi-purpose crew vehicle (Orion MPCV). In FY 2012, NASA will continue to define an affordable, sustainable and realistic SLS development plan. The system development review in the second quarter of FY 2012 will determine whether the maturity level of the program's definition and associated plans is sufficient to begin implementation.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The FY 2012 Budget request for SLS included funding for supporting ground operations development. For FY 2013, in response to direction in the Conference Report (House Report 112-284) accompanying the FY 2012 Consolidated and Further Continuing Appropriations Act (P.L. 112-55), ground operations funding is included in the Ground Systems Development and Operations program. Budget requests for programmatic CoF associated with this program are included in the CECR account section.

ACHIEVEMENTS IN FY 2011

See achievements in Launch Vehicle Development.

SPACE LAUNCH SYSTEM

KEY ACHIEVEMENTS PLANNED FOR FY 2013

See achievements in Launch Vehicle Development.

BUDGET EXPLANATION

As directed by Congress, EGS is included as a separate program in the FY 2013 request. Total funding for SLS, EGS, and programmatic CoF is $1,884.9 million, $25.3 million higher than the FY 2012 estimate ($1,859.6 million). The SLS FY 2013 request includes:

- $1,304.1 million for Launch Vehicle Development;
- $16.5 million for ESD SLS Integration Support;
- $19.4 million for HEOMD SLS Executive Administration;
- $404.5 million for EGS program (see EGS section); and
- $140.4 million for programmatic CoF, included in the CECR request as directed by Congress.

Projects

SLS PROGRAM INTEGRATION AND SUPPORT

SLS Program Integration and Support is comprised of ESD SLS Integration and HEOMD SLS Executive Administration. The ESD SLS integration function assures cross program integration, which includes managing interfaces between the programs and ensuring that necessary cross-program integration activities occur. This effort is critical to making sure that the integrated technical performance of the system meets technical and safety specifications, and supports the programmatic assessment (technical, cost, schedule, acquisition, legislative) that results in an integrated technical, cost and schedule approach. The HEOMD SLS Executive Administration function is responsible for allowing the HEOMD to perform critical activities such as cross-program integration, which includes managing the interfaces between the various programs within the Directorate. This ensures that necessary coordination and integration occurs on a timely basis, to avoid design and cost issues. This function also includes programmatic assessment of all HEOMD programs (technical, cost, schedule, acquisition, legislative) to ensure an integrated approach. Other activity includes strategic and feasibility studies, along with small scale research tasks to plan for future human exploration activities.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**0.0**	**1,313.8**	**1,456.1**	**1,304.1**	**1,399.1**	**1,397.9**	**1,393.4**	**1,364.4**
Change From FY 2012 Estimate		--	--	**-152.0**				
Percent Change From FY 2012 Estimate		--	--	**-10.4%**				

In October 2011, all fifteen Space Shuttle Main Engines are together for the first time inside NASA's Engine Shop at KSC. They will be prepped for shipment to SSC where they'll become part of the propulsion used on the SLS. Each engine is capable of generating a force of nearly 400,000 pounds of thrust at liftoff, and consumes 350 gallons of fuel per second. They are engineered to burn liquid hydrogen and liquid oxygen, creating exhaust composed primarily of water vapor.

PROJECT PURPOSE

Launch Vehicle Development is responsible for providing a safe, affordable and sustainable launch capability for human exploration beyond low Earth orbit, designed to be flexible for crew or cargo missions.

EXPLANATION OF PROJECT CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

The SLS architecture will satisfy a number of cost, schedule, and technical requirements, including:

- Providing an initial, crew-rated lift capability of approximately 70 metric tons;
- Conducting a first uncrewed demonstration flight in 2017;
- Completing design, development, test, and evaluation within a flat budget ;
- Ensuring that the design is evolvable to a lift capability of at least 130 metric tons; and
- Ensuring that production and operations costs are affordable and sustainable over the life of the program.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

In order to satisfy these requirements, the integrated SLS architecture is composed of hardware elements that are designed to take advantage of previous investments in the Space Shuttle and Constellation programs. These elements include stages (both core and upper), engines (RS-25 for core, J-2X for upper), and boosters. For the initial 70 metric ton capability, SLS will utilize a core stage, RS-25d engines, and existing five segment solid rocket boosters. For the evolved capability, SLS will provide a lift capacity of up to 130 metric tons to low Earth orbit by integrating an upper stage and advanced boosters.

Both the initial and evolved capabilities utilize the same core stage, and both the core and upper stages share the same 27.5 ft. diameter tanks as the Space Shuttle external tank. The stages will be based on liquid oxygen and liquid hydrogen technologies, in which the U.S. remains a world leader. In addition to a common tank diameter, the stages will share other attributes, including materials, subsystem components, and tooling. Maximizing commonality between the core and upper stages decreases the costs and risks associated with development, and provides opportunities to improve production efficiency.

The core stage is flanked by twin large boosters to provide additional thrust during ascent. The vehicle uses a “stage and a half” configuration that ignites the core stage engines seconds before liftoff, and then ignites the solid motors at launch. The boosters burn out approximately two minutes into flight, while the core stage engines continue to burn until the desired cutoff point is achieved. For the initial capability flights, the SLS boosters are five segment reusable solid rocket motor boosters derived from the four segment Space Shuttle reusable solid rocket motors and the five segment solid rocket booster from the Ares I crew launch vehicle in the Constellation program. Beyond the initial capability flights, the evolved booster capability will utilize advanced boosters, which will be acquired competitively, and may be liquid or solid.

For engines, the initial capability will utilize the existing inventory of RS-25d Space Shuttle main engines for the core stage. Later, as the existing inventory of RS-25d engines are used for test flights, NASA will introduce an evolved and expendable Space Shuttle main engine designated the RS-25e, with upgrades to reduce costs and improve production sustainability. The evolved capability will also use an upper stage, with the same diameter as the common core stage. The upper stage engine will be the J-2X, which is derived from the upper stage engine developed for the Saturn IV-B and Saturn V launch vehicles, and was being updated with modern design and manufacturing techniques for the Ares family of vehicles.

ACHIEVEMENTS IN FY 2011

NASA announced the SLS architecture on September 14, 2011. Procurement synopses for utilizing existing contracts for stages, engines, and boosters were also announced in September. In December 2011, the SLS program issued a NASA Research Announcement to support advanced booster engineering risk reduction. By October, the SLS program moved the Launch Vehicle Development project into formulation—a critical phase during which the program project will set detailed preliminary cost, schedule, and performance plans for flying the first SLS mission in 2017.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

The SLS engine element completed the first full-scale J-2X upper stage engine test on July 7, 2011; ten planned full-scale engine tests were conducted in calendar year 2011. Also, on September 8, 2011, the third five segment development motor was successfully fired in Alliant Techsystems's (ATK) test site in Promontory, UT. With nearly 1,000 detailed measurements, this hot motor test provided a better understanding of the motor's ballistic and component performance at the upper temperature range on a launch day.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The Launch Vehicle Development project will continue detailed preliminary design and development and undergo PDR to evaluate the completeness/consistency of the program's preliminary design in meeting all requirements with appropriate margins, with acceptable risk, and within cost and schedule constraints. This comprehensive review will include all of the major elements, and will determine the program's readiness to proceed with the detailed critical design phase of the project.

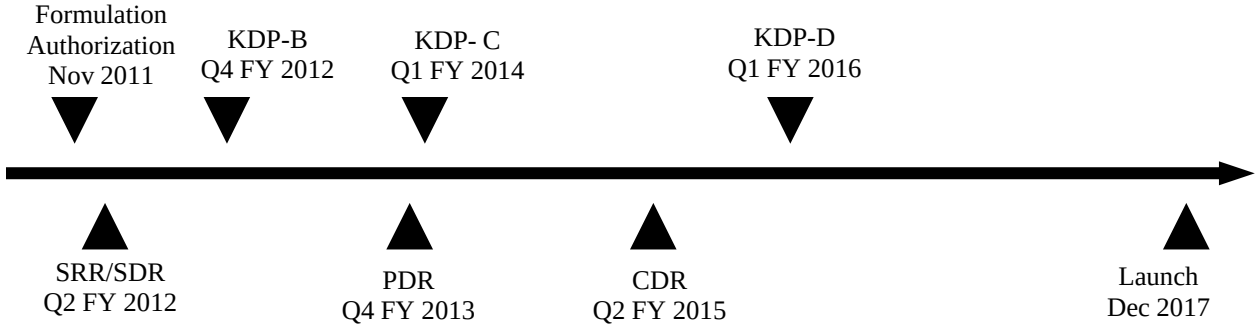
ESTIMATED PROJECT SCHEDULE

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation Authorization	Nov-11	Nov-11
SRR/SDR	Q2 FY 2012	Q2 FY 2012
KDP-B	Q4 FY 2012	Q4 FY 2012
PDR	Q4 FY 2013	Q4 FY 2013
KDP-C	Q1 FY 2014	Q1 FY 2014
CDR	Q2 FY 2015	Q2 FY 2015
KDP-D	Q1 FY 2016	Q1 FY 2016
Launch	Dec-17	Dec-17

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Project Schedule



Project Management & Commitments

SLS launch vehicle development efforts are led by MSFC. The SLS program office has responsibility for meeting architectural requirements within the cost and schedules established by NASA Headquarters.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Engines	Provider: MSFC Project Management: MSFC NASA Center: MSFC, SSC Cost Share: N/A	Responsible for development and/or testing, production, and support for both core stage (RS-25d) and upper stage (J-2X) liquid engines.	Same	Same
Stages	Provider: MSFC Project Management: MSFC NASA Center: MSFC Cost Share: N/A	Responsible for development, testing, production, and support of both the core and upper stages, including liquid engine and avionics integration.	Same	Same
Booster	Provider: MSFC Project Management: MSFC NASA Center: MSFC Cost Share: N/A	Responsible for development, testing, production, and support for the five-segment reusable solid rocket motor to be used on initial capability flights.	Same	Same

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The resources requested for SLS development are not available at the levels and on the schedule requested in this budget, Then: The SLS development will likely experience programmatic delays and increased costs.	The SLS program is taking a number of steps to ensure that SLS can be developed within a flat budget with a first flight by December 2017. Cost and schedule are overriding considerations for the SLS program. The SLS architecture itself is evolvable, with near term development focused on those capabilities specifically required to execute the initial test flights. The evolved capability elements can be matured and introduced as resources permit. The program is also focusing on affordability from development through operations. Cost, schedule, and technical targets are achievable within the budget request. Reductions or delays to providing the resources requested in this budget will likely result in delays that will impact the first launch in 2017 and/or the deferral of development work needed to field the evolved capability, as well as increased overall development cost.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

SLS vehicle procurements are structured to meet the Agency's requirement for an affordable and evolvable vehicle within a schedule that supports various mission requirements. Procurements will include use of existing assets to expedite development, as well as further development of technologies and future competitions for advanced systems and key technology areas specific to SLS evolved vehicle needs.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Element	Vendor	Location
Core and Upper Stages	Boeing Aerospace	Huntsville, AL
Core Stage Engine (RS-25d)	Pratt & Whitney Rocketdyne, Inc	Canoga Park, CA
Upper Stage Engine (J-2X)	Pratt & Whitney Rocketdyne, Inc.	Canoga Park, CA
Booster(Qualification Motors and first two test flights)	ATK Launch Systems	Magna, UT
Advanced Booster Risk Reduction & Demo and Advanced Booster Design Development Test and Evaulation	To be competed	
Spacecraft & Payload Adaptor plus Fairing	To be competed	

INDEPENDENT REVIEWS

Independent reviews will be performed as required by NPR 7120.5. NASA established an SRB to review the SLS program and launch vehicle project.

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Independent Cost Assessment	Booz Allen Hamilton	Q4 FY 2011	NASA engaged Booz Allen Hamilton to perform independent assessments of cost and schedule estimates, independent cost assessments, developed by the SLS, Orion MPCV, and Ground Systems Development and Operations programs, and to assess the sufficiency of reserves contained in the estimates. The program estimates were found to be serviceable in the near term on a three to five year budget horizon. Beyond this horizon, the assumption of large, unsubstantiated, future cost efficiencies lead to the impression that the program estimates were optimistic. Further, a scenario-based risk assessment revealed that the program reserves are insufficient. NASA has committed to working to implement the recommendations of the report address these issues.	N/A
SDR	SRB	N/A	To evaluate whether the program functional and performance requirements are properly formulated and correlated with the Agency and HEOMD strategic objectives; to assess the credibility of the program's estimated budget and schedule.	Q2 FY 2012

LAUNCH VEHICLE DEVELOPMENT

Formulation	Development	Operations

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
SDR	SRB	N/A	To evaluate whether the program functional and performance requirements are properly formulated and correlated with the Agency and HEOMD strategic objectives; to assess the credibility of the program's estimated budget and schedule.	Q2 FY 2012
PDR	SRB	N/A	To evaluate the completeness/ consistency of the program's preliminary design, including its projects, in meeting all requirements with appropriate margins, acceptable risk and within cost and schedule constraints; and to determine the program's readiness to proceed with the detailed design phase of the program.	Q4 FY 2013
CDR	SRB	N/A	To evaluate the integrity of the program integrated design, including its projects and ground systems, to meet mission requirements with appropriate margins and acceptable risk, within cost and schedule constraints; to determine if the integrated design is appropriately mature to continue with the final design and fabrication phase.	Q2 FY 2015

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**250.0**	**304.5**	**404.5**	**455.6**	**455.6**	**455.6**	**455.6**
Change From FY 2012 Estimate	--	--	**100.0**				
Percent Change From FY 2012 Estimate	--	--	**32.8%**				

The mobile launch tower that will support NASA's next exploration rocket is on the crawler-transporter to launch pad 39B at KSC. The 6.8-million pound launcher, towering some 400 feet off the ground is making the 4.2-mile trip to give engineers data on how much the tower sways and wiggles during the journey. Then two weeks of tests at the pad will provide a comprehensive "fit check" to test clearances and connections.

The EGS program will modernize and transform the Florida launch and range complex at KSC in support of the Orion MPCV and the SLS.

PROJECT PURPOSE

The EGS program will explicitly support vertical and horizontal integration and launch of SLS and Orion MPCV by modifying the mobile launcher, Launch Complex 39B, the crawler transporter , and the Vehicle Assembly Building. Additionally, offline processing infrastructure such as the multi-payload processing facility will be upgraded to adequately service Orion MPCV for launch, as well as other landing and recovery activity. Facility modifications to accommodate the SLS and Orion MPCV, along with ground support equipment modifications to service the vehicle are in work. All communication and range systems at KSC and Cape Canaveral Air Force Station will also be modernized to capably support SLS and Orion MPCV.

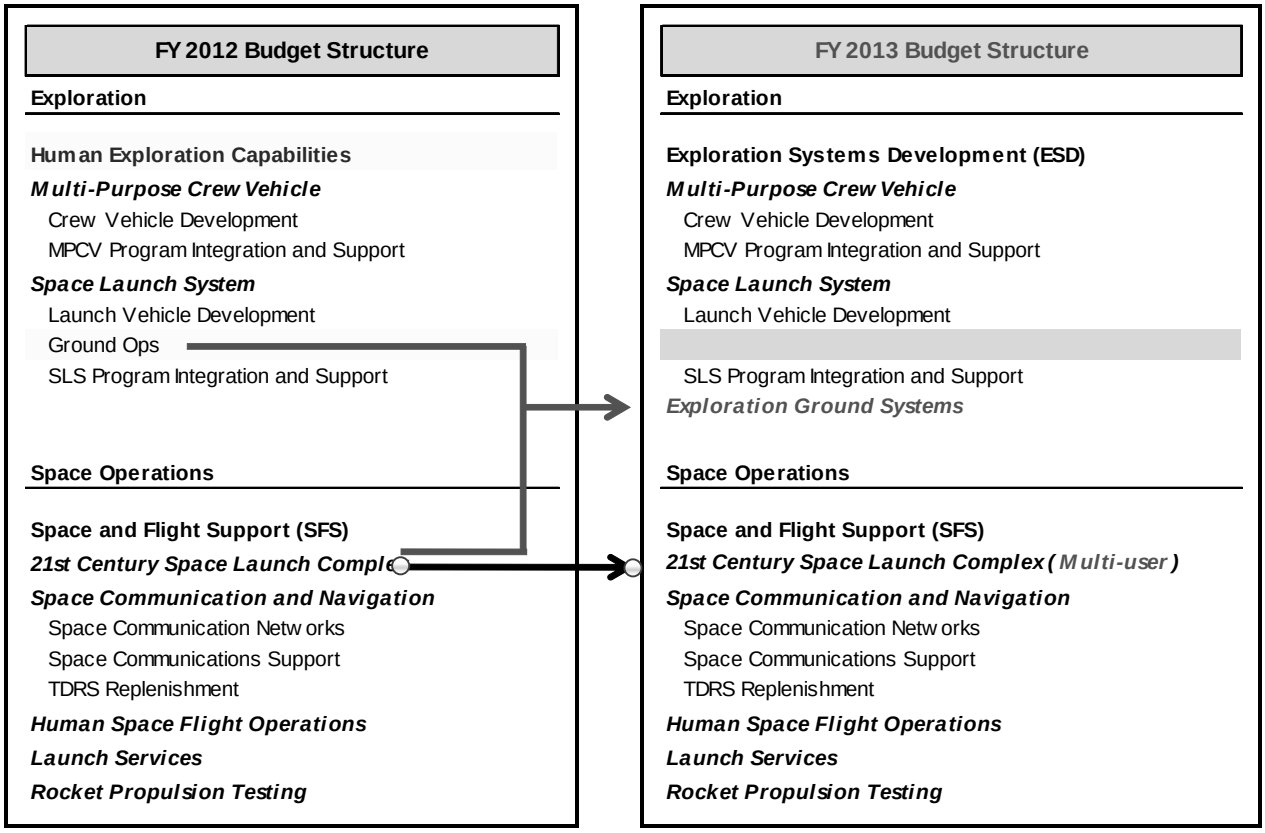
The Ground Systems Development and Operations (GSDO) Program Office at KSC manages both EGS and the 21st Century Space Launch Complex (21CSLC). It will also modernize and transform the Florida launch and range complex at KSC by developing and implementing infrastructure and process improvements to provide more flexible, affordable, and responsive capabilities. The beneficiaries are current and future NASA programs: Orion MPCV, SLS, and additional customers including other government agencies and commercial industry.

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

EXPLANATION OF PROJECT CHANGES

EGS is a new program within the Exploration appropriation. In previous requests, the activity in the EGS program was included under the Space Launch System program. Additionally, Exploration-related content was moved from 21CSLC in the Space Operations account into EGS, as directed by Congress.



PROJECT PRELIMINARY PARAMETERS

EGS primary components are vehicle integration and launch, offline processing, and command, control and communication. Vehicle integration and launch will complete work associated with launch vehicle stacking, launch vehicle integration, spacecraft, rollout, pre-launch and launch operations at the pad, to include the associated facility modifications and upgrades to GSE for the SLS heavy lift rocket launch vehicle. Offline processing will complete work associated with payload processing, manufacturing, testing, servicing and hazardous operations, and recovery in support of the SLS and Orion MPCV. Command, control and communications will complete work to enhance future capability for command and control, weather, telemetry and tracking, communications, and customer interface systems.

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2011

The EGS work content (managed by the GSDO program office) is an extension of the accomplishments started under Constellation program ground operations, and is extensible to the development and operations needed to support the processing, integration, and launch of future NASA human spaceflight missions. This work included completion of a new mobile launcher structure that will be used to support, service, transport, and launch the heavy lift rocket being developed by the SLS program. Renovation of launch complex 39-B began with the removal of the fixed service structure and rotating service structure used by the Space Shuttle Program.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, EGS will refine launch infrastructure and operations requirements concepts and designs in support of the SLS and Orion MPCV programs. Modifications to existing facility systems including Launch Complex 39, the Vehicle Assembly building (VAB), the Mobile Launcher, and command and control systems will be ongoing in this fiscal year. Specifically, at Launch Complex-39, Pad B tank refurbishment, elevator construction, and the flame trench demolition will begin. In the fourth quarter of FY 2013, the Mobile Launcher structural and facility support systems modification contract will commence, strengthening the structure in support of SLS and Orion MPCV use. Within the VAB, electrical and communication cabling will be removed from high bays 1 and 3, and the high bay 3 platform will be demolished. Continued enhancements of command and control, weather, telemetry and tracking, communications, and customer interface systems will also highlight FY 2013.

BUDGET EXPLANATION

The FY 2013 request is $404.5 million. This represents a $88.0 million increase from the FY 2012 estimate ($316.5 million). Budget requests for FY 2013 programmatic CoF associated with this program are included in the CECR section. Funds associated with outyear estimates for programmatic construction remain in programmatic accounts.

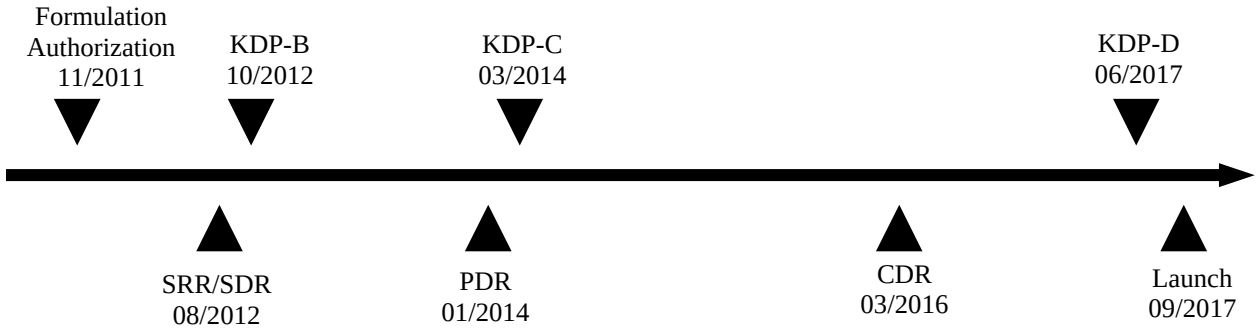
EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

ESTIMATED PROJECT SCHEDULE

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation Authorization	Nov-11	Nov-11
SRR/SDR	Aug-12	Aug-12
KDP-B	Oct-12	Oct-12
PDR	Jan-14	Jan-14
KDP-C	Mar-14	Mar-14
CDR	Mar-16	Mar-16
KDP-D	Jun-17	Jun-17
Launch	Sep-17	Sep-17

Project Schedule



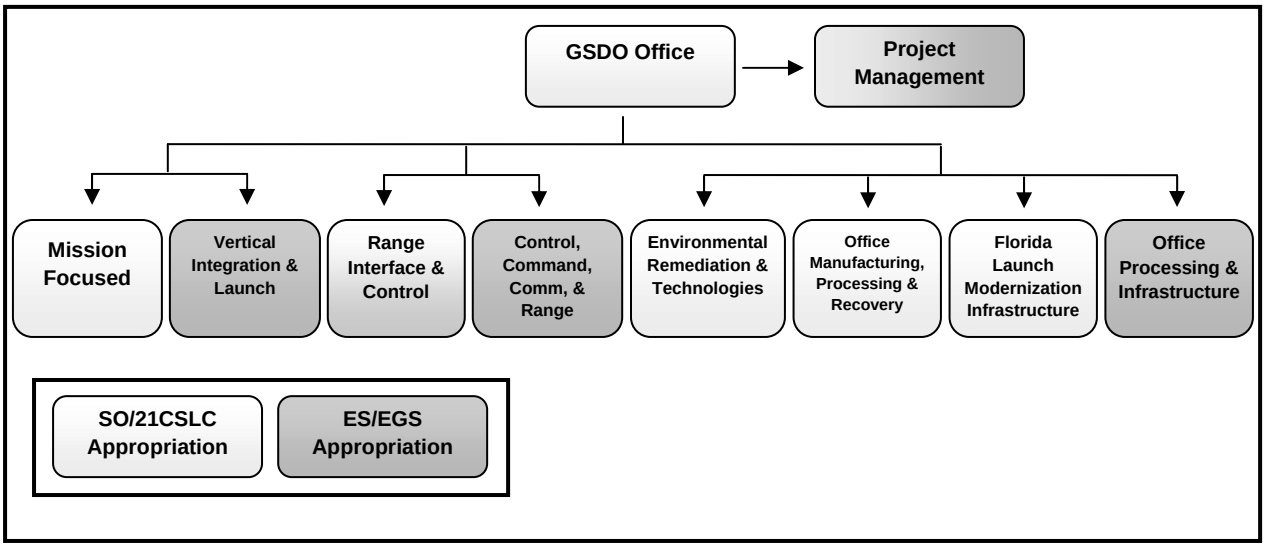
EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

Project Management & Commitments

As noted in the 21CSLC section under the Space Operations account, KSC established the GSDO Program Office in order to develop the necessary infrastructure to support assembly, test, launch and recovery of associated SLS and Orion MPCV elements, and to modernize the launch and range infrastructure at KSC to support multiple customers including NASA, other government agencies, and commercial industry.

The following diagram shows the break out of the 21CSLC content and the EGS content, as managed under the GSDO Program.



Note: *SO = Space Operations account. ES = Exploration account.*

This single-program approach to managing both the 21CSLC content under the Space Operations appropriation, and the EGS content under the Exploration appropriation, provides cost-effective synergy between the various user requirements, while maintaining distinct identification of each element with its appropriation. The GSDO Program Manager is responsible and accountable for the Exploration Ground Systems content in conformance with the governing programmatic and institutional authority requirements documented in NPD 1000.0A.

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Offline Processing	Provider: Exploration Ground Systems Project Management: GSDO Program NASA Center: KSC, JSC, MSFC Cost Share: N/A	Development and operation of capabilities to be used for flight component manufacturing and assembly, offline spacecraft and launch vehicle processing, and the nominal and contingency landing and recovery of elements of the SLS, Orion MPCV, and potentially other government and commercial launch systems and spacecraft.	N/A	Realignment of SLS/MPCV content from 21CLC to EGS
Command, Control, and Communication	Provider: Exploration Ground Systems Project Management: GSDO Program NASA Center: KSC Cost Share: N/A	Command, control, communication and range capability at KSC and at CCAFS in support of the GSDO program. This includes NASA launch control and ground processing capabilities for both ground suppot equipment and spacecraft/launch vehicle systems. This element provides for network backbone infrastructure on KSC and on CCAFS for voice, imagery, transmission, and radio frequency sub-systems as well as interfaces to any remote launch processing locations. It also provides for IT security support throughout the program.	N/A	Realignment of SLS/MPCV content from 21CSLC to EGS

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Vehicle Integration and Launch	Provider: Exploration Ground Systems Project Management: GSDO Program NASA Center: KSC Cost Share: N/A	Development, operation, and sustainment of capabilities associated with vertical and horizontal processing and launch of integrated launch systems and the associated payloads in support of SLS and Orion MPCV elements. The activities in this element could potentially support other government and commercial users of the Florida launch and range complex	N/A	Realignment of SLS/MPCV content from 21CSLC to EGS; EGS CoF funding transfer into CECR

Project Risks

Specific programmatic risks are in work and will be identified as the program works through the SRR/SDR process and ensures interdependencies with SLS and Orion MPCV are understood and documented.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

The EGS program will encompass projects with varying content and sizes. Many of the projects are consistent with the type of architecture and engineering, construction, and programmatic support available within the scope of existing center and program support contracts. Should project size or scope fall outside the scope of existing center capabilities, then competitively bid firm fixed price contracts will be used.

No major contracts or awards are in place at this time.

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Cost	Booz Allen Hamilton	Q4 FY 2011	Task: Provide an independent assessment of the 21CSLC ground support cost estimates, schedules, and risks. Outcome: The independent cost assessment team concludes that the estimate is reasonable and acceptable to serve as the basis for near-term, three to five year, analysis of alternatives and program decisions, but is not sustainable beyond that timeframe.	N/A

EXPLORATION GROUND SYSTEMS (EGS)

Formulation	Development	Operations

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COMMERCIAL CREW

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**300.0**	**406.0**	**829.7**	**829.7**	**829.7**	**829.7**	**829.7**
Change From FY 2012 Estimate	--	--	**423.7**				
Percent Change From FY 2012 Estimate	--	--	**104.4%**				

The image is an artist's conception of the future state of commercial space transportation where spaceflight becomes much more routine, similar to airline operations, with multiple providers. ISS is also shown to depict the near-term NASA market of ISS crew transportation.

Commercial space transportation is vital to the future of human space exploration. As NASA charts a new course to send humans deeper into space than ever before, the Agency is stimulating efforts within the private sector to develop and operate safe, reliable and affordable commercial space transportation systems. Once the capabilities are matured and available to the government and other customers, NASA plans to purchase services to transport crew and cargo to ISS and low Earth orbit; the ISS budget funds purchase of these services. This approach will provide U.S. access to ISS, reduce our dependence on foreign space transportation systems, strengthen America's space industrial base, and provide a catalyst for future business ventures to capitalize on affordable space access.

The Commercial Crew Program is a partnership between NASA and the private sector to build and operate safe, reliable, and cost effective commercial human space transportation systems. In the near term, NASA is a reliable partner with U.S. industry, providing technical and financial assistance during the development phase. In the longer term, NASA plans to be a customer for these services, purchasing transportation for the U.S. and U.S.-designated astronauts to ISS. These activities should stimulate the development of a new industry that will be available to all potential customers, including the United States Government. Success of the Commercial Crew Program would also end the outsourcing of human space transportation to foreign providers. Together with the capabilities to explore deep space provided by SLS and the Orion MPCV, NASA is moving forward on a robust, comprehensive U.S. human spaceflight program.

COMMERCIAL CREW

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Over the last year, NASA has been working to develop a commercial crew acquisition strategy that ensures appropriate safety, accountability, transparency, affordability, and maximum efficiency in the procurement of commercial crew capabilities and services. In FY 2011, NASA's strategy for the program has evolved into an overall hybrid structure for the life cycle of the Commercial Crew Program, originating with a continuation of funded Space Act Agreements for system and element design as outlined in the NASA Authorization Act of 2010, followed by a series of competitively awarded contracts for an integrated crew transportation system. NASA planned to issue a request for proposal in December 2011 for a competitively awarded integrated design contract for the integrated system design phase of the program.

The FY 2012 Consolidated and Further Continuing Appropriations Act provided NASA with $406 million for the program for FY 2012 ($444 million below the FY 2012 requested level). The Conference Report to the Act directed NASA to "work expeditiously to alter its management and acquisition strategy for the program as necessary to make the best use of available resources and to define the most cost effective path to the achievement of a commercial crew capability". Furthermore, the Government Accountability Office's final report resulting from a review of the acquisition approach for commercial crew, dated December 2011, included the following recommendation, "To continue to ensure that NASA's acquisition approach for commercial crew transportation services is reasonable in light of new appropriations, the Administrator of NASA should direct the Commercial Crew Program to reassess its approach for acquiring services before initiating its procurement process for the integrated design contract and subsequent phases."

NASA evaluated a range of alternative approaches for the near term strategy based on the current budget environment, and determined that it needed to adopt an approach that retains competition while permitting the Agency to focus limited resources to support continued progress toward a commercial capability. Rather than moving forward with a firm-fixed price contract for integrated design, NASA will support the design and development of commercial crew transportation systems through the continued use of funded Space Act Agreements for the next phase of the program. This will enhance partner flexibility in technical development throughout the next phase.

NASA supports the increased progress industry can make during the next phase using funded Space Act Agreements, and the Agency plans to eventually transition to a Federal Acquisitions Regulations- (FAR) based contract to evaluate the results of the development effort and undergo certification efforts to ensure that all the necessary safety and performance requirements are met.

ACHIEVEMENTS IN FY 2011

Since 2009, NASA has conducted two CCDev rounds of awards, soliciting proposals from U.S. industry participants to further advance commercial crew space transportation system concepts and mature the design and development of system elements. For CCDev 1, NASA awarded five funded SAAs to Blue Origin ($3.7 million); the Boeing Company ($18 million); Paragon Space Development Corporation ($1.4 million); Sierra Nevada Corporation ($20 million); and United Launch Alliance ($6.7 million). These commercial partners successfully accomplished all funded milestones in the spring of 2011.

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As part of (CCDev 2, NASA awarded four funded Space Act Agreements that are currently being executed to Blue Origin ($22 million), the Boeing Company ($112.9 million), Sierra Nevada Corporation ($105.6 million) and SpaceX ($75 million). During FY 2011, NASA's CCDev 2 partners have continued to successfully complete their milestones.

Blue Origin is maturing its space vehicle design and pusher escape system, as well as accelerating engine development for a reusable booster system. Blue Origin completed five milestones, including a spacecraft review identifying proposed mission objectives with the design concepts to meet them, and an engine thrust chamber assembly interface and test plan review in preparation for their booster system engine component testing scheduled for next year.

Boeing is maturing their crew transportation system and performing development tests. The company has completed five milestones, including a delta systems definition review where Boeing engineers presented updates and improvements to their spacecraft design since the initial review under CCDev 1 and a landing air bag drop demonstration to measure the performance of prototype landing airbags.

Sierra Nevada Corporation is maturing its Dream Chaser spacecraft design and conducting hardware testing. The company has completed four milestones, including a transportation system requirements review and development of a cockpit based flight simulator for engineering development tests.

SpaceX is maturing the Falcon 9/Dragon transportation system focusing on developing a side-mounted launch abort system. The company completed four milestones, including a review showing the feasibility of their design concept, and a preliminary design review for their launch abort system, which demonstrated that SpaceX is ready to proceed with detailed design, fabrication, assembly, integration, and testing of the component test articles.

In addition to these four funded agreements mentioned above, NASA also signed Space Act Agreements without funding with Alliant Techsystems, Inc. (ATK) and United Launch Alliance (ULA). The ATK agreement is to advance the company's Liberty launch vehicle concept, while the ULA agreement is to accelerate the potential use of the Atlas V as part of a commercial crew transportation system. ATK has successfully completed one of five milestones, and ULA completed two of five milestones. In October 2011, NASA signed another Space Act Agreement without funding to Excalibur Almaz, Incorporated to further develop the company's concept for low Earth orbit crew transportation. All agreements, both funded and unfunded, are currently scheduled for completion by the summer of 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2012, the Agency plans to make awards for the next round of Space Act Agreements FY 2013 funds will continue to support milestones under these Space Act Agreements. By the end of FY 2013, NASA plans to have made significant progress towards maturing the design of multiple, end-to-end, integrated crew transportation systems.

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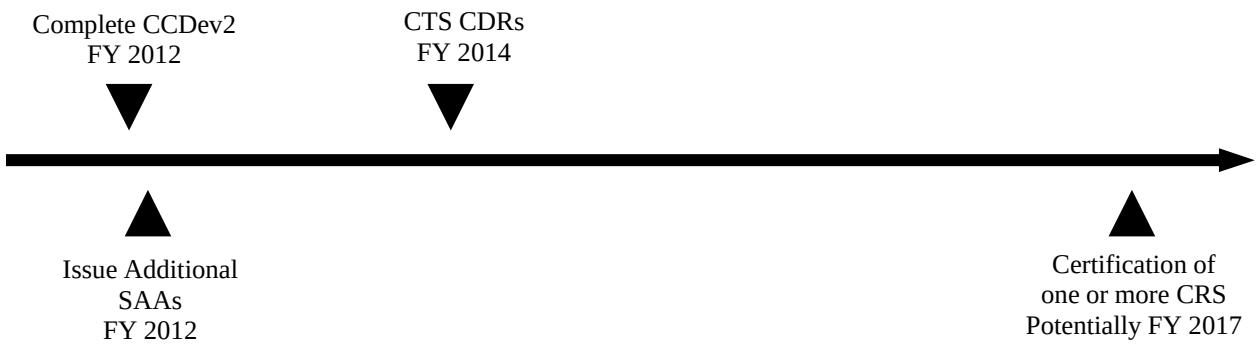
BUDGET EXPLANATION

The FY 2013 request is $829.7 million. This represents a $423.7 million increase from the FY 2012 estimate ($406.0 million). The FY 2013 request includes:

- $767.6 million for the next round of Space Act Agreements with the goal of having multiple providers significantly mature their crew transportation system designs; and
- $62.1 million for program integration and support required to support overall program implementation.

Program Schedule



Program Management & Commitments

While strategic management and oversight of Commercial Spaceflight is performed at Headquarters, program management for the Commercial Crew Program is led by the KSC. These programs have partnered with industry utilizing Space Act Agreements to stimulate efforts to develop and demonstrate cargo and crew transportation capabilities.

Project/Element	Provider	Description
Commercial Crew Program	Provider: Blue Origin, Boeing, Sierra Nevada, SpaceX Project Management: KSC NASA Centers: All Industry Partners: Yes	Support development of a commercial crew space transportation capabilities.

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Program Risks

Risk Statement	Mitigation
If: The funding for commercial crew remains lower than expected and needed, Then: NASA will be forced to reduce the technical scope of the Space Act Agreements, thereby delaying service availability and extending NASA's reliance on foreign providers for human space transportation.	In order to address this risk, NASA altered its acquisition strategy. Rather than moving forward with a firm fixed-price contract(s) for integrated design, NASA will support the design and development of commercial crew transportation systems through the use of funded Space Act Agreements for the next program phase. Space Act Agreements offer more flexibility and efficiency in adjusting to future appropriations. Also, Space Act Agreements enhance partner flexibility in technical development throughout the next phase.
If: commercial crew providers cannot obtain investment capital above the amounts provided by NASA, Then: NASA will either need to more fully fund the system development or experience delays.	NASA will be an ongoing, long-term customer for commercial crew services, providing a strong base market for commercial providers, given the decision to extend the life of ISS. In addition, this budget request provides significant financial and technical assistance to providers to reduce their risk

Acquisition Strategy

The Commercial Crew Program aims to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable, and cost effective access to and from low Earth orbit and ISS. In the early lifecycle stages, the original CCDev activity focused on stimulating industry efforts that successfully matured subsystems and elements of commercial crew spaceflight concepts enabling technologies and capabilities. Subsequently, NASA continued this effort with CCDev 2 to address new concepts to mature the design and development of non-integrated systems and elements, such as launch vehicles or spacecraft.

The next stage of the acquisition life cycle will be a series of competitively awarded Space Act Agreements with the intent of having multiple partners progress in their integrated design and development efforts. The specific content, scope, and duration of the next round was communicated in an announcement for proposals, released on February 7, 2012. After this next Space Act Agreement phase will be a "certification phase," during which NASA will evaluate the technical progress of the commercial partners, and accommodate redesign as necessary to ensure compliance with Agency requirements. This phase may include initial missions to ISS.

NASA plans to competitively award one or more services contracts to obtain longer term crew transportation and emergency rescue services for the ISS. NASA's acquisition strategy balances commercial partner design and schedule flexibility with government insight and oversight responsibilities throughout all program phases. Furthermore, it accommodates maturation of the commercial partner designs and vehicle programs at varying rates. Based on the availability of funding and industry performance, this strategy allows for adjustments in program scope, and enables a domestic capability to

COMMERCIAL CREW

transport crewmembers to ISS, likely by 2017, based on a commercial partner's capability readiness to achieve crew transportation systems certification.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
COTS Space Act Agreements	Orbital	Dulles, VA
COTS Space Act Agreements	SpaceX	Hawthorne, CA
COTS Space Act Agreements	Rocketplane Kistler	Oklahoma City, OK
CCDEV 1 Space Act Agreements	Boeing	Houston, TX
CCDEV 1 Space Act Agreements	Paragon Space Development Company	Tucson, AR
CCDEV 1 Space Act Agreements	United Launch Alliance	Denver, CO
CCDEV 1 Space Act Agreements	Blue Origin	Kent, WA
CCDEV 1 Space Act Agreements	Sierra Nevada	Sparks, NV
CCDEV 2 Space Act Agreements	Blue Origin	Kent, WA
CCDEV 2 Space Act Agreements	Boeing	Houston, TX
CCDEV 2 Space Act Agreements	Sierra Nevada	Sparks, NV
CCDEV 2 Space Act Agreements	SpaceX	Hawthorne, CA
CCDEV 2 Space Act Agreements (unfunded)	ATK	Minneapolis, MN
CCDEV 2 Space Act Agreements (unfunded)	EAI	Houston, TX
CCDEV 2 Space Act Agreements (unfunded)	ULA	Denver, CO

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INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	NAC	Aug-11	Provides independent guidance for the NASA Administrator. While no recommendations were issued related to commercial spaceflight during the last review, a finding was issued citing concern that goals may not be achieved due to inadequate funding authorization by Congress. It should be noted that the funding requested in this budget submit is higher than the authorization funding.	TBD
Other	Aerospace Safety Advisory Panel (ASAP)	Oct-11	Provides independent assessments of safety to the NASA Administrator. ASAP cited a concern that there could be insufficient funding to facilitate this program as envisioned by NASA. However, they issued no recommendations related to the Commercial Crew Program.	TBD
Other	Government Accountability Office (GAO)	Dec-11	Assessed NASA's strategy for acquiring commercial crew services. GAO found that NASA's planned approach for acquiring U.S. commercial crew transportation faces significant challenges, primarily funding levels, which could impact its success. GAO recommended that NASA reassess its approach for commercial crew services due to reduced funding levels. This budget reflects a new strategy change as a result.	N/A
Other	NASA Inspector General	Jun-11	Examined the Agency's efforts to modify its existing safety and human-rating requirements to make them applicable to commercially developed vehicles. Also evaluated the overarching challenges associated with possible approaches NASA may use to certify and acquire commercial crew transportation services. No specific recommendations for corrective action were made.	N/A

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Historical Performance

Through October 31, 2011

Commercial Orbital Transportation System (COTS) Partner*	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through FY 2011 (in $M)	% No. Completed	% Payments Provided	Status
SpaceX	40	396.0	36	376.0	90%	90%	Active
Orbital	29	288.0	23	261.5	79%	91%	Active
Rocketplane-Kistler (RpK)	15	206.8	3	32.1	20%	16%	Terminated

CCDev1 Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through FY 2011 (in $M)	% No. Completed	% Payments Provided	Status
Sierra Nevada Corporation (SNC)	4	20.0	4	20.0	100%	100%	Completed
Boeing	36	18.0	36	18.0	100%	100%	Completed
Blue Origin	7	3.7	7	3.7	100%	100%	Completed
Paragon Space Development Corporation	5	1.4	5	1.4	100%	100%	Completed
United Launch Alliance (ULA)	4	6.7	4	6.7	100%	100%	Completed

CCDev2 Partner	No. of Milestones	Total Potential Value (in $M)	No. Milestones Completed	Payments Through FY 2011 (in $M)	% No. Completed	% Payments Provided	Status
Sierra Nevada Corporation (SNC)	13	105.6	5	42.5	38%	28%	Active
Boeing	15	122.9	5	52.5	33%	47%	Active
SpaceX	10	75.0	4	40.0	40%	53%	Active
Blue Origin	10	22.0	5	11.2	50%	51%	Active
United Launch Alliance (ULA)	5	N/A	2	N/A	40%	N/A	Active
Alliant Techsystems Inc (ATK)	5	N/A	1	N/A	20%	N/A	Active
Excalibur Almaz Inc (EAI)	5	N/A	1	N/A	20%	N/A	Active

**COTS was a previous program funded by the Commercial Spaceflight theme. It has no funding in the FY 2013 President's Budget.*

HUMAN RESEARCH PROGRAM (HRP)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**154.7**	**157.7**	**164.7**	**164.7**	**164.7**	**164.7**	**164.7**
Change From FY 2012 Estimate	--	--	**7.0**				
Percent Change From FY 2012 Estimate	--	--	**4.4%**				

A next-generation ultrasound device for astronaut care and improved ISS research capabilities was delivered to ISS by STS-135, replacing a decade-old machine. The Ultrasound 2 is a commercial off-the-shelf system that was updated to meet space flight standards, and will be a key tool in research for long-duration human exploration. The ultrasound images sent back to Earth allow biomedical researchers to better understand and monitor changes in the human body during space flight. Astronaut Mike Fossum is using Ultrasound 2 to scan JAXA crewmember Satoshi Furukawa.

HRP is focused on investigating and mitigating the highest risks to human health and performance in order to enable safe, reliable, and productive human space exploration. HRP conducts research, develops countermeasures, and undertakes technology development to address human health risks in space and ensure compliance with NASA's health, medical, human performance, and environmental standards. The risks examined by HRP include health concerns from space radiation exposure, behavioral health, and team cohesion challenges associated with confinement and isolation, ensuring vehicle functions are properly designed for efficient human interface in space, and providing for emergency medical care in space. HRP also studies the effects of microgravity on the human body including rapid muscle atrophy, bone loss, neurovestibular system changes that produce motion sickness, significant fluid shifts that affect intracranial pressure, visual changes, cardiovascular function, blood volume, and orthostatic intolerance.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

HUMAN RESEARCH PROGRAM (HRP)

ACHIEVEMENTS IN FY 2011

In FY 2011, HRP made extensive use of ISS to address human health and performance risks associated with long-duration spaceflight, including the flight of 11 major medical experiments. HRP also completed and delivered new ISS biomedical capabilities as well as a model that predicts the lifetime cancer health risk from exposure to deep space radiation. For more detail on these achievements see the project descriptions that follow.

In education and outreach, HRP organized and hosted the 18th International Astronautics Academy's Humans in Space Symposium in Houston and led a successful international outreach program called "Mission X: Train Like an Astronaut" that brought together 14 space agencies with students from around the world to work together to address health and fitness education in young people.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, HRP will use ISS and related agency resources to complete at least two physiological flight experiments that define requirements to address human health and performance risks associated with long-duration spaceflight. For more detail on these achievements see the project descriptions, that follow.

BUDGET EXPLANATION

The FY 2013 request is $164.7 million. This represents a $7.0 million increase from the FY 2012 estimate ($157.7 million).

Projects

EXPLORATION MEDICAL CAPABILITY

This project is responsible for identifying and testing next generation medical care and crew health maintenance technologies during exploration missions, as well as the evolution of exploration health care options based on past experience, anticipated needs, and input from flight surgeons and crew offices. Major deliverables from this project include identifying requirements for medical equipment and clinical care capabilities, developing remote medical technologies, and assessing medical requirements for long-duration space missions (e.g., Mars, Moon, or near-Earth asteroid).

In FY 2011, HRP completed work that will enable future development of an exploration medical suite including: final report on ISS testing of mixed water generation and IV drug mixing capability, ultrasound image catalog for use in autonomous medical care in space, and delivering a training program to medical operations for ultrasound diagnosis of fractures. In addition, HRP completed assessment of technologies that will enable in-flight blood analysis technology for health monitoring and sensor system for noninvasive metabolic rate measurements. Finally, NASA delivered the integrated medical model software tool that defines the optimal medical capability requirements for long-duration space missions

HUMAN RESEARCH PROGRAM (HRP)

like those to Mars, Moon, or an asteroid via a medical database that forecasts potential risks to crew health.

In FY 2013, HRP's exploration medical capability project will deliver an engineering prototype of a smart therapeutic ultrasound device, receive a prototype combined scanning confocal ultrasound diagnostic and treatment system for bone quality assessment and fracture healing, and sensor algorithms for noninvasive continuous metabolic rate measurements.

HUMAN HEALTH COUNTERMEASURES (HHC)

The HHC project provides the biomedical expertise for development and assessment of medical standards, vehicle and spacesuit standards dictated by human physiological needs, and develops biomedical countermeasures that ensure the maintenance of crew health. Major deliverables for the HHC project are research results to define health and medical standards, validated human health prescriptions, validated exercise system requirements, extravehicular activity injury and decompression sickness prevention standards, integrated physiological countermeasures, and criteria for the Agency fitness for duty and crew selection and retention standards. The project also supports biomedical core laboratories that provide the expertise to enable the development of medical standards, the assessment of the risks to crew health and performance, and the validation of countermeasures.

In FY 2011, HHC held a research summit on the recently identified visual impairment, and increased intracranial pressure risk to astronauts during long duration spaceflight; it brought together the Nation's experts to support NASA in identifying approaches to dealing with this significant issue. Based on this summit, HHC formulated a research plan and released a research announcement requesting proposals in this critical area. HHC also completed the instrumented harness final report on distribution of loads during crew exercise. The weight-bearing exercise afforded by treadmill running on the ISS is crucial for effective gravitational loading of the musculoskeletal system and thus for bone health in space. The current ISS treadmill harness caused discomfort in crewmembers, and the new harness design eliminated many of these issues and is now used by crewmembers. Finally, NASA initiated the ISS Sprint study that brings together more than a decade of NASA funded exercise research to test a newly designed exercise prescription. The exercise prescription consists of high-intensity aerobic sprint intervals and a resistive training program intended to better protect cardiovascular, skeletal muscle, and bone health.

In 2013, HHC will perform research studies to reduce crew health risks during missions and long-term health risks *after* missions, including cardiac structure and function and bone demineralization monitoring and mitigation techniques. HHC will complete the ISS treadmill kinematics study final report to inform mission operations and improve exercise countermeasures for bone health, complete the ISS VO_2Max study final report to inform mission operations and recommend update to NASA health standards, and provide a preliminary recommendation for updating the immune standard based on outcome from integrated immune flight study.

BEHAVIORAL HEALTH AND PERFORMANCE (BHP)

The BHP project identifies and characterizes the behavior and performance risks associated with training, living, and working in space, and returning to Earth. The major deliverables for the BHP project include:

HUMAN RESEARCH PROGRAM (HRP)

- Recommendations for NASA medical standards;
- Development of operational tools and technology to prevent performance degradation;
- Human errors or failures during critical operations resulting from sleep loss;
- Circadian de-synchronization, fatigue or work overload;
- Deterioration of morale and motivation;
- Interpersonal conflicts or lack of team cohesion, coordination, and communication;
- Team and individual decision-making; performance readiness factors (fatigue, cognition, and emotional readiness);
- Behavioral health disorders; and
- Individual selection and crew assignments.

In FY 2011, NASA proposed recommendations for ISS lighting assemblies that provide a safe, reversible, and non-pharmacological countermeasure to facilitate crew circadian rhythms, increase alertness, and enhance performance. NASA also delivered the stress management and resilience training for optimal performance on long-duration missions (SMART-OP) software that provides a stress management countermeasure. Executing a long-duration mission poses many stress-inducing challenges such as time away from family, communication delays, and isolation. The SMART-OP program includes education about stress and interactive training exercises that teach users to regulate physiology, think flexibly and realistically, and take effective action to deal with stressors.

In 2013, BHP will use ground-based analog and ISS flight-based studies to evaluate contributing factors to health or performance degradation, errors, or failures during critical mission operations. These studies will evaluate sleep loss and circadian rhythms, medication side effects, fatigue, team cohesion, and training protocols.

SPACE HUMAN FACTORS AND HABITABILITY

This project consists of three main areas:

- Space human factors engineering validates models for predicting the effects of interface designs on human performance, methods for measuring human and human-system performance, and design concepts for, and evaluations of, advanced crew interfaces and habitability systems;
- Advanced environmental health research assesses the acute and long-term health impacts of targeted pollutants in the environment including lunar dust, microorganisms, and atmospheric contaminants; and
- Advanced food technology provides a safe, nutritious, and acceptable food system to maintain crew health and performance. Technology development addresses nutritional, psychological, safety, and acceptability requirements while minimizing mass, volume, waste, power, and trace gas emissions.

In FY 2011, NASA developed and tested multi-spectrum lighting and worked with the ISS program to develop programmable lighting to aid in astronaut adaptation to the work, rest, and sleep cycle. This new lighting approach will be used for all future exploration spacecraft. NASA also held the Net Habitable Volume Workshop that brought together a multidisciplinary group of experts in medical sciences and human habitability and design. The workshop established a foundation for developing requirements for

HUMAN RESEARCH PROGRAM (HRP)

minimal habitable volume for long-duration space missions and the factors that lead to these requirements. NASA delivered a draft standard for allowable exposure to respirable lunar dust to NASA's Chief Health and Medical Officer. The new standard is based on four years of experimental research and would be a key design requirement for lunar habitats, if established.

In 2013, NASA's Space Human Factor and Habitability project will research food nutrition requirements and storage for long duration missions, develop and recommend human/machine interface requirements, recommend permissible exposure limit standards, and test habitat designs to support the crew's ability to optimally function during space missions. NASA will provide a final report and recommendations to applicable NASA standards on the mitigation of transmission delays in teleoperations for long-duration exploration missions.

SPACE RADIATION HEALTH

This project performs investigations to assure that crews can safely live and work in a space radiation environment without exceeding the acceptable exposure limits during and after missions. Major deliverables for the space radiation project include inputs to standards for radiation health, habitability, and environments, requirements for radiation protection; early technology development for monitoring equipment, caution and warning models; and tools to assess and predict risks due to space radiation exposure; and strategies to mitigate exposure effects.

In FY 2011, NASA delivered an updated space radiation cancer risk model that predicts the lifetime cancer health risk from exposure to deep space radiation and it is a vital tool in planning safe exploration missions. NASA also initiated a new collaboration on lung cancer research with the National Institutes of Health National Cancer Institute by jointly sponsoring a workshop "From Mice and Men to Earth and Space: Joint NASA-NCI Workshop on Lung Cancer Risk Resulting from Space and Terrestrial Radiation". Lung cancer is a major issue for NASA, as available data suggest that it is the largest potential cancer risk from exposure to space radiation during space travel for both men and women. Finally, NASA, working with the DoE, upgraded the NASA Space Radiation Laboratory. The new electron beam ion source was commissioned and is supporting space radiation researchers with much-reduced operating costs and greater operational flexibility.

In FY 2013, NASA's Space Radiation Health project will evaluate the increased risk of cancer as a function of age, age at exposure, radiation quality, latency, and gender. These efforts will enable more accurate predictions of cancer and facilitate longer stays in space. NASA will baseline lunar neutron environmental model available on OLTARIS, which is a space radiation analysis tool available on the Internet. It can be used by researchers and mission planners to study the effects of space radiation for various spacecraft and mission scenarios involving humans and electronics.

ISS MEDICAL PROJECT (ISSMP)

ISSMP planning, integration, and implementation services for HRP research tasks and evaluates activities requiring access to space or related flight resources on ISS, Soyuz, Progress, or other spaceflight vehicles and platforms. ISSMP services include operations and sustaining engineering for HRP flight hardware, experiment integration and operation including individual research tasks and on-orbit validation of next

generation on-orbit equipment, medical operations, procedures and crew training concepts. Services also include operation and sustaining engineering for the telescience support center, which provides real-time operations and data services to all HRP flight experiments. ISSMP integrates HRP-approved flight activities and interfaces with external implementing organizations, such as the ISS payloads office and international partners to accomplish the HRP's objectives.

In FY 2011, NASA coordinated and optimized the biomedical research supporting three Shuttle missions and ISS increments 26 to 29. NASA flew 11 major medical experiments to optimize exercise, nutrition and sleep to evaluate the immune system and other human health areas to make exploration missions healthier, safer, and more productive. NASA completed two of these ISS research studies and initiated three new studies. NASA also added new ISS biomedical capabilities including the second-generation ultrasound for medical imaging, the urine monitoring system, and the jointly developed ESA and NASA muscle atrophy research and exercise system.

In 2013, ISSMP will use ISS to understand the significant effects of long duration space flight on the human body by supporting 10 to 15 biomedical flight experiments per each ISS six-month mission.

PROGRAM MANAGEMENT

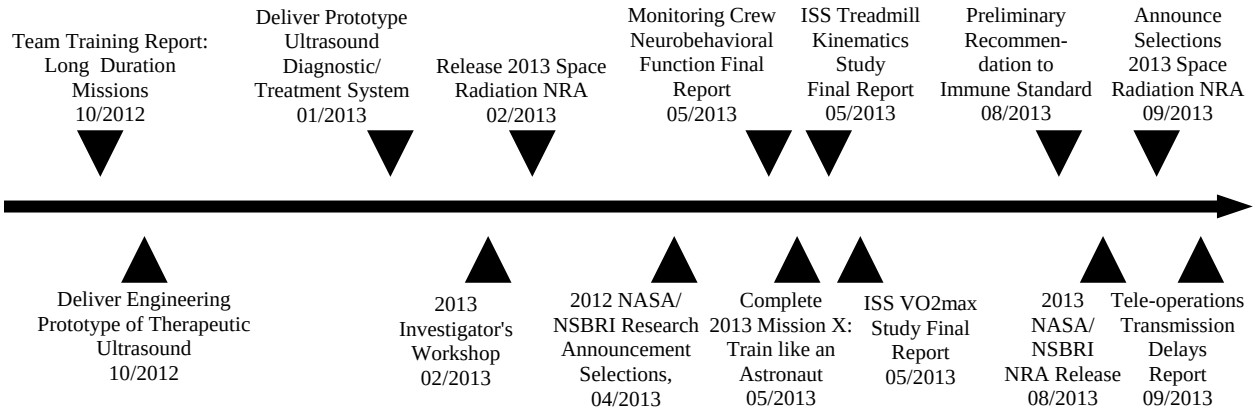
The program management office plans, coordinates, and oversees all HRP research and development projects. Based on NASA's current needs, program management personnel assess the research areas of greatest importance and prioritize resources and research teams accordingly, ensuring integration across projects and facilities. In addition to coordinating research activities within the program, the office also works to cultivate strategic research partnerships with other domestic and international agencies.

In FY 2011, NASA was highly involved internationally by organizing and hosting the 18th International Astronautics Academy's Humans in Space Symposium in Houston, TX. NASA also led the development and execution of a highly successful international outreach program called "Mission X," which brought together 14 space agencies and various partner institutions to work together to address health/fitness education in young people. NASA released two research announcements related to space human health risks and conducted peer reviews of all solicited research proposals.

In FY 2013, the program management office will continue to consult with NASA Headquarters on NASA Research Announcement (NRA) releases and selections, as well as conduct workshops and events in support of human research.

HUMAN RESEARCH PROGRAM

Program Schedule



Program Management & Commitments

HRP is managed by the Human Research Program Office, located at JSC, with support from ARC, GRC, LaRC and KSC. The HEOMD Associate Administrator has delegated the authority, responsibility, and accountability of the Human Research Program manager to the Space, Life and Physical Sciences Research and Applications Division at NASA Headquarters. This division, working closely with the Office of the Chief Scientist, establishes the overall direction and scope, budget, and resource allocation for the program which is then implemented by the NASA Centers.

Project/Element	Provider
Exploration Medical Capability	Provider: JSC Project Management: JSC NASA Center: GRC, ARC, and LaRC Cost Share: N/A
Human Health Countermeasures	Provider: JSC Project Management: JSC NASA Center: ARC and GRC Cost Share: N/A
Behavioral Health and Performance	Provider: JSC Project Management: JSC NASA Center: ARC and GRC Cost Share: N/A

HUMAN RESEARCH PROGRAM

Project/Element	Provider
Space Human Factors and Habitability	Provider: JSC Project Management: JSC NASA Center: ARC Cost Share: N/A
Space Radiation Health	Provider: JSC Project Management: JSC NASA Center: ARC and LaRC Cost Share: Department of Energy
ISS Medical Project	Provider: JSC Project Management: JSC NASA Center: ARC and KSC Cost Share: N/A

Program Risks

Risk Statement	Mitigation
If: If sufficient ISS upmass and sample return are not available, Then: Then HRP cannot complete the investigations identified in its integrated research plan and crew health risks associated with exploration missions will not be adequately addressed.	HRP continues to evaluate the following mitigations: 1. Experiment resupply strategy and contingency approach to reduce upmass requirements; 2. New sample packaging to gain efficiencies for on board sample storage and return; and 3. Development of new capabilities that allow on-orbit analysis to reduce required up and down mass.

Acquisition Strategy

In FY 2013, two NRAs will be used to further efforts in human research. The Space Radiation NRA will focus on better understanding and reducing risks that crews could face from space radiation on exploration missions. The joint NASA and National Space Biomedical Research Institute (NSBRI) NRA to support crew health and performance in space exploration missions will focus on: bone loss; cardiovascular alterations; human performance factors, sleep, and chronobiology; muscle alterations and atrophy; neurobehavioral and psychosocial factors; nutrition, physical fitness, and rehabilitation; sensorimotor adaptation; smart medical systems; biomedical technology development; and analog bed rest investigations.

HUMAN RESEARCH PROGRAM

MAJOR CONTRACTS/AWARDS

Element	Vendor	Location
Consortium of Institutes	NSBRI	HQ

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Peer Panel Reviews	Feb-10	Peer review of NRA/selection of grantees	Feb-12
Quality	External Independent Review	Dec-10	Review of research projects gaps and tasks/contributes to potential project reprioritizations	Feb-12
Quality	Independent Review	Feb-09	Program Implementation Reviews/ contribute to potential project reprioritizations	Aug-12
Quality	National Academies	Jun-08	Review the "NASA Research on Human Health Risks" study and contribute to potential project reprioritizations	Jun-13

ADVANCED EXPLORATION SYSTEMS (AES)

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**77.6**	**142.0**	**169.0**	**169.0**	**169.0**	**169.0**	**169.0**
Change From FY 2012 Estimate	--	--	**27.0**				
Percent Change From FY 2012 Estimate	--	--	**19.0%**				

To enable human exploration beyond Earth orbit in a sustainable and affordable way, advanced technologies and systems such as deep space habitats, EVA and life support systems, and robotic support capabilities will be key. The artist's conception shows astronauts exploring the surface of a near-Earth asteroid.

The AES program is pioneering new approaches for rapid prototype systems development, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. AES projects are selected to address the highest-priority capability needs identified in human spaceflight architecture studies for exploration missions to cis-lunar space, the Moon, near-Earth asteroids, and Mars and its moons. Currently, the program consists of 20 small projects, grouped into five major domains of related activities: crew mobility systems, habitat systems, vehicle systems, operations, and robotic precursor activities.

Early integration and testing of prototype systems is critical to reducing risk and improving affordability of exploration mission elements. Systems developed in the AES program will be demonstrated in ground-based test beds, field tests, underwater tests, and flight experiments on ISS, which is a key stepping stone for enabling deep space exploration. Over time, many AES projects will evolve into larger integrated systems and mission elements that will be tested on ISS before NASA ventures beyond Earth's orbit.

The AES program is also working closely with the Science Mission Directorate (SMD) to pursue a joint program of robotic precursor activities to develop instruments, support research and analysis efforts, and plan robotic precursor missions to acquire critical data on potential destinations for human missions.

In addition to developing building blocks for future missions, the AES program is exploring innovative and affordable ways to drive a rapid pace of progress, streamline project management, and utilize limited resources effectively. Using small, focused projects to develop and test prototype systems in-house will greatly reduce life cycle costs, and minimize the risk of incorporating new technologies into system designs. This model will more effectively develop and apply Agency workforce, providing more hands-on work, rather than contractual oversight experience, to NASA's engineers and technologists.

ADVANCED EXPLORATION SYSTEMS (AES)

EXPLANATION OF MAJOR CHANGES FOR FY 2013

In FY 2012, the Exploration Technology Development (ETD) portfolio was transferred from the HEOMD account to the Space Technology program in the Office of Chief Technologist. The ETD portfolio consists of foundational domains that address long-range technology development needs, maintain critical competencies, and help to infuse mature technologies into near-term technology demonstrations that support exploration missions. This transfer positioned ETD in a technology-focused organization where synergistic interactions with game-changing and crosscutting technologies will help to support multiple customers and mission applications in other NASA programs.

Several existing ETD activities were essential for crew safety, such as extravehicular activity, life support, and habitation systems. These areas are the focus of the AES program to ensure critical exploration-specific needs are met. NASA expanded the scope of AES from this initial set of activities to include other high-priority areas identified in exploration mission architecture studies, but not covered by other NASA programs, with a focus on systems development and integration: crew mobility systems, vehicle systems, mission and ground operations, and robotic precursor activities. Projects were competitively selected from proposals submitted by the NASA Centers on topics in the highest priority areas.

ACHIEVEMENTS IN FY 2011

Although the current AES program began in FY 2012, it built upon the accomplishments of the ETD portfolio, as noted below.

In FY 2011, the program tested the breadboard portable life support system for an advanced spacesuit in the laboratory. This system incorporated new technology components for spacesuit thermal control, pressure regulation, and removal of carbon dioxide. Advanced spacesuits with greater mobility, operational flexibility, and duration are needed for exploring planetary surfaces, and to replace the aging spacesuits used on ISS.

In a desert field test, the program tested a mock-up habitat that included an airlock, a hygiene module, crew workstations, modules for growing plants, and an inflatable loft to provide greater living space. The test allowed designers to evaluate different habitat subsystems and configurations for a future deep space habitat in which the crew would live and work on missions lasting over a year.

The program delivered a radiation assessment detector for launch on the Mars Science Laboratory mission. This detector will measure the interplanetary radiation environment during the trip to Mars, and also on the planet's surface. Characterizing the Mars radiation environment will increase our understanding of the risks that future human explorers will face, and will help to develop more effective countermeasures and radiation shielding.

To simulate asteroid mission operations, the program conducted the NASA extreme environment mission operations underwater test. Divers in spacesuits demonstrated various methods of anchoring to and translating across the surface of an asteroid in low gravity. A submersible simulated a crew excursion vehicle that flies around the asteroid. Such early testing of prototype systems and validation of operational concepts in analog tests helps to reduce mission risk and cost.

ADVANCED EXPLORATION SYSTEMS (AES)

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, the AES program will test a packaged portable life support system for an advanced spacesuit in a vacuum chamber. This is the next step in spacesuit development, following completion of the portable life support system breadboard in FY 2011.

To validate operational concepts for asteroid missions, a prototype crew excursion vehicle moving on an air bearing floor will be used to test techniques for docking and anchoring to a simulated asteroid surface.

On ISS, crew can spend a significant amount of time repairing and maintaining life support systems; for deep space missions, life support systems must be more robust. In FY 2013, the AES program will demonstrate reliable life support systems in a ground test bed.

As humans venture deeper into space, the communications time delay becomes too long to conduct real-time mission control from the ground. Consequently, the crew must perform mission control functions such as planning, scheduling, and procedure execution on their own. In FY 2013, the AES program will demonstrate software tools for automating mission operations to reduce crew workload.

Strategic knowledge gaps are the essential information on potential destinations that must be acquired by robotic precursor missions and astronomical observations to inform the design of human spaceflight systems. In FY 2013, the AES program will establish a set of strategic knowledge gaps for human exploration beyond low Earth orbit that are vetted by the external NASA research community.

Before human missions can be sent to near Earth asteroids, the size, shape, spin rate, and surface properties of these objects must be better understood. Ground-based radar is a low-cost way to image many asteroids that pass close to Earth, eliminating the need to send expensive robotic spacecraft to the asteroids in advance of human missions to gather critical data. In FY 2013, the AES program will use the Goldstone radar to image several asteroids that are candidates for human missions.

BUDGET EXPLANATION

The FY 2013 request is $169.0 million. This represents a $27.0 million increase from the FY 2012 estimate ($142.0 million). The FY 2013 request supports:

- Advancing development of exploration systems to reduce risk, lower lifecycle cost, and validate operational concepts for future human missions beyond Earth orbit;
- Demonstrating prototype systems in ground test beds, field tests, underwater tests, and ISS flight experiments;
- Using innovative approaches for rapid systems development and provide hands-on experience for the NASA workforce;
- Infusing new technologies developed by the Space Technology program into exploration missions; and

- Instrument development, research and analysis efforts, and planning for robotic precursor missions to acquire critical data on potential destinations for future human missions to the Moon, near-Earth asteroids, and Mars.

ADVANCED EXPLORATION SYSTEMS (AES)

Domains

CREW MOBILITY SYSTEMS

The capabilities being developed in this domain will enable crew mobility and EVA systems for exploration of asteroids, the Moon, and Mars. Projects include development of a prototype multi-mission space exploration vehicle to enable exploration of near-Earth asteroids and planetary surfaces, a next generation spacesuit and portable life support system, and a suitport interface to enable rapid EVA from crew vehicles.

As noted previously, NASA developed new technology components in FY 2011 for an advanced spacesuit portable life support system, which were integrated into a breadboard of the portable life support system and tested in the laboratory. In FY 2013, NASA will package the portable life support system into a backpack configuration and test it in a vacuum chamber, test a fusible heat sink for thermal control of the multi-mission space exploration vehicle cabin, and test a suitport integrated with the vehicle cabin.

HABITAT SYSTEMS

The capabilities being developed in this domain will enable the crew to live and work safely in deep space on missions lasting over one year. Projects include development of concepts and subsystems for a deep space habitat, testing of highly reliable life support system components for air revitalization and water recycling in ground test beds, developing common life support system components that can be used in multiple exploration vehicles to reduce costs, developing radiation protection and dosimetry sensors, and conducting experiments to understand how fire propagates in microgravity to improve spacecraft fire safety.

In FY 2013, NASA will conduct an integrated test of habitat subsystems, test life support system components in a ground test bed, and complete the preliminary design review for a large-scale, in-space fire experiment.

VEHICLE SYSTEMS

The capabilities being developed in this domain will enable advanced in-space propulsion stages, and small robotic landers. Projects include the development of reactor fuel elements and engine concepts for nuclear thermal propulsion systems, modular power systems that can be used for multiple exploration vehicles and systems, and a small lander test bed to demonstrate autonomous precision landing.

In FY 2013, NASA will test components for the hydrogen test facility for nuclear thermal propulsion fuel elements, and test a modular fuel cell for powering multiple exploration vehicles.

ADVANCED EXPLORATION SYSTEMS (AES)

OPERATIONS

The capabilities being developed in this domain will enable more efficient mission and ground operations to support human exploration. Projects include analog missions to test prototype systems and operational concepts in representative environments, logistics reduction and repurposing, autonomous mission operations to reduce crew dependence of ground-based mission control, and integrated ground systems for cryogenic propellant storage and handling.

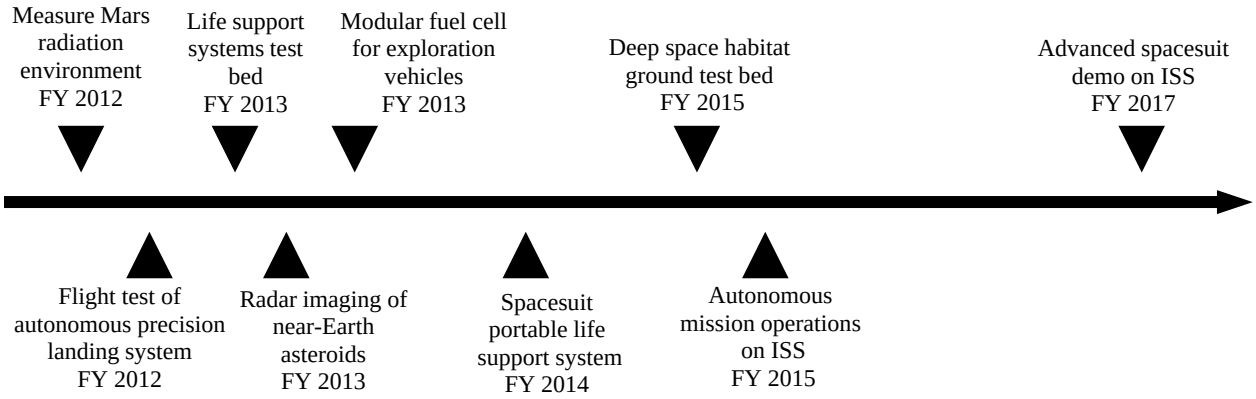
In FY 2013, NASA will demonstrate autonomous propellant handling operations, software tools for autonomous mission operations, and a heat melt compactor to process trash.

ROBOTIC PRECURSOR ACTIVITIES

The capabilities being developed will enable robotic precursor missions and instruments to characterize destinations for human exploration. Projects include imaging near-Earth asteroids using ground-based radar, a radiation assessment detector for characterizing the Mars surface radiation environment, a prototype lunar ice prospecting payload, software tools for searching, visualizing, and analyzing data acquired by robotic precursor missions, and NASA Exploration and Science Institute grants for research on the Moon and small bodies.

In FY 2013, NASA will image near-Earth asteroids using ground-based radar, complete the critical design review for a lunar ice prospecting payload, and select research grants for a NASA Exploration and Science Institute.

Program Schedule



ADVANCED EXPLORATION SYSTEMS (AES)

Program Management & Commitments

The HEOMD Associate Administrator has delegated the authority, responsibility, and accountability for managing the AES program to the AES Division at NASA Headquarters.

The AES Division establishes the overall direction and scope, budget, and resource allocation for projects that are implemented by the NASA centers.

Project managers at the NASA Centers are responsible for project execution. A lead NASA Center is assigned for each project, based on where the required competencies reside, and other NASA centers provide support. The project managers develop project plans, and work with the supporting NASA centers to allocate budget, workforce, and schedule to various tasks. The project managers report directly to the AES Division at NASA Headquarters.

The AES program coordinates with the Planetary Science Division in SMD on the planning and execution of Joint Robotic Precursor Activities (JRPA). These projects within the AES program and SMD are jointly funded and executed. JRPA develops instruments for SMD and international missions to acquire strategic knowledge on potential destinations for future human exploration, and to support related research and data analysis activities. The AES program has overall management responsibility for JRPA.

Project/Element	Provider
Crew Mobility Systems	Projects in this domain are managed by NASA Centers including JSC.
Habitat Systems	Projects in this domain are managed by NASA Centers including JSC, MSFC, and GRC. ESA partners on the planning and implementation of a large-scale fire safety experiment.
Vehicle Systems	Projects in this domain are managed by NASA centers including JSC, MSFC, and GRC. The Air Force Research Laboratory partners on the development of components for a next generation upper stage engine. The Department of Energy partners on the development of nuclear thermal propulsion.
Operations	Projects in this domain are managed by NASA Centers including KSC, ARC, JSC.
Joint Robotic Precursor Activities	Projects in this domain are managed by NASA Centers including JPL, KSC, and MSFC. Joint Robotic Precursor Activities are planned and implemented in collaboration with SMD. CSA is a partner on the development of a lunar ice prospecting payload.

ADVANCED EXPLORATION SYSTEMS (AES)

Project Risks

Risk Statement	Mitigation
If: The AES program does not develop needed capabilities in time to support the design of flight systems, Then: human exploration missions will be delayed, and the costs and risks associated with flight systems development will be substantially higher.	Mission architecture studies are used to define capability needs and priorities. The AES projects are periodically assessed against these priorities, and program content is realigned if necessary as priorities change. The progress of AES projects in achieving planned milestones is evaluated in an annual Continuation Review that involves the flight system developers. Projects that do not make adequate progress will be terminated, and alternate approaches for achieving needed capabilities will be initiated.
If: There are unexpected technical difficulties or catastrophic test failures, Then: development of some prototype systems will be delayed.	Investments in capabilities needed in the near term such as EVA and habitation systems will take precedence over longer-range activities such as operations and vehicle systems. In the event that projects developing near-term capabilities encounter technical difficulties, resources will be reallocated from longer-range activities to address

Acquisition Strategy

The initial set of AES projects was selected via a competitive process in which NASA Centers were invited to submit proposals in targeted areas. Each year, all projects will be assessed in a continuation review. Projects that do not demonstrate adequate progress will be subject to termination, and new projects will be added to the portfolio in specific areas through an annual call for proposals from the NASA centers.

Procurement funding is primarily used to support in-house project activities, such as the purchase of materials, equipment, test facilities, and a limited amount of contractor workforce in areas where NASA can cost effectively leverage skills and knowledge that it currently lacks. Over time, the AES program will also strive to develop these skills within the civil service workforce.

Particular projects may issue competitive solicitations externally or leverage existing contracts for hardware development.

ADVANCED EXPLORATION SYSTEMS (AES)

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Crew Mobility Systems: contract to support spacesuit development	ILC Dover, Cost: $350,000	Frederica, DE

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Independent Assessment	NASA Independent Program Assessment Office	N/A	To ensure that AES program activities are managed in accordance with NASA processes and that program content is aligned with capability needs for human exploration.	2014