Mission Directorate: Exploration Systems

Overview

Five years ago, NASA took on the challenge of reshaping America's leadership in human space exploration by implementing a robust policy to advance the Nation's scientific, security, and economic interests. Reigniting the public's engagement in this bold endeavor, the Agency set out once again to leave low Earth orbit, and is developing the capabilities required to take humans to the Moon, other near-Earth destinations, and eventually to Mars.

During the six Apollo lunar landings, we spent a total of 39 days on the lunar surface. With the International Space Station, we have over ten years experience supporting crews for up to six months at a time, relying on a significant infrastructure, with deliveries of supplies, in low Earth orbit. NASA will eventually develop capabilities to sustain humans beyond low Earth orbit for long periods. Our return to the Moon may be for stays of up to six months, conducting surface operations, learning how to "live off the land", testing new technologies including life support systems, and exploring the lunar surface. The farther we travel beyond the Moon, the more complex the operation, and the more self-sufficient we need to become. Each step will be used to demonstrate capabilities that will increase our capacity to travel beyond Earth and its Moon. These activities combine to form a necessary step in our preparation to explore new worlds.

The Exploration Systems Mission Directorate (ESMD) is leading this effort by forging new capabilities for sustained and affordable human and robotic missions. Within ESMD, two themes encompass the mandate for a new architecture to transport humans into space, as well as the technology development and human research to make it possible. The Constellation Systems Theme focuses on developing NASA's next generation of human exploration spacecraft designed to carry crew and cargo to low Earth orbit in the near term, and then beyond. Also within Constellation Systems, NASA has begun an important partnership with industry via the Commercial Crew and Cargo Program, aimed at spurring private industry to provide cost-effective cargo and crew delivery to the International Space Station (ISS) and expanding the commercial technology sector, while allowing NASA to focus its internal resources on exploration.

The second Theme, Advanced Capabilities, focuses on two essential areas: Human Research, and Exploration Technology Development. The Lunar Reconnaissance Orbiter (LRO) project, ESMD's first step in returning humans to the Moon, was also developed within this Theme. Advanced Capabilities activity reduces the cost and risk of human exploration by mapping potential lunar landing sites, developing and testing critical technologies, and conducting research to increase our understanding of the effects of space on human performance.

Summer 2009 Review of Human Space Flight Activities

In order for the United States to maintain and advance its international leadership in space, NASA will initiate an independent review of ongoing U.S. human space flight development activities as well as alternatives to ensure that the Nation is pursuing the best solution for future human space flight – one that is safe, innovative, sustainable and affordable. The review will develop suitable options for consideration by the Administration regarding a U.S.-led human space flight architecture.

The review will be led by an independent, blue-ribbon team of experts who will work closely with a NASA team. This independent review will provide options and supporting analyses to involved Administration agencies and offices in sufficient time to support an August 2009 decision on the way forward.

The review will evaluate the status and capabilities of the agency's current human space flight development program, as well as other potential architectures. It will examine the capabilities of these architectures (including supporting R&D and complementary robotic activities) to support the International Space Station and exploration missions and will consider options to extend International Space Station operations beyond 2016. The review will address international cooperation and account for US industrial base considerations and US competitiveness implications. The architectures assessed will fit within the current exploration budget topline and not rely upon extending Space Shuttle operations.

Following the human spaceflight review, the Administration will provide an updated request for Exploration activities reflecting the review's results. FY 2010 and outyear funding levels for Exploration activities shown in this document represent the budget request if there were no changes to ongoing activities.

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010*	FY 2011*	FY 2012*	FY 2013*	FY 2014*
FY 2010 President's Budget Request	**3,299.4**	**3,905.5**	**3,963.1**	**6,076.6**	**6,028.5**	**5,966.5**	**6,195.3**
Constellation Systems	2,675.9	3,433.2	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6
Program Integration and Ops	610.4	645.5	642.5	1,423.9	1,405.4	1,501.5	1,813.9
Orion Crew Exploration Vehicle	889.5	1,387.2	1,383.5	1,938.9	2,056.1	1,931.0	1,751.7
Ares I Crew Launch Vehicle	1,030.5	1,067.4	1,415.4	2,143.3	1,985.5	1,950.1	2,012.0
Ares V Cargo Launch Vehicle	15.0	30.0	25.0	25.0	25.0	25.0	25.0
Commercial Crew and Cargo	130.5	303.0	39.1	12.2	-	-	-
Advanced Capabilities	623.5	472.3	457.7	533.3	556.5	558.9	592.7
Human Research Program	149.6	151.9	151.5	151.9	157.4	161.4	166.2
Exploration Technology Develop.	286.9	264.1	287.0	381.2	399.0	397.5	426.5
Lunar Precursor Robotic Pgm	187.1	56.3	19.1	0.2	0.1		
FY 2009 President's Budget Request	**3,143.1**	**3,500.5**	**3,737.7**	**7,048.2**	**7,116.8**	**7,666.8**	**-**
Constellation Systems	2,471.9	3,048.2	3,252.8	6,479.5	6,521.4	7,080.5	-
Advanced Capabilities	671.1	452.3	484.9	568.7	595.5	586.3	-
Total Change from FY2009 President's Budget Request	**156.3**	**405.0**	**225.4**	**-971.6**	**-1,088.3**	**-1,700.3**	

***Following the human spaceflight review, the Administration will provide an updated request for Exploration activities reflecting the review's results. FY 2010 and outyear funding levels for Exploration activities shown here represent the budget request if there were no changes to ongoing activities.**

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems

Theme Overview

The Constellation Systems Theme, consisting of the Constellation Systems Program and the Commercial Crew and Cargo Program, aims to develop capabilities to transport humans to the Moon and back, as well as to low Earth orbit, in a sustainable, safe, and affordable manner as the U.S. prepares for future missions to Mars and other destinations.

Within the Constellation Program are four major project budgets: the Orion crew exploration vehicle, the Ares I launch vehicle designed to lift Orion to low Earth orbit, the Ares V launch vehicle to propel crew and support systems out of low Earth orbit, and Program Integration and Operations, which includes the systems to support ground and mission operations, extravehicular activity, a lunar lander, and lunar surface systems.

After the Space Shuttle retires in 2010, resupply missions to the International Space Station will still be required. NASA's Commercial Crew and Cargo Program is in place to encourage private sector development of a cost-effective, U.S. commercial space transportation capability. At present, the Agency has two funded Space Act Agreement (SAA) partners: Space Exploration Technologies Corporation (SpaceX) of Hawthorne, CA, and Orbital Sciences Corporation of Dulles, VA, as well as unfunded SAA partnerships with PlanetSpace of Chicago, IL and SpaceDev of Poway, CA.

Relevance

Relevance to national priorities, relevant fields, and customer needs:
The U.S. Space Exploration Policy (NP-2004-01-334-HQ) commits the Nation to extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations. Congress then enacted the NASA Authorization Act of 2005 (P.L. 109-155), providing that the Agency "shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program, to promote exploration, science, commerce, and United States preeminence in space, and as a stepping-stone to future exploration of Mars and other destinations."

The Commercial Space Act of 1998 was implemented to stimulate the development of a commercial space industry in the United States. NASA's Commercial Crew and Cargo Program accomplishes this by awarding pre-determined funding for specific commercial demonstrations. Encouraging the growth of a new competitive market will help reduce launch costs and provide the Nation with safe, reliable and economical service to low Earth orbit.

Relevance to the NASA Mission and Strategic Goals:
By developing new space transportation capabilities and supporting systems for human missions to the Moon and other destinations, NASA continues to pioneer the future of space exploration and scientific discovery. Specifically, through development of Orion and Ares I, the Constellation Program supports NASA Strategic Goal 4: "Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement."

NASA's Commercial Orbital Transportation Services (COTS) project is an investment by NASA to spur development of a cost-effective, U.S. commercial capability to carry cargo to the ISS, with future options for transporting crew. The Commercial Crew and Cargo Program directly supports NASA Strategic Goal 5: "Encourage the pursuit of appropriate partnerships with the emerging commercial space sector." See FY 2010 Performance Plan, under Management and Performance, for specific annual goals for this Theme.

Relevance to education and public benefits:
As it has throughout NASA's history, human presence in space will continue to serve as a public symbol of the Nation's leadership in space exploration. The Agency's renewed efforts to leave low Earth orbit, and to explore the Moon and other destinations, will accelerate the development of technologies critical to the economy and national security, while providing a training ground for the next generation of scientists and engineers. Through existing contracts, NASA's exploration initiatives continue to nurture a strong aerospace industry; by enabling emerging enterprises to achieve commercial viability, U.S. technology sectors will expand, providing opportunities that will inspire the Nation's youth to pursue careers in science, technology, engineering, and mathematics.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems

Performance Achievements Highlights:

During FY 2008, Constellation concluded intensive reviews to determine whether defined requirements of key system elements were adequate to begin the design phase. Some hardware has now transitioned into hardware fabrication and test, including parachute, wind tunnel, and engine component testing. Ares I completed integrated launch vehicle design reviews in September, and the upper stage engine (J-2X) passed Critical Design Review, authorizing fabrication. Orion completed manufacture of the crew module for the first pad test of the launch abort system.

Constellation also completed a lunar capability concept review to capture performance and cargo requirements of the lunar transportation system, the Ares V launch vehicle, and a lunar lander. The team considered five options for lunar surface systems, including surface elements, operations concepts, and nuclear and solar power systems. The review was carried out in parallel with Ares V and lander vehicle development, allowing real-time design refinement for the lunar outpost, including habitats, rovers, and other systems needed to live on the Moon for extended periods.

J-2X tests continued to support upper stage engine development for Ares I and the Ares V Earth departure stage. In addition, Orion and Ares performed parachute drop tests in Yuma, AZ, and Orion initiated component testing of the launch abort system, successfully firing the jettison motor at the Aerojet facility in Sacramento, CA. Hardware manufacturing for Orion's first pad abort test was completed to meet a 2009 test launch. The Ares I-X demonstration flight is also on track to meet a mid-2009 launch, with hardware delivery to Kennedy Space Center underway.

Major facility construction activity also took place, including launch control center firing room one renovation, and work on a new test stand needed to verify J-2X engine performance at altitude conditions. NASA has also begun renovation of the dynamic test stand to support the Ares I ground vibration test.

The Commercial Crew and Cargo Program also made significant progress in 2008. SpaceX achieved all milestones on time, including successful completion of major design reviews for the first two missions, first stage integrated engine testing in November, and manufacture of the Dragon capsule qualification unit to support qualification in late 2008, early 2009. Activation of the Cape Canaveral launch site also progressed, with installation of primary ground systems required to support launch.

Also in 2008, NASA entered into a funded SAA with Orbital Sciences Corporation, following a competitive selection process. Orbital completed major readiness and design reviews between June and October.

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Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program

Program Overview

The U.S. Space Exploration Policy calls for a sustained and affordable exploration program to explore the solar system, including a return to the Moon by the end of the next decade, to establish a human presence there, and to open the path to other destinations including Mars. NASA's exploration activity is now in a period of transition, as the Agency works to complete the International Space Station and retire the Shuttle fleet by 2010, while developing the next generation of spacecraft to support human space flight.

The Constellation Program is developing and testing a set of space exploration systems that includes the Orion crew exploration vehicle, the Ares I launch vehicle that is intended to propel Orion to low Earth orbit, and the Ares V, which is intended to carry a lunar lander to low Earth orbit to dock with Orion and deliver the crew and cargo to the Moon. These vehicle designs were conceived during the FY 2005 Exploration Systems Architecture Study, and have continued to undergo refinement as plans for a new space exploration transportation system take shape.

For more information see http://www.nasa.gov/exploration/home/index.html

Project Descriptions and Explanation of Changes

The Constellation Program budget for FY 2010 is divided into four major funding areas: Program Integration and Operations, Orion, Ares I, and Ares V. No major configuration changes have taken place since the FY 2009 request, except as specifically noted.

Program Integration and Operations

Additional project activity is carried within the Program Integration and Operations budget, including development of ground and mission operations, extravehicular activity systems, the lunar lander, and lunar surface systems.

Ground operations systems provide support to vehicle processing, mission planning, crew training, launch, flight control, and crew and return vehicle recovery. Systems include launch site ground processing, integrated testing, logistics services, and launch services for Orion, Ares I, Ares V, lunar lander, and cargo; post landing, recovery and de-integration services for the Orion crew module and cargo, including search and rescue; and Orion refurbishment and maintenance. Also included are post-landing and recovery services for the Ares I first stage and Ares V boosters, as well as facilities, equipment, and software required to perform these tasks.

Mission operations systems include the mission control center in Houston and its interfaces with the flight systems for flight operations; crew and flight controller training facilities; mission planning and flight design tools; personnel for planning, training, and flight operations; and mission operations facilities development and maintenance.

The extravehicular activity (EVA) system and flight crew equipment provide the elements necessary to protect crew members, allowing them to work effectively in pressure and thermal environments that exceed human capability. EVA includes the pressure suits, life support systems, umbilicals, tools and mobility aids, vehicle interfaces, servicing equipment, suit avionics, individual crew survival equipment, and ground support systems. Flight crew equipment includes items interior to the spacecraft for use by the crew, such as restraint and mobility aids, tools, and stowage items.

Orion Crew Exploration Vehicle

The Orion Project (currently in formulation) is responsible for developing NASA's next-generation piloted spacecraft. For missions to the Moon, Orion is designed to carry up to four astronauts to low Earth orbit, where it will link up with a lunar lander for the trip to lunar orbit. It also will be capable of ferrying up to four astronauts (plus additional cargo) to and from the International Space Station (ISS). Orion consists of a crew module, a service module, a spacecraft adapter, and a launch abort system, which will transport crew and cargo to orbit and back, and also serve as a crew rescue vehicle while docked at the ISS. The Orion spacecraft will be used in all phases of the Program.

Additional detail can be found in the Orion Crew Exploration Vehicle Project section of this document.

Ares I Crew Launch Vehicle

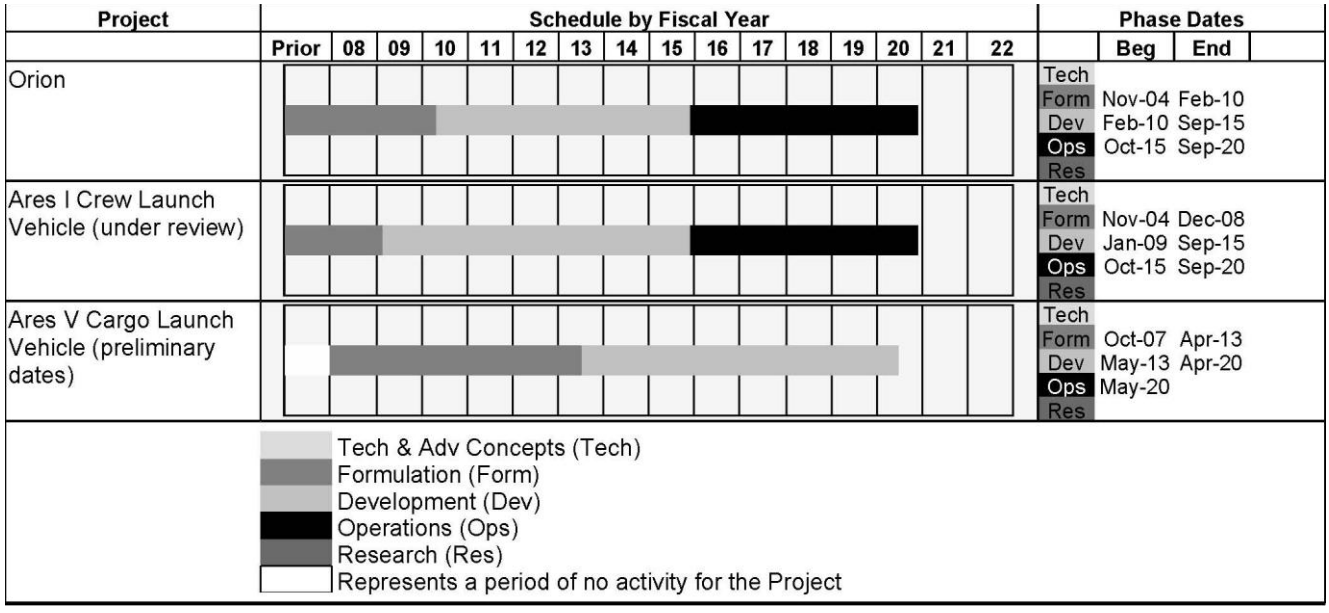
The mission of the Ares I (currently in formulation) is to deliver a safe, reliable, and affordable launch system that supports the Nation's space exploration goals. Ares I is the launch vehicle for Orion, and provides transportation to low Earth orbit. It consists of a 5-segment solid rocket booster first stage, and a cryogenic liquid hydrogen/oxygen fueled upper stage, consisting of a structural tank assembly and a J-2X engine. The first stage is reusable, and the upper stage is discarded after Orion has separated during ascent. Ares I will deliver crew to the International Space Station and to low Earth orbit for missions to the Moon.

Additional detail can be found in the Ares I Crew Launch Vehicle Project section of this document.

Ares V Cargo Launch Vehicle

Ares V (currently in formulation) is designed to provide the heavy lift capability for the Constellation architecture. The vehicle consists of a 6-engine core stage, two five-and-half segment solid rocket boosters, and an Earth departure stage (EDS) powered by a restartable J-2X engine. The EDS serves as the vehicle's second stage, and is key to injecting the lunar lander and EDS stack into the low Earth orbit staging for rendezvous and dock with Orion. After the EDS performs the trans-lunar Injection burn for the lander and Orion, it will be jettisoned.

Implementation Schedule



Program Management

Projects within the Constellation Program reside at Johnson Space Center (Orion, extra-vehicular activity, mission operations), Marshall Space Flight Center (Ares I and Ares V) and Kennedy Space Center (ground operations). Program management responsibility is located at Johnson Space Center.

Acquisition Strategy

Constellation's implementation approach is based on the Agency's goal to balance competition with the health of NASA institutions. Competition is used as a tool to promote best approaches and solutions, and to encourage innovation and efficiency, with the constraint that competition should not undercut the essential competency of the NASA organization.

The acquisition strategy for Constellation includes a combination of sole source and full and open competition opportunities; the overall goal, however, is to maximize competition whenever possible. To date, the only sole source contracts awarded are related to the Ares I project, which include development activities for the reusable solid rocket motor first stage and J-2X upper stage engine. These sole source contracts were awarded because no other providers were available for the capabilities identified by NASA. For example, ATK-Thiokol was awarded the Ares I first stage contract because they are the only provider in the Nation that can manufacture solid rocket motors of the size needed for the Ares I. The J-2X sole source contract was awarded to Pratt Whitney Rocketdyne, because they are the designers of the J-2 and J-2S engines from which the J-2X evolves.

All other contracting activities for Constellation have been, and will be, awarded through full and open competition. Competitive contracts awarded to date include the Orion development contract to Lockheed Martin, the manufacturing contract for the Ares I upper stage to the Boeing Company, and the Ares I upper stage instrument unit avionics production contract to the Boeing Company. The extravehicular activity systems contract will be awarded by mid-2009 through full and open competition. The Program continues to develop its integrated acquisition strategy for ground and mission operations projects, as well as the follow-on production contracts for Orion and Ares I, and development contracts for lunar capability.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program
Project in Formulation:	Orion Crew Exploration Vehicle

Project Purpose

For missions to the Moon, Orion will carry up to four astronauts to low Earth orbit, where it will link up with a lunar surface access module for the trip to lunar orbit. The access module will descend to the Moon's surface while Orion orbits, awaiting its return. At the conclusion of the surface mission, the two vehicles will rendezvous and Orion will transport the astronauts back to Earth, where the capsule will re-enter the atmosphere and descend on parachutes.

Orion will also have the capability to service the International Space Station (ISS). The vehicle will be capable of transporting up to four crew to and from the ISS, and remaining docked for up to six months as a rescue return vehicle.

For more information, please visit:
http://www.nasa.gov/mission_pages/constellation/orion/index.html

Project Preliminary Parameters

Orion will be a five meter-diameter vehicle, capable of transporting four astronauts to the Moon and to the ISS, then returning them safely to Earth. The combined crew and service modules will provide power, life support, and propulsion for rendezvous, orbit correction, and de-orbit. In the event of a launch mishap, a launch abort system will separate the crew module from the launch vehicle and deliver the crew to safety. A thermal protection system will protect the crew during re-entry, and the vehicle is designed to provide for a safe landing nominally on water, and for contingencies on land.

Estimated Project Deliverables

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Crew Module	Lockheed-Martin (Prime Contractor Selected August 2006)	Piloted vehicle	Crew of 6 to ISS	Crew of 4 to ISS
Service Module	Lockheed-Martin (Prime Contractor Selected August 2006)	Provides power, propulsion, and other support services for the Crew Module	same	same
Launch Abort System	Lockheed-Martin (Prime Contractor Selected August 2006)	Separates Crew Module from launch vehicle in the event of a launch mishap	same	same

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program
Project in Formulation:	Orion Crew Exploration Vehicle

Estimated Project Schedules

Preliminary design review for Orion is planned for the 4th quarter of FY 2009.

Project Management

Orion is managed by the Orion Project Office located at Johnson Space Center in Houston, Texas, with support from Langley Research Center in Virginia and Glenn Research Center in Ohio.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Crew Module	Orion Project Office and Crew Module Office, JSC	JSC	None
Service Module	Orion Project Office and Crew Module Office, JSC; Service Module Office, GRC	GRC	None
Launch Abort System	Orion Project Office, JSC; Launch Abort System Office, LaRC	LaRC	None

Acquisition Strategy

The contract for Schedule A Orion design, development, test, and evaluation was awarded to Lockheed Martin in August 2006. Optional Schedules B and C, for additional production, sustaining engineering and lunar development, are also part of the contract. Lockheed Martin's subcontractors include Hamilton Sundstrand, Honeywell, Orbital Sciences Corporation, and United Space Alliance.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program
Project in Formulation:	Ares I Crew Launch Vehicle

Project Purpose

The mission of the Ares I project is to deliver a safe, reliable, and affordable crew launch system that expands America's scientific reach through space exploration, dedicated to enabling human trips to the Moon, Mars and other destinations beyond low Earth orbit. An integral part of the Constellation Program, Ares I is currently scheduled for operation no later than 2015.

Ares I is designed to provide the launch capability for a versatile transportation system to carry crew to low Earth orbit for exploration missions to the Moon and other destinations in the solar system, as well as delivering crew and cargo to the International Space Station after the Shuttle retirement. The Ares I design utilizes NASA heritage systems, with a modified Space Shuttle solid rocket booster as the first stage, and a clean sheet design upper stage, using a J-2X engine derived from the J-2, which was flown on the Saturn launch vehicle.

During the first two minutes of flight, the first stage booster will power the vehicle to an altitude of about 190,000 feet and a speed of Mach 5.7. After its propellant is spent, the reusable booster will separate, and the upper stage's J-2X engine with 294,000 pounds of thrust, will ignite and power the crew vehicle to an altitude of ~80.6 miles. At that point, the upper stage will separate, and Orion's service module propulsion system will complete the trip to a circular orbit.

For more information, please visit:
http://www.nasa.gov/mission_pages/constellation/ares/aresl/index.html

Project Preliminary Parameters

The Ares I is a two-stage series-burn launch vehicle with interfaces for the Orion capsule and the ground systems at the launch site. Ares I hardware elements include the first stage, upper stage, and upper stage engine. The first stage is a 5-segment reusable solid rocket motor that utilizes polybutadiene acrylonitrile propellant. The second, or upper stage, is a self-supporting cylindrical system that houses the liquid oxygen and liquid hydrogen tanks that feed propellant to the J-2X engine, along with the vehicle's avionics, roll control, and the upper stage thrust vector control system.

Ares I will be able to lift an estimated 50,000 pounds to low Earth orbit for International Space Station (ISS) missions, and 56,000 pounds for exploration missions. Utilizing Constellation's Orion/Ares I configuration will provide a significant improvement in crew safety relative to the Space Shuttle, due to its in-line design and launch abort system for crew escape.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program
Project in Formulation:	Ares I Crew Launch Vehicle

Estimated Project Deliverables

The Ares I project is intended to address Constellation Program requirements by developing safe, affordable, and sustainable launch systems to support human exploration missions. The initial operational capability for Ares I is currently scheduled for no later than March 2015, with the first unmanned test flight planned no earlier than August 2009.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Vehicle Integration (VI)	NASA (Gov't-led)	Systems Engineering & Integration (SE&I) function for the Ares I Project	Integrated Vehicle Systems Engineering & Integration (SE&I)	Integrated Vehicle Systems Engineering & Integration (SE&I)
First Stage	ATK-Thiokol	Initial phase of the launch ascent configuration	Ares 1-X motor, 2 demonstration motors (DMs), 2 qualification motors 3 flight test motors	Added DM 3 and DM 4 to DDT&E contract
Upper Stage engine	Pratt & Whitney Rocketdyne	Propulsion source for second phase of the launch ascent configuration	6 development engines, 2 certification engines	Added 38 sea level tests, 27 altitude tests,1 test eng, 4 sets of long lead h/w, & 1 unassembled eng
Upper Stage	NASA-led design/Boeing production	Ares I second stage propellant tank and support systems (MPS, avionics, etc.)	Includes 3 test flight units, 6 flight units, & up to 4 additional flight units/year in yrs 2014-16	Additional Roll Control System Support
Flight and Integrated Test	NASA (Gov't-led)	Includes activation and test development capabilities required to test Ares system	Includes Integrated Vehicle Ground Vibration Test, managing Ares Projects activities for Ares I-X	Includes Integrated Vehicle Ground Vibration Test, managing Ares Projs activities for Ares I-X

Estimated Project Schedule

The Ares I project was authorized to proceed in September 2005; the Preliminary design Review was conducted in August, 2008. Critical Design Review is planned for March 2011.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Constellation Systems Program
Project in Formulation:	Ares I Crew Launch Vehicle

Project Management

The Ares I Project Office located at the Marshall Space Flight Center in Huntsville, AL has project management responsibility for Ares I.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Vehicle Integration	Ares Project Office at Marshall Space Flight Center	Marshall Space Flight Center	None
First Stage	Ares Project Office at Marshall Space Flight Center	Marshall Space Flight Center	None
Upper Stage	Ares Project Office at Marshall Space Flight Center	Marshall Space Flight Center	None
Upper Stage Engine	Ares Project Office at Marshall Space Flight Center	Marshall Space Flight Center	None
Flight and Integrated Test	Ares Project Office at Marshall Space Flight Center	Marshall Space Flight Center	None

Acquisition Strategy

The Ares I launch vehicle will be developed using a combination of NASA and contractor effort. NASA is responsible for overall Ares I vehicle integration, while individual element strategies and responsibilities are outlined below.

The first stage, derived from the Space Shuttle reusable solid rocket motor, was selected as a non-competitive acquisition, performed by Alliant Techsystems Inc. under a cost plus award fee contract.

J-2X upper stage engine was selected as a non-competitive acquisition, performed by Pratt & Whitney Rocketdyne under a cost plus award fee contract. The J-2X predecessors from which the J2X will be derived (J-2 and J-2S, designed and built by Pratt & Whitney) are the exclusive property of NASA. The Agency's decision to select the J-2X engine in effect selected the contractor as well.

NASA's Marshall Space Flight Center leads the team responsible for upper stage design, development, test and evaluation (DDT&E) efforts and, therefore, owns the upper stage design. Additionally, NASA is designing the instrument unit and is responsible for DDT&E efforts related to Ares I avionics. The instrument unit avionics production and the upper stage production were awarded via full and open competition to the Boeing Company; both contracts are cost plus award fee.

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Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Commercial Crew Cargo

Program Overview

One of NASA's strategic goals is to encourage the pursuit of appropriate partnerships with the emerging commercial space sector. The Agency's major activity in this area is the Commercial Orbital Transportation Services (COTS) effort, overseen by the Commercial Crew and Cargo Program. Rather than developing a system that could be operated by NASA or its contractors, this Program is aimed at encouraging the development of commercial space transportation services and an associated market, with multiple suppliers and customers. NASA would be one of these customers, purchasing transportation services on the open market.

This effort is being executed in two phases. The first is a period of private industry development and demonstration of the various space transportation capabilities to and from low Earth orbit determined to be most desirable for government and other customers. During this phase, NASA is providing $500 million of seed capital and technical assistance to promising space firms via funded and unfunded Space Act Agreements (SAA) to stimulate the commercial space transportation market. These COTS partners are to demonstrate capabilities that can be used for ISS resupply: Capability A, delivery of unpressurized cargo; Capability B, delivery of pressurized cargo; and Capability C, delivery and return of cargo to and from orbit. The second phase is a competitive procurement of orbital transportation services to supply ISS, and is the responsibility of the Space Operations Mission Directorate. In addition, with Recovery act funding in FY 2009, NASA initiated development activities to enable future commercial crew launches to the ISS.

The Space Act Agreements NASA has in place with the COTS partners are written to maximize the flexibility of private development efforts. Partners are paid when the Agency certifies that they have passed a series of discrete developmental milestones; if they fail to make progress, they are not paid. Government requirements are kept to a minimum, and are only concerned with assuring safe interaction with the ISS. The partners are not required to follow the standard NASA Program and Project Management Processes and Requirements, NPR 7120.5. Rather, the relationship is intended to encourage innovation and allow partners to use alternatives to the standard NASA program management approaches, while still being held accountable for safety and ISS visiting vehicle requirements that NASA would impose were that partner being utilized for commercial transportation services.

In addition to providing a conduit for funding, the Commercial Crew and Cargo Program coordinates the COTS Advisory Team, made up of over 100 technical experts located throughout NASA. Funded and unfunded partners can utilize these experts as necessary; if a partner requires extensive assistance, NASA helps them arrange reimbursable agreements with NASA centers to acquire the expertise they need.

Plans for FY 2010

SpaceX is currently planning to perform demonstration missions 2 and 3 during FY 2010, aimed at validating their capability to provide cargo transportation to and from the ISS. Orbital is planning to start service module and launch vehicle assembly during FY 2010, with a demonstration flight scheduled for FY 2011. If all goes according to the current schedule for both partners, NASA will have commercial cargo resupply capability to the Space Station.

In FY 2010, the Program will continue to execute the funded Space Act Agreements signed with

SpaceX in August 2006 and Orbital Sciences Corporation in February 2008, and the unfunded agreements signed in FY 2007 and subsequent. Currently, there is no budget or final acquisition strategy for Capability D (crew transport). However NASA will be applying Recovery Act funds to stimulate efforts within the private sector to develop and demonstrate human spaceflight capabilities. The activities supported through Recovery Act funding will help support enhanced technical activities to meet current objectives and milestones, which include development of commercial crew transportation enabling technologies and capabilities, acceleration of the ISS docking system and communications interface, testing and enhancement of cargo launch systems to improve reliability of commercial crew capabilities, and human rating requirements development.

Project Descriptions and Explanation of Changes

Commercial Orbital Transportation Services (COTS)

The Commercial Orbital Transportation Services (COTS) partner agreements are not projects by the standard NASA definition of the term, but individual firms that have entered into Space Act Agreements with the Agency. "Funded partners" are those receiving progress payments and technical assistance from NASA, while "unfunded partners" receive technical assistance, but are not paid.

NASA's funded COTS partners are SpaceX, of Hawthorne CA, and Orbital Sciences Corporation of Dulles, VA.

SpaceX is developing new launch vehicles with the goal of providing reliable, globally cost competitive U.S. space transportation capabilities. Their Falcon 9 launch vehicle is an evolution of their clean sheet design of the Falcon 1 launch vehicle. Their "Dragon" spacecraft and launch vehicle are being designed for either cargo or crew transport. Both launch vehicle and spacecraft offer flexible configurations based on mission requirements, and are currently planned to be recoverable for refurbishment and reuse. SpaceX has chosen Cape Canaveral's launch complex 40 as the site for their launches, with the first ISS demonstration flight planned for completion by May 2010. For Phase 1, SpaceX will demonstrate cargo transportation Capabilities A-C. Additionally, SpaceX currently has an unfunded SAA option to demonstrate Capability D.

Orbital Sciences Corporation is developing a launch system concept comprised of a Taurus II launch vehicle, a new medium class booster using two Aerojet AJ-26 engines and an ATK Castor 30 second stage. Taking advantage of heritage systems, Orbital will use a standard service module derived from the STAR and Dawn spacecraft for all missions and the pressurized cargo module will be based on the ISS multi-purpose logistics module. The Wallops Flight Facility will serve as Orbital's launch site for an ISS demonstration flight, currently scheduled for March 2011. For Phase 1, Orbital will demonstrate cargo transportation Capability B.

In addition, NASA has unfunded Space Act Agreements with PlanetSpace of Chicago, IL and SpaceDev of Poway, CA.

Mission Directorate:	Exploration Systems
Theme:	Constellation Systems
Program:	Commercial Crew Cargo

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Two successful demonstration flights by SpaceX for unpressurized and pressurized cargo.	COTS Projects	Realignment of SpaceX Demo Flight Milestones; Addition of Orbital Sciences as the second funded partner

Program Management

The Commercial Crew & Cargo Program Office (C3PO), located at the Johnson Space Center, is responsible for implementing the Program in support of the U.S. Space Exploration Policy.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Commercial Crew & Cargo COTS Partners	Johnson Space Center will manage the effort	Technical support from all NASA centers as needed	Funded partners: SpaceX and Orbital Sciences Corporation. Unfunded SAAs signed with: SpaceDev, and Planetspace.

Acquisition Strategy

The Commercial Crew and Cargo Program is being implemented through the COTS projects in two phases. The first is being carried out via Space Act Agreements (SAA), while the second will employ standard NASA procurements. The Agency is using its Space Act authority to enter into the funded agreements, which will result in Earth-to-orbit space flight demonstrations of any combination of the following capabilities:

- Capability A: External (unpressurized) cargo delivery and disposal
- Capability B: Internal (pressurized) cargo delivery and disposal
- Capability C: Internal (pressurized) cargo delivery and return

Demonstrations will culminate in cargo transportation missions to/from the ISS.

SAAs with the funded COTS partners are different from traditional NASA development contracts, as they are firm fixed-price arrangements providing a detailed record of pre-negotiated performance milestones and fixed payment schedule to be made upon successful completion of each milestone. Failure to meet a milestone can lead to termination of the SAA, after consultation with the partner. Unfunded partners have similar relationships and agreements with NASA, but do not receive milestone payments. They participate through the COTS Advisory Team in order to draw on NASA technical knowledge, and the Agency acknowledges their progress.

NASA also has an option to exercise a Capability D, which would consist of one or more missions to low Earth orbit and the ISS as necessary to satisfy the Agency's human rating requirements for future NASA crew transportation missions. While this option is not currently funded, NASA will be applying Recovery Act funds to stimulate efforts within the private sector to develop and demonstrate human spaceflight capabilities. The activities supported through Recovery Act funding will help support enhanced technical activities to meet current objectives and milestones, which include development of commercial crew transportation enabling technologies and capabilities, acceleration of the ISS docking system and communications interface, testing and enhancement of cargo launch systems to improve reliability of commercial crew capabilities, and human rating requirements development..

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities

Theme Overview

The Advanced Capabilities Theme is composed of Exploration Technology Development (ETDP), Human Research (HRP), and the Lunar Precursor Robotics Program (LPRP). Effort within these programs is geared to provide advanced technologies and knowledge to implement the U.S. Space Exploration Policy through the use of ground and space flight activities.

ETDP provides new technologies that will enable NASA to conduct future human missions and reduce risk and lifecycle cost. Primary customers for this effort are the designers and developers of flight systems in the Constellation Program. ETDP investments reduce the risk of infusing new technologies into flight projects by maturing them to the level of demonstration in a relevant environment, in time to support the Preliminary Design Review of the target flight system.

HRP investigates and mitigates the highest risks to astronaut health and performance in support of NASA exploration missions. The Program's primary goal is to develop and provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable and productive human space exploration.

LPRP includes the Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observing and Sensing Satellite (LCROSS) spacecraft, which are scheduled to launch in June 2009. LRO's topographic mapping, resource identification and mapping, and radiation characterization is important to Constellation efforts to return humans to the Moon by 2020. Data from these activities will be integrated by a lunar mapping and modeling activity and will support astronaut safety, landing site selection, and engineering requirements for lunar surface hardware. LCROSS will gather information about volatiles, possibly including water ice, in permanently shadowed polar craters.

Relevance

Relevance to national priorities, relevant fields, and customer needs:
In accordance with the U.S. Space Exploration Policy (NP-2004-01-334-HQ), the Advanced Capabilities Theme provides the knowledge, technology, and innovation that will enable current and future exploration missions. As astronauts journey to the Moon and beyond, they will be exposed to microgravity, radiation, and isolation for long periods of time. Keeping crews physically and mentally healthy and productive during such long-duration missions will require new technologies and capabilities. NASA studies how the space environment, close quarters, heavy workloads, and long periods of time away from home contribute to physical and psychological stresses, and will develop technologies that can prevent or mitigate these effects. The Agency pursues innovative ways to meet the basic needs of oxygen, water, food, and shelter with exploration systems that can operate dependably for weeks on the Moon, and eventually, for months on Mars.

The Advanced Capabilities Theme uses the International Space Station (ISS) as a research and technology demonstration location, supporting ISS's designation as a national laboratory. NASA leverages the microgravity environment of the facility to conduct human, life and microgravity research, demonstrate countermeasures to maintain human health and performance during exploration missions, and demonstrate vital technologies in the space environment.

Relevance to the NASA Mission and Strategic Goals:
Advanced Capabilities activity supports NASA's mission to pioneer the future in space exploration and scientific discovery by acquiring new and vital knowledge and by identifying, developing, and transitioning new technologies that enable the systems concepts and capabilities needed to expand and sustain human presence in space. The Advanced Capabilities Theme supports the following Agency Strategic Goals:

Strategic Goal 2: "Complete the International Space Station in a manner consistent with NASA's International Partner commitments and the needs of human exploration". The Advanced Capabilities Theme supports this goal with continued delivery and operation of scientific payloads and research facilities on the ISS in order to conduct biological and physical research support.

Strategic Goal 3: "Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration." Activities in the areas of life support, environmental monitoring, and ground and flight research, which help reduce the probability and consequences of adverse human health effects for long-duration space missions, support this goal.

Strategic Goal 4: "Bring a new Crew Exploration Vehicle into service as soon as possible after shuttle retirement." Efforts related to thermal protection systems, carbon dioxide and moisture removal amine system technology, and development of habitability standards support Goal 4.

Strategic Goal 6: "Establish a lunar return program having the maximum possible utility for later missions to Mars and other destinations." ESMD supports this goal by developing the LRO and LCROSS to provide information about potential human exploration sites on the Moon.

See FY 2010 Performance Plan, under Management and Performance, for specific annual goals for this Theme.

Relevance to education and public benefits:
Programs within the Advanced Capabilities Theme support educational outreach activity at K-12, undergraduate, and graduate levels. NASA's Fit Explorer project trains students (in grades 3 through 5) like astronauts by completing physical activities modeled after the real-life physical requirements of humans traveling in space. Students track their progress while recording goals, data, experiences and observations in a journal. Students also gain an understanding of the science behind nutrition and physical fitness by participating in structured hands-on activities that relate physical Earth-based needs to the requirements of exploring space. By providing ideas for Space Grant and Graduate Student Research Programs, NASA promotes educational opportunities for students at colleges and universities across the nation.

To implement these programs, NASA will leverage the expertise of academia, government agencies, and industry to carry out research and development efforts. By advancing diverse, novel technologies through projects with non-traditional research partners, small businesses and others, public benefits will include new technologies such as power generation, communications, computing, robotics, and improved materials from space exploration research and execution for industry and general public use.

In addition, HRP will further advance medical knowledge and diagnostic and treatment technologies NASA uses to keep humans healthy and productive in space, improving the medical treatment and health of humans on Earth. Research into human adaptation to microgravity has helped scientists better understand changes that come with aging, such as bone loss, muscle atrophy, and loss of balance. NASA-developed telemedicine technologies that help doctors on Earth monitor and treat astronauts in space through computer-assisted imaging and diagnostics, video, and telecommunications, will help deliver quality medical care to people in underserved areas of the world.

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities

Performance Achievement Highlights:

Programs within the Advanced Capabilities Theme accomplished significant milestones in FY08. The HRP reduced the probability and consequences to the health of humans in long-term space environment exposure for the following biomedical risks: inability to adequately treat an ill or injured crew member; compromised EVA performance and crew health due to inadequate EVA suit systems; inadequate nutrition; and, space radiation exposure. As part of an operational evaluation, renal stone countermeasure experiments have been completed on the ISS and reports published at the ISS science website. The final report for NASA internal use was delivered in September 2008. HRP also completed the EVA human-suit interface requirements to avoid biomechanical injury, support metabolic thermal load, and minimize risk of decompression sickness; an Antarctic study on efficacy of vitamin D supplementation in an Antarctic ground analog of space flight; development of computational tools and models to assess crew exploration vehicle design for radiation protection; and, the risk model for acute radiation sickness.

The LRO project successfully met the critical milestones for the performance period. Both the LRO and LCROSS spacecraft have been delivered to the launch site and are on-track for June 2009 launch.

ETDP demonstrated a proof-of-concept small pressurized rover for transporting astronauts. Spacesuits attached to exterior of rover cabin via suit-port interface allowed crew to perform rapid EVA. The Program also performed end-to-end testing of two proof-of-concept in-situ resource utilization (ISRU) systems for producing oxygen from lunar regolith which allowed for a systems level demonstration of the excavation, mobility and the reactor systems. The Scarab rover with on-board sampling drill and ISRU package designed to prospect for ice in lunar craters was also used as a part of this test.

ETDP tested a deep throttling liquid hydrogen-liquid oxygen rocket engine for the lunar lander descent stage, as well as performed a human-in-the-loop test of the prototype carbon dioxide and moisture removal system for Orion. Development of this system for both moisture and carbon dioxide removal eliminates the need for a condensing heat exchanger. A flash lidar sensor for autonomous landing and hazard avoidance system was tested on a helicopter.

The Program also launched the "electronic nose" instrument for monitoring atmospheric contaminants as an example of development and deployment of advanced monitoring technologies on the ISS. Additional activity included delivery of the combustion integrated rack microgravity research facility to the ISS, offering the capability to conduct fundamental and applied research in combustion sciences.

For more information, see Strategic Goals 2, 3 (Sub-goal 3F), 4 and 6 in the FY 2008 Annual Performance Report, included in this budget.

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities
Program:	Human Research Program

Program Overview

The Human Research Program (HRP) is focused on investigating and mitigating the highest risks to human health and performance to enable safe, reliable, and productive human space exploration. Documents developed by the Exploration Systems Mission Directorate and Constellation Program provide mission architecture definitions, mission concepts of operations, vehicle, habitat, and space suit performance requirements, and other technical information needed to focus HRP efforts for specific exploration missions. HRP conducts research, develops countermeasures, and undertakes technology development to inform and support compliance with NASA's health, medical, human performance, and environmental standards.

HRP activities are designed to:

-Develop capabilities, necessary countermeasures, and technologies in support of human space exploration, focusing on mitigating the highest risks to crew health and performance.

-Enable the definition and improvement of human spaceflight medical, environmental, and human factors standards.

-Develop technologies that serve to reduce medical and environmental risks, to reduce human systems resource requirements (mass, volume, power, data, etc.) and to ensure effective human-system integration across exploration mission systems.

-Ensure maintenance of Agency core competencies necessary to enable risk reduction in the areas of space medicine; physiological and behavioral effects of long duration spaceflight on the human body; space environmental effects, including radiation, on human health and performance; and space human factors.

This Program supports performance goals that will: deliver a Human Interface Design Handbook for use in designing exploration vehicles; deliver and publish an initial version of the acute radiation risk projection model for lunar missions; and deliver a device for launch to the ISS to test the technology of producing medical grade water on a spacecraft.

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

Plans for FY 2010

The ISS Medical Project (ISSMP) will provide planning, integration, and implementation services for HRP research tasks and evaluation activities requiring access to space or related flight resources on the ISS, Shuttle, Soyuz, Progress, or other spaceflight vehicles and platforms. It will support experiments during six-crew operation, develop alternative sample preservation techniques to reduce downmass requirements, and enable cooperative science with Russian collaborators.

The Research Infusion projects will continue using the NASA Space Radiation Laboratory at Brookhaven National Lab to evaluate the increased risk of cancer as a function of age, age at exposure, radiation quality, latency, and gender. These efforts will support more accurate prediction of risks and facilitate longer stays in space. In addition, space radiation research will increase efforts to evaluate central nervous system and degenerative tissue risks as well as develop computational tools to project health risks and evaluate vehicle designs for radiation protection.

Ongoing technology activity will allow NASA to meet the level of care standards for space exploration missions including: medical kit requirements, medical-grade water production system, ventilation system that uses cabin oxygen instead of stored oxygen, capability to analyze blood and saliva-borne biomarkers, and tools for medical decision-making during exploration missions. Ground based analog models will be used to optimize human systems performance in the design of the Orion crew vehicle and other exploration systems; develop a permissible exposure limit for lunar dust, and develop food-packaging systems to ensure safe storage and delivery of food on long-term missions.

HRP will also 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 rhythm, medication side effects, fatigue, team cohesion, and training protocols. Additional studies will be performed to reduce both the crew health risks during exploration missions and long-term health risks afterward, including cardiac structure and function, stability of pharmaceuticals and nutrients in a space environment, development of a food system that meets all nutrition requirements for long-duration missions, and bone demineralization monitoring techniques.

The Program will also release two joint NASA/ National Space Biomedical Research Institute (NSBRI) research solicitations in support of space exploration, focused on health effects from space radiation and human physiological changes associated with exploration. NSBRI will also implement approximately sixty exploration-focused research grants.

Project Descriptions and Explanation of Changes

Research Infusion

Activities within the Research Infusion projects include: space radiation; behavioral health and performance; exploration medical capability; space human factors and habitability; human health countermeasures; and, program science management/ NSBRI.

Anti-oxidants represent a potential countermeasure for several human risks as documented in the research plan. Based on a focused anti-oxidant workshop, HRP funding has been leveraged by working with NIH through a joint anti-oxidant research solicitation. To facilitate negotiations and collaboration on a joint NIH/NASA anti-oxidant solicitation in 2010, funding to support human health countermeasures was required.

ISS Medical Project

The ISSMP includes current ISS biomedical research capabilities and on-orbit validation of next generation on-orbit equipment, medical operations, procedures, and crew training concepts.

Efficient and effective utilization of the ISS is essential in meeting the objectives of the HRP. Activity in this area supports experiments during six-crew operation, develops alternative sample preservation techniques to reduce downmass requirements, and enables cooperative science with Russian collaborators.

Program Management

The Program is managed by the Human Research program office, located at the Johnson Space Center (JSC) in Houston, Texas.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Research Infusion	Human Research Program Office - JSC	JSC, LRC, ARC, GRC, KSC	National Space Biomedical Research Institute, Department of Energy (Brookhaven National Laboratories), National Institutes of Health (University of Texas Medical Branch), Numerous National Universities
ISS Medical Project	Human Research Program Office - JSC	JSC, KSC, ARC	European Space Agency, Japanese Aerospace Exploration Agency, German Aerospace Center, Canadian Space Agency, Numerous National Universities

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities
Program:	Human Research Program

Acquisition Strategy

NASA Research Announcements (NRA) will be used to further efforts in human research. In FY 2010, 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/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 lunar analog bed rest investigations. Directed research projects will focus on exercise, musculoskeletal, and cardiovascular countermeasures; behavioral health; immunology; nutrition; extravehicular activity physiology; food and drug stability; and space radiation health.

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities
Program:	Exploration Technology Development

Program Overview

The Exploration Technology Development Program (ETDP) develops new technologies that will enable NASA to conduct future human and robotic exploration missions, while reducing mission risk and cost. ETDP's primary customers are the designers of flight systems in the Constellation Program. By maturing new technologies to the level of demonstration in a relevant environment early enough to support a flight system's Preliminary Design Review (PDR), NASA can significantly reduce both cost and risk. ETDP is currently maturing near-term technologies to enable Orion IOC in 2015, and developing long-lead technologies needed for the lunar exploration missions no later than 2020.

ETDP includes the International Space Station Research and the Technology Infusion projects. Space Station research includes ISS flight experiments, free-flyer experiments, and ground-based research that investigate the effects of microgravity on fluid physics, combustion, and fundamental biology for both exploration and non-exploration research. The Technology Infusion project was formulated to address the high priority technology needs for lunar exploration identified by the Exploration Systems Architecture Study (ESAS). Content has evolved since that time to reflect better system requirements definition in the Constellation Program, and to incorporate new technology needs for the lunar outpost identified by the Lunar Architecture Team (LAT).

To ensure that technology development is meeting mission requirements, technical performance goals have been established for all projects with the Constellation Program. Once technology products have reached the required level of maturity, the Constellation Program assumes management responsibility for inserting them into the design of its flight projects.

For more information, please see http://www.nasa.gov/exploration/acd/technology_dev.html.

Plans for FY 2010

The ISS Research project will deliver two fluid physics and two life science payloads for launch to ISS, as well as conduct four microgravity research experiments on board ISS, and one life science experiment on a free-flyer (Bion M1).

Technology Infusion activity will include evaluation of candidate filtration units for removal of lunar dust from the cabin atmosphere, as well as candidate technologies for carbon dioxide reduction; development of manufacturing concepts for 10-meter diameter composite structures for the Ares V launch vehicle; develop and test several candidate technologies for production of high pressure oxygen to recharge extra vehicular activity (EVA) portable life support systems; test a prototype main engine for a lunar lander ascent stage using liquid oxygen and liquid methane propellants; and demonstrate an autonomous hazard avoidance system for a lunar lander in a helicopter flight test, a prototype linear induction pump suitable for circulating liquid metal coolant through a 40 KW reactor, and the experimental on orbit operation of instruments that monitor air quality on the ISS.

Project Descriptions and Explanation of Changes

Technology Infusion

Activities in the Technology Infusion project include: structures, materials, and mechanisms; advanced composites technology; thermal protection systems; dust mitigation; propulsion and cryogenics advanced development; cryogenic fluid management; energy storage; thermal control; intelligent software design; automation for operations; high performance and radiation hardened electronics; autonomous landing and hazard avoidance technology; integrated systems health management; advanced environmental monitoring and control; fire prevention, detection, and suppression; exploration life support; EVA technologies; in-situ resource utilization; human robotic systems; fission surface power systems; mini-RF (miniature radio frequency); and surface power systems.

Content was realigned to support technical capabilities, and reprioritized to support three high priority efforts to maintain critical capabilities in entry, descent, and landing; optical communications; and photovoltaic technology. Funding was transferred from the Lunar Precursor Robotic Program to ETDP to support lunar mapping and modeling.

Work in advanced composites technology began in 2009 in response to new Ares V and lander requirements. In addition, technology demonstration of a lunar fission surface power system using a reactor simulator was delayed one year to FY 2013.

ISS Research

The ISS Research project performs fundamental microgravity research in biology, materials, fluid physics, and combustion using facilities on the International Space Station (ISS). It includes using the ISS as a test bed for exploration technology development, and non-exploration research that has been mandated by Congress to sustain U. S. capabilities in microgravity science.

Program Management

The Program is managed by the Exploration Technology Development program office, located at the Langley Research Center in Hampton, Virginia.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Technology Infusion (Autonomous Landing & Hazard Avoidance Technology)	ETD Program Office - LRC	JSC, LRC	APL (Applied Physics Laboratory)
ISS Research	NASA Headquarters and ETD Program Office - LRC	GRC, ARC, MSFC, KSC	European Space Agency, Russian Space Agency
Technology Infusion (Propulsion and Cryogenics Advanced Development)	ETD Program Office - LRC	GRC , MSFC, JSC	Northrop Grumman, Aerojet, Pratt & Whitney Rocketdyne
Technology Infusion (In-Situ Resource Utilization)	ETD Program Office - LRC	JSC, GRC, KSC	Canadian Space Agency, Lockheed Martin, and NORCAT (Northern Centre for Advanced Technology)
Technology Infusion (miscellaneous areas)	ETD Program Office - LRC	LRC, GRC, ARC, JSC, JPL, MSFC, HQ, KSC, GSFC	
Technology Infusion (Human Robotic Systems)	ETD Program Office - LRC	JSC, ARC, GRC, LRC, JPL, GSFC, KSC	Michelin, MDA (MacDonald, Dettwiler and Associates Ltd.)
Technology Infusion (Fission Surface Power Systems)	ETD Program Office - LRC	GRC, MSFC, HQ	Department of Energy
Technology Infusion (Advanced Composites Technology)	ETD Program Office - LRC	LRC, GRC, ARC, MSFC	Northrop Grumman, Boeing, ATK (Alliant Techsystems Inc.)
Technology Infusion (High Performance and Radiation Hardened Electronics)	ETD Program Office - LRC	MSFC, LRC, GSFC, JPL	Sandia National Lab
Technology Infusion (Energy Storage)	ETD Program Office - LRC	GRC, JPL, JSC, KSC	DARPA (Defense Advanced Research Projects Agency), ABSL (AEA Battery Systems, Ltd.)

Acquisition Strategy

All projects are managed at NASA Centers, which issue competitive contracts for research and development support. The ISS Research Project issues competitive NASA Research Announcements to select grants for microgravity research in life and physical sciences.

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Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities
Program:	Lunar Precursor Robotic Program

Program Overview

LPRP contains the Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observing and Sensing Satellite (LCROSS) missions, which are currently scheduled for a June 2009 launch. The LCROSS mission will be completed with lunar impact in late 2009 with data analysis occurring through early 2010. LRO will complete its primary Exploration mission by the fourth quarter of 2010, with data analysis occurring through early 2011. LRO management for the extended mission will transition to the Science Mission Directorate. Lunar mapping and modeling activities carried under LPRP will transition to ETDP, and the Lunar Precursor Robotic Program will be closed out.

Plans for FY 2010

In FY 2009, LRO and LCROSS completed instrument and subsystem integration and environmental testing, and are preparing to launch in June 2009. The LCROSS spacecraft will complete its flight mission in 2009 by impacting the lunar surface and investigating the possible presence of water in a permanently shadowed crater. Data analysis and closeout of the LCROSS project will occur in early 2010. LRO's primary Exploration mission continues into the fourth quarter 2010, after which the mission will be managed by the Science Mission Directorate.

Mission Directorate:	Exploration Systems
Theme:	Advanced Capabilities
Program:	Lunar Precursor Robotic Program

Project Descriptions and Explanation of Changes

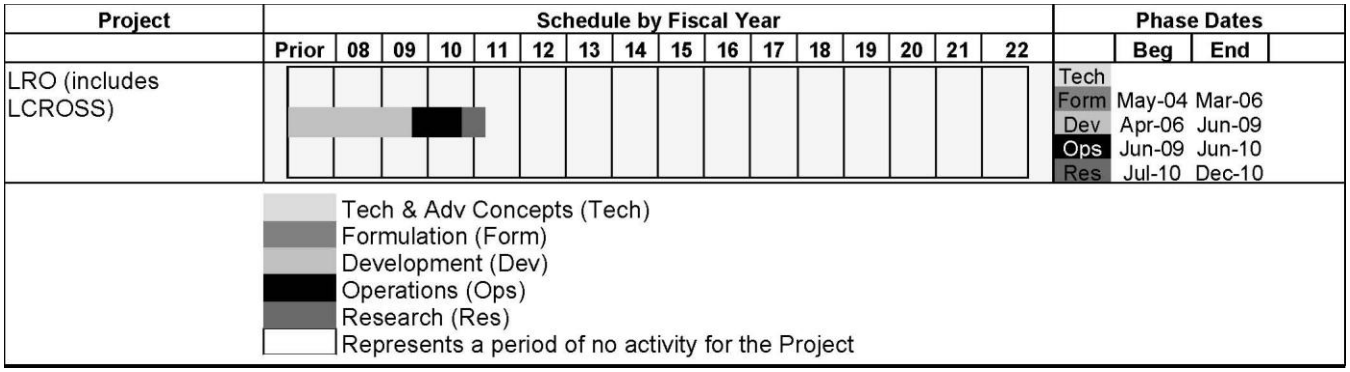
Lunar Reconnaissance Orbiter (LRO)

The Lunar Reconnaissance Orbiter project consists of the two spacecraft, LRO and LCROSS. The LRO spacecraft is a lunar orbiter with six instruments and a technology demonstration payload, which will perform reconnaissance of the Moon in order to map and image the lunar surface, take high-resolution images of areas of interest, assess light, thermal, and radiation environments, and map resources. The LCROSS impactor and shepherding spacecraft, which are co-manifested with LRO on the same launch vehicle, will attempt to identify water in a permanently shadowed crater.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Launch LRO/LCROSS mission in FY2009	LPRP/LRO	No Change

Implementation Schedule



Program Management

The Lunar Precursor Robotic Program is managed at Marshall Space Flight Center; the LRO and LCROSS spacecraft are managed by project offices at Goddard Space Flight Center and Ames Research Center, respectively.

Acquisition Strategy

Acquisitions are completed.