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**Statement of  
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Exploration Systems Mission Directorate  
National Aeronautics and Space Administration**

**before the**

**Subcommittee on Space and Aeronautics  
Committee on Science and Technology  
U.S. House of Representatives**

Chairwoman Giffords and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the President's FY 2011 budget request for NASA's Exploration Systems Mission Directorate (ESMD). NASA is grateful for the support and guidance received from this Subcommittee through the years and we look forward to working with you on enactment of the President's new direction.

The President's FY 2011 budget request outlines an innovative course for human space exploration, but does not change our goal – extending human presence throughout our solar system. NASA's exploration efforts will focus not just on our Moon, but also on near-Earth asteroids, Lagrange points, and ultimately Mars. While we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development. The research and technology investments included in this budget describe the many near-term steps NASA will be taking to create the new knowledge and capabilities required for humans to venture beyond low-Earth orbit (LEO) to stay.

ESMD will lead the Nation on this new course of discovery and innovation, providing the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. ESMD's investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore destinations in our solar system that we have not been to before.

At the highest level, the President and his staff, as well as NASA senior leadership, closely reviewed the Augustine Committee report, and came to the same conclusion as the Committee: The Constellation program was on an unsustainable trajectory. They determined that, given the current budget environment, Constellation's funding needs would have required terminating support of the International Space Station (ISS) in 2016 and ESMD would not have had sufficient resources to significantly advance the state of the art in the technology areas that would be needed to enable lowering the cost of heavy-lift access to space, and developing closed-loop life support; advanced propulsion technology; and radiation protection and other technologies on a faster schedule. The President determined that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration. At the same time,

under the new plan, NASA would ensure continuous American presence in space on the ISS throughout this entire decade, re-establish a robust and competitive American launch industry, start a major heavy lift technology program years earlier, and build a technological foundation for sustainable beyond-LEO exploration of our moon, near-Earth asteroids, Lagrange points, and ultimately Mars.

The FY 2011 budget request for Exploration is \$4,263.4 million, an increase of \$483.6 million above the FY 2010 enacted level. Included in this budget request is funding for three new, robust programs that will expand the capabilities of future space explorers far beyond those we have today. NASA will embark on these transformative initiatives by partnering with the best in industry, academia and other Government agencies, as well as with our international partners. These partners have been integral to much of NASA's previous success and are vital to our bold new vision.

NASA will encourage active public participation in our new exploration missions via a new participatory exploration initiative. Additionally, the FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-low-Earth orbit missions. The FY 2011 budget request also includes a 40 percent increase over last year's investment in the Human Research Program, to help prepare for future human spaceflight exploration beyond LEO. Lastly, the budget request includes funding for the Constellation Program close-out activities spread across FY 2011 and FY 2012.

In your invitation, you asked me to address three matters: the new Exploration elements in the FY 2011 budget request; current status of the Constellation Program; and responsibilities and reporting schedules of "tiger teams" that have been established to support transition efforts following the proposed cancellation of Constellation. The remainder of my testimony provides answers to your questions.

### **Key Elements of the New Plan**

The Exploration FY 2011 budget request includes three new robust research and development programs that will enable a renewed and reinvigorated effort for future crewed missions beyond LEO:

- **Technology Development and Demonstrations:** This effort will include two programs – a Flagship Demonstration Program and an Enabling Technology Development Program – that would invent and demonstrate large-scale technologies and capabilities that are critical to future space exploration, including cryo-fluid management and transfer; automated rendezvous and docking, closed-loop life support systems; in-situ utilization and advanced in-space propulsion. Once developed, these technologies will address critical requirements needed to send crews to a variety of exciting destinations beyond LEO. The flagship projects will be funded at \$400 million to \$1 billion over a period of up to five years, including launch costs, while shorter-duration enabling projects will be funded at \$120 million or less and will focus on near-term development and demonstration of prototype systems to feed flagship and robotic precursor missions. Such projects could include laboratory experiments, Earth-based field tests and in-space technology demonstrations. By allowing for flight demonstrations, some at a flagship scale, this Technology Development and Demonstration effort resolves the achievement gap between lab demonstration and flight testing that might otherwise prevent NASA from implementing the capabilities that are critical for sustainable human exploration beyond Earth in a timely manner.
- **Heavy-Lift and Propulsion Research and Development Program:** ESMD will lead research and development activities related to space launch propulsion technologies. This effort would

include development of a U.S. first-stage hydrocarbon engine for potential use in future heavy lift (and other) launch systems, as well as basic research in areas such as new propellants, advanced propulsion materials manufacturing techniques, combustion processes, and engine health monitoring. Additionally, NASA will initiate development and in-space testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and potentially also low-cost liquid oxygen/liquid hydrogen engines. This work will build from NASA's recent R&D experience in this area, and the test articles will be viewed as a potential prototype for a subsequent operational engine that would be restartable and capable of high acceleration and reliability. These technologies would increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs – with the clear goal of taking us farther and faster into space consistent with safety and mission success criteria. In support of this initiative, NASA would explore cooperative efforts with the Department of Defense and also develop a competitive process for allocating a small portion of these funds to universities and other non-governmental organizations. This research effort along with many of our new technology initiatives will be coordinated with the broader Agency technology initiative led by NASA's new Chief Technologist.

- **Exploration Precursor Missions:** An additional key contributor to a robust exploration program will be the acquisition of critical knowledge gained through the pursuit of exploration precursor robotic missions. Led by ESMD, this effort will send precursor robotic missions to candidate destinations that will pave the way for later human exploration of the Moon, Mars and its moons, and nearby asteroids. Like the highly successful Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) missions that captured the Nation's attention last fall, future exploration precursor missions will scout locations, gather key knowledge and demonstrate technologies to identify the most compelling and accessible places to explore with humans and validate potential approaches to get them there and back safely. These missions will provide vital information—from soil chemistry to radiation dose levels to landing site scouting to resource identification—necessary to plan, design and operate future human missions. These missions will help us determine the next step for crews beyond LEO, answering such questions as: Is a particular asteroid a viable target for crewed mission? Do the resources at the lunar poles have the potential for crew utilization? Is Mars dust toxic? While there may be some synergies between this program and the Planetary Science theme within NASA's Science Mission Directorate, care will be taken to avoid unnecessary duplication. While Science missions are driven purely by science objectives set by the National Academy of Sciences, the Exploration precursor missions will be driven by the needs of human spaceflight. In many cases, there is a synergy between these goals, and ESMD will leverage this synergy when it exists, as we have done successfully for the LRO/LCROSS missions. Dedicated precursor exploration missions are planned to remain below \$800 million in total cost, and many will be considerably less expensive. NASA plans to begin funding at least two dedicated precursor missions in 2011, and to identify potential future missions to begin in 2012 and/or 2013. Additionally, a new portfolio of explorer scouts will execute small, rapid turn-around, highly competitive missions to exploration destinations. Generally budgeted at between \$100 million and \$200 million lifecycle cost, these missions will allow NASA to test new and innovative ways of doing robotic exploration of destinations of interest to future human exploration. Selected projects may provide multiple small scouting spacecraft to investigate multiple possible landing sites, or provide means of rapid-prototyping new spacecraft approaches.

Cross-Agency teams for each of these three areas are working to develop plans that delineate key areas for research and development, specify milestones for progress and set launch dates for relevant missions. They will report to the Administrator over the coming months, and the results of their efforts will be shared with the Congress when they are complete. Additionally, NASA plans to embark on these

transformative initiatives by partnering with the best in industry, academia and other government agencies, as well as with our international partners. These partners have been integral to much of NASA's previous success and are vital to our bold new approach.

To more fully engage the public in these transformative efforts, NASA will establish a Participatory Exploration Office that will be charged with encouraging public involvement and interaction in the experience of discovery. Imagine how excited 11-year-old elementary school students would be if they got to actually pilot a rover on the lunar or Martian surface while they were learning about the planets in science class. Or imagine college students helping to design exploration payloads that will travel aboard the next-generation exploration precursor robotic missions. This is the primary goal of participatory exploration – empowering the general public to contribute to the Agency's research, development and discovery activities.

With regard to commercial crew and cargo, the FY 2011 budget request builds upon NASA's successful commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-LEO missions. Specifically, the budget request includes \$6 billion over five years to spur the development of U.S. commercial human spaceflight vehicles. This investment funds NASA to contract with industry to provide astronaut and international partner transportation to the ISS as soon as possible, reducing the risk of relying solely on foreign crew transports, and frees up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration. We also believe it will help to make space travel more accessible and more affordable. An enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities and energy in this area, and spawn other businesses and commercial opportunities, which will spur growth in our Nation's economy. And, a new generation of Americans will be inspired by these commercial ventures and the opportunities they will provide for additional visits to space. NASA plans to allocate this FY 2011 funding via competitive solicitations that support a range of activities such as human-rating existing launch vehicles and developing new crew spacecraft that can ride on multiple launch vehicles. NASA will ensure that all commercial systems meet stringent human-rating and safety requirements before we allow any NASA crew member (including NASA contractors and NASA-sponsored international partners) to travel aboard a commercial vehicle on a NASA mission. Safety is, and always will be, NASA's first core value. In addition, the budget request includes \$312 million in FY 2011 for incentivizing NASA's current commercial cargo program. These funds -- by adding or accelerating the achievement of already-planned milestones, and adding capabilities or tests -- aim to expedite the pace of development of cargo flights to the ISS and to improve program robustness.

Lastly, the Exploration FY 2011 budget request includes \$1,900.0 million for Constellation Closeout requirements, and a total of \$2,500.0 million over the FY 2011-2012 timeframe. These funds would be used for related facility and close-out costs, potentially including increased costs for Shuttle transition and retirement due to Constellation cancellation. The Agency has established senior planning teams to outline options for Constellation close out expeditiously and thoughtfully and to assess workforce, procurement and other issues, which will report to the Administrator over the coming months, to ensure that people and facilities are best utilized to meet the needs of NASA's new missions. NASA will work closely with the Congress as these activities progress.

### **Status of the Constellation Program**

NASA recognizes that the cancellation of the Constellation Program will personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make the Constellation Program successful. I appreciate and commend the dedication

and sacrifice that these skilled Americans have made in our Nation's human spaceflight program. Civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation, and our contractor colleagues should know that NASA is working expeditiously to offer new opportunities for them to partner with the Agency on our new Exploration portfolio.

Consistent with the provisions of the FY 2010 Consolidated Appropriations Act (P.L. 111-117), NASA is continuing to implement the programs and projects for the architecture of the Constellation Program. NASA completed the Constellation Preliminary Design Review earlier this month, and will complete documentation of the PDR this year. In light of the FY 2011 budget request's proposal regarding the Constellation Program, the Administrator has instructed the Constellation Program to refrain from initiating new work not currently under contract, and also to refrain from expanding the scope of any work that currently is under contract. All work that is currently under contract is continuing. These actions are prudent and necessary steps, and are consistent with the provisions of P.L. 111-117.

Please see the attached charts, which provide a list of major program acquisitions to date; the status of key milestones and program activities planned for the Constellation Program in FY 2010; and a brief overview of the accomplishments of the program to date.

#### **“Tiger Team” Responsibilities and Reporting Schedules**

Although NASA is continuing Constellation Program activities in FY 2010, at the same time, NASA must plan for all likely budget outcomes so that the Agency is ready to implement any new direction and implement appropriate transition activities. This is consistent with how the Agency plans to implement any pending budget in any given year. Forward preparation and planning work is always necessary, even though a budget has not become law.

Following the release of the FY 2011 budget request, NASA established six study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new Exploration program. The work undertaken by these teams is a necessary part of that planning. This is only an evaluation of plans, and no termination action has been directed or taken. The data assembled by the study teams will equip NASA with vital and substantive information that we will need once the new fiscal year begins and once NASA embarks on its efforts to implement the FY 2011 budget request.

The six study teams and their areas of planning are as follows:

- **Constellation Transition:** The team is leveraging expertise from across the Agency to develop a rapid and cost effective ramp-down plan that will free the resources required for new programs. As part of the early characterization and integrated planning effort, this team has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other government agency interface issues to determine what infrastructure and hardware could be used by the new programs and projects. The transition plan will outline three phases as part of an action plan for initial deliverables: Near-term actions, cancellations of Constellation, and transition of assets/resources to new Exploration focus areas and other NASA programs, where appropriate.
- **Heavy Lift and Propulsion Technology:** The team is formulating plans for a program that will investigate a broad scope of research and development activities to support next-generation space launch propulsion technologies. This includes foundational propulsion research and demonstrations of first stage and in-space engines.

- **Commercial Crew:** The team is formulating plans to expedite and improve robustness of ISS crew and cargo delivery. In addition, the team is developing a plan that supports the development of commercial crew transportation providers to whom NASA could competitively award crew transportation services.
- **Exploration Robotic Precursors:** The team is formulating plans for a series of candidate exploration robotic precursor missions to scout targets for future human activity. Potential destinations include the Moon, Mars and its moons, Lagrange points and nearby asteroids.
- **Flagship Technology Demonstrations:** The team is formulating plans for a series of in-space demonstrations that validate next generation capabilities key to sustainably exploring deep space.
- **Enabling Technology Development and Demonstration:** The team is formulating plans for conducting smaller scale development and testing of key, long-range exploration technologies.

The teams are being led primarily by Headquarters personnel, but include membership from the Centers, other Mission Directorates and other Cross-Agency groups. Members were selected based on their subject matter expertise. Each team has the ability to utilize resources anywhere in the Agency, including tapping experts at all Centers.

With the exception of the Constellation Transition team, the teams are engaged in pre-formulation activities: developing program strategy; identifying needs and goals; exploring alternate implementation strategies; and establishing high level milestones and a budget profile. The focus is at the program level with identification of potential projects or missions. Therefore, the teams will not engage in workforce assignments nor will they define Center participation or management of programs. The teams also will not develop or award new contracts. Decisions related to team activities are made through normal Agency approval processes.

It is expected that teams will complete a majority of their work by the end of the 3rd quarter of FY 2010. As that effort is completed over the next several months, NASA will share our findings with Congress and engage with this Subcommittee on our planned next steps.

After assessing the current Constellation baseline status and developing the action plan for a Constellation transition, and receiving appropriate legislative direction, future implementation and execution of the plan will be transferred to a Constellation Transition and Closeout Project. Existing Agency infrastructure will be utilized to the maximum extent possible to codify decisions and conduct reviews, analysis, and integration of transition activities and plans, such as: the ESMD Program Management Council; the Agency Program Management Council; the Center Management Council; the Constellation Control Board; the Systems Engineering and Integration Control Board; the Budget Rollout Integration Team and the Transition Control Board.

## **Conclusion**

Americans and people worldwide have turned to NASA for inspiration throughout our history – our work gives people an opportunity to imagine what is barely possible, and we at NASA get to turn those dreams into real achievements for all humankind. This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in fulfilling jobs, and engages people around the world as we enter an exciting new era in space. NASA looks forward to working with the Subcommittee on implementation of the FY 2011 budget request.

Chairwoman Giffords, thank you for your support and that of this Subcommittee. I would be pleased to respond to any questions you or the other Members of the Subcommittee may have.



# Constellation Program FY 2010 Planned Events

(As of March 4, 2010)

- NOTE: NASA is continuing to execute the FY 2010 baseline program. However, it is possible that changes could happen due to efforts by the Agency to fit within the constraints imposed by the FY 2010 budget. Please see response to Question 2 for more information.

Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
<u>Programmatic Reviews</u>								
	▲ 3/3 CXTF PDR Kick off ▲ 3/4-5 Cx PDR Board		▲ 5/13 Ares US FSW PDR2 Board	▲ 6/2 u/r GO PDR Board				
		▲ 4/6-7 GO PDR Kickoff ▲ 4/12 Orion Software PDR Board			▲ 7/9 MO PDR ▲ Jul – Ares I Interim CDR			
<u>Development Events</u>								
	● 2/11 Orion Parachute Drop Test @ Yuma Proving Grounds ● 2/25-2/26 EVA Prime IBR/EVA CSSS ATP2					Sep Ares I FS DM-2 Test	●	
	● 3/2-18 Orion PA-1 LAS Softmate/Phasing Test ● 3/17 Orion ACM DM-2 Test (Elkton, MD) ● 3/23-24 Orion PA-1 Pre-FTRR @ WMSR		● 4/1 Orion PA-1 FTRR @ JSC u/r ● 4/14 Ares FS Drogue Parachute Drop Test @ Yuma ● 4/15 Orion STORM DTO FRR			Sep CM GTA ATT Complete u/r	●	
			● May Orion PA-1 Launch @ White sands u/r ● 5/11-5/13 GO IBR u/r			Sep – EVA Suit PDR	●	

ATP – Authority to Proceed  
 CDR – Critical Design Review  
 CLIN – Contract Line Item Number  
 Cx – Constellation

CXTF – Constellation Training Facility  
 DDT&E – Design, Development, Test & Evaluation  
 EGLS – Exploration Ground Launch System  
 EVA – Extravehicular Activity

FS – First Stage  
 FSW – Flight Software  
 GO – Ground Operations  
 IBR – Integrated Baseline Review

MO – Mission Operations  
 PDR – Preliminary Design Review  
 US – Upper Stage

# Constellation Program Major Acquisitions



Project	Description
Orion	Orion Contract Award: 31 Aug 2006
Ares I	J-2X Contract Award (PWR): 16 Jul 2007
	1 <sup>st</sup> Stage Contract Award (ATK): 10 Aug 2007
	Upper Stage Production Contract Award (Boeing): 28 Aug 2007
	Instrument Unit Avionics Production Contract Award: 12 Dec 2007
EVA	Space Suit Systems Contract Award: 26 Feb 2010 (Definitized)
Ground Ops	Mobile Launcher contract Award (Hensel-Phelps): 8 May 2008
	Ground Support Equipment IDIQ Contract Award (Multiple): 6 Jun 2008
Lunar Surface Systems	Concept Development Broad Area Announcement (BAA) Contract Awards (Multiple): 28 Jul 2008
	<i>Concept Development Outbrief: 25-27 Feb 2009</i>

## Achievements of NASA's Constellation Program

The following are some of the Orion Project's key achievements:

- The Orion PDR was conducted during the summer of 2009, and completed in August 2009. The PDR was an extensive review of Orion's detailed subsystems and integrated systems designs to date. The PDR board unanimously recommended proceeding with detailed designs toward Critical Design Review (CDR) in February 2011.
- In 2009, NASA conducted preliminary capsule recovery tests at both the Navy's Carderock facility in Maryland and in the ocean near Kennedy Space Center (KSC) in Florida. Using a mockup of the Orion capsule, these Post-landing Orion Recover Tests involved search and rescue teams simulating stabilization and recovery of the Orion capsule in a variety of sea state conditions. Results were intended to lead to design features for both the spacecraft and recovery equipment, as well as contributing to development of the final recovery procedures.
- Fabrication of the Orion Ground Test Article crew module is progressing at the Michoud Assembly Facility in Louisiana. Completion is estimated for the fall of 2010, followed by completion of the service module and launch abort system ground test article, currently scheduled for 2011. NASA is using a friction stir welding technique on this ground test article, and is hoping to demonstrate the longest continuous friction stir weld ever attempted.
- In May 2010, NASA plans to perform its first developmental test of the Orion Launch Abort System (LAS) at the White Sands Missile Range, New Mexico. Orion's Launch Abort System (LAS) includes three newly designed solid rocket motors: 1) abort motor, 2) jettison motor, and 3) attitude control motor. All of these motors have been successfully demonstrated in static firings on the ground. The next step is the Pad Abort-1 test, which will be the first integrated firing of all three motors in a real flight environment.

The following are some of the Ares I Project's key achievements:

- Having completed its PDR in 2008, the Ares I Project is now working toward its CDR, which is scheduled for September 2011.
- In September 2009, NASA and ATK conducted the first successful test of the Ares I's five-segment development motor in Promontory, Utah. Beyond validating the basic performance characteristics of the stage, the test has enhanced modeling and understanding of key attributes that have historically been very difficult to predict analytically such as erosive burning, thrust oscillations and thrust tail off. The next static test, DM-2, is currently scheduled for September 2010.
- In October 2009, the Ares I-X test flight took place at Kennedy Space Center in Florida. Data from more than 700 on-board sensors showed that the vehicle was effectively controlled and stable in flight. Thrust oscillation frequencies and magnitude data from the Ares I-X flight also were consistent with measurements from recent Shuttle flights that were instrumented, leading us to conclude that the oscillation vibration on the Ares I would be within the bounds that the Ares I is currently being designed to. In the end, this test flight provided tremendous insight into the aerodynamic, acoustic, structural, vibration, and thermal forces that Ares I would be expected to experience.
- J-2X Test Hardware Status: Having passed its CDR in 2008, development and verification testing at the component and subsystem level continues. Current planning includes a fully assembled engine, minus the full nozzle extension, to be available the end of calendar year 2010,

followed by receipt of an additional developmental engine in 2011. Static fire testing for engines is currently slated to begin in the February-March 2011 time frame.

The following are some of the recent infrastructure achievements for the Constellation Program:

- The Operations and Checkout building at KSC was completed in January 2009, marking activation of High Bay Facility. When outfitted, the O&C will support final assembly of the Orion spacecraft.
- The final 600-foot Lightning Protection Tower at KSC's Pad B was completed in February 2009. This was where the Ares I-X test flight launched from in October 2009.
- Workers at KSC topped out the tenth and final segment of the new mobile launcher (ML) after it was lifted by crane and lowered onto the ninth segment in January 2010. When completed, the tower will be 345 feet tall and have multiple platforms for personnel access. Its base was made lighter than Space Shuttle mobile launcher platforms so the crawler-transporter can pick up the heavier load of the tower and a taller rocket.
- A-3 Test Stand at Stennis Space Center in Mississippi: Construction of the long-duration altitude test stand for the J-2X engine is nearly 75 percent complete. When completed in 2012, the A-3 facility will provide a unique critical capability to simulate environments at greater than 100,000 ft altitude necessary to demonstrate altitude starting and perform full-duration hot-fire testing.
- Space Environmental Test Facility (SET) at Glenn Research Center's Plum Brook Station in Ohio: Construction started in 2007 and is about 75 percent complete. SET is planned for conducting qualification testing of the fully integrated Orion spacecraft, including vibration, acoustics, and EMI testing.