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Statement of
The Honorable Charles F. Bolden, Jr.
Administrator
National Aeronautics and Space Administration

Before the

Committee on Science, Space and Technology
U.S. House of Representatives

Chairman Hall and Members of the Committee, thank you for the opportunity to appear before you today to discuss the future of NASA's human spaceflight program, and in particular the progress NASA is making on developing the next-generation human spaceflight transportation systems known as the Space Launch System (SLS) and the Multi-Purpose Crew Vehicle (MPCV), as well as their associated mission and ground support elements and other programs.

With passage of the NASA Authorization Act of 2010 (P.L. 111-267) on October 11, 2010, NASA has a clear direction for our human spaceflight programs. NASA appreciates the significant effort made in advancing this important bipartisan legislation, and we look forward to working with you to shape a promising future for our Nation's human spaceflight programs. With the enactment of the FY 2011 Full-Year Continuing Appropriations Act (P.L. 112-10), NASA is aggressively moving forward with our next-generation human spaceflight system development efforts as authorized.

The President's FY 2012 budget request continues to focus Agency efforts on a vigorous path of innovation and technological development leading to an array of challenging and inspiring missions to destinations with an incredible potential for discovery, increasing our knowledge of our solar system, developing technologies to improve life, expanding our presence in space, increasing space commerce, and engaging the public. The request supports an aggressive launch rate of about 40 missions from FY 2011 through FY 2012, including U.S. and international flights to the International Space Station (ISS) as well as science missions flown to Earth orbit and beyond. Within the human spaceflight arena, our foremost priority is safely and productively conducting our current human spaceflight endeavor. The FY 2012 budget request also maintains a strong commitment to human spaceflight beyond low-Earth orbit (LEO) via a capability-driven architecture that will focus on increasingly complex missions as we develop the technical expertise to reach destinations ever deeper into our solar system. At present, as designated by the President, our initial destination for a human mission is a crewed flight to an asteroid by 2025, followed by a human mission to Mars in the mid-2030's. Our post-Shuttle human spaceflight plan also focuses on utilization and operation of the ISS and on establishing a U.S. commercial cargo and crew capability to reach this National Laboratory. It establishes critical priorities and invests in the technologies and excellent science, aeronautics research, and education programs that will help us win the future.

In terms of our next-generation human spaceflight system, the SLS and MPCV will be capable of transporting astronauts to multiple destinations beyond LEO. The capabilities provided by these two vehicle systems are necessary for all activities LEO. While our plan calls for the initial destination for human flight beyond LEO to target an asteroid by 2025, other destinations could include cis-lunar space such as the Earth-Moon Lagrange points, the lunar surface, and eventually Mars and its moons. All of these places hold incredible information for us – information that we probably do not even know exists at this point. Compelling missions to advance exploration will be enabled by coupling these spacecraft systems with others needed for particular missions. This journey begins with the SLS and MPCV as the first important core elements of the evolutionary exploration approach to accomplishing a broad spectrum of missions.

To date, as NASA has reported to the Committee, the Agency has determined that the beyond-LEO version of the Orion Crew Exploration Vehicle is NASA's new MPCV, and as such, the current Orion contract with Lockheed Martin Corporation is being used through at least the development phase of the vehicle.

NASA has been working expeditiously to complete assessments of SLS design options and develop a final integrated proposal for MPCV/Orion and SLS. NASA has been conducting detailed technical analysis since the enactment of the NASA Authorization Act of 2010, and is working towards selecting a technical approach that will meet the intent of the SLS configuration described in the NASA Authorization of 2010 and enable the Nation to conduct a sustainable program of exploration. NASA's intent is that the design would evolve over time to meet the end goals of the SLS configuration in the Authorization Act. NASA is exploring strategic approaches that would be adaptable to modifications in annual funding and still make significant progress toward the end design. The SLS and MPCV teams are continuing to develop an integrated development plan that will be affordable in the near term and over the long run. In doing so, we are striving to design an evolvable and interoperable human spaceflight transportation system that will serve us for decades to come as we explore multiple compelling mission destinations. Due diligence will ensure the best value for the taxpayer with respect to cost, risk, schedule, performance, and impacts to critical NASA and industrial skills and capabilities in this multi-billion dollar endeavor.

While NASA has made significant progress to date on both the SLS and the MPCV, much work remains ahead for the Agency, as we finalize development plans and acquisition decisions per normal Agency processes for the SLS—decisions that must remain consistent with NASA's Strategic Plan and Agency commitments, as well as the NASA Authorization Act of 2010.

In a constrained budget environment, NASA knows how important it is to identify ways to make our programs and projects more efficient, so finding and incorporating these efficiencies remains a primary goal. We have embraced the challenge to deliver human spaceflight systems for lower cost, and the opportunity to become more efficient, innovative and agile in our programs. For example, we are revising the management of our requirements, contracts, and projects and incorporating approaches to ensure affordability in the near term and over the long run. This includes the use of focused insight/oversight, specifying to industry – where appropriate -- what we need instead of how to build it, designing for cost-effective operations, increasing the use of common components and parts, and wisely consolidating infrastructure.

The remainder of my testimony will address progress made to date on the SLS and MPCV Programs, as well as outlining the work ahead of us in order to ensure that we develop systems that reflect the NASA Authorization Act of 2010 using an affordable, sustainable and realistic approach.

However, before I explore those topics, I would like to take a moment to personally recognize the thousands of NASA civil servants and industry team members who have worked selflessly for countless hours, often under difficult circumstances and in a turbulent environment, to make our human spaceflight programs and projects productive and successful. In the days ahead, these incredible and talented employees will continue to do whatever it takes to make sure that the United States remains the world's leader in human spaceflight. After all, they do not know how to commit to anything less. I would also like to thank the Committee for its continued strong support for NASA's human spaceflight programs and their value to the Nation, especially as we work hard to finalize details of a well-thought-out strategy for our next-generation human spaceflight programs.

An Integrated Launch System: A Work in Progress

Over the last several months, NASA has been evaluating options for developing an integrated and incremental development approach for the SLS, MPCV and the associated ground operations that will be capable of achieving progress in an incremental manner while also reflecting the goals and objectives of the NASA Authorization Act of 2010, the FY 2011 Full-Year Continuing Appropriations Act (P.L. 112-10), and in a sustainable manner.

In order to accomplish this task, NASA put together a series of teams to develop an Analysis of Alternatives (AoA) that would meet future human spaceflight goals established by law and by Administration policy. In general, an AoA is a study intended to aid decision making by comparing various options and illuminating the risk, uncertainty, and the relative advantages and disadvantages of alternatives being considered to satisfy a mission need.

The AoA process produced many important results that will help inform NASA's final decision for the architecture approach for SLS by evaluating various technical designs. This SLS process has also sought to incorporate input from industry via a broad area announcement which collected industry suggestions and comments that have proven to be very useful in the design development process. NASA's goal is to develop an SLS architecture that represents the best ideas from industry and NASA.

NASA is currently evaluating the potential options for future missions that could enable continued progress toward longer-duration, beyond-LEO destinations. NASA is strongly considering an early flight test program, not unlike that we are conducting with our commercial partners for the evolving LEO capability. Such a program has many benefits, such as earlier access to data that could inform future design iterations or be applied to other programs, etc. and could also mitigate gaps in the current NASA industrial base and workforce skills. If implemented, NASA believes that this early mission strategy could effectively utilize and evolve existing capability (workforce, hardware, and contracts) to begin the next human exploration venture quickly. Over the next months, NASA will continue to evaluate this type of integrated strategy, including cost and schedule, through normal Agency program formulation activities, and we will continue to keep Congress apprised of our progress. Final acquisition decisions for the SLS are expected in the next couple of months, and we will provide those to Congress as soon as they are available.

Very early on in this process, I directed that we complete an Independent Cost Assessment (ICA) of our integrated SLS/MPCV development approach – particularly in terms of the Agency's initial cost and schedule estimates for the SLS. This ICA work is ongoing. I want to have a sanity check on our cost and schedule estimates before we make a final commitment to what will be a critical, but expensive venture for our nation. NASA has contracted with the firm of Booz Allen Hamilton, Inc. to perform this work, and final results from the company are expected in late July/early August. To be clear, the ICA will only have the fidelity that reflects the maturity of the SLS architecture concepts described above. I have also chosen not to do comparative cost estimates of all the alternatives to enable the assessment to focus on some of the most promising alternatives. Since the SLS proposal is still considered to be in the pre-formulation phase, the initial assessment will be a rough order of magnitude (ROM), which is typical of pre-formulation planning that occurs before a decision is made to baseline and fund a program. Official baselining of a program occurs upon successful completion of the Preliminary Design Review, when system requirements are fully defined and system design concepts are mature. It is at this point that the Agency will commit to an established life cycle cost and schedule.

The MPCV Program

The NASA Authorization Act of 2010 directs that NASA develop an MPCV that continues the advanced development of the human safety features, designs, and systems in the Orion Project.

The MPCV will transport the crew from the Earth's surface to a nearby destination or staging point and return the crew safely back to the Earth's surface at the end of a mission. The MPCV will provide all services necessary to support a crew of up to four for up to 21-day missions (for very long beyond-LEO missions, such as exploration of near-Earth asteroids or other planetary bodies, additional elements – a space habitation module for example – will be included to provide long-duration deep space habitation capability).

Mounted on top of the SLS for launch and ascent, the MPCV will be capable of performing abort maneuvers to safely separate from the launch vehicle and return the crew to the Earth's surface. The MPCV will also be capable of performing in-space aborts if conditions require the immediate safe return of the crew. MPCV will include the necessary propulsive acceleration capability to rendezvous with other mission elements and return the flight crew from the destination to the Earth's surface. In-space operations, such as rendezvous and docking and extravehicular activities, will be performed with the MPCV in conjunction with other mission elements.

The NASA Authorization Act of 2010 requires that the MPCV be capable of efficient and timely evolution – something that has been in practice throughout the design process for the Orion vehicle. Continuing this process for MPCV will allow for an incremental or "block" development and mission capability approach. This will allow for early progress to be made on the fabrication of key design aspects, depending on available funding, while utilizing early testing to buy down risks associated with subsequent block configurations. Each test cycle will also provide an opportunity to on-ramp or off-ramp capabilities as the design evolves.

In late May, and after careful analysis and deliberations by a senior management team, I decided to accept the Orion-based reference vehicle design, first outlined in NASA's January 2011 report to Congress, as the Agency's MPCV. As part of my decision process, I determined that the Orion was already being built to meet the requirements of a deep-space vehicle and that the Agency's current Orion contractual partnership with Lockheed Martin Corporation maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010. Therefore, the current contract will be used at least for the development phase of the MPCV.

Moving forward, work on the MPCV will focus only on the deep-space design. While the MPCV could be called upon to service the ISS – a backup requirement established by the NASA Authorization Act of 2010 -- it should be well understood that utilizing the MPCV for routine ISS transportation would be a very inefficient and costly use of the MPCV deep-space capability. NASA is confident in the ability of our commercial and international partners to provide all currently foreseen support for the ISS. Therefore, there is no intention to conduct routine LEO missions with the MPCV.

It is important to point out that my decision regarding MPCV does not reflect a "business as usual" approach for the Agency. Over the last year, the NASA/Lockheed Martin team has shown exceptional creativity in finding ways to keep costs down by implementing new management techniques, technical solutions and innovation within the Orion Project. Since the NASA Authorization Act of 2010 was signed into law, the Orion government and industry team has assessed and implemented additional affordability initiatives that have reduced Design, Development, Test and Evaluation costs and enabled schedule acceleration. These initiatives include but are not limited to:

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

Over the last year, NASA developed and executed plans for an incremental development approach for the Orion, due in large part to the constrained fiscal environment. This approach deferred work on some systems while focusing on core components and systems that could be applicable to MPCV, with the aim of attempting to enable incremental test flights and subsequent upgrades to full operational capabilities as quickly as the budget profile allows. In doing so, NASA deliberately prioritized Constellation funds, including those for Orion, to maximize their use in support of transition to SLS and MPCV. Examples are listed below.

- Assembly of the Orion Ground Test Article (GTA) was recently completed, with the GTA being prepared for a series of ground-based environmental tests to validate the Orion design and computer models. The GTA is undergoing vibration and acoustic testing this summer, and will undergo drop testing at Langley Research Center Water Basin Facility in Virginia this fall. Data collected from GTA testing will be incorporated into MPCV development efforts so as to result in a safe, reliable and affordable human-rated crew capsule. Design work for the subsequent test article is also proceeding, including conducting periodic technical reviews. In FY 2012, testing on the GTA will be completed. Fabrication work and assembly work for the following test article will also be well underway.

- A new sensor technology has been developed that will allow easier, safer, and more affordable on-orbit rendezvous and docking to the ISS for future spacecraft, including the MPCV as well as commercial cargo and crew providers. The Orion Vision Navigation System (VNS) is an advanced Light Detection And Ranging (LiDAR) - based relative navigation sensor with performance specifications unmatched in today's relative navigation sensor market. The VNS uses cross-cutting technology that has been developed in partnership with commercial vendors and is applicable to future spacecraft requiring rendezvous and dockings, as well as terrestrial commercial applications. In May 2011, NASA tested the VNS system aboard STS-134. During this test, a prototype docking camera provided a resolution 16 times higher than the current Space Shuttle docking camera. Once completed, the VNS system should be able to provide rendezvous data to approaching vehicles as far away as three miles, which is three times the range of the current Shuttle navigation sensor.

- During the last year, progress continued on the construction and outfitting of Orion support facilities. NASA is now in the process of deciding how and when these facilities will be used by the MPCV Program.

NASA is hoping to be able to launch an initial uncrewed test flight of an integrated early version of the SLS and the MPCV as early as 2017.

The SLS Program

The SLS will be the Nation's first exploration-class, heavy-lift launch vehicle since the Saturn V and will serve as the critical next step beyond the Space Shuttle and three decades of LEO operations.

The NASA Authorization Act of 2010 directs that NASA develop an SLS that is capable of accessing cis-lunar space and other regions of space beyond LEO. The Act also states that the SLS must be capable of lifting the MPCV, and that the SLS must be able to initially lift 70-100 metric ton (mT) to LEO, while ultimately being evolvable to a lifting capacity of 130 mT or more. As such, the SLS flights will be capable of lifting the MPCV and other exploration flight elements into space for missions to the Moon, Lagrange points, asteroids, and ultimately to Mars. The MPCV design will be optimized for beyond-LEO exploration, and while contingency utilization for the ISS is a possibility, consistent with the Authorization Act of 2010, doing so would represent a highly inefficient vehicle usage

In January 2011, NASA announced that it had chosen a Reference Vehicle Design for the SLS derived from Ares and Space Shuttle hardware. That concept vehicle utilized a LOX/LH2 core, five-segment solid rocket boosters, and a J-2X-based Upper Stage as the 130-mT version of the vehicle – evolvable from the 70-100-mT version. As envisioned, this Reference Vehicle Design would allow for use of existing Shuttle and Ares hardware assets in the near term, with the opportunity for later upgrades and/or competition for eventual upgrades in designs needed for affordable production. However, NASA has continued to study other alternative architectures as part of its due diligence. In so doing, NASA has identified several characteristics that the ultimate SLS design may include.

- **Evolvable development:** While our initial development efforts would focus on the 70-100-mT lift capability, in parallel, we would plan to capitalize on synergies between Core Stage and Upper-Stage design and manufacturing, thereby allowing us to develop some of the upper-range capabilities for an eventual 130-mT vehicle at the same time, as funding permits. Doing so is actually a fairly natural, evolvable progression in terms of developing these capabilities.

- **Commonality of systems:** The use of common elements (e.g., common propellants, common manufacturing, and common avionics and control systems) across the entire SLS can enable the same or similar equipment and manufacturing to be used for both systems. This makes more efficient use of the infrastructure and increases throughput through manufacturing. This ultimately can lower costs.

- **Modularity of Elements:** With the availability of three stages (Core, First, and Upper) to work with, NASA could structure each specific launch vehicle to achieve specific requirements such as thrust capability. Doing so would allow NASA to capitalize on cost savings. For example, if a specific mission did not need 130 mT in thrust capability, NASA could potentially save funds by not having to use booster stages on that mission. In addition, modularity offers the benefit of metering development costs commensurate with available funding levels.

- **Industrial Base:** We would work with the space launch community in general in an effort to help strengthen the overall industrial base.

- **Flexibility:** Although the SLS is expected to be costly to fly, it will have an unmatched payload capacity. The ability of the SLS to carry either the MPCV or large cargo also allows the SLS to carry robotic payloads for science or national security missions, although there are currently no requirements for such large payloads. The additional volume and lift capability could allow designers to either simplify the spacecraft by choosing to reduce deployments or eliminate the need for costly weight reductions;, to take advantage of the additional volume and lift capability to enable more capable missions; or to increase the duration and frequency of launch windows for planetary missions. To ensure that we have kept other agencies informed with our future plans for launch systems, we have provided periodic briefs on the progress of our SLS and MPCV deliberations to their senior leadership.

To be clear, as previously stated, much work remains ahead for the SLS team. We are working hard to finalize the analysis on the best option for venturing beyond LEO as quickly as possible and at the lowest near-term development cost.

Currently, NASA has procurement teams mapping SLS requirements (those outlined in the NASA Authorization Act of 2010 and those we are currently developing). For the SLS, NASA is reviewing each element of Ares (First Stage, Upper Stage, Upper Stage J-2X engine, and avionics) and Shuttle Program contracts (Space Shuttle Main Engines, External Tank, SRB) to determine whether the new SLS requirements would be within scope of current contracts. At the same time, NASA is assessing SLS competition options, including the potential degree of competition.

Although NASA must still finalize an integrated test flight plan, based on the President's FY 2012 budget request, NASA is targeting that the first uncrewed SLS developmental flight or mission could take place in late 2017 to support a crewed mission by the early 2020s and a visit to an asteroid in 2025. This target date also depends on how quickly acquisition decisions are made so that physical development work can begin on SLS elements and integration processes.

NASA is strongly considering an early mission/test flight strategy that would include early flights that would begin with a lift capacity in the 70-100 mT range, sufficient to get out of LEO with meaningful mission content, with the first flight targeted for the end of 2017 and the second flight targeted for 2021. Therefore, the 70-100 mT flight configuration will offer early development of the Core Stage, continuation of the Orion-based design as the MPCV, an Upper Stage/kick motor capability that will enable a series of development missions/test flights beyond LEO, and use of existing solid rocket boosters.

Early test flights for the SLS, if carefully planned, could enable NASA to reduce development risk, drive innovation within the Agency and in private industry, and accomplish early exploration objectives. I have stressed to the SLS team that we must make every test flight count in a constrained budget environment; that is why the NASA teams are still working to develop an integrated SLS/MPCV test flight schedule that will be part of an overall incremental development approach consistent with anticipated cost constraints.

Moving forward on the SLS, one of NASA's greatest challenges will be to reduce the development and operating costs (both fixed and recurring) for human spaceflight missions to sustain a long-term U.S. human spaceflight program. We must plan and implement an exploration enterprise with costs that are credible and affordable for the long term under constrained budget environments. As such, our development efforts also will be dependent on a realistic budget profile and sufficiently stable funding over the long term, coupled with a successful effort on the part of NASA and our eventual industry team to reduce costs and to establish stable, tightly-managed requirements.

Additionally, the SLS Program will continue to examine ways to increase efficiency and agility to deliver an affordable and achievable heavy-lift system as soon as possible. Examples being considered in formulating SLS plans include the following:

- Consolidating infrastructure wisely;
- Using common parts and common designs across the Government to reduce costs;
- Ensuring requirements are appropriately specific and also that requirements applied to NASA crew launch vehicles are similar to those provided to our eventual commercial crew partners, thereby ensuring that NASA vehicles are not required to meet more substantial requirements than commercial crew vehicles and vice versa;
- Conducting insight/oversight activities of our contract partners in a smarter way, thereby using our resources more appropriately to focus on the high-risk items; and
- Ensuring that there are no unique configurations or developments that do not end up directly supporting the final system.

NASA has continued to make progress on developing a crew launch vehicle over the last year. Due to legal restrictions that have since been rescinded, NASA had been prevented from terminating any Constellation-related work. However, in the meantime, the Agency was able to prioritize Constellation work that had a high likelihood of feeding forward into the new SLS and MPCV Programs.

For example, during FY 2011, the former Ares Project worked closely with SLS planning team to focus their development efforts on technologies and processes that could be utilized in the eventual SLS configuration, including vehicle avionics, J-2X Engine testing, First Stage motor testing (Development Motor-3), and installation of Upper Stage tooling applicable to large-diameter tanks. At the same time, the former Ares Project deferred activities that were Ares-I-dependent, including a ground vibration test article and design of Upper Stage component hardware, such as the reaction control system.

The J-2X engine is an example of significant progress made during FY 2011 that could be directly applicable to the SLS Upper Stage engine. The J-2X engine is fully assembled and installed in the A-2 Test Stand at NASA's Stennis Space Center and has been readied for its first round of testing. The engine began a series of 10 test firings on July 6 and testing will occur over several months. Collected data will verify the engine functions as designed.

Conclusion

In 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.

With the passage of the NASA Authorization Act of 2010, NASA has a clear direction and is making plans for moving the Agency forward. Today, we have a roadmap to even more historic achievements that will spur innovation, employ Americans in fulfilling jobs, and engage people around the world as we enter an exciting new era in space. NASA appreciates the significant effort that has gone into advancing this bipartisan legislation.

Let me assure you that NASA is committed to meeting the spaceflight goals of the Nation and fulfilling the requirements of the NASA Authorization Act of 2010. As such, we are committed to developing an affordable, sustainable, and realistic next-generation human spaceflight system that will enable human exploration, scientific discovery, broad commercial benefits, and inspirational missions that are in the best interests of the Nation. We look forward to working with you and other Members of Congress as we finalize our strategy for achieving human spaceflight to many destinations in our solar system.

Chairman Hall and Members of the Committee, I would like to conclude my remarks by thanking you again for your continued support for NASA and its human spaceflight programs. I would be pleased to respond to any questions you or the other Members of the Committee may have.