SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Examining NASA's Development of the Space Launch System and Orion Crew Capsule

Wednesday, September 12, 2012
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The purpose of the hearing held by the Subcommittee on Space and Aeronautics is to examine on-going development of the Space Launch System (SLS), the Orion capsule and related systems, as well as discuss how these technologies can be used for future scientific missions.

Witnesses

Mr. Dan Dumbacher, Deputy Associate Administrator for Exploration Systems Development, NASA

Mr. Cleon Lacefield, Vice President and Orion Program Manager, Lockheed Martin Corporation

Mr. Jim Chilton, Exploration Vice President, The Boeing Company

Dr. Matt Mountain, Director, Space Telescope Science Institute

Over-Arching Questions

1. What achievements have been accomplished to date with SLS and Orion development, and what are next steps and near-term goals?

2. What design assumptions is NASA using for propulsion systems for both first and upper stages?

3. What are the biggest technical, programmatic, and risk reduction challenges now confronting the SLS and Orion programs, and what steps are being taken to address them?

4. How do we ensure the long-term success of the SLS and Orion programs?

Background

NASA's next generation heavy-lift launch vehicle – the Space Launch System (SLS) – together with the Orion crew capsule will provide our country a capability that has not existed since the Apollo lunar program (1972) – the ability to send humans beyond Earth orbit to lunar or other deep space destinations. It also makes possible our nation's ability to send larger, more sophisticated scientific payloads to distant planets and other deep-space destinations, and provide a backup capability for the US government to access the International Space Station in the event that commercial crew or Soyuz services are unavailable. NASA's current development schedule assumes an operational SLS and Orion to be ready by 2021. No specific destination has been announced for a first mission, although NASA and the White House have suggested visiting a near-Earth asteroid. The agency is currently undertaking a survey to identify likely targets.

The Space Launch System is modeled on the Ares V that was to be the heavy-lift launch vehicle of the *Constellation* program canceled by the Obama Administration in February 2010. As part of its redirection of the human space flight program, NASA began to aggressively advocate development of a commercial crew program to ferry astronauts to the ISS[1], and proposed delaying decisions on design and development of a heavy-lift launch system until 2015. With the impending retirement of the space shuttle and risks of losing national aerospace capabilities, perhaps indefinitely, Congress disagreed with accepting any delays in the development of a national heavy lift capability. The 2010 NASA Authorization Act (PL 111-267) directed the agency to initiate development of SLS "as soon as practicable", to extend and modify *Constellation* contracts where applicable, to develop an initial lift capability of 70 metric tons (to eventually reach at least 130 metric tons), to carry the Orion crew capsule, and to serve as a back-up capability for crew access to ISS in the event that commercial or Russian services could not do so.

The same law also directed NASA to continue development of the Orion crew capsule that also had its start as part of the *Constellation* program.

No matter that PL111-267 was signed into law October 11, 2010, NASA waited seven months before officially designating Orion as part of its new deep-space architecture, and took an additional four months (Sept. 14, 2011) before announcing the design of its Space Launch System. Frustration over the delays became so great that the Senate Commerce Committee subpoenaed NASA for records related to these two programs.

[1] The Full Committee has scheduled an oversight hearing Friday, Sept. 14, 2012, at 9:30 am, on the Commercial Crew Program.

Orion Multipurpose Crew Capsule

As previously noted, the Orion crew capsule was originally part of the *Constellation* program that was to be flown atop both the smaller Ares I rocket (for ISS and low Earth orbit missions), as well as the larger Ares V for deep space missions. While it looks similar to an Apollo capsule, Orion has a 16.5 foot diameter versus 12.8 for the Apollo, is heavier, and has greater interior volume. Key features include a launch abort system, life support system, thermal protection, avionics, and propulsion. It is currently being designed to carry as many as four crew. Lockheed Martin is the prime contractor, and the program is managed by the Johnson Space Center.

Orion is much farther along in development than SLS, because the Administration's decision to cancel Constellation was more disruptive to the launch vehicle development than to Orion's. In 2009 (under the *Constellation* program) a full scale engineering model was used to conduct a successful test of the launch abort system at the White Sands Missile Range, New Mexico. Full scale models have also been used to carry out splashdown testing at NASA's Langley Research Center and parachute drop tests at the Army's Yuma Proving Ground in Arizona. NASA and its contractors are also carrying out a number of activities related to developing and testing subsystems and manufacturing processes.

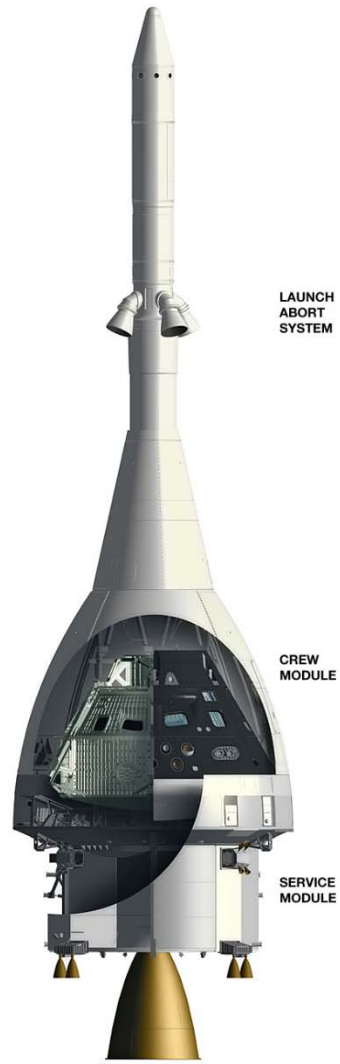

Image Credit: NASA

Another full-scale engineering model is scheduled to be launched in 2014 atop a Delta IV Heavy-Lift Launch Vehicle to test a number of vehicle systems. The uncrewed flight will take Orion on two highly elliptical orbits and re-enter the Earth's atmosphere at a speed equal to about 85% of lunar return velocity (20,000 mph). This will generate significantly higher temperatures during reentry than experienced by the space shuttle or other craft returning from the space station orbit and allow NASA to assess the heat shield's performance. The flight, dubbed EFT-1 (Exploration Flight Test-1), will also perform a number of other risk-reduction activities including a full scale test of the parachute system and a water landing in the Pacific.

A follow-on uncrewed flight test is scheduled for the end of 2017and will be launched atop an SLS first stage. EM-1 (Exploration Mission-1) will put Orion on a circumlunar trajectory before returning to Earth for reentry. Thereafter, NASA plans call for Orion (and SLS) to fly the first operational mission in 2021.

Orion's design also assumes a service module (SM) to provide power, propulsion, and consumable gases for life-support. For the EFT-1 flight, a truncated SM will be used to supply propulsion and battery power, but so far the agency has provided no concrete plans on how and when an operational SM will be developed and manufactured. Without a service module, flights of more than a few hours duration will not be possible.

Space Launch System

The initial version of the SLS will be comprised of a core stage using a liquid hydrogen, liquid oxygen propulsion system, with two five-segment solid rocket motor boosters. NASA has an inventory of 15 Space Shuttle main engines (SSME) to power the first several flights, but will eventually fund development of less expensive, 'expendable' SSME variants. The SLS will initially be able to launch 70 metric tons but will eventually be upgraded to at least 130 metric tons with development of more powerful boosters, and an upgraded upper stage using a J-2X engine. Like Orion, much of the SLS owes its heritage to the *Constellation* program, specifically the proposed Ares V heavy-lift launch vehicle. The SLS is similar in appearance to the previous Ares V, but less capable. Boeing is the prime contractor for the core stage. The SLS program is managed by the Marshall Space Flight Center.

NASA has identified SLS preliminary parameters to be:

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

In order to minimize development and production costs, the SLS core and upper stages will share the same diameter as the Space Shuttle External Tank (27.5 feet) enabling the manufacture and machining of these components using the same production hardware. SLS will also use many of the same subsystems, materials, and tooling.

Earlier this year SLS successfully completed its Systems Requirements Review/System Definition Review. The next major formulation review will be the Preliminary Design Review (PDR) scheduled for the 4th quarter of FY2013, which will evaluate the completeness of the SLS's design in meeting all requirements with appropriate margins, with acceptable risk, and within cost and schedule constraints. PDR includes all major elements and determines the program's readiness to proceed to Critical Design Review scheduled for the 2nd quarter of FY2015.

Image Credit: NASA

For initial SLS flights, NASA will rely on an existing cryogenic upper stage already in use on the Boeing-designed Delta 4 rocket. Eventually NASA intends to use the much more powerful J-2X engine, designed and built by Pratt & Whitney Rocketdyne, to power the upper stage, enabling heavier spacecraft to escape Earth orbit. Earlier this summer the J-2X engine successfully performed a 22.5 minute test firing at the Stennis Space Center. The final development and testing phase of the J-2X engine is awaiting NASA's decision to begin development of the 130 metric ton variant "block 2" upper stage for the SLS. The Stennis Space Center manages the program for NASA.

The first two flights of SLS will use two solid-rocket motor boosters similar to those utilized by the Space Shuttle, although they will be longer – a five segment design. The manufacturer, ATK, has successfully performed three test burns of five segment motors. NASA is in the early stages of competing the development of advanced boosters, which may be either solid or liquid. In July 2012, the agency announced the selection of six study proposals (offered by four companies) for initial study of advanced booster risk-reduction work.

Budget

Exploration Systems Development: Orion and SLS Budgets (FY2013 PBR; $=millions)

	FY 11 Actual	FY12 Estimate	FY13 Auth	FY13 Request	FY13 vs. FY12
Orion Crew Vehicle Development	$1,086.0	$1,142.9	$1,400.0*	$968.5	-$174.4
Orion Program Integration & Support	$110.0	$57.1	---	$56.4	-$0.7
Space Launch System	$1,313.8	$1,456.1	$2,640.0*	$1,304.1	-$152.0
SLS Program Integration & Support	$222.3	$46.4	---	$35.9	-$10.5
Exploration Ground Systems	$250.0	$304.5	---	$404.5	$100.0
TOTAL	$2,982.1	$3,007.0	$4,040.0*	$2,769.4	-$237.6

**Authorization assumes – but does not call out – ground systems and other program support.*

NASA's FY13 budget request for Orion and Space Launch System is only 69% of amounts authorized in the 2010 NASA Authorization Act, and as shown in the table, is $237.6 million less than amounts appropriated during FY12.

Future Scientific Missions Enabled by SLS

NASA relies on a variety of small to medium-lift vehicles to launch robotic science missions into space. The size and weight of payloads is limited by lift capacity and the size of the payload faring of the launch vehicle. The Space Shuttle was NASA's most powerful launcher, capable of taking over 50,000 pounds to low Earth orbit (LEO), but with its retirement NASA now relies on a variety of expendable launchers such as the Delta 4 and Atlas 5 rockets that typically lift 20,000- 25,000 pounds to LEO. Only the United Launch Alliance Delta 4 Heavy, currently the largest launch vehicle in America's fleet, is capable of lifting approximately 50,000 pounds to LEO.

The Ares V heavy-lifter, as proposed in the *Constellation* program, was designed to carry about 140 metric tons to LEO in an 8 meter faring, far surpassing any existing launch system. NASA asked the National Academy of Sciences in 2007 to evaluate the potential for new science opportunities enabled by the Ares V which resembles today's planned SLS both in appearance and lift. The final report, *Launching Science: Science Opportunities Provided by NASA's Constellation System*, (http://www.nap.edu/catalog.php?record_id=12554), published in 2009, examined a number of possible mission concepts that might be possible in the 2020 – 2035 time frame.

Not surprisingly the report's findings and recommendations examined a number of 'flagship' mission concepts, including space-based telescopes and large planetary exploration spacecraft. Among their findings and recommendations -

- Most suitable missions were in the $5 billion estimated cost range (excluding launch costs);
- Astronomy, astrophysics, and planetary science missions tended to generate the most proposals;
- Earth science and heliophysics disciplines did not propose missions requiring heavy-lift launchers;
- International cooperation could provide access to international scientific expertise and technology useful for large, complex missions and could reduce costs through provision of instruments by international partners;
- With advanced robotic servicing technology, heavy-lift launch vehicles make possible the servicing and in-space assembly of large spacecraft; and
- NASA should preserve the capability for Orion crew capsules to carry small scientific payloads and should ensure that the Ares V development team (now SLS) considers the needs of scientific payloads in their system designs.