Written Statement for Testimony

Jim Chilton

Boeing Space Exploration Vice President

Program Manager, Space Launch System Stages

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Good morning, Chairman Hall, Ranking Member Johnson and members of the committee. On behalf of the Boeing Company, I wish to extend our thanks for your continued support of human spaceflight. Your efforts enabled a safe fly-out of the Space Shuttle, supported the completion of the International Space Station, and outlined a path forward for the future of human space exploration. Without the support of your committee these achievements would not have been possible. It is my great honor to participate with the other witnesses on this panel to share Boeing's activities in support of NASA for the Space Launch System.

In the current environment there are 3 elements to NASA's path forward for human space flight for space exploration: development of capability for human exploration beyond low Earth orbit, utilization of the International Space Station, and commercial services for cargo and crew to the International Space Station. As stated in NASA documentation, the Space Launch System (SLS) is the enabler for human deep space exploration and is needed to propel Exploration elements free of Earth's gravitational forces. SLS will be capable of lifting the Orion MPCV, cargo and other exploration elements to Lagrange points, the moon, asteroids, and ultimately missions to Mars. It will expand scientific missions by enabling the launch of large robotic payloads and also serve as a backup launch system for supplying and supporting the International Space Station cargo and crew requirements not met by other available launch vehicles.

1. Challenges – Technical, Programmatic, and Risk Reduction

As we all know development programs often face challenges, and managing them is key to assuring program success. It is worth noting up front that many potential challenges on SLS have already been avoided by adapting proven approaches to the SLS mission. Foremost among these is avoiding the need for significant technology development. NASA wisely selected an architecture that allows reuse of elements and approaches from other successful programs. This separation of product development from technology development increases our confidence in schedule and cost predictions relative to starting from scratch.

With that said, we do see challenges. Accomplishing rapid development of the core stage is foremost among these. This is the only all new element of the Space Launch System, and is the backbone on which the other elements depend. The Core stage engines are heritage Space Shuttle Main Engines; the strap on boosters, in final phase of testing, are upgraded solid rocket boosters from the space shuttle program; and the SLS Block 1 interim upper stage is directly adapted from the Delta IV heavy launch vehicle. The core stage on the other hand, is a clean sheet design, albeit one that leans heavily on existing design practice and manufacturing technologies. To some extent, the existing elements are awaiting the core stage to catch up with them. To provide a sense of this schedule challenge, we can compare the time allotted for design and delivery of a core stage to the lead time required to produce a shuttle external tank to an existing design. As the shuttle program neared its end, schedule estimates for call up of an external tank ranged from 36 to 44 months. This was for production of an existing, certified design. The core stage timeline, which includes creation and certification of a new design, is 51 to 54 months from the system requirements review. It is clear from this comparison that achieving early design progress against stable requirements and funding will be necessary to enable core stage development success.

Integrating existing elements in new ways with the emerging design of the core stage is another challenge. The core stage will fly with a 4 engine cluster, vs. the 3 engine cluster used for the Space Shuttle. Each of the RS-25 engines must support different operating regimes. The Delta IV upper stage flying on top of core stage must accommodate different loads and guidance requirements. Integration of the five-segment SRBs will also be different that the four-segment SRBs used for the Space Shuttle. Although the risk of developing new elements is reduced by reuse of these heritage systems, the connections and interactions between the existing elements and the emerging core stage design must be carefully predicted and managed. New ground interfaces must be established as well. All this integration is ably led by the government engineers at the Marshal Space Flight Center, who provide analysis and integration to the industry team members responsible to deliver elements. These integration products are the foundation on which the core stage schedule and overall vehicle success depend. Without timely and accurate delivery of these integration products, none of the elements can be delivered to predictable schedules or predictable performance.

The flat budget profile, which is atypical for development programs, creates a unique challenge necessitating that SLS development occurs through an evolutionary process. Constrained budgets prohibit simultaneous development of the core stage, upper stage, payload fairings, new engines, and advanced boosters for final 130mT SLS configuration. The common Core Stage is the first priority for the SLS vehicle and the only new SLS element, but there is enough funding for limited development of a second new element. We are retaining the option for that element to be a larger upper stage, which offers a big improvement in BEO performance from the Block 1.

Another challenge is to maximize production and operations efficiency during the design and development phase. Many in industry assert that economic efficiency is only possible at high production rates. In a government system with fixed annual budgets, it is important not to design a system that requires other buyers who enable the high volume desirable for better economics. Our experience indicates that planning for high rates and then not achieving them can create an insurmountable economic challenge. This is especially true for launch vehicles, where new demand does not appear to be stimulated as capacity at lower prices becomes available. Therefore, enabling an efficient system for low production rate is our goal for SLS. We are adapting our design to maximize production efficiency in areas of tooling, headcount, procurement processes, and even the number of lifts and moves on the factory floor. This will enable the country to finally have access to an exploration class rocket within predicted annual budgets, which we see as a definition of affordability more appropriate than costs that are scaled around potential production rates.

We are working hard to reduce risk through adaptation of existing subsystem and component designs, careful work placement, and early demonstrations in areas where history indicates surprises can occur. An example of this approach is in our avionics approach and hardware- software integration. We are striving to ensure SLS is a standalone exploration class rocket that can be adapted to a wide variety of missions that emerge over many years. This requires the vehicle to have a guidance system independent of any specific payload or crew system so it can serve multiple users in crew and cargo configurations. To maximize our integration flexibility and ensure this happens on time, we have chosen to produce key elements of the avionics system in house. Noteworthy among these is the vehicle flight computer, which is based on a proven Boeing design used in commercial satellites. Not only does this allow lower costs, it has enabled rapid progress. We already have a test version in the government labs at the MSFC, on which NASA developed software is up and running. Critical design review of this flight computer commenced two weeks ago, and the first flight configuration circuit boards are being installed this week, We are incrementally adding the avionics systems and components in the lab environment to minimize the chances that surprises in the interactions between the systems disrupts progress in certifying the design. The approach described for avionics and software is representative of our risk reduction approach, and is in use across our subsystems. We rely heavily on reuse of designs from the space shuttle and other proven space systems across the board.

There are important goals to ensure SLS is protected and nurtured long enough to succeed.

First, prevent temporary budget variations from impacting schedules. Stable funding that keeps pace with inflation allows the program to maintain a steady and predictable rhythm. Construction of facilities tasks must be fully funded even under continuing resolution conditions until the factory is in place. It is also essential to have final and well defined contracts in place, with terms and conditions locked down to keep suppliers engaged and on track to original plans.

Second, recognize that current funding profiles mean NASA will have to evolve the launch vehicle to the final capability of 130mT to low-Earth orbit, which more importantly delivers approximately 50mT beyond low-Earth orbit. Given the current funding constraints only one new SLS element can be developed at a time. The decision for which element is next, is driven by LEO vs. BEO capability considerations and will directly impact the breadth of exploration missions which can be performed. If the true intent of the Exploration program is to explore beyond low-Earth orbit, the 50mT to BEO figure of merit should be used to guide the future evolution path. Supporting NASA as their evolution decisions emerge is important for stability.

Finally, assure constancy of purpose by keeping decisions made. This is applicable at all levels including keeping the architecture stable. For example, there is no need to revisit trades such as the one already completed that compared small vs. big rockets for deep space missions. The Augustine review panel concluded a big rocket is required for deep space exploration. Also in response to a question published in the April 30th 2012 Space News interview Norm Augustine was quoted "It was the view of both the reports that I worked on that we indeed need a heavy-lift launch system". It is also essential to get final and well defined contracts in place, to allow integrated baseline reviews early enough to control long term costs and schedules.

2. Current Progress

We have made significant progress on core stage development during the first nine months of the SLS Stages contract. In June we conducted the Stages Systems Requirement Review (SRR) and Systems Definition Review (SDR) two months ahead of the SRR contract requirement. We have also completed the first hardware deliveries, and have demonstrated a rapid increase in design release tempo.

On the manufacturing side, major tooling installations will begin at the Michoud Assembly Facility late this year, with a goal to have the factory complete and active in early 2014. The 2014 target date is dependent on government-led facility preparations.

Manufacturing process development is engaged with the Core Stage design team and is influencing the design to ensure affordable production. Manufacturing development test welds are underway using our new tooling and we will use four weld thicknesses and fifteen unique weld schedules for Core Stage rather than the fourteen weld thicknesses and seventy-four unique weld schedules for the Space Shuttle External Tank. To further reduce production costs, Core stage will use conventional rather than exotic materials for primary structure (AL2219 instead of AL2195). All major tool designs are on schedule to be completed by the end of the calendar year.

Avionics test units and prototypes are in the labs and are functional to retire hardware/software Integration risk early. Our single board software test bed flight computer was delivered to the avionics lab in April 2012. The redundant inertial navigation unit development test unit has also been delivered to the lab. These early prototype deliveries have enabled closed loop simulated vehicle fly out which were accomplished with the actual flight software. The flight computer critical design review was completed in August 2012.

Our next steps are exciting. Our design release tempo is increasing, and development testing will continue into 2013. We are currently targeting for a preliminary design review in late 2012 or early 2013. The design review will include key interface definitions which will drive the overall vehicle and ground systems design. Critical design review is scheduled for mid-2014 to support a first flight in 2017. We are also working to get final and well defined contracts in place, to allow integrated baseline reviews early enough to control long term costs and schedules.

3. Future Human Exploration and Scientific Missions Enabled by SLS

The SLS will provide an exploration capability beyond Apollo. SLS can be configured to transport crew, cargo, exploration elements, and science payloads to the far reaches of deep space.

As stated earlier, to accomplish any BEO mission requires a SLS type launch vehicle to escape Earth's gravity. The initial SLS capability rocket, using the smaller interim cryogenic propulsion upper stage, would enable capability demonstrations of the Orion MPCV. Early missions might include crew assessments of the deep space environment or telepresence lunar robotics. An evolved capability configuration, using a large upper stage with existing engines, would enable NASA to accomplish more ambitious HSF Exploration missions such as Earth-Moon Libration points, a return to the Moon, an Asteroid, or Mars precursor missions. All of these destination missions would benefit from the fully evolved SLS because they could be done at lower cost with fewer launches.

Robotic science missions will also be greatly enhanced by SLS. Robotic missions to the outer planets or a sample return mission from Mars would benefit from the greater lift capacity of SLS especially in its fully evolved capability. The additional payload volume of a full size fairing allows room for larger spacecraft. Next generation space telescopes will benefit from the SLS fairing because of the improved optics from larger mirrors. Outer planet missions with long journeys will benefit from the shorter trip times that SLS can offer.

In closing, our country's success in space has always been driven by NASA's unrelenting focus on mission objectives. The call for a robust capability and multiple destinations strikes an exciting challenge to create the space transportation architecture of the future. Today's plan for NASA – 1) space exploration beyond LEO, led by NASA with institutional funding; 2) supported by private enterprise providing space transportation to ISS in a public sector partnership with NASA – provides a balanced and cost effective approach to continue the great work being accomplished onboard ISS, and continue the great challenge of human space exploration to destinations beyond earth's orbit.