Hearing of the House Committee on Science, Space, and Technology
Subcommittee on Space

"Deep Space Exploration: Examining the Impact of the President's Budget"

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Testimony of Douglas R. Cooke
Cooke Concepts and Solutions

Thank you Chairman Babin and members of the committee for the opportunity to address important budget-related aspects of running Deep Space Exploration programs; the Space Launch System, the Orion Crew Vehicle and the associated Ground Systems. I applaud your bipartisan support. I also applaud the people at NASA and in industry who work diligently every day to make these and other important NASA programs successful.

My interest in human exploration of space has been a primary focus of my life and career since the flights of Yuri Gagarin and the Mercury astronauts. The success of programs to send people to the Moon, Mars and its moons is of paramount importance to me, and I believe important to everyone for many reasons. I began work at NASA after Apollo. I worked on Space Shuttle, Space Station and Exploration Programs anticipating the day Americans would travel again and explore places like the Moon and Mars. I believe in the idea that NASA human space flight should focus on exploration beyond Low Earth Orbit and transfer the routine travel to Earth orbit to American companies, as they are ready, safe and become certified.

The questions you are asking here are important ones that specifically address Deep Space Exploration, and the impacts of the President's budget. That is the part of the NASA budget I will focus on.

The most challenging aspect of management and successful execution of these programs is the impact of constrained budgets and unplanned changes to operating budgets, whether real or contrived. The technical challenges are fun in comparison and engineers can solve them.

The disparity between the President's Budget Request and budgets passed by Congress for Exploration vehicles (i.e., the Space Launch System and Orion) causes problems in managing these programs. It also causes issues in perceptions of program health.

To advance these programs Congress has consistently passed budgets each year that are significantly greater than the President's Budget Request (PBR). It has been clear Congress intends to follow through with this necessary funding, yet the Administration continues to ask for less.

NASA managers are required to plan the complex development schedules to the President's Budget Request over the 5-year runout, rather than the more probable budgets passed year after year by Congress. NASA fixed costs, including people and facilities are included, and are a higher percentage of the lower PBR budget, as compared with the budgets appropriated by Congress. This leaves less money for SLS and Orion progress. Constrained budgets limit what work can be accomplished in parallel and moves stated flight dates later than if they planned to Congressional budget runouts.

Another constraint applied to program budgets is protection for Termination Liability, where funds are held back to cover costs in case the program is terminated for the convenience of the government. Currently this is approximately $420M for SLS and Orion. Since these amounts are held back from spending, they are not available for program execution. It is the responsibility of the contractors to protect for this, but the biggest source of unnecessary uncertainty has been created by the Administration that has enforced this legal requirement using the most onerous terms.

The constrained President's budget also affects the content of the programs and the decisions NASA can make. NASA talks about evolving the SLS and Orion design developments. Their development is evolving because there isn't sufficient funding in the Administration's planning budget to design and build the components of the complete vehicles in parallel. That would be more efficient than taking wasteful intermediate steps. For example, the SLS Program could likely move forward with the Exploration Upper Stage if they could plan on receiving Congressional budget levels. The first test flight of the SLS will use the Interim Cryogenic Upper Stage (ICPS), a modified Delta upper stage with a lift capacity of about 70 metric tons to orbit. If the SLS Program could count on the appropriated budget levels, it could make the decision now to fund the Exploration Upper Stage (EUS). If it were ready for the first crew flight with Orion and SLS, NASA would save about $150M on human rating the ICPS for that flight, a cost that will otherwise be wasted in the long term. (The $150M human rating cost is according to a recent article, quoting NASA.) This $150M could then also be applied to the EUS development. The SLS would have lift capability of over 100 metric tons for exploration missions with the EUS upper stage.

The SLS design itself is a compromise, because there wasn't enough money in the President's budget to build what was considered to be the best design. However, it is still a very good design. The preferred design would have used the RS-68 engine for the Core Stage. These engines are currently used on the Delta. The engine production would have been least expensive long term but cost more in the near term. The RS-68 based Core Stage design would have required engine modifications necessary for human rating and a new large diameter tank design.

Since the Shuttle was being retired we could use the remaining used RS-25 Shuttle main engines for the first few SLS flights. They were in hand, human rated and low cost. RS-25s are more efficient than the RS-68s and can use the smaller Shuttle diameter

tank. We could not afford the larger diameter tank for the RS-68s at that time. As the existing inventory of Shuttle engines is used up, however, this engine design will have to be modified for follow-on engines to simplify the nozzle design and to make them less complex to manufacture.

Between Bill Gerstenmaier and myself, we decided we could afford only the Core Stage with RS-25s, because of the near term cost difference. It had to be started right away to catch up with other SLS components. We already had the five segment solid boosters well underway, in full scale testing, and under contract with ATK. We would come back to develop an advanced booster with more performance when we could afford it. We had an upper stage design for Ares I from the Constellation Program that could be modified under contract with Boeing, for SLS.

These are examples of the kinds of decisions that are driven by a severely constrained budget. At that time were “under the gun” to have an Independent Cost Assessment to show there was a reasonable chance of executing this program within the budget. That was before we would be allowed to announce the SLS design and move forward with the program. This announcement eventually occurred in September 2011.

Another example of budget inefficiency is associated with the Orion Pad Abort Test in 2010. The test was flawless. Unfortunately, contractors who were critical to the success of the test were laid off, because under funding constraints, the next Orion development priorities required the funding. So people with important knowledge and experience in an important spacecraft design were lost. That system will obviously be used again and the knowledge will have to be reestablished.

Under constrained budgets, the Orion Program has also had to back off of full concurrent development of its systems, which would allow for all systems to be developed in parallel in a more integrated manner. This has been necessary to focus on flight test milestones such as EFT-1 last December. Now they will focus on what is needed for the EM-1 test with SLS and evolve to the full crew vehicle design for EM-2. This too is inefficient as compared with full concurrent development. Generally speaking, the inability to use concurrent development will add cost to a program and draw out the schedule.

These are just examples of the inefficiencies associated with overly constrained budgets. Planning with Congressional Budget levels and NASA being able to state what is really needed for these programs would result in much more efficient developments and lower long-term costs to the nation.

Another source of inefficiency is budget instability or unanticipated changes. Contracts are negotiated with companies for content and schedule. Flight dates and expectations are set. When there are major policy or priority shifts, or disruptions to the budget process and funding, these detailed plans and their interdependencies have to be changed. Schedules and contracts are then changed at additional cost, adding to the problem. These issues are not new with the current programs.

My first major encounter with this problem was on Space Station Freedom, when in 1993 I was on a red team review. It was apparent that one major problem was that the budget was changed year to year resulting in major contract changes every year. Following the redesign and transition to the International Space Station Program, Congressional budgets were initially stable at $2.1B per year. Although not optimum from a development standpoint, we could plan to that and make steady progress.

Continuing Resolutions create perturbations in spending rates, as programs are required to plan for the least amount from the current year funding, or the House or Senate appropriations bill levels. NASA has tended to protect for the worst possible scenario based on anti-deficiency regulations. If an appropriations bill is passed later, any additional funds are released later in the year. Although beneficial to the program, this creates inefficient spending profiles.

Using the current case, the 2016 President's Request for SLS, Orion and Ground Systems is $2.863B. Under the current Continuing Resolution NASA should be spending at a rate commensurate with the 2015 level of $3.245B, or $382M more. In fact, the current spending level is $118M more than the President's Budget proposes for the year 2020 in their 5-year runout. On the other hand, for the fiscal year 2016 alone, this year's House Bill is $546M over the President's 2016 Request and the Senate's Bill is $647M more. These varying budget levels over a 5-year runout have a significant effect on schedule and program content, and ultimately the pace of human exploration.

If a budget bill is passed for NASA this year at these higher levels, the programs will adjust spending upward. Programs will make the most of these funds in advancing progress, but changing spending rates creates inefficiencies. NASA will still have to plan to the President's reduced level for 2017 and beyond. I am an advocate for the higher levels. If the Administration would propose budgets at needed levels within small percentage points of consistent Congressional levels, spending rates would be much more stable. This would allow for much more efficient program development at a faster pace, with much better value for the taxpayer. This is particularly true for long-lead time programs which are required to advance a robust space exploration program.

I believe a disparity in policy priorities has remained since the cancellation of the Constellation Program in February 2010. This was obviously the biggest program disruption imaginable. Congress immediately reacted to ensure that contracts would not be cancelled until a reasonable outcome could be resolved. That policy outcome was the NASA Authorization Act of 2010. It was not until September of 2011 that the final Administration hurdles were cleared. That was when the SLS program was announced.

Unstable budgets for Exploration programs did not begin or end there. Beginning budget projections for Exploration and Constellation in 2005 were adversely affected by budget issues. Reductions included funds for the last 2 Shuttle flights that OMB did not provide for. In 2009 there were deductions for Soyuz seats to ISS, the cost of cargo missions to ISS, transfers to help Shuttle Transition and Retirement and transfers to

other NASA mission priorities. Admittedly there were also natural program content changes with increased costs as designs were refined. There was a full year continuing resolution in 2007, and Exploration lost $577M. This did not affect Constellation, but we cancelled a lunar robotic lander mission to protect programs that were higher priority. This basically eliminated most Exploration Program flexibility afterwards. The original intent in the NASA planning was that Exploration would be increased with the wedge from retirement of the Space Shuttle. That did not happen, because the Shuttle funds went to other Administration policy priorities, not Exploration.

The 2010 President's Budget Request (generated in 2009) transferred out of the 2009 Exploration budget projected runout about $1B in 2011 to 1.7 B in 2013, basically eliminating human lunar mission long lead content through 2014. This was the budget that the Augustine Committee was given to evaluate in 2009. In their report "Seeking A Human Space Flight Program Worthy of a Great Nation," the Augustine Committee stated:

Options for the human spaceflight program: The Committee developed five alternatives for the Human Spaceflight Program. It found:

- Human exploration beyond low-Earth orbit is not viable under the FY 2010 budget guideline.
- Meaningful human exploration is possible under a less-constrained budget, increasing annual expenditures by approximately $3 billion in real purchasing power above the FY 2010 guidance.

- Funding at the increased level would allow either an exploration program to explore the Moon First or one that follows the Flexible Path. Either could produce significant results in a reasonable timeframe.

Constellation was cancelled the following February 2010.

I was asked to comment on use of the Joint Confidence Levels, an analysis used in the KDP-C milestone of SLS last year and the KDP-C milestone of Orion this year. These milestones led to NASA announcements of delays for SLS of one year and up to a two-year slip of the first crewed flight. Theoretically, the JCL is a good statistical analysis tool for evaluating uncertainties in programs that affect budget and schedule. An accurate JCL calculation requires meticulous collection of extremely detailed program schedules with planned tasks and their costs measured against available budget and reserves. To assemble this data is a monumental effort, costing significant program

resources. The JCL provides a valuable function for rigorous inspection of a program. However from direct experience with implementing it, I believe it has little utility for predicting schedule milestones in this current budget environment, when planning to the President's Budget Request rather than the actual Congressional appropriated budgets. Uncertainties created outside the program swamp uncertainties inside the program.

In contrast, the Commercial Orbital Transportation Services (COTS) development of cargo transportation capability to the International Space Station (ISS) did not require development of a JCL and doing so was not possible under a Space Act Agreement in any event. To my knowledge "Commercial Crew" capability development does not have a JCL either. I am not sure it is even possible, since these are fixed cost contracts with cost sharing. NASA also waived "Certified Cost and Pricing" from FAR regulations in these contracts. Therefore NASA does not necessarily have the cost data or programmatic insight to perform this independent analysis. In my view, the only estimates of flight dates are what the provider claims. Yet for SLS and Orion, scrutiny is intense and NASA announcements of flight date slips are due to a JCL that is based on questionable assumptions. JCL outcomes can become self-fulfilling prophecies.

Because budgets are actually higher year-to-year compared to the President's Budget Request, programs maintain earlier planning dates. This is positive, but the situation creates confusion and headlines. To their credit, NASA is trying to mitigate this confusion internally and externally. It would be better if the source of uncertainty were not there in the first place.

Even under the duress of these burdens, excellent progress is being made on Deep Space human space flight programs. Companies from our aerospace industrial base are now building flight hardware that we will see launched and flown. SLS and Orion are these first critical developments for our human exploration of the Solar System. They have both reached their Key Decision Point-C (KDP-C) milestones where NASA commits to their technical, cost and schedule baselines.

The International Space Station (ISS) is providing the means for human research, testing and technology demonstrations in preparation for human exploration missions to the Moon, Mars and other destinations. Astronaut Scott Kelly and Cosmonaut Mikhail Kornienko have completed six months of a one year stay on the ISS, adding to the significant body of human research that is being conducted to prepare for Mars missions. Six months is the approximate transit time between the Earth and Mars. Methodical research and technology testing on ISS provide information needed for astronaut health and leads to reliable systems for them to thrive and be productive on exploration missions. Great progress is being made on mitigating the effects of weightlessness and other issues.

NASA is well into development of a heavy lift rocket, the Space Launch System (SLS). It is essential for Mars missions to minimize the number of launches and provide large payload volumes. The SLS has recently completed its Critical Design Review (CDR),

where the program demonstrated that it is ready to proceed to full-scale fabrication, assembly, integration and testing. This will lead to its first test flight with Orion, EM-1. The SLS core stage welding of the first tank is underway. Avionics are being tested. The five segment solid booster project is preparing for the second full scale qualification test firing. The RS-25 engines have completed the first series of engine firings at 109% thrust levels, higher than was flown on the Space Shuttle. A new engine controller has been designed to replace the Shuttle controller and was tested in this series.

The Orion spacecraft, successfully flight tested last December, will be the launch and high speed entry spacecraft needed to safely return exploration crews.The successful Orion EFT-1 flight test demonstrated many spacecraft systems, including navigation, guidance, flight control, ground control of the spacecraft, electronic systems, the high speed entry heat shield, landing systems, ground processing and others. Efficiencies in the design and manufacturing are being made based on that experience. The heat shield is being lightened. Welds have been significantly reduced to improve manufacturing. The next flight spacecraft is now being built. Between SLS and Orion, the Michoud Assembly Facility in Louisiana is filling with flight hardware.

Our international partners want to explore with us. For that reason, they also depend on the success of these programs; and genuine progress is being made. With the progress made and the amazing potential for future exploration, the SLS and Orion programs deserve good stewardship. The NASA-industry team should be afforded the opportunity to manage to the best of their abilities, in a stable, positive budget environment. The espoused goal of going to Mars needs to be supported with appropriate funds and positive help from the Administration, including OMB and OSTP.

In addition to the budget issues discussed, there are a related set of points. To provide the best opportunity for success and efficiency for all programs, I believe a strong effort needs to be made by NASA to draw the appropriate line in:

- Division of development responsibilities between government (NASA) and contractors.
- Insight and oversight of programs
- Streamlined human rating requirements, including safety.
- Verification of requirements and hardware certification
- Parts quality and inspection
- Contracting practices

The objective is to have the most efficient NASA programs possible, while preserving safety, accountability for the essential requirements, and accountability for taxpayer dollars.

There are significant differences between the way “Commercial Cargo and Crew” and the more traditional SLS and Orion programs are run with regard to these points. With the experience gained thus far, best practices should be established that could be applied to both.

Again, I want to thank this committee and your staff again for your continued support of NASA and human space flight.

I welcome your questions.

Short Biography: Douglas R. Cooke

Doug Cooke is an aerospace consultant with over 42 years in human space flight programs. He advises on company and program strategies, program management, proposal development, strategic planning and technical matters. He retired from NASA after a 38-year career at Johnson Space Center (JSC) and NASA Headquarters, where in his last 3 years he served as the Associate Administrator of the Exploration Systems Mission Directorate (ESMD). In his last year at NASA, he led efforts to adopt the current vehicle designs for the Orion and Space Launch System. During his career, he had senior leadership responsibilities and achievements during critical periods of the Space Shuttle, ISS, and Human Exploration human spaceflight programs. As Associate Administrator, Mr. Cooke was responsible for the Constellation, Lunar Reconnaissance Orbiter, Lunar Crater Observation and Sensing Satellite, Commercial Cargo and Crew, Human Research and Exploration Technology Programs. Prior to this he was Deputy Associate Administrator of ESMD, since its formation in 2004. He has been in leadership positions for most of NASA's advanced studies in human space exploration since 1989, including the White House studies "The 90 Day Study" in 1989 and the "Synthesis Group Report, America at the Threshold" in 1990. He also had several high priority detail assignments to other NASA centers and NASA Headquarters. Mr. Cooke was NASA technical advisor to the Columbia Accident Investigation Board in 2003. He is on the Board of Advisors for the Coalition for Space Exploration and a member of the National Research Council Space Technology Roundtable; Mr. Cooke has also been a member of the International Space Station (ISS) Advisory Committee.

Mr. Cooke has received the Presidential Distinguished Rank Award, Presidential Meritorious Rank Award, NASA Distinguished Service Medal, three NASA Exceptional Achievement Medals, NASA Outstanding Leadership Medal, NASA Exceptional Service Medal, two JSC Certificates of Commendation, a number of NASA Group Achievement Awards, and the Space Transportation Association Lifetime Achievement Award. Most recently he was awarded the Texas A&M Outstanding Aerospace Engineer Alumni Award. Mr. Cooke received a B.S. in aerospace engineering from Texas A&M University.