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

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

CHARTER

Friday, October 9, 2015
9:00 a.m. – 10:30 a.m.
2318 Rayburn House Office Building

Purpose

At 9:00 a.m. on Friday, October 9, 2015, the Subcommittee on Space will hold a hearing entitled *Deep Space Exploration: Examining the Impact of the President's Budget*. The purpose of this hearing is to examine the President's five-year budget projection for the Space Launch System and Orion crew vehicle development programs. The Subcommittee will evaluate NASA's plans for future major tests and milestones and how the budget requested by the Administration affects development schedules and milestones for these programs.

Witnesses

- **Mr. Doug Cooke –** Owner, Cooke Concepts and Solutions and former NASA Associate Administrator for Exploration Systems
- **Mr. Dan Dumbacher-** Professor of Practice, Purdue University and former NASA Deputy Associate Administrator, Human Exploration and Operations Mission Directorate

Background

Following the Space Shuttle *Columbia* accident in February 2003, the subsequent investigation, and the policy debate on the future of human spaceflight with the retirement of the Space Shuttle, President George W. Bush announced a new "Vision for Space Exploration" in January 2004, to reinvigorate and redirect NASA's human exploration program. The policy outlined the next major steps for NASA with the International Space Station, missions for astronauts to return to the Moon, onward to Mars and beyond. NASA was directed to "implement an integrated, long-term robotic and human exploration program structured with measurable milestones and executed on the basis of available resources, accumulated experience, and technology readiness."[1] The Constellation Program—comprised of the Orion Crew Exploration Vehicle, Ares I crew launch vehicle, Ares V heavy-lift launch vehicle, along with new space suits and the Altair lunar lander—was born out of this vision. The Constellation Program began with NASA's budget request for Fiscal Year 2005 and development of these systems continued until Fiscal Year 2010 (FY10).

[1] National Aeronautics and Space Administration-*The Vision for Space Exploration, February 2004.* Retrieved at http://www.nasa.gov/pdf/55583main_vision_space_exploration2.pdf

President Barack Obama significantly cut the Constellation program's 5-year budget projection in the Administration's FY10 budget request released in May 2009,[2] and then directed NASA, through the Office of Science and Technology Policy, to establish a blue ribbon committee to review the plans and programs going forward. The Committee report observed that "[t]he U.S. human spaceflight program appears to be on an unsustainable trajectory" under the 10-year funding profile assumed in the President's FY10 budget.[3]

The President's FY11 budget request, released in February 2010 proposed to cancel the entire Constellation program. Additionally, the President proposed to cancel a return mission to the Moon in favor of a trip to an asteroid and then to orbit Mars. The President outlined his plans for NASA in a speech at Kennedy Space Center in April 2010. Later that year, Congress authorized some of the changes to the human exploration program, while mandating continued development of the Orion Multipurpose Crew Vehicle (Orion) and heavy-lift Space Launch System (SLS).[4]

Since the NASA Authorization Act of 2010, the President has consistently requested lower levels of funding for the SLS and Orion programs. Despite these annual reductions by the Administration, Congress continued to fund the programs at the levels necessary to keep the programs on track, eventually leading to the achievement of successful milestones such as Exploration Flight Test – 1 (EFT), the first uncrewed flight of Orion; Qualification Motor Test – 1 (QM-1), the first test of the five segment booster; and a test of the RS-25 engines that will power the SLS.

On August 27, 2014, NASA announced a one year slip of EM-1, the first launch of SLS, from 2017[5] to 2018.[6] This announcement was made despite numerous statements from NASA officials to Congress that the program was on schedule and that no additional funding was needed. Last month, NASA made a similar announcement about the Orion, pushing the launch readiness date for Exploration Mission-2 (EM-2) back two years to no later than 2023[7] from an original date of 2021.[8]

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[2] See page EXP-2 at http://www.nasa.gov/pdf/345955main_8_Exploration_%20FY_2010_UPDATED_final.pdf.

[3] See pages 7 and 9 of the report *Seeking a Human Spaceflight Program Worthy of a Great Nation* by the Review of U.S. Human Spaceflight Plans Committee (October 2009) found at: http://www.nasa.gov/pdf/617036main_396093main_HSF_Cmte_FinalReport.pdf

[4] NASA Authorization Act of 2010 (P.L. 111-267) found at: https://www.congress.gov/111/plaws/publ267/PLAW-111publ267.pdf

[5] Verbal testimony of NASA Administrator Charles F. Bolden during question and answer period before the House Committee on Science, Space, and Technology, Hearing Titled "An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014," April 24, 2013.

[6] NASA Press Release, August 27, 2014, "NASA Completes Key Review of World's Most Powerful Rocket in Support of Journey to Mars." Retrieved at: https://www.nasa.gov/press/2014/august/nasa-completes-key-review-of-world-s-most-powerful-rocket-in-support-of-journey-to

[7] NASA Press Release, September 16, 2015, "NASA Completes Key Milestone for Orion Spacecraft in Support of Journey to Mars." Retrieved at: https://www.nasa.gov/press-release/nasa-completes-key-milestone-for-orion-spacecraft-in-support-of-journey-to-mars

[8] Verbal testimony of NASA Administrator Charles F. Bolden during question and answer period before the House Committee on Science, Space, and Technology, Hearing Titled "An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014," April 24, 2013.

Exploration Systems Development Budget

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Exploration Systems Development	3,115.2	3,245.3	2,862.9	(382.4)	2,895.7	2,971.7	3,096.2	3,127.1
Orion Multipurpose Crew Vehicle	1,197.0	1,194.0	1,096.3	(97.7)	1,119.8	1,122.9	1,126.7	1,138.0
Space Launch System	1,600.0	1,700.0	1,356.5	(343.5)	1,343.6	1,407.6	1,516.5	1,531.6
Exploration Ground Systems	318.2	351.3	410.1	58.8	432.3	441.2	453.0	457.5

The Exploration Systems Development program is responsible for the design, construction, and integration of the next step in human exploration beyond low-Earth orbit (LEO). There are three separate systems that make up the program; the SLS heavy lift rocket, the Orion, and Exploration Ground Systems (EGS). The President's budget request for Exploration Systems Development is $2.86 billion, an 11.7 percent reduction from the FY15 appropriation.

Orion Crew Vehicle – The Orion is the next generation crew vehicle that will carry astronauts beyond LEO. Although Congress has consistently appropriated roughly $1.2 billion per year for the development of Orion in recent years, NASA requested a reduction in funding for the fourth year in a row. The request of $1.096 billion is a reduction of approximately eight percent from the FY15 enacted levels. Last December, NASA completed Exploration Flight Test 1 (EFT-1), which is the first in a series of flight tests for the SLS/Orion systems. EFT-1 was a major success and was the subject of a Subcommittee hearing last December.[9]

Space Launch System – The SLS is the next generation heavy lift launch vehicle that will carry astronauts beyond LEO and will eventually have a 130 ton "lift to low-Earth orbit" capability, as required by federal law.[10] This year's request includes a reduction of approximately $343.5 million (20 percent) relative to the enacted FY15 levels.

Exploration Ground Systems - The Exploration Ground Systems program received an increase in the President's budget request of $58.8 million as a result of continued work at the Kennedy Space Center to ensure the facility is prepared to handle the SLS in 2018. NASA has stated that this work is on track for that launch date. Both the Government Accountability Office (GAO) and the NASA Inspector General have cautioned that potential schedule risks for the ground systems program could delay EM-1.[11]

[9] Subcommittee on Space hearing: An Update on the Space Launch System and Orion: Monitoring the Development of the Nation's Deep Space Exploration Capabilities. See: http://science.house.gov/hearing/subcommittee-space-hearing-update-space-launch-system-and-orion-monitoring-development

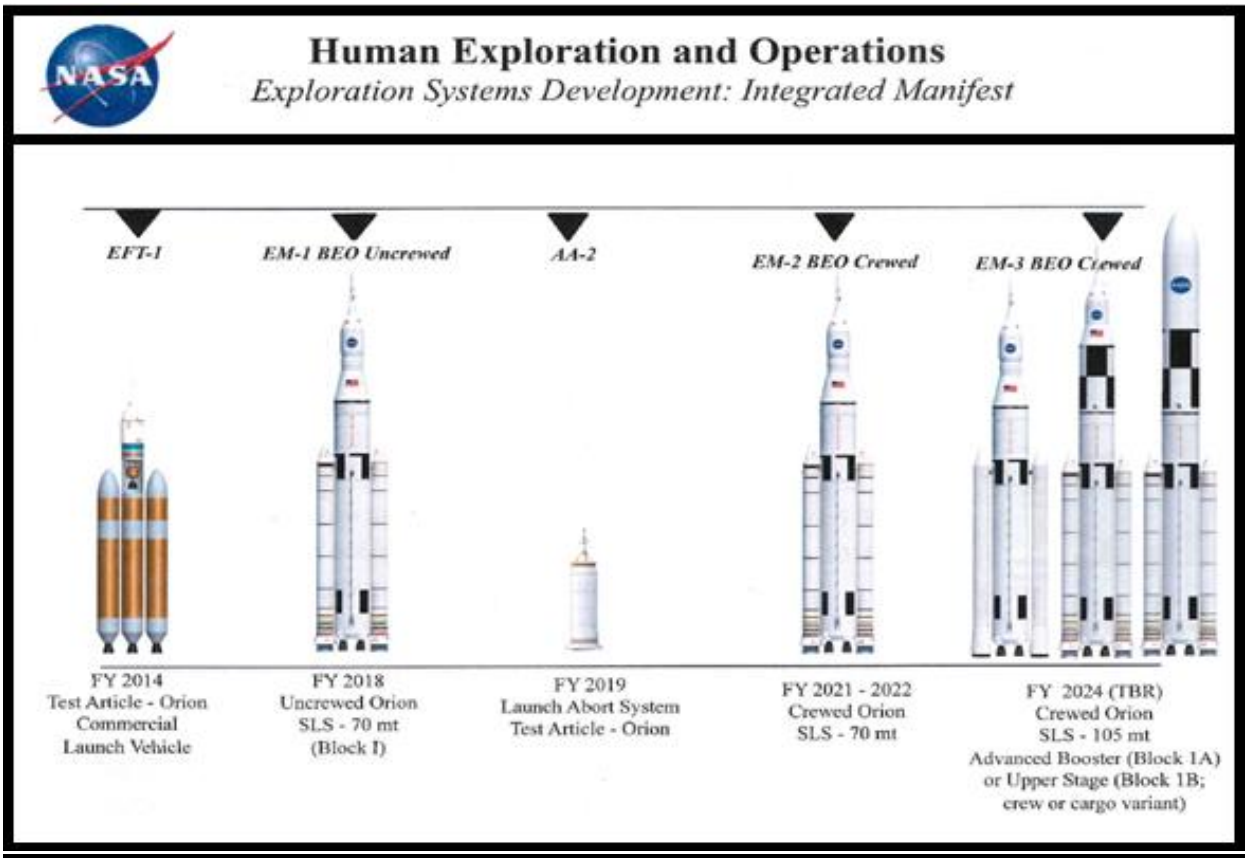
[10] 51 USC 18322(c)

[11] Testimony of Cristina T. Chaplain, Director, Acquisition and Sourcing Management, before the House Committee on Science, Space and Technology, December 10, 2014. http://gao.gov/assets/670/667350.pdf

SLS and Orion Schedule

The first test flight of the Orion program was conducted on December 5, 2014. The Orion was launched atop a United Launch Alliance Delta IV Heavy rocket from Cape Canaveral Air Force Station. The mission was conducted for NASA by Lockheed Martin under a commercial launch license. The Exploration Flight Test-1 (EFT-1) was conducted to validate various systems including Orion's heat shield, avionics, and parachutes used for landing. In FY18, NASA plans to launch the SLS for the first time with an uncrewed Orion to a circumlunar orbit. This flight, Exploration Mission-1 (EM-1) will demonstrate the integrated capability of both systems. The Exploration Mission-2 (EM-2)–planned for not later than 2023–would launch an Orion and SLS with as many as four astronauts.

The Orion and SLS programs are not currently baselined to the same launch readiness date. The Orion program baseline is committed for the EM-2 launch and the SLS program is committed for the EM-1 launch. NASA informed the Committee in previous responses to questions for the record that it will not create an integrated EM-1 launch date until the end of calendar year 2015 after all the element Critical Design Reviews (CDRs) are complete.[12]



[12] Testimony of Associate Administrator Bill Gerstenmaier in response to questions for the record for Science, Space, and Technology, Subcommittee on Space hearing on December 10, 2014, *An Update on the Space Launch System and Orion: Monitoring the Development of the Nation's Deep Space Exploration Capabilities.*

SLS KDP-C

In August of 2014, NASA completed Key Decision Point-C (KDP-C) for the SLS program, which included a cost and schedule commitment. In this agency baseline commitment, the Administration slipped the launch readiness date for EM-1 to November 2018 despite numerous assertions from the Administration that no additional funds beyond previous requests would be needed to keep the SLS and Orion on schedule. NASA program managers contend that there is a two pronged process to managing the SLS program.[13] The program has the official NASA agency baseline commitment used for cost controls and accounting measures as required under federal law[14] and separate from that is a "management agreement" or "internal planning date" used by program managers.[15]

According to NASA program managers, when building a JCL, they project funding levels in line with the President's budget request, as opposed to the amount previously appropriated for the program in the previous fiscal year or historical norm.[16] In the FY13, FY14, and FY15 budget requests, the Administration asked for reductions of $157.5 million, $75.1 million, and $219.7 million respectively.[17] Had Congress agreed to the requests compared to the enacted appropriation, the SLS program would have incurred over $450 million in reductions.

In testimony before the House Committee on Science, Space, and Technology on April 24, 2013, Administrator Bolden testified on the topic of SLS funding reductions, saying:

> *"If I added $300 million to the SLS program, you wouldn't know it."*[18]

In that same hearing, in reference to the President's budget request, when asked about reductions to the program, he added:

> *"We have asked for, and I think Bill Gerstenmaier, the head of the Human Exploration Operations Mission Directorate, has stated over and over that this is the amount of money that we need to deliver SLS on the date and time that we said, 2017 for the inaugural mission..."*[19]

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[13] NASA Associate Administrator Bill Gerstenmaier testified on December 10, 2014 that NASA was internally planning to a different launch readiness date for the SLS than was in the agency baseline commitment. Hearing transcript retrieved at http://www.gpo.gov/fdsys/pkg/CHRG-113hhrg92331/html/CHRG-113hhrg92331.htm.

[14] 51 USC 30104

[15] NASA Associate Administrator Bill Gerstenmaier testified on December 10, 2014. Hearing transcript retrieved at http://www.gpo.gov/fdsys/pkg/CHRG-113hhrg92331/html/CHRG-113hhrg92331.htm.

[16] NASA Associate Administrator Bill Gerstenmaier testified on December 10, 2014 that the development of the JCL and the agency baseline commitment were "consistent with the President's budget request" and that NASA "[has] been trying to work to an earlier schedule and that is based on the risk mitigation for the extra funding we have received from Congress, so we have kind of kept both plans in place." Hearing transcript retrieved at http://www.gpo.gov/fdsys/pkg/CHRG-113hhrg92331/html/CHRG-113hhrg92331.htm.

[17] *Ibid.*

[18] Verbal testimony of NASA Administrator Charles F. Bolden during question and answer period before the House Committee on Science, Space, and Technology, Hearing Titled "An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014," April 24, 2013.

[19] *Ibid.*

Following this hearing, the members of the Committee submitted additional questions for the record to follow up on these statements. In response to a related question from Space Subcommittee Chairman Palazzo, Administrator Bolden stated:

> "*The FY2014 President's Budget Request….provides the necessary funding profile required to keep SLS, Orion, and EGS moving forward to achieve EFT-1 in 2014, EM-1 in 2017, and EM-2 in 2021."*[20]

Despite these statements, the GAO noted: "According to the program's risk analysis…the agency's current funding plan for SLS may be $400 million short of what the program needs to launch by 2017."[21] Despite these claims and the finding of the GAO, when NASA released the KDP-C Decision Memo and the agency baseline commitment a year later, it supported a slip of one year in the launch readiness date for SLS from 2017 to 2018.

Orion KDP-C

Similarly, the Orion program recently finished KDP-C and released an agency baseline commitment. The Orion is NASA's next generation human exploration vehicle. It will have the capability to carry astronauts to the Moon and Mars and will be the first deep space human exploration vehicle to launch since the Apollo program.

The next test of Orion, Exploration Mission-1 (EM-1), is scheduled for no later than 2018 (as supported by the delayed launch readiness date for SLS in the Administration's KDP-C) and will include the first launch of the SLS with the Orion. Like EFT-1, EM-1 will not be crewed, but will test critical life support systems. The final test, Exploration Mission-2 (EM-2), was originally scheduled for 2021 (now not later than 2023) and will include the SLS and Orion. It will have at least two crewmembers aboard. That flight will take astronauts to lunar orbit and back and will be the first time humans have been to the Moon since Apollo 17 (December 1972)

The President's budget request for the Orion has been consistently lower than NASA's own cost estimates to maintain mission milestones. In the FY13, FY14, and FY15 budget requests, the Administration asked for reductions of $175.1 million, $87 million, and $144.2 million respectively.[22] Had Congress agreed to the requests compared to the enacted appropriation, the Orion program would have incurred over $400 million in reductions, and would likely face potentially longer delays.

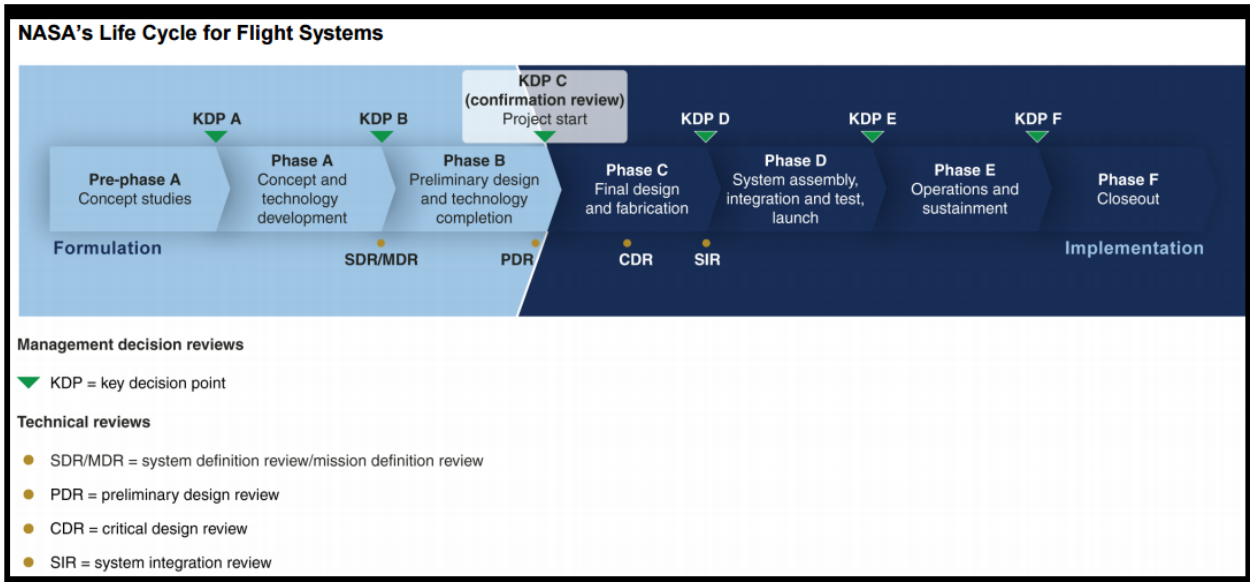
As with the SLS, the Orion KDP-C resulted in a launch readiness slip and the promise that program managers were working towards different internal dates than the agency baseline commitment.[23] The baseline includes a "no later than" date of April 2023 for launch readiness on

[20] Answers to Questions for the Record from NASA Administrator Charles F. Bolden regarding House Committee on Science Space and Technology Hearing Titled "An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014," October 28, 2013.
[21] Space Launch System - Resources Need to be Matched to Requirements to Decrease Risk and Support Long Term Affordability. Government Accountability Office, Retrieved at http://www.gao.gov/products/GAO-14-631
[22] President's Budget Requests for Fiscal Year 2013, Fiscal Year 2014, and Fiscal Year 2015.
[23] NASA Press Release, September 16, 2015, "NASA Completes Key Milestone for Orion Spacecraft in Support of Journey to Mars." Retrieved at https://www.nasa.gov/press-release/nasa-completes-key-milestone-for-orion-spacecraft-in-support-of-journey-to-mars

the EM-2 mission. This is an indication that the Administration believes, with a 70 percent confidence level, that if the President's budget request was enacted, the Orion could be ready to launch for a crewed mission by 2023, directly in contradiction to the Administration's previous budget requests and the testimony of the Administrator which touted a launch readiness of 2021.[24]

Agency Baseline Commitment

All flight development programs at NASA go through a specific development cycle which includes management key decision points (KDP) to determine the fitness of a program for the next stage of agency commitments.[25] The graphic below from the GAO illustrates this lifecycle process and the various stages of development.[26]



Each of the KDP's represents a "gate" that the program must pass through to proceed to the next phase of development. There are three sub-phases of development in the "formulation" phase of the program. The most critical milestone for a flight development program, KDP-C, takes the program through preliminary design review into the implementation phase of development. During KDP-C, NASA makes an "agency baseline commitment"[27] to Congress and the Office of

[24] Answers to Questions for the Record from NASA Administrator Charles F. Bolden regarding House Committee on Science Space and Technology Hearing Titled "An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014," October 28, 2013.
[25] Government Accountability Office Report Gao-15-320SP, released March 2015, "NASA: Assessments of Selected Large-Scale Projects." P. 5. Retrieved at http://www.gao.gov/assets/670/669205.pdf
[26] *Ibid.*,p. 6.
[27] NASA Procedural Requirement 7120.5E defines the agency baseline commitment as "an integrated set of project requirements, cost, schedule, technical content, and an agreed-to JCL that forms the basis for NASA's commitment to the external entities of OMB and Congress. Only one official baseline exists for a NASA program or project, and it is the Agency Baseline Commitment."

Management and Budget (OMB) on schedule and cost requirements. Progress on the project is measured against this baseline, including statutory reporting requirements.[28]

As part of the agency baseline commitment, NASA program managers provide Congress and OMB with a "joint cost and schedule confidence level" that justifies the agency baseline commitment on cost and schedule.[29]

Joint Cost and Schedule Confidence Level (JCL)

The JCL process essentially makes a commitment to Congress and OMB that the agency believes, given a specific schedule and budget requirements, it is confident that that program will be able to close out within the parameters of the agency baseline commitment. Beginning in 2009, in response to recommendations from GAO, NASA implemented a minimum 70 percent JCL for all projects undergoing a KDP-C.[30]

The development of a JCL is technical in nature and requires significant data analysis and risk modeling. According to the NASA Cost Estimating Handbook (CEH), "the backbone to the entire JCL analysis is the schedule. Having a quality schedule with logic networking is the key to a successful JCL."[31] According to the CEH, there is a six step process for the development of a JCL:[32]

> *Step Zero: Identify goals for the JCL*
> *Step One: Build a JCL schedule/logic network (a summary analysis schedule)*
> *Step Two: Load cost onto the schedule activities*
> *Step Three: Incorporate risk list*
> *Step Four: Conduct uncertainty analysis*
> *Step Five: Calculate and view results, and iterate as required*

According to NASA's CEH, the second step in the JCL development process is to build a schedule and logic network and then load cost for the schedule into the analysis. Put plainly, in the creation of the JCL, one must first determine the schedule and then determine the cost associated with that schedule. The CEH states that "once a robust schedule that accurately portrays project work flow is established, the next step is to costload the schedule. Cost loading is accomplished by mapping cost to schedule. You want to load the cost effort for each task by how that cost (or effort) interacts with the schedule activity." It is important to note that, in this

[28] Section 30104 of title 51, U.S. Code, requires NASA to notify Congress if a program with a life-cycle cost of greater than $250 million is going to exceed its agency baseline commitment for either; cost of greater than 15 percent, or schedule by greater than six months. Programs that slip more than 25 percent must be reauthorized by Congress.
[29] NASA Procedural Requirement 7120.5E defines the joint cost and schedule confidence level as "(1) The probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date. (2) A process and product that helps inform management of the likelihood of a project's programmatic success. (3) A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not a specific methodology (e.g., resource-loaded schedule) or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from appropriations or managed outside of the project. JCL calculations include the period from KDP C through the hand over to operations, i.e., end of the on-orbit checkout.
[30] NASA Inspector General Report No. IG-15-024, "Audit of NASA's Joint Cost and Schedule Confidence Level Process." P.3. Retrieved at http://oig.nasa.gov/audits/reports/FY15/IG-15-024.pdf
[31] NASA Cost Estimating Handbook, J.1.6.2, p. J-11. Retrieved at http://www.nasa.gov/sites/default/files/files/CEH_Appj.pdf
[32] *Ibid.*

process, the development of a JCL schedule comes first and cost loading comes second. This sequence ensures that project development is driven by a logical schedule, rather than budget.

Key Questions

- When developing the JCL for the SLS and Orion, did NASA start with a schedule and cost load that schedule, or did it start with a budget and build a schedule to match it?
- When the Administration requires NASA to use the President's Budget Request instead of realistic appropriations levels as a baseline for the JCL, how does that effect the development of the program?
- How do large discrepancies between Congressional appropriations and budget requests effect management of the programs?
- Are NASA managers required to develop program development plans based on the President's budget request, or are they free to present realistic timelines and budgets in line with historic appropriation levels?
- How have the Administration's budget requests for large reductions in the SLS and Orion budgets affected the ability of NASA managers to run these programs efficiently and effectively?
- How are the risk reduction, schedule, and cost controls used by NASA to manage these programs affected by favorable Congressional appropriations?