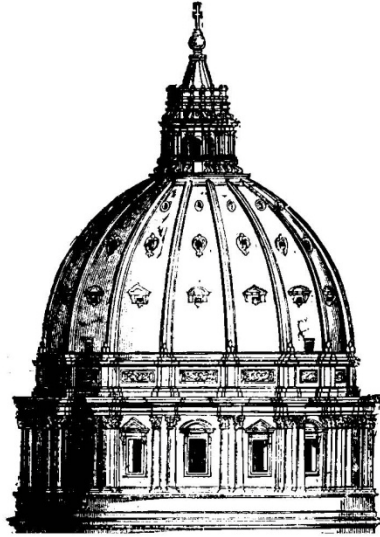


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# NASA's Constellation Program: To Fly or Not to Fly

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## SUMMARY

Since 1958, the National Aeronautics and Space Administration (NASA) has been America's space agency. According to the agency's website, "NASA has accomplished many great scientific and technological feats in air and space." While true, that does not absolve the White House and Congress from their responsibility to review and scrutinize NASA's programs and overall execution of its mission.

NASA was conceived in an era when people thought big government could accomplish anything. Today, most Americans realize the power of competition and the expansive capabilities of the commercial sector. As noted in a May 17, 2010 *Space News* editorial, "we are stuck in the old space economy, characterize[d] by big government programs, a few big contractors, little competition and no growth. In contrast, the new space economy will have a mix of government and commercial programs, a diversity of contractors, strong competition and exponential growth."<sup>1</sup>

One program that is symbolic of the "old" NASA and what the "new" NASA needs to become is Constellation, the latest in a long series of troubled post-Apollo human spaceflight programs within the U.S. space agency. Constellation is already years behind schedule with cost estimates growing well beyond initial promises and, more importantly, any realistic view of future NASA resource availability.

The major components of Constellation include the Ares I medium-lift and Ares V heavy-lift boosters, the Orion crew capsule, the Earth Departure Stage and the Altair lunar lander. The stated goals of the program were to gain significant experience in operating away from Earth's environment, developing new technologies required for exploring the solar system and conducting fundamental science. In 2006, the Government Accountability Office (GAO) estimated that the total budget required for implementing the Constellation Program (through initial lunar missions) was nearly \$230 billion.<sup>2</sup> In 2009, the GAO concluded that "while the agency has already obligated more than \$10 billion in contracts, at this point NASA does not know how much Ares I and Orion will ultimately cost, and will not know until technical and design challenges have been addressed."<sup>3</sup>

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<sup>1</sup> *Space News*, "The New Space Economy," United Launch Alliance, May 17, 2010.

<sup>2</sup> Government Accountability Office, "NASA: Long-Term Commitment to and Investment in Space Exploration Program Requires More Knowledge," July 2006, <http://www.gao.gov/new.items/d06817r.pdf>.

<sup>3</sup> Government Accountability Office, "NASA: Constellation Program Cost and Schedule Will Remain Uncertain Until a Sound Business Case is Established," August 2009, <http://www.gao.gov/products/GAO-09-844>.

Due to the programmatic, technical and long-term sustainability concerns raised by the GAO, the Congressional Budget Office (CBO) and others,<sup>4</sup> in May 2009 President Obama appointed former aerospace executive Norm Augustine to lead the Review of Human Spaceflight Plans Committee to propose new options for human space exploration.

As a result of the findings of the GAO, CBO and the Review of Human Spaceflight Plans Committee, the President's fiscal year (FY) 2011 budget for NASA proposed to cancel major elements of the Constellation program such as Ares 1, Ares V and the Orion crew capsule. (The Administration subsequently revised its plan to continue the development of Orion as a crew escape capsule.) The Administration's new approach to human space exploration fully embraces many of the initial principles of President George W. Bush's exploration policy from 2004, such as relying more on America's growing commercial space industry.

Despite this effort to terminate an enormously wasteful and ineffective program and harness America's relentless free enterprise, Senator Richard Shelby (R-Ala.), has indicated that he is willing to do whatever it takes to save the program. *The Huntsville Times* reported on May 15, 2010, that "U.S. Sen. Richard Shelby, R-Tuscaloosa, has raised the stakes in the fight over NASA's Constellation program by attaching a measure to protect it to an emergency war funding bill that must pass Congress this year."

According to Citizens Against Government Waste's *2010 Congressional Pig Book* database, Sen. Shelby earmarked 60 projects worth \$173 million in fiscal year 2010, so it is no surprise that he is abusing the appropriations process by slipping the Constellation program into the emergency spending bill. This is one of many reasons why taxpayers remain outraged over excessive spending in Washington.

## CONSTELLATION PROGRAM ORIGINS AND HISTORY

### *The Vision for Space Exploration*

On January 14, 2004, President George W. Bush announced his "Vision for Space Exploration" with the goal to "extend human presence across the solar system."<sup>5</sup> Resulting from the Columbia Accident Investigation Board's recommendation that human spaceflight required a more substantial purpose than simply swimming in the shallow waters of low Earth orbit, President Bush wanted NASA to send astronauts further out into the frontier. To implement his vision, the President instructed NASA to:

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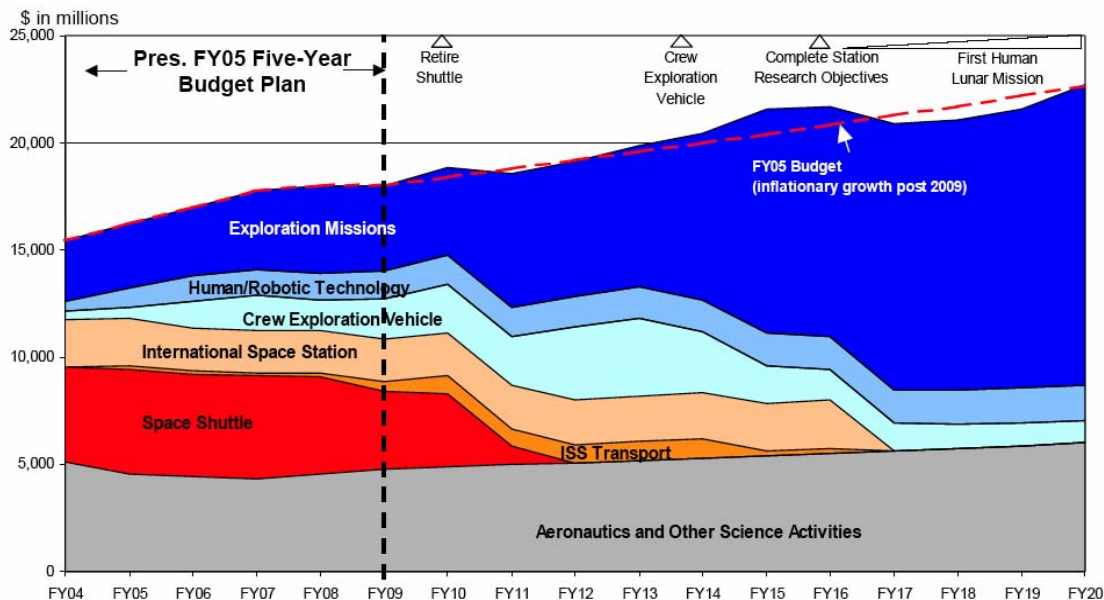
<sup>4</sup> Space Frontier Foundation, "Unaffordable and Unsustainable," 2006, <http://www.scribd.com/doc/19093881/Unaffordable-Unsustainable-Signs-of-Failure-in-NASAs-Earth-to-orbit-Transportation-Strategy>.

<sup>5</sup> NASA, "The Vision for Space Exploration," February, 2004, [http://www.nasa.gov/pdf/55583main\\_vision\\_space\\_exploration2.pdf](http://www.nasa.gov/pdf/55583main_vision_space_exploration2.pdf).

- Complete the International Space Station (ISS) by the end of 2010 and retire the Space Shuttle;
- Acquire crew and cargo transportation to and from the ISS, as required, after the Space Shuttle is retired;
- Develop a new Crew Exploration Vehicle (CEV, later renamed Orion) to provide crew transportation for missions beyond the ISS and low Earth orbit;
- Conduct an initial crewed flight of Orion exploration no later than 2014;
- Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than 2020; and
- Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions and after successfully demonstrating sustained human exploration missions to the Moon.

The focus of this plan was human exploration beyond low-Earth orbit. A cost estimate was not originally provided with this new plan. However, FY 2005 NASA budget documents indicated that \$12.6 billion would be added to its otherwise flat line human spaceflight budget through 2009.<sup>6</sup>

### NASA's Exploration Budget Estimates, 2004 (NASA)<sup>7</sup>



NOTE: Exploration missions – Robotic and eventual human missions to Moon, Mars, and beyond  
 Human/Robotic Technology – Technologies to enable development of exploration space systems  
 Crew Exploration Vehicle – Transportation vehicle for human explorers  
 ISS Transport – US and foreign launch systems to support Space Station needs especially after Shuttle retirement

<sup>6</sup>Congressional Research Service, "The National Aeronautics and Space Administration's FY 2005 Budget Request: Description, Analysis, and Issues for Congress," December 10, 2004, <http://ncseonline.org/nle/crsreports/04dec/RL32676.pdf>.

<sup>7</sup>NASA, "Strategy Based on Long-Term Affordability," 2004, <http://history.nasa.gov/sepbudgetchart.pdf>.

*Aldridge Commission and the Steidle Era*

In announcing the Vision for Space Exploration, President Bush appointed former Undersecretary of Defense Pete Aldridge to chair a commission that would develop strategic recommendations for implementing the plan. The recommendations included that “NASA recognize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA, and most immediately in accessing low-Earth orbit.”<sup>8</sup>

Bush’s NASA Administrator, Sean O’Keefe, appointed retired Navy Admiral Craig Steidle to manage what became known as the Exploration Systems Mission Directorate. Committed to avoiding NASA’s history of failed monolithic hardware development efforts, Steidle took a very open (and non-NASA-like) approach to gathering innovative technical ideas from small and large companies, universities, and even individuals. He also proposed a “fly off” of differing concepts for the Crew Exploration Vehicle by 2008.

*Exploration Systems Architecture Study Leads to Constellation Program*

In March, 2005, President Bush appointed Dr. Michael Griffin, a former senior executive of Orbital Sciences Corporation as NASA Administrator. Importantly, Griffin had served as NASA’s Associate Administrator for Exploration under President George H. W. Bush, during the Space Exploration Initiative, which Congress rejected. Furthermore, Griffin had written extensively on space transportation architectures, and co-led a study of exploration approaches in 2004 for the Planetary Society. Upset with Steidle’s “open competition of ideas” approach, Griffin already knew what NASA should do to explore space, and wanted the agency to rebuild its own technical capabilities (which had declined to sharply in over three decades since Apollo) and tell its contractors what to build and how to build it.

First, he appointed Doug Stanley, a former protégé from Orbital Sciences Corporation, to undertake an Exploration Systems Architecture Study (ESAS) in mid-2005 to define top-level requirements and determine the optimum configurations for crew and cargo launch systems to support the proposed lunar and Mars exploration programs.<sup>9</sup> ESAS proposed a space transportation architecture that echoed much of the original Apollo approach and maximized the use of systems and technologies of the Space Shuttle, and of course its contractor base. (Not surprisingly, the results looked a lot like the study Griffin co-authored in 2004.) When asked why NASA would repeat the same approach as Apollo, Griffin defended Constellation as much more than that... it was “Apollo on Steroids.”<sup>10</sup>

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<sup>8</sup> President’s Commission on Implementation of United States Space Exploration Policy, “A Journey to Inspire, Innovate, and Discover,” June 2004, page 7.

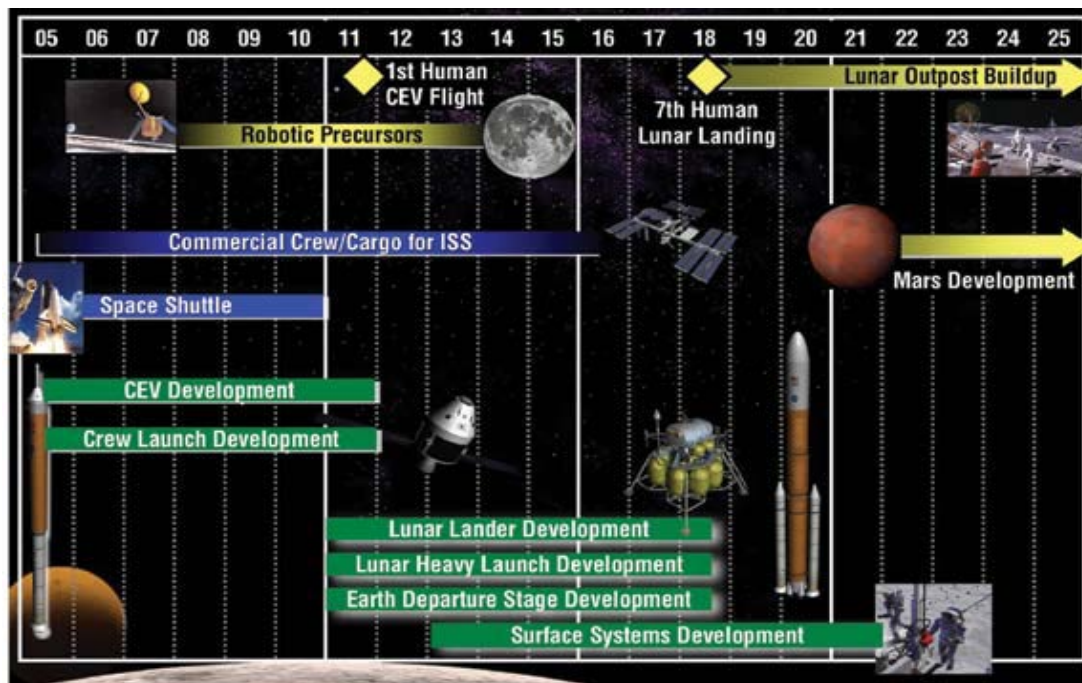
<sup>9</sup> NASA, “Exploration Systems Architecture Survey,” November 2005, [http://www.nasa.gov/pdf/140649main\\_ESAS\\_full.pdf](http://www.nasa.gov/pdf/140649main_ESAS_full.pdf).

<sup>10</sup> *New Scientist*, “NASA unveils vision for return to Moon,” September 19, 2005, <http://www.newscientist.com/article/dn8022-nasa-unveils-vision-for-return-to-moon.html>.

Major exploration systems were referred to as the Orion Crew Exploration Vehicle (CEV), the Ares 1 Crew Launch Vehicle, the Ares 5 Cargo Launch Vehicle, an Earth Departure Stage (really just the upper stage of the Ares 5), and the Altair lunar lander.

A breakout of the ESAS implementation plan is illustrated below.

**ESAS Implementation Roadmap, 2006 (NASA)<sup>11</sup>**



Following the ESAS study, NASA began to implement this proposed architecture for the “Constellation Program.” The CEV was renamed “Orion,” and was designed to include a capsule-shaped pressurized crew module to support a crew of six (later reduced to four to save weight), a launch abort system, and an unpressurized service module to provide propulsion and electrical power. In a competition, Lockheed Martin was chosen over a Northrop Grumman-Boeing team to develop Orion under NASA’s supervision. The first crewed flight of Orion was originally scheduled for 2012 to support the ISS, although Griffin suggested it might be ready by 2011. Orion’s driving design requirements were, however, focused on human exploration beyond low-Earth orbit, which made the spacecraft more difficult and expensive to develop, and therefore it has taken significantly longer than promised.

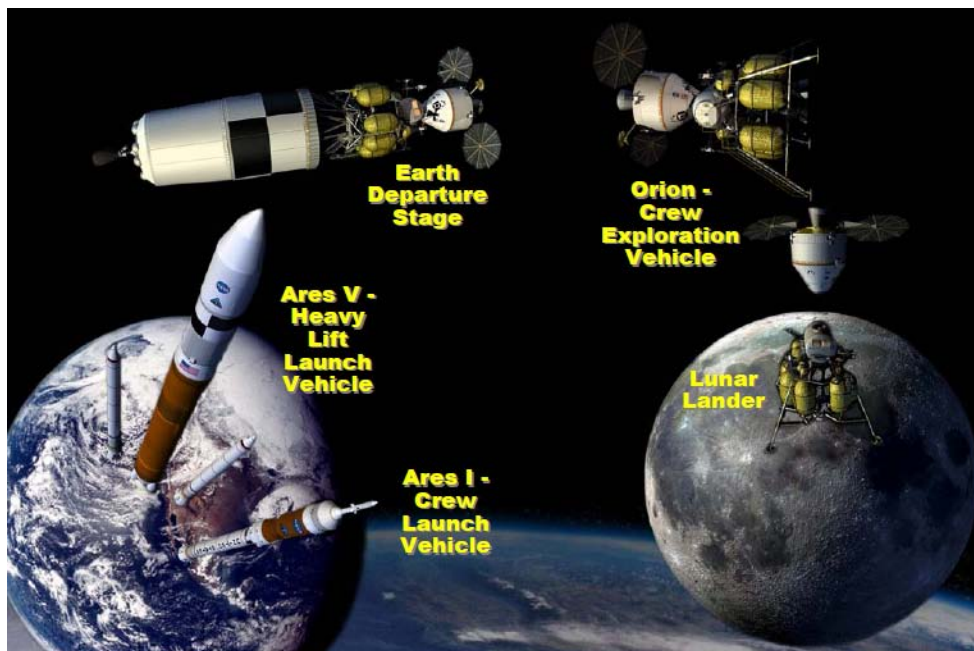
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<sup>11</sup> NASA, “Human Space Flight Transition Plan,” 2005, [http://www.nasa.gov/pdf/315546main\\_space\\_flight\\_transition\\_plan.pdf](http://www.nasa.gov/pdf/315546main_space_flight_transition_plan.pdf).

The proposed Crew and Cargo Launch Vehicles were renamed Ares I and Ares V and were designed to utilize derivatives of the Space Shuttle's solid rocket boosters (SRBs), external tank, and propulsion systems. Ares I was designed to launch Orion, which would then rendezvous and dock with an Earth Departure Stage coupled with the Altair lunar lander, both launched aboard the Ares V.<sup>12</sup>

In September of 2005, Griffin hired Scott Horowitz to be his Associate Administrator for Exploration Systems. Horowitz was the former Director of Space Transportation and Exploration at Alliant Techsystems (ATK), who had conceived of the design that became Ares 1.<sup>13</sup> Upon returning to NASA in September of 2005, Horowitz gave ATK a sole-source contract for the Ares 1's four-segment first stage, and competitively awarded Boeing a production (but not a design) contract for the Ares 1 upper stage. After several months of development, Ares 1 was redesigned to use an even larger, 5-segment booster and a new upper stage engine, which delayed development by several years, to no earlier than 2015.

### Components of Project Constellation, 2006 (NASA)<sup>14</sup>



In September 2009, the Orion vehicle passed a preliminary design review, a series of checkpoints that occurs in the design life cycle of a complex engineering project before hardware manufacturing can begin. The Ares 1 Program had a mostly-successful launch

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<sup>12</sup> ESAS.

<sup>13</sup> Scott Horowitz, Astronaut Biography, <http://www.jsc.nasa.gov/Bios/htmlbios/horowitz.html>.

<sup>14</sup> John Connolly, Constellation Program Office, NASA, "Constellation Program Overview," October 2006, [http://www.nasa.gov/pdf/163092main\\_constellation\\_program\\_overview.pdf](http://www.nasa.gov/pdf/163092main_constellation_program_overview.pdf).

of the so-called Ares 1-X test vehicle in October 2009. The test used a four-segment booster, plus a dummy fifth segment, and a large inert structure representing the shape and mass of the upper stage and Orion spacecraft, and cost taxpayers \$445 million. To date, a total of \$9 billion has been spent on Constellation.<sup>15</sup>

Compared to the initial plan, the Constellation program has delivered limited progress due to technical challenges, schedule slips, and somewhat constrained funding. So far, only the Ares 1 booster and Orion vehicles are currently in development; the remaining architecture elements related to lunar missions remain in the conceptual design phase.

### *Constellation Funding Gap*

Probably the biggest obstacle to any space flight (or government initiative) is funding. While initially described as “affordable and sustainable,” the Constellation architecture chosen during ESAS required continuously increased human spaceflight budgets over multiple decades. Initially, this planned growth required both a top-line increase in overall NASA spending, and the reduction of previously-projected out-year budgets for science and aeronautics. The ESAS estimated the cost of the manned lunar program through 2025 to be \$217 billion, \$7 billion more than NASA's projected exploration budget through that time. The ESAS report had stated that the proposal was achievable using only existing NASA funding, without significant cuts to NASA's other programs.<sup>16</sup>

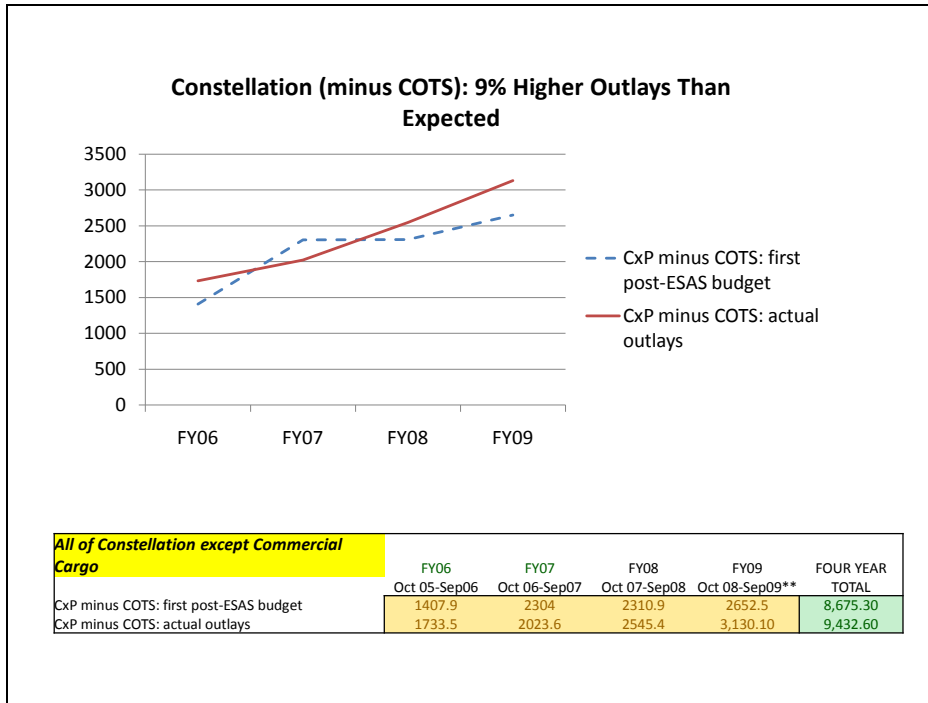
As time went on, NASA did not get all of the funding it wanted. Reductions in the projected increases for the agency, continuing resolutions, and other circumstances did not provide the anticipated funds for exploration. Nevertheless, NASA slashed funding for exploration technology, ISS research, and other programs in order to provide essentially all of the funds originally projected for Ares 1 and Orion through FY2009.<sup>17</sup>

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<sup>15</sup> Kenneth Chang, “Obama Calls for End to NASA's Moon Program,” *The New York Times*, February 1, 2010, <http://www.nytimes.com/2010/02/02/science/02nasa.html>.

<sup>16</sup> NASA, “Exploration Systems Architecture Survey,” November 2005, [http://www.nasa.gov/pdf/140649main\\_ESAS\\_full.pdf](http://www.nasa.gov/pdf/140649main_ESAS_full.pdf).

<sup>17</sup> Budget data based on White House Presidential Budget Submissions for NASA for FY2006-FY2009.



However, it soon became apparent that more funds were needed. President Bush’s call to retire the Shuttle by 2010 and to end U.S. budgetary support for ISS operations after 2015 raised significant concerns not only in Congress but also with international partners in the Space Station. Questions about whether the Shuttle could safely carry out enough flights to complete assembly and deliver sufficient spare hardware to the ISS by 2010 were raised. (The Shuttle did not return to flight status after the *Columbia* tragedy until July 2005, and then took eleven months to fly again.) International partners complained that NASA was abandoning them on ISS only five years after it was completed, and full utilization could begin.

All of this threatened Constellation, because NASA needed a prompt Shuttle retirement (freeing up \$2 billion or more per year) in order have the funds to complete Orion and Ares 1, and a cessation of spending on ISS (freeing up another \$2 billion) in order to afford to develop the heavy lift Ares 5, let alone Altair, by 2020.

## INDEPENDENT ANALYSIS

The programmatic, technical and financial problems with Constellation have been extensively documented by the Government Accountability Office (GAO), the Congressional Budget Office (CBO) and the Review of Human Spaceflight Plans Committee.

### *Government Accountability Office (GAO)*

The Constellation Program has been scrutinized since its inception for uncertain cost estimates, cost growth, major technical difficulties, and a consistently delayed timeline. In the early stages of the program, a July 17, 2006 GAO report stated that “the agency

cannot at this time provide a firm estimate of what it will take to implement the architecture...NASA will be challenged to implement the architecture recommended in the study within its projected budget.”<sup>18</sup> Three years and \$10 billion later, the GAO, in its August 26, 2009 report, found that, “NASA estimates that Ares I and Orion represent up to \$49 billion of the over \$97 billion estimated to be spent on the Constellation program through 2020. While the agency has already obligated more than \$10 billion in contracts, at this point NASA does not know how much Ares I and Orion will ultimately cost, and will not know until technical and design challenges have been addressed.”<sup>19</sup>

#### *Congressional Budget Office (CBO)*

In April 2009, the CBO released a report on “The Budgetary Implications of NASA’s Current Plans for Space Exploration.”<sup>20</sup> This report found that to meet the goals laid out in President Bush’s Vision for Space Exploration, “NASA reduced its planned budgets supporting science and research in aeronautics by more than 40 percent and made plans to complete the construction of the International Space Station and retire the space shuttle by 2010.”<sup>21</sup>

On the basis of cost growth that has occurred in the past, CBO concluded that the costs of NASA’s current development programs could grow by 50 percent on average. If NASA’s funding was maintained at \$19.1 billion annually, and the agency realized cost growth consistent with historical data, its planned schedules for exploration programs would be delayed significantly. The report found that “initial operating capability for Ares 1 and Orion would be pushed to at least late 2016, the return of humans to the moon would slip to 2023, and 15 of 79 science missions would be delayed beyond 2025.”<sup>22</sup>

#### *The Review of U.S. Human Spaceflight Plans Committee*

The committee was appointed by President Obama to conduct an independent review of NASA’s current human spaceflight programs and provide alternative options that would ensure “the nation is pursuing the best trajectory for the future of human spaceflight.” The committee concluded that, “the U.S. human spaceflight program appears to be on an unsustainable trajectory. It is perpetuating the perilous practice of pursuing goals that do not match allocated resources.”<sup>23</sup>

In reviewing the progress to date on Constellation, the committee noted that the original 2005 schedule showed Ares I and Orion available to support the ISS in 2012, two years

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<sup>18</sup> Government Accountability Office, “NASA: Long-Term Commitment to and Investment in Space Exploration Program Requires More Knowledge,” July 2006, <http://www.gao.gov/new.items/d06817r.pdf>.

<sup>19</sup> Ibid.

<sup>20</sup> Congressional Budget Office, “The Budgetary Implications of NASA’s Current Plans for Space Exploration,” April 2009, <http://www.cbo.gov/doc.cfm?index=10051>.

<sup>21</sup> Ibid.

<sup>22</sup> Ibid.

<sup>23</sup> NASA, “Seeking a Human Spaceflight Program Worthy of a Great Nation,” October 2009, [http://www.nasa.gov/pdf/396093main\\_HSF\\_Cmte\\_FinalReport.pdf](http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf).

after scheduled Shuttle retirement. However, the committee determined that NASA had changed that date to 2015: “An independent assessment of the technical, budgetary and schedule risk to the Constellation Program performed for the Committee indicates that an additional delay of at least two years is likely. This means that Ares I and Orion will not reach the ISS before the Station’s currently planned termination, and the length of the gap in U.S. ability to launch astronauts into space will be at least seven years.”<sup>24</sup>

In lieu of an Ares 1 and Orion system, the committee presented alternatives to the Constellation program that would utilize commercial space transportation services to bring astronauts to and from the International Space Station. While cautious, the report stated that this approach offers the possibility of lower operating costs for ISS support and potentially accelerates the availability of U.S. access to low-Earth orbit.<sup>25</sup> Furthermore, establishing these commercial opportunities could increase launch volume and potentially lower costs to NASA and all other launch services customers.

## CONCLUSION

The problems with the continuation of the Constellation Program are well documented. To meet its goals, NASA would need a drastically increased budget over multiple decades or reduce its budgets for virtually all other NASA work and end U.S. involvement in the \$100 billion International Space Station (ISS). An April 21, 2010 editorial in the *National Review* referred to Constellation as “a programmatic disaster,”<sup>26</sup> while the *Washington Post* has referred to it as “ill-conceived” and “under-funded.”<sup>27</sup> For the *National Review* and the *Washington Post* to agree, something must be seriously off-track.

The Administration has taken a step in the right direction by proposing to cancel the unsustainable Constellation Program in favor of looking to increased reliance on the private sector and investment in technologies that can lower the cost of human space exploration. With changes in procurement practices and increased competition driving innovation up and prices down, the United States should finally get its human spaceflight efforts back on schedule and within a reasonable budget.

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<sup>24</sup> NASA, “Summary Report of the Review of U.S. Human Spaceflight Plans Committee,” October 2009, [http://www.nasa.gov/pdf/384767main\\_SUMMARY%20REPORT%20-%20FINAL.pdf](http://www.nasa.gov/pdf/384767main_SUMMARY%20REPORT%20-%20FINAL.pdf).

<sup>25</sup> Ibid.

<sup>26</sup> Rand Simberg, “Obama’s Space Program: More Conservative than Bush’s,” *National Review*, April 21, 2010, <http://article.nationalreview.com/432073/obamas-space-program-more-conservative-than-bushs/rand-simberg>.

<sup>27</sup> Editorial, “Obama Should Rethink NASA’s Space Program,” *The Washington Post*, April 23, 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/04/22/AR2010042205398.html>.