United States Government Accountability Office

GAO

Testimony

Before the Subcommittee on Space and Aeronautics, Committee on Science, Space and Technology, House of Representatives

For Release on Delivery
Expected at 10:00 a.m. EST
Thursday, May 26, 2011

COMMERCIAL LAUNCH VEHICLES

NASA Taking Measures to Manage Delays and Risks

Statement of Cristina T. Chaplain, Director
Acquisition and Sourcing Management

May 26, 2011

COMMERCIAL LAUNCH VEHICLES

NASA Taking Measures to Manage Delays and Risks

GAO Highlights

Highlights of GAO-11-692T, a report to the Subcommittee on Space and Aeronautics, Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

Since the National Aeronautics and Space Administration (NASA) created the strategy for the Commercial Orbital Transportation Services (COTS) project in 2005, the space landscape has changed significantly—the Space Shuttle program is retiring and the Ares I will not be available—increasing the importance of the timely development of COTS vehicles. The lack of alternatives for supplying the International Space Station and launching science missions have all contributed to an increased need for the COTS vehicles. The two COTS project partners, Orbital and SpaceX, have made progress in the development of their respective vehicles; however, both providers are behind schedule. As a result, the project recently received an additional $300 million to augment development efforts with risk reduction milestones.

This testimony focuses on: (1) COTS development activities, including the recent funding increase; (2) the extent to which any COTS demonstration delays have affected commercial resupply services (CRS) missions and NASA's plans for meeting the space station's cargo resupply needs; and (3) lessons learned from NASA's acquisition approach for COTS.

To prepare this statement, GAO used its prior relevant work and conducted additional audit work, such as analyzing each partner's agreement with NASA and interviewing NASA officials. New data in this statement was discussed with agency and company officials who provided technical comments, which we included as appropriate.

View GAO-11-692T or key components. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

SpaceX and Orbital continue to make progress completing milestones under their COTS agreements with NASA, but both partners are working under aggressive schedules and have experienced delays in completing demonstration missions. SpaceX successfully flew its first demonstration mission in December 2010, but the mission was 18 months late and the company's second and third demonstration missions have been delayed by almost 2 years due to design, development, and production challenges with the Dragon spacecraft and Falcon 9 launch vehicle. Orbital faced technical challenges developing the Taurus II launch vehicle and the Cygnus spacecraft and in constructing launch facilities, leading to multiple delays in completing program milestones, including its demonstration mission. NASA has amended its agreements with the partners to include a number of new milestones, such as additional ground and flight tests, to reduce remaining developmental and schedule risks; most of the new milestones completed thus far were finished on time, but many milestones remain.

Based on the current launch dates for SpaceX's and Orbital's upcoming COTS demonstration missions, it is likely that neither will launch its initial CRS mission on time, but NASA has taken steps to mitigate the short-term impact to the space station. The launch windows for SpaceX's first and second CRS flights are scheduled to occur either before or during its upcoming COTS demonstration flights and will need to be rescheduled. Orbital's first CRS flight will also likely shift due to a Taurus II test flight. NASA officials said that the agency will have to renegotiate the number of flights needed from each partner and re-baseline the launch windows for future CRS missions once COTS demonstration flights are completed. NASA has taken steps to mitigate the short-term impact of CRS delays through prepositioning of cargo, some of which will be delivered on the last space shuttle flight. Despite these efforts, NASA officials said they would still need one flight in 2012 from SpaceX's and Orbital's vehicles to meet science-related cargo needs.

In considering the use of a Space Act agreement for COTS, NASA identified several advantages. These advantages include sharing costs with agreement partners and promoting innovation in the private sector. A disadvantage, however, is that NASA is limited in its ability to influence agreement partners in their approach. At the time the agreements were awarded, NASA was willing to accept the risks of using a Space Act agreement given the goals of the project and alternative vehicles that were available to deliver goods to the space station. As the project has progressed, however, and these alternatives are no longer viable or available, NASA has become less willing to accept the risk involved and has taken steps aimed at risk mitigation. Given a critical need, the risk is present that the government will be required to make additional investments to meet mission needs. The amount of investment can be lessened by ensuring that accurate knowledge about requirements, cost, schedule, and risks is achieved early on. GAO has made recommendations to NASA and NASA is taking steps to help ensure that these fundamentals are present in its major development efforts to increase the likelihood of success.

Mr. Chairman and Members of the Subcommittee:

Thank you for inviting me here today to discuss the status of the National Aeronautics and Space Administration's (NASA) Commercial Orbital Transportation Services (COTS) project. GAO conducted work examining the COTS project in 2009 and reported that progress was being made, but several risks persisted given aggressive project schedules.[1] Since NASA devised its strategy for the COTS project in 2005, the space landscape has changed quite significantly, increasing the importance of the timely development and success of COTS vehicles to NASA. Specifically, with the impending retirement of the space shuttle in July 2011, the United States will lack a domestic capability to send crew and cargo to the International Space Station and face a cargo resupply shortfall between 2012 and 2020 that cannot be met by international partners' space vehicles alone.[2] The Ares I project, which was originally intended to be operational in 2010 and to fill the gap between the retirement of the Space Shuttle program and the availability of the COTS vehicles, pushed its launch readiness date to 2015 and is now being restructured into a new program that will not be operational until at least 2016. Further, the Delta II launch vehicle, which has carried the majority of NASA's science missions over the last several years, is retiring, the impact of which is beginning to be felt by NASA's science projects.[3] These changes have resulted in an increased need for the vehicles being developed for COTS not only to address the cargo resupply shortfall as intended, but also to support a large number of future science missions at a reasonable cost to NASA. While COTS partners have made progress in the development of their vehicles, they have also experienced delays and NASA has provided additional funding to the partners to reduce the risk that their vehicles would experience further delays.

Against this backdrop, my testimony today will focus on: (1) the COTS development activities, including a discussion of the need for the recent

[1]GAO, *NASA: Commercial Partners Are Making Progress, but Face Aggressive Schedules to Demonstrate Critical Space Station Cargo Transport Capabilities*, GAO-09-618 (Washington, D.C.: June 16, 2009).

[2]International partners' vehicles include the Russian Federal Space Agency's Progress (cargo) and Soyuz (crew), the European Space Agency's Automated Transfer Vehicle (cargo), and the Japan Aerospace Exploration Agency's H-II Transfer Vehicle (cargo).

[3]GAO, *NASA: Medium Launch Transition Strategy Leverages Ongoing Investments but is Not Without Risk*, GAO-11-107 (Washington, D.C.: Nov. 22, 2010).

funding augmentation; (2) the extent to which any COTS demonstration delays have affected Commercial Resupply Services (CRS) missions to the space station and NASA's plans for meeting space station cargo resupply needs; and (3) lessons learned from NASA's acquisition approach for COTS.

In preparing this statement, we relied on our prior report related to the COTS project and conducted additional audit work in May 2011 to update information from that report.[4] Specifically, we analyzed each COTS partner's agreement with NASA, amendments to those agreements, documentation from NASA and partner quarterly program management reviews, and each partner's CRS contract. We interviewed NASA COTS and International Space Station program officials and company officials. We discussed new information presented in this statement with agency and company officials who provided technical comments that we incorporated as appropriate. Our prior work on the COTS project, as well as the work conducted for this statement, was performed in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

In 2004, President George W. Bush announced his Vision for Space Exploration that included direction for NASA to pursue commercial opportunities for providing transportation and other services to support the space station after 2010. When the project was established in 2005, the approach that NASA laid out was a marked change in philosophy for how the agency planned to service the space station—by encouraging innovation in the private sector with the eventual goal of buying services at a reasonable price. As a result, the agency chose to utilize its other transaction authority under the National Aeronautics and Space Act of 1958,[5] as opposed to a more traditional Federal Acquisition Regulation (FAR) based contract. Generally speaking, other transaction authority

[4]GAO-09-618.

[5]Pub. L. No. 85-568, § 203 (1958). This act is commonly referred to as the Space Act and agreements signed utilizing NASA's other transaction authority are known as Space Act agreements.

enhances the government's ability to acquire cutting-edge science and technology, in part through attracting companies that typically have not pursued government contracts because of the cost and impact of complying with government procurement requirements. These types of agreements are not considered federal government contracts, and are therefore generally not subject to those federal laws and regulations that apply to federal government contracts.

NASA established the Commercial Crew and Cargo program office at Johnson Space Center in 2005 and budgeted $500 million for fiscal years 2006 through 2010 for the development and demonstration of cargo transport capabilities. COTS partners, Orbital Sciences Corporation (Orbital) and Space Exploration Technologies Corporation (SpaceX), have also made significant investments in developing these capabilities. The COTS project was originally intended to be executed in two sequential phases: (1) private industry development of cargo transport capabilities in coordination with NASA and (2) procurement of commercial resupply services to the space station once cargo transport capabilities had been successfully demonstrated. In August 2006, NASA competitively awarded a $278 million Space Act agreement to SpaceX to develop and demonstrate end-to-end transportation systems, including the development of the Falcon 9 launch vehicle and Dragon spacecraft, ground operations, and berthing with the space station. In February 2008, NASA awarded a $170 million Space Act agreement to Orbital to develop two COTS cargo capabilities, unpressurized and pressurized[6] cargo delivery and disposal, to culminate in one demonstration flight of its Taurus II launch vehicle and Cygnus spacecraft.[7]

Before either partner had successfully demonstrated its COTS cargo transport capabilities, the International Space Station program office awarded two CRS contracts in December 2008 to Orbital and SpaceX under a separate competitive procurement from COTS. These FAR-based contracts were for the delivery of at least 40 metric tons (approximately

[6]Pressurized cargo refers to cargo that is carried inside the spacecraft. This cargo includes items such as food, water, and materials to support scientific experiments.

[7]NASA originally awarded a $207 million Space Act agreement to Rocketplane Kistler (RpK), but the agreement was terminated in October 2007 after RpK had missed technical and financial milestones. Subsequently, Orbital was awarded the remaining funds—$170 million. In March 2009, Orbital and NASA amended this agreement, removing its unpressurized cargo demonstration and replacing it with a pressurized demonstration, scheduled for March 2011.

88,000 pounds) to the space station between 2010 and 2015. Orbital was awarded 8 cargo resupply missions for approximately $1.9 billion and SpaceX was awarded 12 cargo resupply missions for approximately $1.6 billion.

In June 2009, we found that while SpaceX and Orbital had made progress against development milestones, the companies were working under aggressive schedules and had experienced schedule slips that delayed upcoming demonstration launch dates by several months. In addition, we reported that the vehicles being developed through the COTS project were essential to NASA's ability to fully utilize the space station after its assembly was completed and the space shuttle was retired. Finally, we found that NASA's management of the COTS project generally adhered to critical project management tools and activities.

Since our 2009 report, the two COTS project partners, Orbital and SpaceX, have made progress in the development of their respective vehicles. SpaceX successfully flew its first COTS demonstration mission in December 2010 and Orbital is planning to fly its COTS demonstration mission in December 2011. Both providers, however, are behind schedule—SpaceX's first COTS demonstration mission slipped 18 months and Orbital's first mission was initially planned for March 2011. Such delays are not atypical of development efforts, especially efforts that are operating under such aggressive schedules. Nonetheless, the criticality of these vehicles to the space station's operations, as well as NASA's ability to affordably execute its science missions has heightened the importance of their timely and successful completion and lessened the level of risk that NASA is willing to accept in this regard. As a result, the project recently requested and received an additional $300 million to augment the partner development efforts with, according to NASA, risk reduction milestones.

Demonstration Missions Have Been Delayed, but Progress Against New Milestones Could Reduce Further Technical and Schedule Risk

SpaceX: Performance Against Prior Milestones

SpaceX has successfully completed 18 of 22 milestones to date, but has experienced lengthy delays in completing key milestones since we last reported on the company's progress in June 2009. SpaceX's agreement with NASA established 22 development milestones that SpaceX must complete in order to successfully demonstrate COTS cargo capabilities. SpaceX's first demonstration mission readiness review was completed 15 months behind schedule and its successful first demonstration mission was flown in December 2010, 18 months late. The company's second and third demonstration missions have been delayed by almost 2 years to November 2011 and January 2012, respectively.[8] Several factors contributed to the delay in SpaceX's first demonstration mission readiness review and demonstration mission. These factors include, among others, delays associated with (1) launching the maiden Falcon 9 (non-COTS mission), such as Falcon 9 software and database development; (2) suppliers; (3) design instability and production; (4) Dragon spacecraft testing and software development; and (5) obtaining flight safety system approval. For example, SpaceX encountered welding issues during production of the Dragon propellant tanks and also had to redesign the Dragon's battery.

In preparing for its second COTS demonstration flight, SpaceX has experienced additional design, development, and production delays. For example, several propulsion-related components needed to be redesigned,

[8]According to the COTS program manager, NASA is also discussing with SpaceX about the possibility of combining the second and third demonstration missions into a single mission. SpaceX officials told us they have already begun building the Dragon spacecraft for the second COTS demonstration mission so that it can be fully capable of berthing with the space station.

the Dragon spacecraft's navigation sensor experienced development testing delays, and delays were experienced with launch vehicle tank production. For example, SpaceX's decision to incorporate design changes to meet future CRS mission requirements has delayed the company's second demonstration mission. Integration challenges on the maiden Falcon 9 launch and the first COTS demonstration mission have also kept SpaceX engineers from moving on to the second COTS demonstration mission.

SpaceX officials cited the completion of Dragon development efforts, NASA's safety verification process associated with berthing with the space station, and transitioning into efficient production of the Falcon 9 and Dragon to support space station resupply missions as key drivers of technical and schedule risk going forward. For completing 18 of the 22 milestones, SpaceX has received $258 million in milestone payments thus far, with $20 million yet to be paid. Appendix I describes SpaceX's progress meeting the COTS development milestones in its agreement with NASA.

Orbital: Performance Against Prior Milestones

Orbital has successfully completed 15 of 19 COTS milestones to date—8 more than when we initially reported on the program in June 2009. Programmatic changes and developmental difficulties, however, have led to multiple delays of several months' duration and further delays are projected for completing the remaining milestones. For example, according to Orbital officials, the demonstration mission of Orbital's Taurus II launch vehicle and Cygnus spacecraft has been delayed primarily due to an increase in design effort to develop a pressurized cargo carrier in place of the original Cygnus unpressurized cargo design. After NASA awarded Orbital a CRS contract for eight pressurized cargo missions, NASA and Orbital amended their COTS demonstration agreement to replace the unpressurized cargo demonstration mission with a pressurized cargo demonstration. This delayed existing milestones, and the schedule was revised to shift the COTS demonstration mission from December 2010 to March 2011. Since that time, the schedule for some of Orbital's milestones has been revised again and the demonstration mission is now planned for December 2011.

COTS program and Orbital officials also noted technical challenges as reasons for milestone delays. For example, Orbital officials said there are several critical Taurus II engine and stage one system tests that need to be completed by the end of the summer, but that the risk inherent in these tests is mitigated through an incremental approach to testing. Specifically, single engine testing has been successfully completed, and testing will be

extended this summer to the full stage one (i.e., two-engine) testing. COTS program and Orbital officials also noted delays in Cygnus avionics manufacturing, primarily driven by design modifications aimed at increasing the safety and robustness of the system. According to these officials, integration and assembly of the first Cygnus spacecraft has begun and is now in the initial electrical testing phase.

Additionally, the completion of the company's launch facilities at the Mid-Atlantic Regional Space Port in Wallops Island, Virginia, remains the key component of program risk. NASA COTS program and Orbital officials cite completion of the Wallops Island launch facilities as the critical factor for meeting the COTS demonstration mission schedule. Orbital officials said additional resources have been allocated to development of the launch complex to mitigate further slips, and an around-the-clock schedule will be initiated later this summer to expedite the completion of verification testing of the liquid fueling facility, which is the primary risk factor in completing the launch facility.

For completing 15 of the 19 milestones, Orbital has received $157.5 million, with $12.5 million remaining to be paid. Appendix I depicts Orbital's progress in meeting the COTS development milestones in its agreement with NASA.

Risk Reduction Milestones Recently Added to COTS Agreements

In addition to the prior milestones negotiated under the COTS project, NASA has amended its agreements with SpaceX and Orbital to include a number of additional milestones aimed at reducing remaining developmental and schedule risks. COTS officials told us that some milestones reflect basic risk reduction measures, such as thermal vacuum testing, that NASA would normally require on launch vehicle or spacecraft development. A series of amendments were negotiated from December 2010 to May 2011 after Congress authorized $300 million for commercial cargo efforts in fiscal year 2011. These amendments add milestones to (1) augment ground and flight testing, (2) accelerate development of enhanced cargo capabilities, or (3) further develop the ground infrastructure needed for commercial cargo capabilities. These milestones were added incrementally due to NASA operating under continuing resolutions through the first half of fiscal year 2011.

In May 2009, the President established a Review of U.S. Human Space Flight Plans Committee composed of space industry experts, former astronauts, government officials, and academics.[9] In its report, the committee stated that it was concerned that the space station, and particularly its utilization, may be at risk after Shuttle retirement as NASA would be reliant on a combination of new international vehicles and as-yet-unproven U.S. commercial vehicles for cargo transport. The committee concluded that it might be prudent to strengthen the incentives to the commercial providers to meet the schedule milestones. NASA officials stated that if funding were available, negotiating additional, risk reduction milestones would improve the chance of mission success, referring specifically to the companies' COTS demonstration missions. Of the $300 million, $236 million, divided equally between SpaceX and Orbital, will be paid upon completion of the additional milestones.[10] Additionally, NASA officials stated the International Space Station program office will pay SpaceX and Orbital $10 million each to fund early cargo delivery to the space station on the companies' final COTS demonstration missions. The COTS program manager stated that SpaceX and Orbital recognize their responsibility under the COTS agreements for any cost overruns associated with their development efforts, and that the companies did not come to NASA with a request for additional funding.

SpaceX has completed 4 of its new milestones on time but has experienced minor delays in completing 3 others. SpaceX's agreement with NASA was amended three times between December 2010 and May 2011 to add 18 development milestones that SpaceX must complete in order to successfully demonstrate COTS cargo capabilities. Some of the new milestones, for example, are designed to increase NASA's confidence that SpaceX's Dragon spacecraft will successfully fly approach trajectories to the space station while others are intended to improve engine acceptance rates and vehicle production time frames. Milestones completed thus far include a test of the spacecraft's navigation sensor and thermal vacuum tests. For completing 7 of the 18 milestones, SpaceX has

[9]Review of U.S. Human Spaceflight Plans Committee, *Seeking a Human Spaceflight Program Worthy of a Great Nation* (Washington, D.C.: October 2009).

[10]The COTS program manager reported that $34 million of the $300 million was for NASA Headquarters and Johnson Space Center program support and administration as well as technical and mission support for the remaining COTS demonstration flights and $10 million would be spent on milestone payments for Orbital's Milestones 20 and 21 and SpaceX's Milestone 22.

received $40 million in milestone payments thus far, with $78 million yet to be paid.

Orbital has completed 4 of its 10 new milestones on schedule and 1 of the new milestones was delayed by about 1 month. In concurrence with NASA's request, Orbital agreed to add an initial flight test of the Taurus II launch vehicle to reduce overall cargo service risk. The test flight not only separates the risks of the first flight of Taurus II from the risks of the first flight of the Cygnus spacecraft, but provides the opportunity to measure the Taurus II flight environments using an instrumented Cygnus mass simulator. The Taurus II test flight is scheduled for October 2011. Overall technical risks associated with Cygnus development are expected to be reduced through additional software and avionics tests. Milestones completed thus far include early mission analyses and reviews, as well as delivery of mission hardware. For completing the first 5 new milestones, Orbital has received $69 million, with $49 million remaining to be paid. Appendix I describes SpaceX's and Orbital's progress meeting the new COTS development milestones in their agreements with NASA.

COTS Delays Will Likely Cause Resupply Flights to Slip, but NASA Has Taken Steps to Mitigate Short-Term Impact

Based on the current launch dates for SpaceX's and Orbital's upcoming COTS demonstration missions, it is likely that both commercial partners will not launch their initial CRS missions on time, but NASA has taken steps to mitigate the short-term impact to the space station. The launch window for SpaceX's first CRS flight is from April to June 2011 and from October to December 2011 for its second CRS flight. These launch windows are either scheduled to occur before or during SpaceX's upcoming COTS demonstration flights and thus will need to be rescheduled. In the case of Orbital, NASA officials told us that the launch window for its first CRS flight is from January to March 2012, but will likely slip from those dates given the Taurus II test flight added to its milestone schedule. NASA officials added that once SpaceX and Orbital have finished completing their COTS demonstration flights, NASA will have to renegotiate the number of flights needed from each partner and re-baseline the launch windows for future CRS missions.

International Space Station program officials told us they have taken steps to mitigate the short-term impact of CRS flight delays through prepositioning of cargo on the last space shuttle flights, including cargo that is being launched on the planned contingency space shuttle flight in early July 2011. Officials added that these flights and the planned European Space Agency's Automated Transfer Vehicle and Japan's H-II Transfer Vehicle flights in 2012 will carry enough cargo to sustain the six

person space station crew through 2012 and to meet science-related cargo needs through most of 2012. Despite these steps, NASA officials said they would still need one flight each from SpaceX's and Orbital's vehicles in order to meet science-related cargo needs in 2012. Beyond 2012, NASA is highly dependent on SpaceX's and Orbital's vehicles in order to fully utilize the space station. For example, we reported in April 2011 that 29 percent of the flights planned to support space station operations through 2020 were dependent on those vehicles.[11] In addition, NASA officials confirmed that the agency has no plans to purchase additional cargo flights on Russian Progress vehicles beyond 2011 and the European Space Agency and the Japan Aerospace Exploration Agency have no current plans to manufacture additional vehicles beyond their existing commitments or to accelerate production of planned vehicles. We reported previously that if the COTS vehicles are delayed, NASA officials said they would pursue a course of "graceful degradation" of the space station until conditions improve. In such conditions, the space station would only conduct minimal science experiments.[12]

Even With Identified Advantages, NASA Has Taken Measures to Address Risks to COTS Strategy

NASA's intended use of the COTS Space Act agreements was to stimulate the space industry rather than acquiring goods and services for its direct use. Traditional FAR contracts are to be used when NASA is procuring something for the government's direct benefit.[13] NASA policy provides that funded Space Act agreements can only be used if no other instrument, such as a traditional FAR contract, can be used.[14] Therefore, Space Act agreements and FAR-based contracts are to be used for different purposes. In considering the use of funded Space Act agreements for COTS, NASA identified several advantages. For example:

- The government can share costs with the agreement partner with fixed government investment.
- Payment to partner is made only after successful completion of performance-based milestones.

[11]GAO, *International Space Station (ISS) – Ongoing Assessments for Life Extension Appear to be Supported*, GAO-11-519R (Washington, D.C.: Apr. 11, 2011).

[12]GAO, *International Space Station: Significant Challenges May Limit Onboard Research*, GAO-10-9 (Washington, D.C.: Nov. 25, 2009).

[13]31 U.S.C. § 6303.

[14]NASA Policy Directive 1050.1I, Authority to Enter into Space Act Agreements (Dec. 23, 2008).

- The government can terminate the agreement if the partner is not reasonably meeting milestones.
- Limited government requirements allow optimization of systems to meet company's commercial business needs.

These types of agreements can also have disadvantages, however. For example, Space Act agreements may have more limited options for oversight as compared to other science mission and human spaceflight development efforts that are accomplished under more traditional FAR contracts. NASA identified other disadvantages of using a Space Act agreement. For example:

- The government has limited ability to influence agreement partners in their approach.
- The government lacks additional management tools (beyond performance payments at milestones) to incentivize partners to meet technical and schedule performance.

Given the intended goals of the project and the availability of alternative vehicles to deliver goods to the space station when the COTS agreements were signed, NASA was willing to accept the risks associated with the disadvantages of using a Space Act agreement.[15] As the project has progressed, however, and these alternatives are no longer viable or available, NASA has become less willing to accept the risks involved. As a result, the agency took steps aimed at risk mitigation, primarily through additional funding.

I would like to point out that neither Space Act agreements nor more traditional FAR contracts guarantee positive outcomes. Further, many of the advantages and disadvantages identified by NASA for using a Space Act agreement can also be present when using FAR-based contracts, depending on how the instrument is managed or written. For example, both a FAR contract and a Space Act agreement can provide for cost sharing and the government also has the ability to terminate a FAR contract or a Space Act agreement if it is dissatisfied with performance.

[15]NASA goals were to: (1) implement Space Exploration policy with investments to stimulate the commercial space industry; (2) facilitate U.S. private industry demonstrations of cargo and crew space transportation capabilities with the goal of achieving safe, reliable, cost-effective access to low-Earth orbit; and (3) create a market environment where commercial services are available to the government and private sector customers.

The ineffective management of the instrument can be an important contributor to poor outcomes. For example, although a Space Act agreement may lack management tools to incentivize partners, we have reported in the past that award fees, which are intended to incentivize performance on FAR-based contracts, are not always applied in an effective manner or even tied to outcomes.[16] Additionally, the oversight that NASA conducts under a FAR-based contract has not always been used effectively to ensure that projects meet cost and schedule baselines.[17]

Even with the advantages and disadvantages that can be present in various instruments, given a critical need, the government bears the risk for having to make additional investments to get what it wants, when it wants it. The additional investment required, however, can be lessened by ensuring that accurate knowledge about requirements, cost, schedule, and risks is achieved early on. We have reported for years that disciplined processes are key to ensuring that what is being proposed can actually be accomplished within the constraints that bind the project, whether they are cost, schedule, technical, or any other number of constraints.[18] We have made recommendations to NASA and NASA is taking steps to address these recommendations to help ensure that these fundamentals are present in its major development efforts to increase the likelihood of success.

Mr. Chairman, this concludes my prepared statement. I would be happy to respond to any questions you may have at this time.

[16]GAO, *NASA Procurement: Use of Award Fees for Achieving Program Outcomes Should Be Improved*, GAO-07-58 (Washington, D.C.: Jan. 17, 2007).

[17]GAO, *NASA: Assessments of Selected Large-Scale Projects*, GAO-11-239SP (Washington, D.C.: Mar. 3, 2011).

[18]GAO, *NASA: Assessments of Selected Large-Scale Projects*, GAO-09-306SP (Washington, D.C.: Mar. 2, 2009); GAO, *NASA: Assessments of Selected Large-Scale Projects*, GAO-10-227SP (Washington, D.C.: Feb. 1, 2010); and GAO-11-239SP.

Appendix I: COTS Partners' Progress Completing Prior and New Milestones

Table 1: SpaceX's Progress Completing Prior COTS Development Milestones

Milestone number	Milestone description	Scheduled completion date	Completed on time (Yes/No)	Delay if applicable (months)	Payment amount (millions)
1	Project Management Plan Review	Sept. 2006	Y	-	$23.1
2	Demo 1 System Requirements Review	Nov. 2006	Y	-	$5
3	Demo 1 Preliminary Design Review	Feb. 2007	Y	-	$18.1
4	Financing Round 1	Mar. 2007	Y	-	$10
5	Demo 2 System Requirements Review	Mar. 2007	Y	-	$31.1
6	Demo 1 System Critical Design Review	Aug. 2007	Y	-	$8.1
7	Demo 3 System Requirements Review	Oct. 2007	Y	-	$22.3
8	Demo 2 Preliminary Design Review	Dec. 2007	Y	-	$21.1
9	Draco Initial Hot-Fire	Mar. 2008	Y	-	$6
10	Financing Round 2	Mar. 2008	Y	-	$10
11	Demo 3 Preliminary Design Review	Jun. 2008	Y	-	$22
12	Multi-engine Test	Sept. 2008	Y	-	$22
13	Demo 2/Demo 3 System Critical Design Review	Dec. 2008	Y	-	$25
14	Financing Round 3	Mar. 2009	Y	-	$10
15	Demo 1 Readiness Review	Mar. 2009	N	15	$5
16	Communications Unit Flight Unit Design, Accept, Delivery	May 2009	N	2	$9
17	Demo 1 Mission	Jun. 2009	N	18	$5
18	Demo 2 Readiness Review	Sept. 2009[a]	N	24 (projected)	$5
19	Demo 2 Mission	Nov. 2009[a]	N	24 (projected)	$5
20	Cargo Integration Demonstration	Jan. 2010	Y	-	$5
21	Demo 3 Readiness Review	Jan. 2010[a]	N	23 (projected)	$5
22	Demo 3 Mission	Mar. 2010[a]	N	22 (projected)	$5
				Total:	**$278 million for the completion of all milestones** **$258 million paid to date**

Source: NASA and SpaceX.

[a]NASA is currently reviewing a proposed amendment that would change the completion dates for milestones 18, 19, 21, and 22. In particular, Demo Mission 2 (milestone 19) would take place in November 2011 and Demo Mission 3 in January 2012.

Table 2: Orbital's Progress Completing Prior COTS Development Milestones

Milestone number	Milestone description	Scheduled completion date	Completed on time (Yes/No)	Delay, if applicable (months)	Payment amount (millions)
1	Program Plan Review	Mar. 2008	Y	-	$10
2	Demo Mission System Requirements Review	Jun. 2008	Y	-	$20
3	Unpressurized Cargo Module Preliminary Design Review	Jul. 2008	Y	-	$10
4	DELETED COTS System Preliminary Design Review was milestone 4, but it has been renumbered as milestone 10	No longer applicable	No longer applicable	-	No longer applicable
5	COTS Integration/Operations Facility Review	Sept. 2008	Y	-	$10
6	Pressurized Cargo Module Preliminary Design Review	Oct. 2008	Y	-	$10
7	DELETED Unpressurized Cargo Module Critical Design Review	No longer applicable	No longer applicable	-	No longer applicable
8	Instrumentation Program and Command List	Feb. 2009	Y	-	$10
9	Completion of ISS Phase 1 Safety Review	Mar. 2009	Y	-	$10
10	COTS System Preliminary Design Review	Apr. 2009	N	1	$20
11	DELETED Unpressurized Cargo Module Fabrication Started	No longer applicable	No longer applicable	-	No longer applicable
11	Pressurized Cargo Module Critical Design Review	Jul. 2009	Y	-	$10
12	Cygnus Avionics Test	Aug. 2009	Y	-	$10
13	Completion of ISS Phase 2 Safety Review	Aug. 2009	N	3	$10
14	COTS System Critical Design Review	Sept. 2009	N	6	$10
15	Service Module Core Assembly Completed	Dec. 2009	N	8	$7.5
16	Service Module Test Readiness Review	Apr. 2010	N	7	$7.5
17	Service Module Initial Comprehensive Performance Test	Jul. 2010[a]	N	11 (projected)	$5
18	Launch Vehicle Stage 1 Assembly Complete	Oct. 2010[a]	N	11 (projected)	$2.5
19	Cargo Integration Demonstration	Dec. 2010	Y	-	$2.5
20	Mission Readiness Review	Feb. 2011[a]	N	8 (projected)	$2.5
21	System Demonstration Flight	Mar. 2011[a]	N	9 (projected)	$2.5
			Total:		**$170 million for completion of all milestones $157.5 million paid to date**

Source: NASA and Orbital.

Note: When Orbital amended its agreement with NASA in March 2009, it deleted milestones 7 and 11, and moved milestone 4 to become milestone 10. These changes are indicated in this revised schedule.

[a]Milestones 17, 18, 20, and 21 were amended in March 2011 to reflect updated milestone descriptions and completion dates. In particular, the System Demonstration Flight (milestone 21) is now planned for December 2011.

Table 3: SpaceX's Progress Completing New COTS Development Milestones

Milestone number	Milestone description	Scheduled completion date	Completed on time (Yes/No)	Delay if applicable (months)	Payment amount (millions)
23	Modal Test Plan and Setup	Nov. 2010	Y[a]	-	$5
24	Modal Test	Dec. 2010	Y	-	$5
25	Light Detection and Ranging (LIDAR) Test (open loop)	Dec. 2010	Y	-	$5
26	Solar Array Deployment and Component Thermal Vacuum Tests	Dec. 2010	Y	-	$5
27	Light Detection and Ranging (LIDAR) Test Plan (closed loop)	Mar. 2011	N	< 1[b]	$5
28	Thermal Vacuum System Test Plan and Procurement	Mar. 2011	N	< 1[c]	$5
29	Overall Infrastructure Plan and Long Lead Procurement	Mar. 2011	N	< 2[d]	$10
30	Thermal Vacuum System Tests	Jul. 2011	-	-	$20
31	Test Site Infrastructure Implementation	Jun. 2011	-	-	$5
32	Dragon Trunk Acoustic Test	Jun. 2011	-	-	$10
33	Light Detection and Ranging (LIDAR) Test (closed loop)	Aug. 2011	-	-	$5
34	Design Review of Enhanced Powered Cargo Accommodations	Aug. 2011	-	-	$5
35	Design Review of Pressurized Cargo Volume Increase	Aug. 2011	-	-	$5
36	Full Dragon Electromagnetic Interference/Capability Test and Second Flight-Like Hardware in the Loop Simulator	Jul. 2011	-	-	$10
37	Dragon Cargo Racks and Hatch Simulator	Aug. 2011	-	-	$3
38	Ground Demonstration of Enhanced Powered Cargo	Sept. 2011	-	-	$5
39	Launch Site Infrastructure Implementation	Sept. 2011	-	-	$5
40	Production Infrastructure Implementation	Sept. 2011	-	-	$5
				Total:	**$118 million for the completion of all milestones**
					$40 million paid to date

Source: NASA and SpaceX.

[a]The fifth amendment to SpaceX's agreement with NASA included Milestone 23 with a due date of November 2010. Because NASA did not sign this amendment until December 2010 and SpaceX completed the milestone that same month, NASA views this milestone as having been completed on time.

[b]SpaceX successfully completed Milestone 27 on April 18, 2011.

[c]SpaceX successfully completed Milestone 28 on April 28, 2011.

[d]SpaceX successfully completed Milestone 29 on May 10, 2011.

Table 4: Orbital's Progress Completing New COTS Development Milestones

Milestone number	Milestone description	Scheduled completion date	Completed on time (Yes/No)	Delay, if applicable (months)	Payment amount (millions)
22	Mission Concept Review for Taurus II Maiden Test Flight	Dec. 2010	Y	-	$20
23	Taurus II Maiden Flight Preliminary Mission Analysis	Feb. 2011	Y	-	$10
24	Cygnus Mass Simulator Design Review	Mar. 2011	Y	-	$10
25	Installation of Additional Processor in the Loop Simulators	Apr. 2011	N	< 1[a]	$5
26	PROX Flight Equivalent Unit Test Unit	May 2011	-	-	$5
27	Taurus II Maiden Flight Stage 1 Core delivered to Wallops Flight Facility (WFF)	Apr. 2011	Y	-	$24
28	Taurus II Maiden Flight Upper Stage delivered to WFF	Jun. 2011	-	-	$20
29	Taurus II Maiden Flight Cygnus Mass Simulator at WFF in preparation for integration with Taurus II Maiden Flight Launch Vehicle	Jun. 2011	-	-	$10
30	Taurus II Maiden Flight Launch Vehicle Stage 1 Assembly Complete	Jul. 2011	-	-	$10
31	Taurus II Maiden Flight	Oct. 2011	-	-	$4
				Total:	**$118 million for the completion of all milestones** **$69 million paid to date**

Source: NASA and Orbital

[a]Orbital successfully completed Milestone 25 on May 20, 2011.

Appendix II: GAO Contacts and Staff Acknowledgments

GAO Contacts

For questions about this statement, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this testimony.

Staff Acknowledgments

Individuals making key contributions to this statement include Shelby S. Oakley, Assistant Director; Jeff Hartnett; Andrew Redd; Megan Porter; Laura Greifner; and Alyssa Weir.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday afternoon, GAO posts on its Web site newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to www.gao.gov and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's Web site, http://www.gao.gov/ordering.htm.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Ralph Dawn, Managing Director, dawnr@gao.gov, (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548