SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NASA's Commercial Cargo Providers; Are They Ready to Supply the Space Station in the Post-Shuttle Era?

Thursday, May 26, 2011
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Introduction

The last Space Shuttle mission is scheduled for the 8th of July. After that, how will NASA supply, maintain, and utilize the multi-billion dollar International Space Station (ISS)?

NASA plans to rely on new commercial launch service providers to supplement the international partners. NASA has spent $500 million since 2005 on the Commercial Orbital Transportation Services (COTS) program, intended to demonstrate commercial cargo delivery capabilities to the International Space Station (ISS) from two commercial partners, Space Exploration Technologies (SpaceX) and Orbital Science Corporation (Orbital). Despite initial assurances that NASA would not expend any money to buy services until these systems were fully demonstrated, NASA has spent over $466 million toward the purchase of cargo delivery services even though no demonstration flights to the ISS have been performed. Furthermore, last year NASA requested an additional $312 million "augmentation" (a 62 percent increase above initial COTS estimates) to reduce risk and improve the schedule. To date NASA has spent over $1.25 Billion on the Commercial Cargo effort without accomplishing a demonstration to the ISS. Questions for Congress include; 1) when will these systems be ready, 2) how much additional work, time, and money will be required to make the systems operational, and 3) where will the money come from?

Past Expenditures, Commercial Cargo FY2005 – FY2011[1]

$'s in Millions	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*Total*
Commercial Orbital Transportation Services (COTS)	$22.8	$101.2	$41.2	$130.7	$153.0	$39.0	$12.0	$500.0
Cargo Augmentation							$288.0†	$288.0
Commercial Resupply Services (CRS) [n]					$87.6	$231.0	$147.7	$466.3
Total	**$22.8**	**$101.2**	**$41.2**	**$130.7**	**$240.6**	**$270.0**	**$447.7**	**$1,254.3**

† Includes $20 million paid for CRS services [n] Included in amounts shown below

Projected Expenditures, Commercial Cargo (FY2011 – FY2016)

FY 2012 Budget Request *$'s in Millions*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*Total*
Commercial Resupply Services (CRS)	$516.5	$795.4	$801.3	$964.6	$998.5	$1,043.5	**$5,119.8**

[1] Phasing of the CRS funding reflects information provided by NASA subsequent to the original publishing date.

Witnesses

Mr. William H. Gerstenmaier, Associate Administrator, Space Operations Mission Directorate, National Aeronautics and Space Administration;

Ms. Christina Chaplain, Director, Acquisition and Sourcing Management, Government Accountability Office

Ms. Gwynne Shotwell, President, Space Exploration Technologies

Mr. Frank L. Culbertson, Jr., Senior Vice President and Deputy General Manager, Advanced Programs Group, Orbital Sciences Corporation

Background

In the NASA Authorization Act of 2005 (§505, P.L. 109-155) Congress directed the agency to, *"…ensure that the International Space Station can have available, if needed, sufficient logistics and on-orbit capabilities to support any potential period during which the Space Shuttle or its follow-on crew and cargo systems are unavailable, and can have available, if needed, sufficient surge delivery capability or prepositioning of spares and other supplies needed to accommodate any such hiatus.*"

Congress directed NASA to develop a contingency plan to ensure that vital equipment and supplies could be delivered to the ISS in case the Space Shuttle or an international partner's crew and cargo capability was unavailable. NASA's 2006 Strategic Plan established a goal of supporting a crew of six astronauts on the space station by the end of 2009 using 1) the Space Shuttle until its retirement; 2) vehicles developed by international partners; and 3) new commercial cargo service providers. In March 2006 *NASA's International Space Station Contingency Plan* proposed a two-phase development plan for the Commercial Orbital Transportation Services (COTS).

At that time the NASA-developed Constellation system (consisting then of the Ares 1 crew launch vehicle, Orion crew capsule, and Ares 5 heavy lift launch vehicle), was anticipated to be the government replacement for the Space Shuttle, expected to retire in 2010. The Ares launcher and Orion spacecraft could provide assured back-up for commercial cargo services. NASA's FY2009 budget request stated, *"It [Orion] will be capable of ferrying up to six astronauts (plus additional cargo) to and from the International Space Station if commercial transport services are unavailable."* The assumption that the Ares 1 and Orion capsule could be available in the 2013 timeframe gave the agency an opportunity to experiment by incentivizing industry to undertake a series of demonstration test flights of cargo delivery systems. According to NASA briefings the "*COTS approach is designed to lower barriers to entry for entrepreneurial space transportation companies*," and act as a "*catalyst for technology demonstrations where the potential high return on investment outweighs the associated financial risk.*"

Phase 1: Commercial Orbital Transportations System (COTS) Demonstrations

NASA budgeted $500 million in FY2006-FY2010 for the first phase, the Commercial Orbital Transportation Services (COTS) and planned to use "*funded Space Act Agreements with one or more U.S. companies to develop and demonstrate the vehicles, systems, and operations to support a human space facility like the ISS. These commercial services may also be used to provide logistics support in case the Shuttle or its follow-on crew and cargo systems are not available at some point in the future.*" NASA expected these companies to develop and demonstrate end-to-end transportation systems including the launch vehicles, spacecraft, ground and mission operations, and berthing with the ISS.

Space Act Agreements are used to establish enforceable promises between NASA and another party requiring a commitment of NASA resources such as for funding or technical engineering support. According to GAO, "*generally speaking, other transaction authority (e.g. 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.*" NASA found Space Act Agreements advantageous because the government can share costs with the agreement partner, and limited government requirements allow companies to optimize the systems to meet their business needs. However, it is important to note that these types of agreements are not federal government contracts, and Space Act Agreements are not subject to the Federal Acquisition Regulations (FAR) which contain a number of accounting standards, reporting requirements, and other procurement rules designed to prevent fraud, waste and abuse. Using Space Act Agreements to procure such large and complex systems is a relatively new development, and the government has limited ability to influence the agreement partners. In briefings by senior NASA officials leading up to this hearing, committee staff was told, "NASA did not get the level of detail with Space Act Agreements that they expected." The Committee has asked the U.S. Government Accountability Office witness to give GAO's perspectives on the use of Space Act Agreements and Federal Acquisition Regulations for these types of procurements.

In August 2006, NASA awarded and funded Space Act Agreements for the COTS program to two companies; SpaceX and Rocketplane Kistler. Company briefings from that time show COTS flight demonstrations were projected as early as 2008 and demonstration test flights completed by 2010. Rocketplane Kistler was subsequently unable to meet financing requirements and was replaced by Orbital Sciences in February 2008.

SpaceX was awarded $278 million for three demonstration flights of the Falcon 9 launch vehicle and Dragon capsule, designed with the capability to return pressurized cargo mass to Earth. SpaceX develops and manufactures most of the Falcon 9 and Dragon components in-house in an effort to keep development costs low and avoid dependence on external suppliers. SpaceX launches from Complex 40 at Cape Canaveral Air Force Station, Florida. SpaceX has received $258 million in milestone payments for completing 18 of 22 COTS milestones. Please see Appendix 1 for Space X's schedule milestone chart.

Both Orbital and SpaceX are making steady progress toward accomplishing their COTS demonstration flights. SpaceX successfully completed its first COTS demonstration flight on December 8, 2010. The Dragon capsule orbited the Earth twice and was recovered from the Pacific off the California coast. That mission did not reach the altitude or orbit of the ISS, but did test the Falcon 9 launch vehicle and Dragon capsule during reentry. SpaceX's second test flight has recently slipped from July 2011 to November 2011. During the second test flight the Dragon capsule is slated to conduct orbital maneuvers, attain the altitude and orbit of the ISS, and maneuver in close proximity to the ISS. In SpaceX's third test flight the Dragon capsule is slated to approach the ISS, be grappled by the space station robotic arm, and berth to the ISS.

Orbital was awarded $170 million for one demonstration flight of the Taurus 2 and Cygnus capsule, designed to deliver pressurized cargo to ISS but not return to Earth. Orbital has teamed with several external and international space companies to develop and manufacture the Taurus 2 and Cygnus capsule in an effort to reduced development risk by using proven systems. Orbital plans to launch their first COTS demonstration flight in December, 2011 from the Mid-Atlantic Regional Spaceport at NASA's Wallops Island Flight Facility, Virginia. Orbital has received $157.5 million in milestone payments for completing 15 of 19 COTS milestones. Please see Appendix 1 for Orbital's schedule milestone chart.

Phase 2: Procurement of Commercial Resupply Services (CRS)

The second phase, purchase of Commercial Resupply Services (CRS), was to be a competitive procurement of demonstrated services to deliver pressurized and unpressurized cargo to the ISS. These commercial entities would provide all prelaunch assembly and integration, launch licensing, and launch activities – in the case of SpaceX including the landing and recovery of the Dragon capsule – under a firm, fixed-price contract. NASA cargo on these missions is not guaranteed or insured. In the event of a launch failure, the commercial entities are not liable for the replacement of the cargo or the launch vehicle. NASA assumes the risk of loss. Launch licensing from the Federal Aviation Administration's Office of Commercial Space Transportation would be required since NASA would not be managing or conducting these activities.

The CRS contract was to be awarded only *after* successfully demonstrating all the COTS resupply capabilities to the ISS. In the COTS Final Selection Statement NASA describes the second phase as, "*A potential competitive procurement of orbital transportation services to resupply the ISS with cargo…**if a capability is successfully demonstrated** and the Government determines it is in its best interest*." [Emphasis added] After the initial COTS participants had successfully demonstrated the ability to access and berth with the ISS, NASA then planned to buy those delivery services using a FAR-based contract. This approach would minimize the financial and developmental risk to the U.S. Government by permitting NASA to select from among already proven and demonstrated systems and capabilities. However NASA did not follow this path.

By 2008, delays in the demonstration of COTS capabilities, the impending retirement of the Space Shuttle in 2010, and the long lead times needed to engage either COTS providers or international partners raised concerns that the ISS could not be maintained unless more supplies (including some large items only the Shuttle could carry) could be delivered. The following table shows the flight rate of the various systems.

Flight Rate to International Space Station

	2011	2012	2013	2014	2015
COTS Demonstration Flights					
SpaceX *Falcon 9/Dragon*	1	1			
Orbital *Taurus II/Cygnus*	2				
Commercial Resupply Services					
SpaceX *Falcon 9/Dragon*		3	3	3	3
Orbital *Taurus II/Cygnus*		2	2	2	2
International Partner Capabilities					
Russian *Progress*		4†	4	4	4
European *Autonomous Transfer Vehicle (ATV)*		1	1	1	
Japanese *H-II Transfer Vehicle (HTV)*		1	1	1	1

† does not include 0.5 metric ton (1102 pounds) of capacity assigned to U.S.

NASA's risk summary report states that a delay in 2010 by the commercial partner's vehicles would result in a significant scaling back of the ISS for scientific research. If delays extended into 2011, NASA could no longer support a space station crew of six astronauts. The capabilities of NASA's international partners to access the ISS with the Soyuz, Progress, ATV and HTV would enable limited functioning, but a loss of U.S. capability threatened to cause NASA to abandon the U.S. side of the ISS. This resulted in two significant events; 1) the addition of additional Shuttle flights, and 2) the initiation of the CRS contract including milestone progress payments to commercial providers before they had demonstrated any COTS capabilities.

The terms of the contracts awarded to SpaceX and Orbital call for delivery of at least 40 metric tons (approximately 88,160 pounds) of cargo to the space station between 2010 and 2015 for $3.5 billion. SpaceX was awarded $1.6 billion to deliver 20 metric tons on 12 cargo resupply missions. Orbital was awarded $1.9 billion to deliver 20 metric tons on 8 cargo resupply missions.

The following chart lists approximate costs to deliver one pound of cargo to the ISS under various programs. Development costs are not included in these calculations, and are considered proprietary information by the COTS partners.

	Space Shuttle *	Russian Progress	Commercial Resupply Services (CRS)
Approximate cost per pound to ISS	$21,268	$18,149	$26,770

*Calculated assuming four missions per year with a capability to deliver 16 metric tons (35,264 pounds) to the space station at a total annual program cost of $3.0 Billion. $3,000,000,000 ÷ (4 flights × 35,264 pounds/flight) = $21,268 per pound. Assumes no additional cost to transport 28 astronauts to the space station and return.

Costs for the Russian Progress and the Commercial Resupply program are NASA estimates.

The CRS estimate would be higher, at around $39,700 per pound, if derived using a method similar to that used for the Space Shuttle; i.e. Dividing the CRS program cost ($3.5 billion) by the mass delivered to the space station (40 metric tons, i.e. 88,160 pounds).

Delays in Commercial Cargo Systems Led to Additional Shuttle Flights

NASA estimates that the ISS requires about 83 metric tons (a metric ton equates to 2,204 pounds) of dry cargo between 2010 and 2015. Dry cargo consist of scientific experiments, tools, food, spare parts and other equipment, but does not include propellants, water, atmospheric gases and other liquids. Without the Space Shuttle, NASA's international partners lack sufficient capabilities to satisfy the ISS cargo resupply needs.

As a result, NASA faces a 40 metric ton (approximately 88,160 pounds) shortfall between 2010 and 2015. In 2008 Congress was aware that delays in the COTS cargo demonstration program threatened the scientific utilization of the space station. According to NASA, the projected delays of the commercial vehicles in 2010 would cause significant scaling back of NASA's use of the space station for scientific research. Delays extending into 2011 would mean NASA could no longer maintain a space station crew of six astronauts and the ability to conduct scientific research would be significantly compromised.

Thus, Sec. 611 of the NASA Authorization Act of 2008 [P.L.110-422] authorized two additional logistics flights, *"In addition to the Space Shuttle flights listed as part of the baseline flight manifest as of January 1, 2008, the Utilization flights ULF–4 and ULF–5 shall be considered part of the Space Shuttle baseline flight manifest and shall be flown prior to the retirement of the Space Shuttle, currently scheduled for 2010."*

Continuing launch delays for the first commercial COTS demonstration extended into the fall of last year as Congress negotiated the 2010 NASA Authorization Act. To reduce risk and ensure the viability of ISS, Congress authorized another Space Shuttle flight (STS-135, the last mission of the program, now scheduled for July 8th), *"The Administrator shall fly the Launch-On-Need Shuttle mission currently designated in the Shuttle Flight Manifest dated February 28, 2010, to the ISS in fiscal year 2011, but no earlier than June 1, 2011, unless required earlier by an operations contingency…"*

The need for a costly additional shuttle mission underscored the importance of a U.S. Government backup capability for assured access to ISS. Sec. 2(9) of the NASA Authorization Act of 2010 states, *"While commercial transportation systems have the promise to contribute valuable services, it is in the United States' national interest to maintain a government operated space transportation system for crew and cargo delivery to space."*

According to NASA, the STS-135 mission is critical because it will provide about one year of schedule margin. At the March 15th, 2011 Senate Commerce, Science and Transportation Committee hearing on *The Challenges Facing NASA*, Associate Administrator Bill Gerstenmaier explained the critical nature of the STS-135 mission given the concerns for commercial COTS schedule, *"We see that mission as extremely critical to us. What that mission provides for us is it gives us some margin that if the commercial providers are late and they don't fly in 2011 and 2012 as they plan, then we have got some time through 2012 that we will have enough supplies pre-positioned on Space Station that we can continue to do quality research, we continue to keep our crew size at six onboard station through that period of 2012 all the way until 2013. If we don't have that shuttle flight, then it's absolutely mandatory that the commercial cargo providers come on-line at the end of this year and early in 2012. I don't think that is a prudent strategy. We need some margin just as in the shuttle world, we thought we understood where we were going to go fly, then we had the tank problem that slowed us down a couple*

months. I would expect small problems to show up in the commercial providers as well. We need some margin to do that."

NASA Assumes Development Risk: Procures Commercial Resupply Services (CRS) before COTS Capabilities are Demonstrated

In December 2008, two years before the first COTS cargo demonstration would be performed; NASA awarded Commercial Resupply Services (CRS) contracts to the two COTS partners. Both companies are working under aggressive schedules and have experienced schedule slips which have delayed the COTS test and demonstration flights. In spite of the delays of the COTS demos, NASA has used the CRS contracts to make progress payments to the COTS partners for milestones associated with future CRS cargo delivery missions. To date NASA has paid SpaceX more than $185.6 million for milestones tied to four CRS missions, and has paid Orbital more than $280.7 million for milestones tied to three CRS missions. This $466 million does not include milestone payments that are funded by the recent cargo "augmentation."

By purchasing CRS years before the COTS systems had been demonstrated, NASA assumed significantly more risk for ensuring the success of the cargo providers. NASA has indicated that they are "too important to fail." This concept has important policy and budgetary implications for future commercialization proposals such as the Administration's proposed commercial crew efforts. Administrator Bolden has repeatedly told Congress that NASA would do "whatever it takes" to make these ventures succeed. According to briefings provided to Committee staff, "*NASA is depending on our commercial cargo partners. We need their COTS development efforts to succeed so that they can begin providing cargo resupply to the International Space Station…*" Legitimate questions have been raised about this approach since it differs from what was originally intended to be a merit-based and market-based competition.

Delays Result in a 62 Percent Increase for COTS Cargo Augmentation

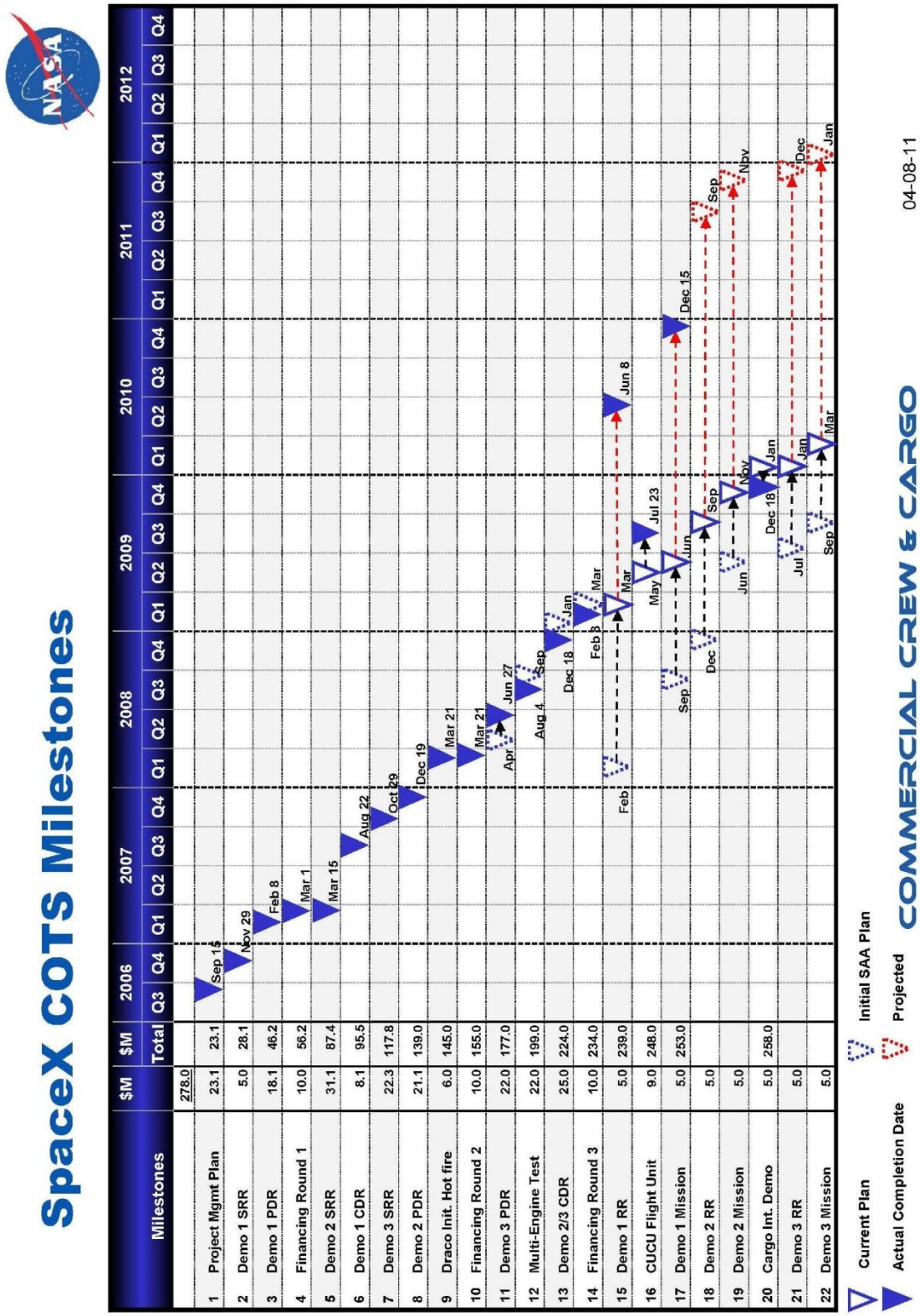
NASA's FY 2011 budget requested an additional $312 million—a 62% increase in the cost of the COTS program—in an attempt to speed up the COTS development activities and help ensure mission success. NASA worked with each COTS partner to develop a series of additional "risk reduction" milestones designed to improve the likelihood of successful COTS demonstrations. SpaceX and Orbital will each receive $128 million toward these milestones. To date SpaceX has been paid $40 million for the first seven augmentation milestones, and completed 25 out of a total of 40 COTS milestones. Orbital has been paid $64 million for four augmentation milestones, and completed 21 out of a total of 31 COTS milestones.

COTS Cargo Augmentation could Reduce a Mission for SpaceX and Add a Mission for Orbital

Last year, SpaceX asked NASA for permission to combine the second and third COTS demonstration missions. At that time NASA deferred any decision on a combined mission until after it had reviewed all the data from the first COTS mission. In January 2011 NASA gave SpaceX a list of the data it would need to evaluate the impacts and assess the risks of combining the second and third missions. NASA is now evaluating a range of safety and technical concerns and hopes to complete an assessment in mid-June. If the missions are combined and both sets of test objectives are accomplished, then presumably NASA would pay for meeting both sets of milestones and relieve SpaceX of the requirement to conduct a third demonstration flight.

Whereas SpaceX is doing much of their development in-house, Orbital's COTS concept takes advantage of a number of previously developed heritage systems. For example, Orbital's Taurus 2 uses two Aerojet AJ-26 engines, an ATK Castor 30 solid rocket motor second stage, and a standard service module derived from NASA's STAR and Dawn spacecrafts. Orbital's COTS demonstration consists of one mission of the Taurus 2 and Cygnus capsule to the ISS planned for December 2011. NASA is working with Orbital to evaluate adding a Taurus 2 demonstration flight in October 2011, prior to the first COTS demonstration to the ISS. Both Orbital and NASA wanted such a flight in the initial agreement, but it was not funded.

Appendix 1


SpaceX COTS Milestones
Milestones
$M Total
2006 Q3 Q4
2007 Q1 Q2 Q3 Q4
2008 Q1 Q2 Q3 Q4
2009 Q1 Q2 Q3 Q4
2010 Q1 Q2 Q3 Q4
2011 Q1 Q2 Q3 Q4
2012 Q1 Q2 Q3 Q4
278.0
1 Project Mgmt Plan 23.1 23.1
2 Demo 1 SRR 5.0 28.1
3 Demo 1 PDR 18.1 46.2
4 Financing Round 1 10.0 56.2
5 Demo 2 SRR 31.1 87.4
6 Demo 1 CDR 8.1 95.5
7 Demo 3 SRR 22.3 117.8
8 Demo 2 PDR 21.1 139.0
9 Draco Init. Hot fire 6.0 145.0
10 Financing Round 2 10.0 155.0
11 Demo 3 PDR 22.0 177.0
12 Multi-Engine Test 22.0 199.0
13 Demo 2/3 CDR 25.0 224.0
14 Financing Round 3 10.0 234.0
15 Demo 1 RR 5.0 239.0
16 CUCU Flight Unit 9.0 248.0
17 Demo 1 Mission 5.0 253.0
18 Demo 2 RR 5.0
19 Demo 2 Mission 5.0
20 Cargo Int. Demo 5.0 258.0
21 Demo 3 RR 5.0
22 Demo 3 Mission 5.0
Sep 15
Nov 29
Feb 8
Mar 1
Mar 15
Aug 22
Oct 29
Dec 19
Mar 21
Mar 21
Apr
Jun 27
Aug 4
Sep
Jan
Dec 18
Feb 8
Mar
Feb
Mar
Jun 8
May
Jul 23
Jun
Sep
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Dec 15
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Dec 18
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Dec
Sep
Mar
Jan
Current Plan
Initial SAA Plan
Actual Completion Date
Projected
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04-08-11

SpaceX Augmented COTS Milestones

	Milestones	$M	$M Total	2007 Q1	2007 Q2	2007 Q3	2007 Q4	2008 Q1	2008 Q2	2008 Q3	2008 Q4	2009 Q1	2009 Q2	2009 Q3	2009 Q4	2010 Q1	2010 Q2	2010 Q3	2010 Q4	2011 Q1	2011 Q2	2011 Q3	2011 Q4	2012 Q1	2012 Q2	2012 Q3	2012 Q4
		118.0																								
23	Modal Test Plan	5.0	5.0																Dec 16							
24	Modal Test	5.0	10.0																Dec 16							
25	LIDAR Test (open loop)	5.0	15.0																Dec 16							
26	Solar Array Deploy Test	5.0	20.0																Dec 16							
27	LIDAR Test Plan (closed loop)	5.0	25.0																	Mar 31						
28	Thermal Vacuum Test Plan	5.0	30.0																Mar	–	Apr 6					
29	Infrastructure Plan	10.0	40.0																Mar	–	May 10					
30*	Thermal Vacuum Test	20.0																			Jul					
31	Test site Infrastructure Implementation	5.0																		Jun						
32	Dragon Trunk Acoustic Test	10.0																		Jun						
33	LIDAR Test 6 DOF (closed loop)	5.0																			Aug					
34	Design Rev. Enhanced Powered Cargo Accom.	5.0																			Aug					
35	Design Rev. Pressurized Cargo Vol Increase	5.0																			Aug					
36	Dragon EMI/EMC Test (HITL)	10.0																			Jul					
37	Dragon Cargo Racks & Hatch Simulator	3.0																			Aug					
38	Ground Demo Enhanced Powered Cargo	5.0																			Sep					
39	Launch site Infrastructure Implementation	5.0																			Sep					
40	Production Infrastructure Implementation	5.0																			Sep					
	SAA Total	396.0	298.0																							

Current Plan

Actual Completion Date

Initial SAA Plan

Projected

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05-12-11

Orbital COTS Milestones

	Milestones	$M	$M Total	2008 Q1	2008 Q2	2008 Q3	2008 Q4	2009 Q1	2009 Q2	2009 Q3	2009 Q4	2010 Q1	2010 Q2	2010 Q3	2010 Q4	2011 Q1	2011 Q2	2011 Q3	2011 Q4	2012 Q1	2012 Q2	2012 Q3	2012 Q4
		170.0																				
1	Program Plan Review	10.0	10.0	Mar 31																		
2	Demo Mission SRR	20.0	30.0	Jun		Jul 17																
3	UCM PDR	10.0	40.0		Jul		Aug 14															
4	DELETED																					
5	COTS Int/Ops Facility	10.0	50.0			Sep 22	Oct															
6	PCM PDR	10.0	60.0				Oct 9	Nov														
7	DELETED																					
8	IP&CL Submission	10.0	70.0					Feb 18														
9	ISS Phase 1 SRP	10.0	80.0						Mar 27													
10	COTS System PDR	20.0	100.0			Sep		Apr		May 22												
11	PCM CDR	10.0	110.0								Jul 31											
12	Cygnus Avionics Test	10.0	120.0						Jun			Aug 13										
13	ISS Phase 2 SRP	10.0	130.0							Aug			Nov 6									
14	COTS System CDR	10.0	140.0					Mar		Sep				Mar 23								
15	SM Core Assembly Complete	7.5	147.5								Oct		Dec			Aug 30						
16	SM Test Readines Review	7.5	155.0									Jan		Apr			Nov 17					
17	SM Initial CPT	5.0											May					Jun				
18	LV Stage I Assy. Complete	2.5												Sep					Sep			
19	Cargo Int. Demo	2.5	157.5													Dec 6						
20	Mission Readiness Review	2.5													Oct				Oct			
21	System Demo Flight	2.5														Dec				Dec		

Current Plan

Actual Completion Date

Initial SAA Plan

Projected

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03-30-11

Orbital Augmented COTS Milestones

Milestones	$M	$M Total	2008 Q1	2008 Q2	2008 Q3	2008 Q4	2009 Q1	2009 Q2	2009 Q3	2009 Q4	2010 Q1	2010 Q2	2010 Q3	2010 Q4	2011 Q1	2011 Q2	2011 Q3	2011 Q4	2012 Q1	2012 Q2	2012 Q3	2012 Q4
	118.0																					
22 TII Test Flight Mission Review	20.0	20.0													Dec 15							
23 TII Test Flight Mission Analys.	10.0	30.0													Feb 23							
24 Cygnus Mass Sim. (CMS) DR	10.0	40.0													Mar 03							
25 Install Add'l PITL Simulators	5.0														Apr	May						
26 PROX FEU Test Unit	5.0															May						
27 TII Maiden Flt Stg 1 Core Del.	24.0	64.0														Apr 28						
28 TII Maiden Flt Uppr Stage Del.	20.0																Jun					
29 TII Maiden Flt CMS Delivered	10.0																Jun					
30 TII Maiden Flt Stage 1 Assy.	10.0																	Jul				
31 TII Maiden Flight	4.0																		Oct			
SAA Total	288.0	221.5																				

Current Plan
Actual Completion Date
Initial SAA Plan
Projected

COMMERCIAL CREW & CARGO

04-28-11