Testimony before the House Science, Space and Technology Committee's Subcommittee on Space and Aeronautics

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Good morning Chairman Palazzo, Ranking Member Costello and members of the subcommittee. I appreciate the opportunity to participate in this hearing regarding the status of our commercial cargo delivery capabilities to low earth orbit. Our job on this program is to help maximize our nation's return on investment in the remarkable orbiting facility known as the International Space Station.

It is especially fitting that this hearing is being held one day after the 50th anniversary of President Kennedy's speech to Congress boldly committing our nation to landing a man on the moon. It's not entirely clear to me, however, exactly what our nation's – or the world's - next audacious goal will be in space, but I know for sure that the next big achievement will not be possible without maximum safe, efficient, and continuous use of the International Space Station as a waypoint on that journey. Just as Mercury, Gemini, X-1, and X-15 paved the way for Apollo and Shuttle, the ISS, with the help of both commercial and government

transportation systems, will pave the way for human exploration of the rest of the Solar System. Its potential as a National Research Laboratory, development center, and engineering test bed must be fully realized in order to take the higher risk steps necessary to send crews beyond low-earth orbit for extended periods of time, as well as to justify the extensive investment by the US and all of our partners in this complex and highly capable facility.

Orbital Sciences Corporation is proud to have been selected by NASA in 2008 to be one of the participants in NASA's Commercial Orbital Transportation Services (COTS) and related Commercial Resupply Services (CRS) programs. This partnership between NASA and private industry has energized our company— which next year will mark 30 years of building and operating some of our nation's most advanced and innovative launch vehicle, spacecraft and satellite systems—to develop dependable means of launching cargo and supplies to the ISS, and disposing of unneeded waste, following the retirement of the Space Shuttle. When I left the astronaut corps, I had spent over 20 years of my NASA career, plus my Navy service, working diligently to ensure safety of flight and mission success. When I joined Orbital, I immediately recognized a company team that had a similar focus, and a record of tremendous innovation with such vehicles as the Pegasus air launched rocket and the Minotaur launch vehicle. Our work force is skilled, extremely dedicated to the mission at hand, and individually accountable

for meeting our performance and safety requirements. I've had the privilege of working with superb organizations in the Navy and at NASA, and I now consider it a privilege to be a part of an Orbital team that can stand toe-to-toe with any in the government.

Even prior to Orbital's partnership with NASA in the COTS program, we were developing, with our own funding, a new medium-class space launch vehicle, the Taurus II. Taurus II is a two-stage vehicle—with an optional third stage—that will provide low-Earth orbit launch capabilities for payloads weighing over 5,000 kg and access to geosynchronous orbit for smaller spacecraft. This vehicle will provide responsive, low-cost, and reliable access to space not only for CRS missions, but also for national security payloads, NASA science payloads, and certain commercial satellites as well. The Cygnus advanced maneuvering spacecraft is capable of carrying up to 2700 kg of cargo to the ISS, and possesses a multi-use potential as well. It can be used as a maneuvering and hosting spacecraft for a variety of government and private sector customers.

One unique aspect of our involvement in COTS/CRS is that we will initially launch the Taurus II and Cygnus cargo delivery spacecraft from NASA's Flight Facility at Wallops Island, Virginia. While Kennedy Space Center provides outstanding launch service to a wide variety of users, and remains a potential future site for Taurus II operations, Orbital, NASA, and the Commonwealth of

Virginia have committed significant financial and technical resources to enable the United States to have a second major east coast launch facility, providing resiliency and flexibility to our nation's space launch capabilities. An added item of interest about Wallops is that members of Congress (and others) can actually view Taurus II launches at this space port from the Capitol Building, so we hope through these launch activities to generate renewed interest in space flight locally and throughout the six-state Mid-Atlantic region.

COTS/CRS provides a new model for U.S. government/private-sector collaboration to develop and operate dual-use space systems. In this collaboration, Orbital has contributed about 60 percent of the development costs for launch vehicle, cargo delivery and disposal systems, and much of the ground-support infrastructure, up front. This high level of investment from a private company recognizes the potential benefits of having a consistent customer in NASA for cargo delivery and disposal in support of the ISS's logistics needs in the near future, and also requires us to work hard to develop new markets for a variety of other users.

The Orbital COTS Program will literally get off the ground with a test of the Taurus II launch system in early fall. Our current target date for the Taurus II test launch from launch pad 0A at the Mid-Atlantic Regional Space Port (MARS) on Wallops Island is mid-October. Our Orbital/MARS/NASA team of over 400

scientists, engineers and technicians, including our teammates from around the industry, is working with great dedication toward this major milestone. Yet as we look forward to the first launch of Taurus II, we are well aware that there are significant risks to the schedule, as there are in any major aerospace development program. Orbital and our government partners are developing a rocket, a spacecraft, and a launch and control infrastructure simultaneously. This is a significant undertaking, which for the most part has gone extremely well. The Taurus II vehicle planned for the Test Launch is currently undergoing tests at the newly opened Horizontal Integration Facility, or HIF, at Wallops Island. The MARS-developed launch pad and liquid fueling facility are completing construction, and will begin certification testing in early July.

Like most of the aerospace industry, Orbital uses Earned Value Management Systems to track our progress on schedule and cost performance. I can tell you today that based on our internal budgeted costs of work scheduled we are 95 percent complete with Taurus II development and have completed successfully the first 41 months of the 46 month Taurus II schedule. There is also great progress to report at Wallops, where the HIF and Payload Processing Facility are essentially ready to support launches. Development of the launch pad and related support facilities is 90 percent complete.

With respect to development of the Cygnus Advanced Maneuvering Spacecraft, the first flight unit is on track for a December 2011 launch that will demonstrate our capabilities of providing cargo to the ISS. We developed Cygnus on an aggressive 45 month schedule, and are on track to finish the final six months on time.

The Cygnus Service Module for the Demonstration mission is being assembled at our Dulles, VA, facility, and has begun our normal ISO-certified Integration and Test process, which will be followed by thorough environmental testing of the fully assembled spacecraft, tests which we require prior to launch for all of our spacecraft.

The service module for our first CRS mission is in the manufacturing flow as well, following closely behind the Demonstration mission hardware, and hardware for the second CRS mission is arriving at the plant. The hardware acceptance review for our Pressurized Cargo Module (PCM) is occurring this week with our industrial partner, Thales Alenia, with the PCM and its support equipment being essentially complete and ready for shipment to the US. Last December we completed a very successful cargo loading demonstration of the PCM to be used for the first CRS mission, and just this month we conducted a very successful crew equipment interface test with the astronauts and representatives from NASA's

mission operations directorate in the actual PCM slated for the COTS Demonstration mission.

The COTS Demonstration mission in December will mark the first use of a dedicated Mission Control Center for Cygnus flight operations. Mission Control Center Dulles, a state of the art facility at Orbital's headquarters five miles north of Dulles airport, was dedicated last November, with the participation of NASA Administrator Charles Bolden, and our operators will work hand in hand with ISS Mission Control at NASA's Johnson Space Center, and other ISS partner nation control centers, to manage the critical rendezvous and berthing of the Cygnus at the ISS. The COTS demonstration mission will be a culmination of all the hard work that has gone into the design, development, and the safety reviews for operations in proximity with the ISS, as well as the many hours of joint testing we are conducting with NASA. Orbital has worked closely with NASA to move further into the ISS Human Spaceflight mode of operation, successfully completing the first two phases of NASA's Safety Review Panel, and are well on the path to completing the requirements of the third and final Safety Review Panel, a prerequisite for approaching the Space Station.

Success on the December COTS demonstration mission will then lead directly to CRS, the actual contract covering the repetitive delivery of cargo to the ISS, with two Orbital CRS missions slated every year from 2012 to 2015. Again,

this is a very ambitious schedule, and we will know with greater certainty the exact dates to target for cargo delivery once we have the experience of our first test launch and demonstration flight.

To address our current schedule status versus the original program plan, there are two significant factors that prevented us from achieving the original target dates for the COTS demonstration: First, the change from an unpressurized cargo module to a pressurized cargo module, executed at Orbital expense in response to a desire from NASA to duplicate the requirements of the CRS contract on the Demonstration mission; and secondly, the unexpected challenges encountered in the development of a minimally equipped Pad 0A into the Mid-Atlantic Regional Spaceport's Medium Class Launch Facility at Wallops Island. These challenges have been addressed, and while all activities are not yet complete, the threats to the remaining schedule are small compared to what we have encountered in the past two years.

That in summary is our progress to date. Our Orbital-NASA partnership for the development of a cargo delivery capability to ISS is on track, moving ahead steadily, and, in fact, nearing completion.

The subcommittee has also asked Orbital to respond to three specific questions, which I'm pleased to do. First, you asked about the justification and

rationale for each of the risk-reduction milestones funded by the COTS Augmentation that was supported by Congress in the FY 2010 NASA Authorization Bill.

Some history may be useful in this regard. The original NASA COTS competition for $500M resulted in NASA selecting Space X and Kistler Aerospace for the program in August 2006, with Space X receiving the majority of the funding, and Kistler a lesser amount of the $500M. After NASA decided to terminate its funded space act agreement with Kistler, the remaining $170 million was re-competed and awarded to Orbital in February 2008. In determining how best to utilize the reduced funding available for COTS, Orbital was placed in the position of bidding a single demonstration mission along with the development of the Cygnus spacecraft.

Both the Orbital and NASA COTS program offices recognized the elevated risk in the plan for launching the first Cygnus maneuvering spacecraft on the first Taurus II launch vehicle flight. Due to the limited funding remaining in the program, however, this was viewed as a necessity. There is acceptance in the industry that first flight missions of new launch vehicles historically have elevated risk associated with them, largely due to the complexity inherent in launch vehicles, the necessarily small margins of safety in vehicle designs to meet

performance-to-orbit goals, and the fact that critical elements of the launch vehicle can never be fully tested in exact flight-like conditions through ground testing.

When the possibility of additional funding for risk reduction was presented, Orbital and NASA mutually agreed that a Test Flight of the Taurus II launch vehicle prior to the COTS demonstration mission was the best use of risk reduction funding. This approach added significant content and value to the program as well as an additional meaningful test of the system. The concept for the Test Flight is to launch a Taurus II vehicle with an instrumented Payload Simulator that mimics the mass properties and other key characteristics of the Cygnus spacecraft. This Test Flight would verify the operation of the launch vehicle and also return valuable launch-environment data from the Payload Simulator. After completing the test flight, the COTS Demonstration mission can be properly focused on the operation of the Cygnus spacecraft and its rendezvous and proximity operations with the ISS.

Therefore, in the context of the above discussion of risk at the programmatic level for the COTS program, Orbital and NASA worked together to develop the 10 COTS Augmentation Milestones that authorized the Test Flight as a top priority, and then added other Cygnus-related risk reduction elements to the program that were deemed beneficial to reducing risk on the spacecraft. Milestones 25 and 26 require the development and installation of additional ground simulators of the Cygnus system to facilitate joint testing and verification between NASA and

Orbital prior to acceptance for flight. Milestones 22-24 and 27-31 are associated with deliveries of key components of the test flight and completion of critical readiness reviews. The criteria for success are clearly described for each of the milestones in an amendment to the SAA.

To further discuss the addition of the test flight and the risk that Orbital assumed in adding content to the program, a typical launch service procurement spans 24 months. This span is necessary to authorize subcontracts for long lead suppliers such that all hardware elements can be delivered to the launch site with sufficient time to integrate and test the launch vehicle prior to flight. In the case of Taurus II, the 2nd stage solid rocket motor is the longest lead item requiring 18-21 months lead time. The liquid first stage tanks require 18 months lead time. The plan to incorporate the Test Flight into the program is to utilize the first hardware set previously assigned to the COTS-Demo mission for the Test Flight, and then to re-assign the second hardware set previously assigned to Orb-1 CRS mission to COTS-Demo, and so on. In this way, the earliest opportunity for the Test Flight can be accommodated while minimizing the impact to the COTS-Demo launch date.

To protect for the possibility for the Test Flight, Orbital proceeded at risk in summer 2010 to order a replacement Stage 2 motor assembly from ATK along with other long lead purchases of ordnance and separation joints. This hardware

was necessary to backfill the hardware queue to ensure later flights could still be executed on time given the insertion of the Test Flight into the manifest as the first flight of Taurus II. These long lead purchases were made prior to receiving any COTS Augmentation funds and prior to being sure that the COTS Augmentation funds would ultimately be added to the program due to the extended debate on the budget and continuing resolution in Congress. This decision to proceed at risk was based on Orbital's desire to protect for the earliest opportunity for a Test Flight given the uncertain FY11 budget situation for NASA that existed last fall. Two incremental amendments to the COTS Space Act Agreement occurred prior to negotiation of the full suite of milestones authorizing the Test Flight mission.

Your second question was about Orbital's plan to recover in the event of a launch failure or loss of a COTS demonstration flight or a CRS missions. I assure you that Orbital is placing maximum emphasis on identifying and addressing risks, as well as ensuring that testing and analysis are in place to minimize the chance of failure. Based on my experience in this high-risk, high-reward business, the most significant thing an organization can do is to inculcate in its members from top to bottom the strong belief that we will do everything possible to successfully complete our mission, and that each person who has a job to do on the project will be held to the highest level of accountability for their work. This includes taking the approach that safety and mission success will never be a lower priority than

schedule, which will occasionally result in delays. And that we are doing, including using every company resource, engineering expertise, and operational experience available, as well as the advice and insight of both NASA and our own outside experts. Yet, if we do suffer a setback, as occasionally happens in this business, what we will do to recover, and our schedule for recovery will very much depend upon the circumstances of the setback, what is learned from a careful review of the available data to determine root cause, and what corrective actions are necessary to be taken. An additional factor to consider is that since we will have three or four Cygnus spacecraft and four or five Taurus II vehicles in production at any one time, we will be able to quickly move to the next mission and provide the needed cargo, providing we are able to identify and correct the cause quickly. This makes a lengthy stand-down in operations unlikely. Having participated in accident investigations in both NASA and the Navy, I know that it is impossible to tell exactly what course will be followed in recovering from an accident, but having the correct program discipline, data retention, and attention to detail prior to an incident will facilitate that recovery. We have instilled those values in our team, which should also minimize the chance of it occurring.

Finally, you have asked Orbital to discuss the biggest challenges confronting us in the development and demonstration of our launch and cargo systems. I will address some of the technical challenges for the launch vehicle first:

The development of a new launch vehicle system is a very complex and expensive task. If the development is done from scratch, meaning that every subsystem and component and software item is brand new, it is an extremely difficult task to complete on schedule and on budget.

In the case of Taurus II and Cygnus, Orbital is able to take advantage of many heritage flight-proven design features. These include:

a. Launch vehicle avionics – Using heritage common hardware for flight control and sequencing, navigation, flight termination, tracking, and telemetry subsystems. These common subsystems are used on Minotaur, Pegasus, Taurus XL, and Ground-Based Midcourse Defense Orbital Boost Vehicle.
b. Launch vehicle software – Using Object-Oriented code base common across Orbital rocket programs.
c. Stage 1 tanks structure – Using 3.9m diameter core based directly on the Zenit Ukranian launch vehicle design, using same pressurization components as Zenit.
d. Stage 1 Propulsion – Using existing AJ26 LOX/RP engines with large stock in inventory at Aerojet.
e. Stage 2 Propulsion – Using Castor 30 motor assembly built by ATK based on Castor 120 heritage design.

f. Cygnus Service Module – Star Bus and Leo Star heritage design for propulsion, command and data handling systems, and software
g. Pressurized Cargo Module – Thales Alenia heritage for the development of pressurized modules for NASA and ESA, to include several ISS pressurized modules.

However, there are other critical program areas where Taurus II was not able to utilize heritage designs and new developments were required:

a. Launch Pad With Liquid Fueling Facility – Despite performing extensive searches early in the program, there was no launch pad available on a US federal range that could accommodate the Taurus II vehicle without significant modification. A new launch pad was therefore required, and a trade study between Florida/Cape Canaveral Air Force Station and Virginia/NASA Wallops Flight Facility was conducted. Wallops was ultimately selected and Pad 0A was razed and completely rebuilt to accommodate a medium class liquid rocket.
b. Stage 1 Propulsion Test Facility – Despite performing a search through the National Rocket Propulsion Test Alliance (NRPTA), no existing stage test facility was available that could accommodate the Taurus II vehicle Stage 1 Static Fire Test without significant upgrade/modification

or modernization. It was decided to utilize Launch Pad 0A as the stage test facility and pad systems were designed and built at increased cost to accommodate the increased loads on the pad induced by the Stage 1 Static Test firing.

c. Stage 1 Engine Propulsion Test Facility – After performing a search through the NRPTA for a test stand to use for single engine testing for the AJ26 engine, two were identified as primary candidates – one at the Air Force Research Laboratory/Edwards AFB, and one at the NASA Stennis Space Center. However, both stands required significant funding to bring to a test ready condition. The Stennis E-1 stand was chosen but had to be significantly modified from horizontal test configuration to vertical test configuration along with other areas of modification.

The above three areas of the program that required significant development resources to be applied constituted the biggest challenges to the development of the Taurus II launch vehicle. The fixed price nature of the COTS program funding meant that cost and schedule overruns experienced during the development of the three facilities listed above were largely the responsibility of Orbital to resolve.

Some may see the challenge of estimating costs for the fixed price Cargo Resupply Contract so soon after our late award of the recompeted COTS SAA, and before development costs or risks were completely understood as a significant risk,

and in many ways it is. This issue is somewhat offset by the fact that a contract was indeed awarded, and provided we execute the contract well, this will somewhat justify both the risk and expense of the development effort. It is true, however, that the CRS contract is a financial risk to Orbital, requiring the submittal of fixed delivery mission prices so far in advance of the actual mission execution, with the period of performance spanning a five year period, and before critical development risks were completely identified or addressed.

In summary, the biggest challenge to the company is that a complex program with three major new elements is being developed in essentially a fixed price environment through Space Act Agreements, which provide no company protection for cost overruns or changes in government requirements. And the subsequent business is also fixed price and totally dependent on the success of the work under the SAA. These are challenges that Orbital accepts as good for the nation in the long run, and worth the risk from a long-term business viewpoint. It is important to take a long view on this job. The ISS must be successfully resupplied, possibly for decades. It's true that the technical challenges are also large, but these will be resolved over time by the professionals working the program.

We hope these responses will help serve the needs of the subcommittee as you work with NASA to help ensure that our nation's new path forward to utilize

the private sector in support of critical space program objectives is successful. Our company and our team recognize that we have an important role in the ISS mission, and we will take all of the steps necessary with our NASA partner to ensure that our flights are safe and missions successful. Thank you again for the opportunity to testify before this important hearing.