SPACE ACT AGREEMENT AMENDMENT TWO
BETWEEN
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND
ORBITAL SCIENCES CORPORATION
FOR
COMMERCIAL ORBITAL TRANSPORTATION SERVICES DEMONSTRATION
(COTS)

PURPOSE AND AGENCY COMMITMENT

The purpose of this Amendment is to modify the Agreement NNJ08TA32S to define how the parties will collaborate on the provision of communication services and proximity operations support during the flight demonstration under this Agreement. In addition, the executive summary and milestones are updated to reflect a change from the development and flight demonstration of an unpressurized cargo transportation capability to a pressurized cargo transportation capability. These changes result in a higher fidelity flight demonstration and improve the approach for meeting the goals and the objectives of the COTS project.

Articles 3, 7, 20, 27, 28, and Appendices 1, 2, 3, and 4, are amended as follows:

ARTICLE 3. RESPONSIBILITIES

The following NASA responsibilities are added:

NASA shall:

(8) Provide TDRSS communications and NISN network services for Orbital Cygnus and Launch Vehicle for the entire duration of the COTS demonstration flight under NASA's standard terms and conditions for the provision of such services for a NASA mission, at no cost to Orbital.

(9) Provide the ISS Proximity Operations (PROX) system for use in performing Cygnus rendezvous and proximity operations activities for the COTS demonstration flight, including update of PROX software, as required, at no cost to Orbital. This includes obtaining the necessary integration, testing, and operational support required from the Japan Aerospace Exploration Agency (JAXA) during development of the Orbital COTS System and performance of the demonstration mission, as well as provision of test and flight encryption keys for the ISS PROX system, at no cost to Orbital.

(10) Loan equipment to Orbital as identified and described in Appendix 4.

ARTICLE 7. NASA FURNISHED INFORMATION AND SERVICES

Paragraph A is replaced in its entirety with the following:

A. NASA may, at its sole discretion and on terms to be negotiated between the Parties, provide Orbital additional NASA services, technical expertise, or Government Property. Additional NASA services, technical expertise, or Government Property may be provided on either a reimbursable or non-reimbursable basis. Specific services and property will be identified in modifications to this Agreement. Unless NASA specifically requires Orbital to use NASA furnished services, technical expertise or Government Property to fulfill its obligations under this Agreement, any decision by Orbital to use NASA furnished services, technical expertise or Government Property shall be at Orbital's option and sole discretion. Orbital shall remain solely responsible for completion of its milestones under this Agreement regardless of the availability or use of such optional NASA services, technical expertise, or Government Property.

ARTICLE 20. PRINCIPAL POINTS OF CONTACT

The NASA Administrative Contact is replaced as follows:

Charles Bell
Agreements Officer

Johnson Space Center
2101 NASA Parkway, Code BD
Houston, TX 77058
Phone: 281-483-8479
Fax: 281-483-0503
Email: charles.c.bell@nasa.gov

ARTICLE 27. SIGNATURE BLOCK

Article 27 SIGNATURE BLOCK shall be renumbered to Article 28 and Article 27 shall be replaced in its entirety with the following:

ARTICLE 27. LOAN OF GOVERNMENT PROPERTY

(A) In order to further activities set forth in this Agreement, the Parties acknowledge that NASA shall loan the following Government property to Partner: Property Listed in Appendix 4.

(B) The property listed above (hereinafter referred to as the "PROPERTY") is not being provided to Partner as a substitute for the purchasing of the same type of property by

Partner under any contract or grant that Partner has, or may have, with a third party. Furthermore, such PROPERTY is not excess to NASA's requirements and its use is anticipated upon its return to NASA.

(C) In support of this loan the Partner shall:
(1) Install, operate, and maintain the PROPERTY at Partner's expense;
(2) Furnish all utilities (e.g., water, electricity) and operating materials required for the operation of the PROPERTY;
(3) Bear all costs associated with the use and enjoyment of the PROPERTY under the terms of this Agreement, including but not limited to such costs as packing, crating, shipping, installing, maintaining, licensing, and operating the PROPERTY;
(4) Transport the PROPERTY in accordance with good commercial practice;
(5) Acknowledge that the privilege of using and enjoying the said PROPERTY exists solely by virtue of this Agreement with NASA, the owner of said PROPERTY, and not as of right;
(6) Identify, mark, and record all of the PROPERTY promptly upon receipt, and maintain such identity so long as it remains in the custody, possession, or control of Partner.
(7) Maintain suitable records for each item of PROPERTY. As a minimum, such records shall show description, identification number, unit cost, quantity, dates of receipt, condition upon receipt, and location. Partner shall perform an inventory of the PROPERTY one (1) year from the effective date of this Agreement, and every year thereafter, if the Agreement is still in effect, and send such inventory report to NASA. The report shall include a statement validating any requirement to continue the loan. Further, Partner shall provide to NASA upon reasonable request, records sufficient to disclose the date of inspections, the deficiencies discovered as a result of inspections, and the maintenance actions performed. This annual report shall be submitted to the following NASA point of contact (POC):

NASA Johnson Space Center
ATTN: Supply Equipment Management Officer (SEMO)
Mail Code JB / Logistics Division
2101 NASA Parkway
Houston, Texas 77058

(8) Assume responsibility for loss or damage to the PROPERTY, reasonable wear and tear excepted and, with the same limitation for wear and tear, agrees to return the PROPERTY to NASA in as good condition as when received. It is understood that Partner is financially responsible (up to the price paid for the Property by NASA, as documented on the NASA shipping forms/documents) for any damage to the PROPERTY while it is in the care, custody, and control of Partner, its employees, contractors, subcontractors, agents, or principal investigators.
(9) Report any loss, damage, or destruction of PROPERTY to the NASA POC identified above within ten (10) working days from the date of the discovery thereof.

APPENDIX 1

Figure 1 is replaced with the following to delete reference to the Unpressurized Cargo Module and reflect change in spacecraft name to *Cygnus*:

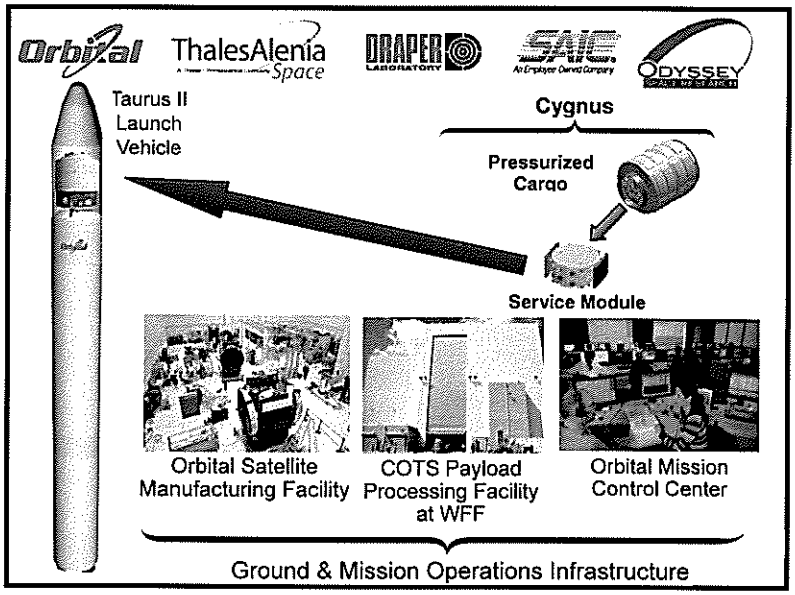

Figure 1. The Major Elements of Orbital's COTS System Architecture Provide Safe, Reliable and Cost-Effective Cargo Delivery to ISS

Figure 2 is replaced with the following to delete references to Capability A and upgraded systems, and reflect change in spacecraft name to *Cygnus.*

Highlights of Orbital's COTS Operational System	
Basic System	Capability B Cargo Delivery & Disposal (Available 2011 With 2009 ATP)
Cygnus Visiting Vehicle	Modular Architecture With High TRL Systems and/or In-Production Systems
	Service Module: Dawn Fault-Tolerant Avionics & Orbital's STAR Spacecraft Propulsion and Power Structure
	Pressurized Cargo Module (PCM): Based on Scaled-Down MPLM Design & Subsystems
COTS Launch Vehicle	Multi-Vehicle/Multi-Site Compatibility
	Launchers: Taurus II (Primary). Delta IV and Atlas V (Alternates)
	Launch Sites: Wallops Flight Facility (Primary), Cape Canaveral Air Force Station (Alternate)
COTS Mission Operations	Cygnus Monitoring and Control by Orbital From Orbital's Mission Control Center in Dulles, Virginia (MCC-D) in Continuous Coordination With NASA Johnson Space enter (JSC) Mission Control Center in Houston (MCC-H)

Figure 2. Orbital's COTS Operation System Provides a Flexible Solution to Capability B Missions with Extensibility to Capabilities A & C.

Figure 3 is replaced with the following to reflect launch date change to March 2011, change to Pressurized Cargo Module vehicle configuration, change of spacecraft name to *Cygnus,* and deletion of *simulated* berthing to mission timeline day 4.

Summary of COTS Demonstration Mission			
Launch Date			March 2011
Vehicle Config			Operational Service Module With Pressurized Cargo Module
Launch Site			Wallops Flight Facility
Duration			5 Days Minimum Mission Duration
Mission Timeline	**D a y**	1	Launch & Cygnus Checkout
		2	Orbit Phasing & Collision Avoidance Maneuver Demo
		3	ISS Rendezvous
		4	Approach, Proximity Operations, SSRMS Capture, Berthing, Release, Departure
		5	On-Orbit Operations, Reentry (Actual Reentry Could Be Deferred forAdditional Onorbit Testing)

Figure 3. Proposed Demonstration Mission Validates Service Module and Key Operations and Procedures

Figure 4 is replaced with the following to reflect deletion of Unpressurzed Cargo Module and updated Pressurized Cargo Module design.

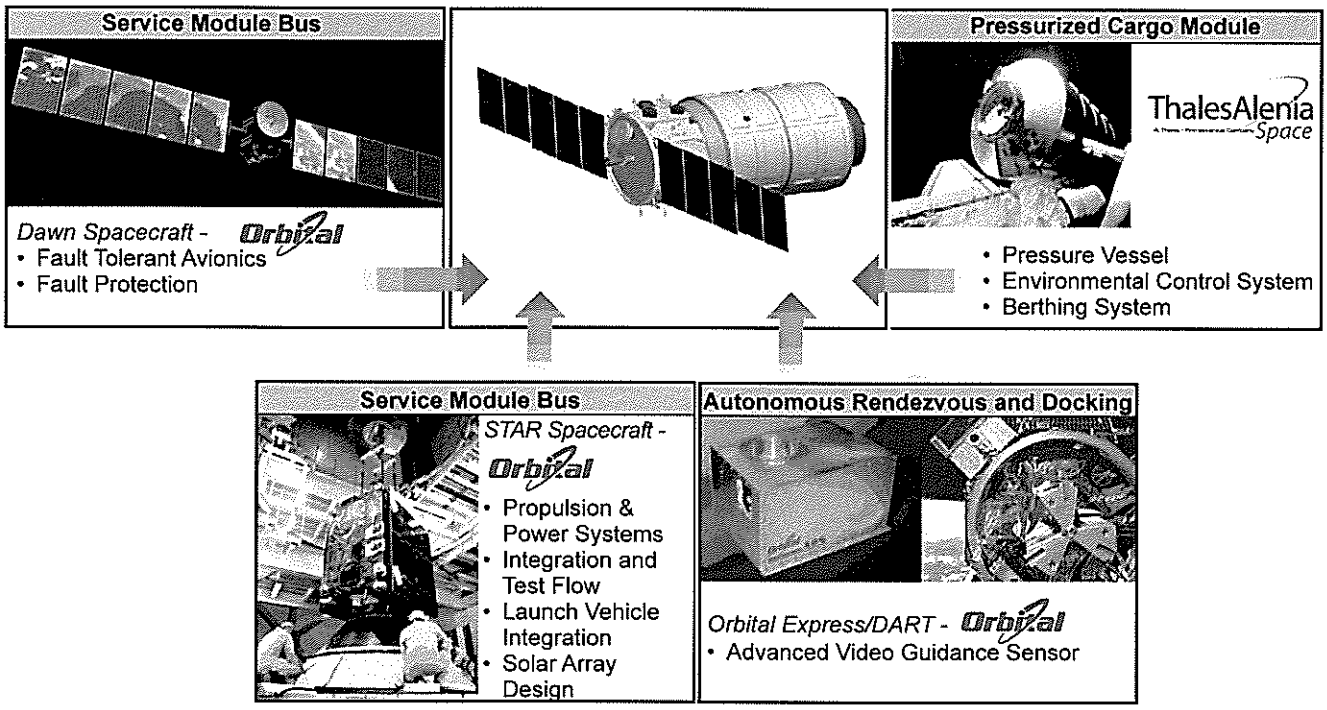

Figure 4. The Cost and Risk of Orbital's Concept are Reduced by Appropriate Re-Use of Heritage

Figure 6 is replaced with the following to reflect updated Pressurized Cargo Module design and change in spacecraft name to *Cygnus*.

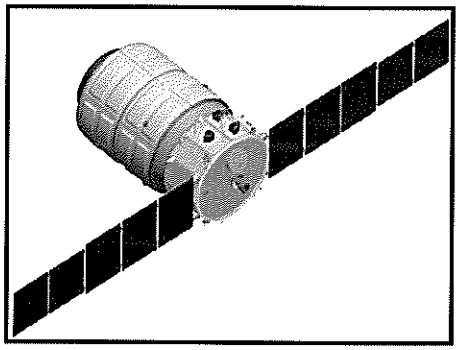

Figure 6. Orbital's Proposed Cygnus Spacecraft with Pressurized Cargo Module.

Section I.E3 COTS TECHNICAL APPROACH

The first paragraph is replaced in its entirety with the following:

Our COTS technical approach parallels the two distinct phases of NASA's COTS program. During the demonstration phase (2008-2011), Orbital will develop and qualify a new, lower-cost medium launch vehicle; design, manufacture, qualify and integrate the Cygnus including service module with a Pressurized Cargo Module (PCM); and establish ground infrastructure and mission operations capabilities. Working closely with NASA, Orbital will also develop the essential human spaceflight safety practices and cost-disciplined commercial protocols in this phase, to support future COTS operational missions. The culmination of this phase will occur in 2011 with the COTS demonstration flight to ISS where we will demonstrate the rendezvous, proximity operations, SSRMS capture, and berthing at ISS. Building on the results of this initial phase, Orbital will be able to provide operational COTS missions to ISS in the follow-on service phase, with the first such mission(s) taking place in 2011.

Section I.E3 COTS Launch Vehicle

The first sentence is replaced with the following:

From the Wallops Flight Facility (WFF) launch site, the basic Taurus II launch vehicle will allow our Cygnus vehicle to deliver 2.0 mT of pressurized cargo to ISS and dispose of at least the same amounts of mass in a controlled reentry.

Section I.E3 COTS Visiting Vehicle

This section is replaced in its entirety with the following:

Cygnus Vehicle

Our Cygnus vehicle is illustrated in Figure 6. It is composed of two elements. The Service Module and the Cargo Module. The Service Module provides the propulsion and "housekeeping" services for the duration of the mission. The Cygnus is compatible with Orbital's Taurus II launch vehicle as well as other launchers such as the Delta IV and Atlas V EELVs.

The Pressurized Cargo Module (PCM) similar to the flight-proven Multi-Purpose Logistics Module developed and built by our partner Thales Alenia Space - Italy. Smaller and lighter than the MPLM, the PCM uses a Common Berthing Mechanism (CBM) as the mechanical interface to the ISS. The Cargo Module will be designed with two configurations. The Standard configuration will carry up to 2000kg of cargo while the Enhanced will carry up to 2700kg. The Service Module will be designed to accommodate both Cargo Module Configurations.

Section I.E3 COTS Mission Operations

This section is replaced in its entirety with the following:

COTS mission operations in the demonstration mission will demonstrate launch, a series of maneuvers to catch up and rendezvous with the ISS, and grapple/berthing operations. These operations will be monitored and controlled by Orbital personnel from Orbital's Mission Control Center in Dulles, VA (MCC-D) in continuous coordination with NASA personnel at Johnson Space Center's (JSC) Mission Control Center in Houston (MCC-H). Following its stay at ISS, the Cygnus vehicle will execute a standard de-orbit/disposal maneuver with a targeted re-entry over the Pacific Ocean.

APPENDIX 2 – Milestones and Success Criteria is replaced in its entirety with the following:

APPENDIX 2 – Milestones and Success Criteria

Capabilities A and B

Milestone 1: Program Plan Review Orbital shall conduct a program plan review meeting with NASA and its subcontractor team to describe the plan for program implementation, which includes management planning for Design, Development, Testing, & Evaluation (DDT&E), integrated program schedule to the element and subsystem level detail through Phase 1 demonstration completion, financing, supplier engagement, risks and anticipated mitigations. Orbital shall provide a presentation of the program plan, along with a hard copy of the presentation materials, and responses to any NASA Action Items. Success Criteria: Successful completion of the program plan review as described above.	Amount: $10,000,000 Date: Mar-08
Milestone 2: Demo Mission SRR Orbital shall conduct a System Mission System Requirements Review (SRR) in accordance with the SRR definition in Appendix 3. Success Criteria: Successful completion of the SRR.	Amount: $20,000,000 Date: Jun-08
Milestone 3: Unpressurized Cargo Module (UCM) PDR Orbital shall conduct a UCM Preliminary Design Review (PDR) in accordance with the PDR definition in Appendix 3. Success Criteria: Successful Completion of the PDR	Amount: $10,000,000 Date: Aug-08

Milestone 4: DELETED This milestone, which was for performance of the COTS System PDR, has been renumbered as Milestone 10 in Amendment 2. Milestone 4 is shown as deleted to retain numbering of later milestones already completed by Orbital.	N/A
Milestone 5: COTS Integration/Operations Wallops Flight Facility Review Orbital shall conduct a review of construction and facility modification plans (including required regulatory and safety plans) required to support the integration and launch of the Orbital COTS demonstration mission from the Mid Atlantic Regional Spaceport (MARS) at the Wallops Flight Facility. Success Criteria: Successful Completion of the COTS Integration/Operations Wallops Flight Facility Review including presentation of associated plans and schedules resulting in the approval to proceed with facility construction and modifications by the proper governing authorities.	Amount: $10,000,000 Date: Sept-08
Milestone 6: Pressurized Cargo Module (PCM) PDR Orbital shall conduct a PCM Preliminary Design Review (PDR) in accordance with the PDR definition in Appendix 3. Success Criteria: Successful Completion of the PDR	Amount: $10,000,000 Date: Oct-08
Milestone 7: DELETED This milestone was deleted in Amendment 2. Milestone 7 is shown as deleted to retain numbering of Milestone 8 already completed by Orbital.	N/A

Milestone 8. Submittal of Instrumentation Program and Command List (IP&CL). The CVV Instrumentation Program and Command List (IP&CL) will be prepared and released for use shortly befor the Demo Mission CDR. The mission database release is required to support development of the CVV Dynamic Spacecraft Simulator (DSS) and to commence integrated avionics hardware/software testing (Milestone 10). For the initial database release, the CVV ground commands and telemetry, as well as CVV stored command sequences (RTS and TMON) will be defined to the extent possible. Success Criteria: Delivery of IP&CL to NASA.	Amount: $10,000,000 Date: Feb-09
Milestone 9: Completion of ISS Phase 1 Safety Review. Orbital shall complete a Phase 1 Safety Review with the ISS Safety Review Panel (SRP). Success Criteria: Completion of the Phase 1 Safety Review in accordance with SSP 30599 (Safety Review Process) and authorization from the SRP to proceed to the Phase 2 Safety Review.	Amount: $10,000,000 Date: Mar-09
Milestone 10: COTS System PDR Orbital shall conduct a COTS System Preliminary Design Review (PDR) in accordance with the PDR definition in Appendix 3. The scope of the PDR shall include all elements of the standard Orbital COTS System (active and non-active configurations). Any configurations of the COTS system unique to the demonstration flight shall also be addressed. Success Criteria: Successful completion of the PDR in accordance with the PDR criteria defined in Appendix 3.	Amount: $20,000,000 Date: Apr-09

Milestone 11: PCM CDR Orbital shall conduct a Critical Design Review (CDR) for active and passive configurations of the Standard and Enhanced PCM in accordance with the PDR definition in Appendix 3. Any configurations of the Standard PCM unique to the demonstration flight shall also be addressed. Success Criteria: Successful Completion of the CDR in accordance with the CDR criteria defined in Appendix 3.	Amount: $10,000,000 Date: Jul-09
Milestone 12. COTS Visiting Vehicle (Cygnus) Avionics Test Orbital shall conduct Cygnus Hardware-In-The-Loop (HITL) Avionics Testing that integrates high fidelity models to validate flight-like hardware and software performance and operations. The test configuration shall include, as a minimum, the Cygnus simulator in HITL mode, MIL-STD-1553 interface testing between the Cygnus simulator and quad-string Computer Avionics Unit (CAU), four flight computer Engineering Development Units (EDUs), and four Draper Network Element cards for FlatSat integration. Test configurations, objectives, and success criteria shall be performed in accordance with a test plan to be developed by Orbital and provided to NASA. Success Criteria: Conclusion by an Orbital review board that the objectives and success criteria defined in the test plan have been satisfied.	Amount: $10,000,000 Date: Aug-09
Milestone 13: Completion of ISS Phase 2 Safety Review. Orbital shall complete a Phase 2 Safety Review with the ISS SRP. Success Criteria: Completion of the Phase 2 Safety Review in accordance with SSP 30599 (Safety Review Process) and authorization from the SRP to proceed to Phase 3.	Amount: $10,000,000 Date: Aug-09

Milestone 14: COTS System CDR Orbital shall conduct a COTS System Mission Critical Design Review (CDR) in accordance with the CDR definition in Appendix 3. The scope of the CDR shall include all elements of the Orbital COTS System, including the active and non-active configurations for both the Standard and Enhanced PCMs. Any unique configurations particular to the COTS system for the flight demonstration shall also be addressed. Orbital shall also provide a copy of the FAA Licensing Package. Success Criteria: Successful Completion of the CDR in accordance with the CDR criteria defined in Appendix 3.	Amount: $10,000,000 Date: Sep-09
Milestone 15: Service Module Core Assembly Complete Orbital shall complete assembly of the Service Module structure and be ready for the service module structure static load test. Success Criteria: Successful completion of a structure assembly. Conduct structure test readiness review.	Amount: $7,500,000 Date: Dec-09
Milestone 16: Service Module Test Readiness Review Orbital shall conduct a SM TRR prior to the integration and test phase of the service module in accordance with the TRR definition in Appendix 3. A Comprehensive Performance Test (CPT) plan shall be developed and provided to NASA for review, with NASA concurrence to be provided for performance parameters associated with ISS interfaces. Success Criteria: Review board acceptance of readiness for start of integration of service module components in Orbital's Satellite Manufacturing Facility.	Amount: $7,500,000 Date: Apr-10

Milestone 17: Service Module Initial CPT Complete First Comprehensive Performance Test (CPT) of the Service Module Complete, in accordance with a detailed CPT test plan. This integrated system test will perform functional testing of all bus subsystems and obtain pre-environmental baseline performance data. Success Criteria: Successful test completion in accordance with the approved CPT Plan.	Amount: $5,000,000 Date: July-10
Milestone 18: Launch Vehicle Stage 1 Assembly Complete Orbital shall complete assembly of the elements of the launch vehicle's first stage. The first stage consists of the Stage 1 core tank structure, the stage 1 Main Engine System (MES), the MES heat shield, the aft skirt, the forward skirt, the avionics, the cable harnesses, and the ordnance. Success Criteria: Stage 1 management state achieves Green Acceptance Tag configuration per Orbital standards. Stage test data is complete and documented. Work package data is complete.	Amount: $2,500,000 Date: Oct-10
Milestone 19: Cargo Integration Demonstration Orbital shall conduct a cargo integration demonstration using a sample manifest of non-powered cargo simulators to be provided by NASA. The demonstrations shall include loading and unloading of cargo simulators within the PCM and demonstration of cargo handling procedures. The demonstration shall be performed in accordance with a written plan developed by Orbital and evaluated by NASA. Success Criteria: Successful completion of Cargo Integration Demonstration in accordance with the demonstration plan objectives and success criteria.	Amount: $2,500,000 Date: Dec-10

Milestone 20: Mission Readiness Review Orbital shall conduct a Mission Readiness Review (MRR) to demonstrate that all elements of the COTS Demo mission are ready, including: launch vehicle, Cygnus, range safety, and ground systems. Success Criteria: All COTS Demo Mission elements confirmed ready for flight (pending standard open work prior to launch) and all residual risks items closed or retired.	Amount: $2,500,000 Date: Feb-11
Milestone 21: System Demonstration Flight Orbital shall complete a demonstration mission using an Orbital COTS System configuration that includes each of the following mission phases: (a) launch of the Cygnus; (b) orbital check-out of Cygnus systems; (c) rendezvous, proximity operations, SSRMS capture, and berthing with the ISS; (d) crew ingress and check-out of Cygnus systems while berthed to ISS; (e) release and departure of Cygnus; and (f) de-orbit and safe re-entry. Success Criteria: Successful completion of each phase of the demonstration mission and confirmation that the flight environment for cargo is within expectations.	Amount: $2,500,000 Date: Mar-11

APPENDIX 3 – Success Criteria for COTS Milestone Reviews is updated as follows:

Strike current title Preliminary Design Review (PDR), Applicable to Appendix 2 Milestones 3, 4 and 6 in its entirety and replace with:

Preliminary Design Review (PDR), Applicable to Appendix 2 Milestones 3, 6 and 10

Strike current title Critical Design Review (CDR), Applicable to Appendix 2 Milestones 7 and 9 in its entirety and replace with:

Critical Design Review (CDR), Applicable to Appendix 2 Milestones 11 and 14

Strike current title Test Readiness Review (TRR), Applicable to Appendix 2 Milestone 13 in its entirety and replace with:

Test Readiness Review (TRR), Applicable to Appendix 2 Milestone 16

APPENDIX 4 – NASA Equipment Loaned to Orbital is added as follows:

Appendix 4 – NASA Equipment Loaned to Orbital

The following equipment will be loaned to Orbital to enable accomplishment of COTS system development and execution of the demonstration flight. Orbital shall manage the loaned equipment in accordance with the provisions defined in Article 27.

1) ISS Command and Data Handling simulators. Note: This is to support RF communications verification interface.	Return date: Not later than 1 month following completion of ISS C&DH interface testing
2) Variety of cargo bags and non-powered cargo to support performance of a cargo accommodation demonstration. Types of cargo bags and containers to be provided could include half, single, double, triple, M01, M02, and M03 Crew Transfer Bags (CTBs), Contingency/Collapsible Water Containers (CWCs), and Coldbags.	Return date: Not later than 2 months following completion of Orbital COTS Demonstration flight.
3) Up to four (4) single and double middeck stowage lockers (flight unit or development unit) to support performance of a cargo accommodation demonstration.	Return date: Not later than 2 months following completion of the Orbital COTS Demonstration flight.
4) Powered cargo and powered cargo ground support equipment required to verify the interfaces between the cargo and Cygnus.	Return date: Not later than 2 months following completion of the Orbital COTS Demonstration flight.

5) Berthing Mechanisms or components, including test equipment needed to verify the interface.	Return date: Not later than 2 months following completion of the Orbital COTS Demonstration flight.
6) Ground and flight cables to test interfaces between the Cygnus and ISS hardware and/or simulators.	Return date: Not later than 2 months following completion of the Orbital COTS Demonstration flight.

ARTICLE 28. SIGNATURE BLOCK

The terms and conditions of this Space Act Agreement, as modified by this Amendment are hereby incorporated herein.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BY: _____
Douglas R. Cooke
Associate Administrator,
Exploration Systems Mission Directorate

ORBITAL SCIENCES CORPORATION

BY: _____
Dr. Antonio L. Elias
Executive Vice President and General Manager, Advanced Programs Group