The Gift of Quality

Enabling Human Exploration

March 2015

Speaker: David Swanson

Education: Masters in Space Operations, Electrical Engineering and Military Arts & Sciences

Experience:

24.5 Years in US Air Force;
- Military Space Operations and Acquisition
- Director of Engineering, Space and Missiles Systems Center, LA AFB
- Assistant Professor at USAFA

3.75 Years as Senior Director, Safety and Mission Assurance, Orbital ATK, Space Systems Group
- Safety and Environmental Director
- Quality Function: Internal and Supplier Oversight
- Mission Assurance Function
- Specialty Engineering: Reliability, Radiation, Parts/Materials/Processes, Failure Analysis
- Configurations Management
- ISO 9000 and AS 9100 Quality Management System

Topics

- Introduction: The Gift of Quality
- Overview of Orbital ATK
- How Orbital Bakes in Mission Success
- Resupplying the International Space Station

Quality is "Non-Value" Added

QUALITY IS A "COST AVOIDANCE" ACTIVITY Lean Thinking

The Gift of Quality

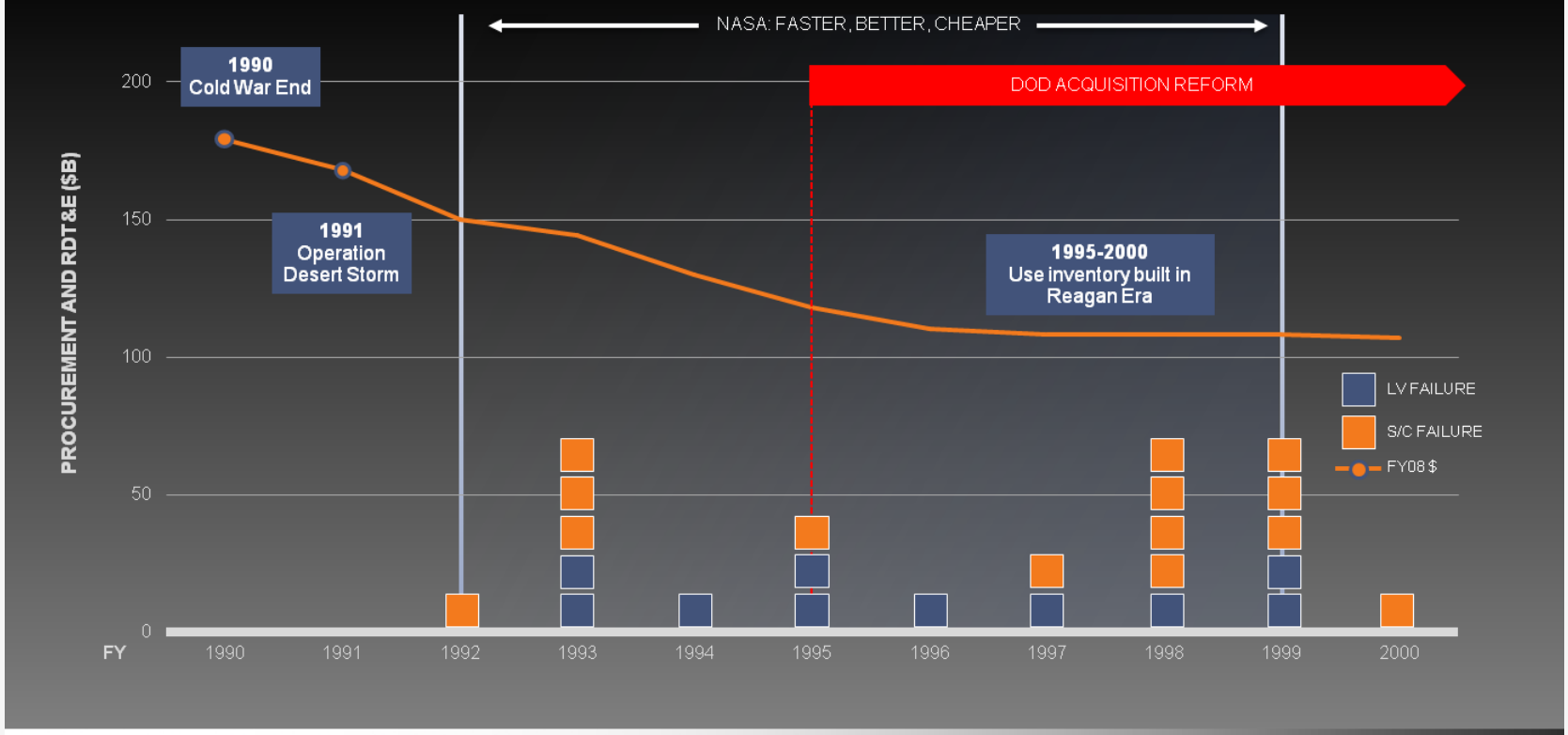
- Specified Performance
- Reduces Cost
- On Time Delivery

Global Value Stream

Market Forces Drive Business to Reduce Quality Oversight

- The Need to be Quicker to Market
- Consumer Electronics Influence Decision Makers
  - Quickly Evolving, Disposable, Durable (on Earth)
- Pressure to Reduce Cost and Meet Demand for Lower Price
- Schedule Pressures in Design and on the Factory Floor

SPACE - "One Strike and You're Out Business"

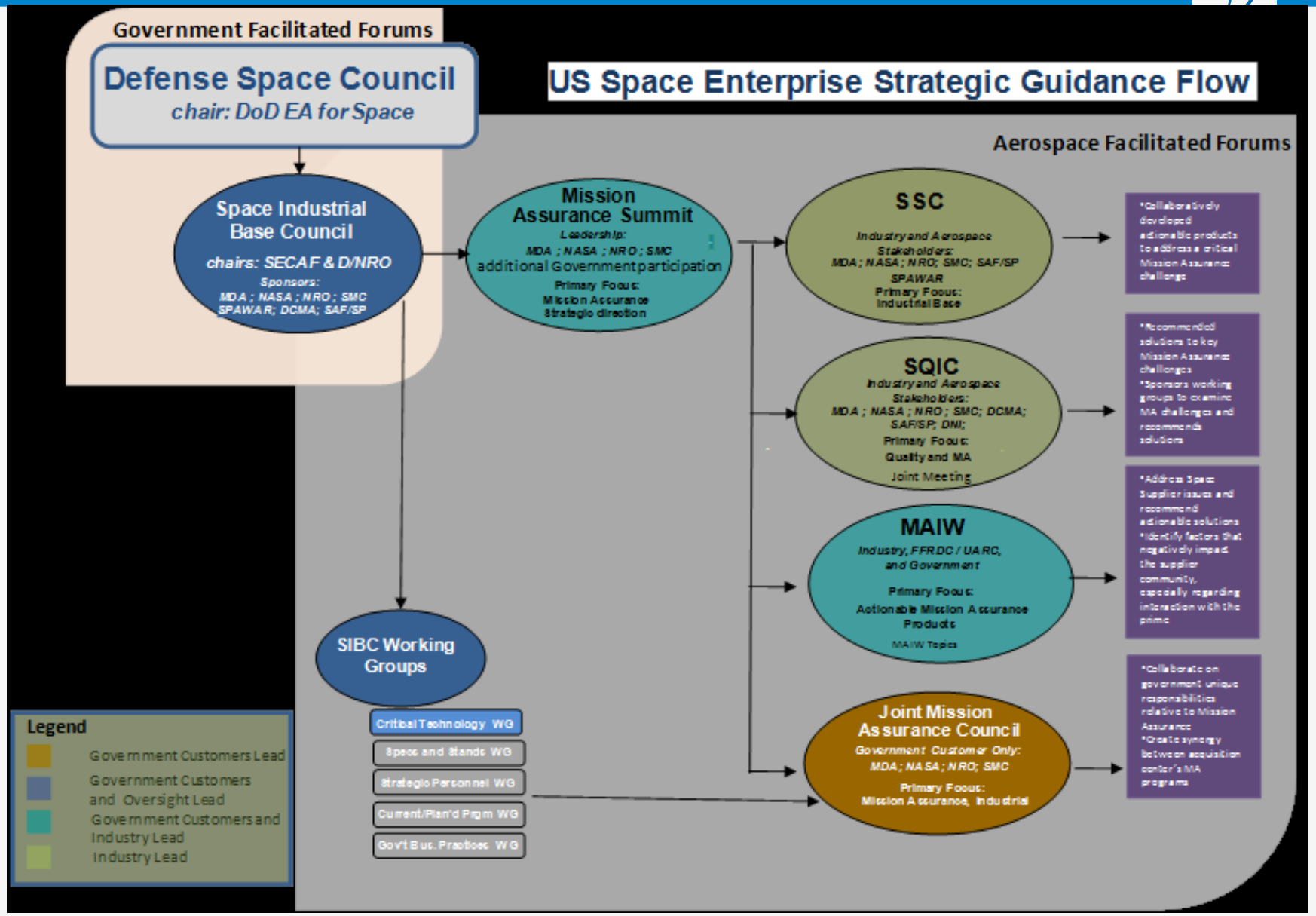


Defense Modernization to 2000

Modernization Accounts had declined

Source: U.S. Office of Management and Budgets

Collaborative Mission Assurance Community



An Introduction to Orbital ATK, Inc.

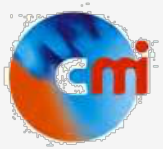
Company Overview Presentation

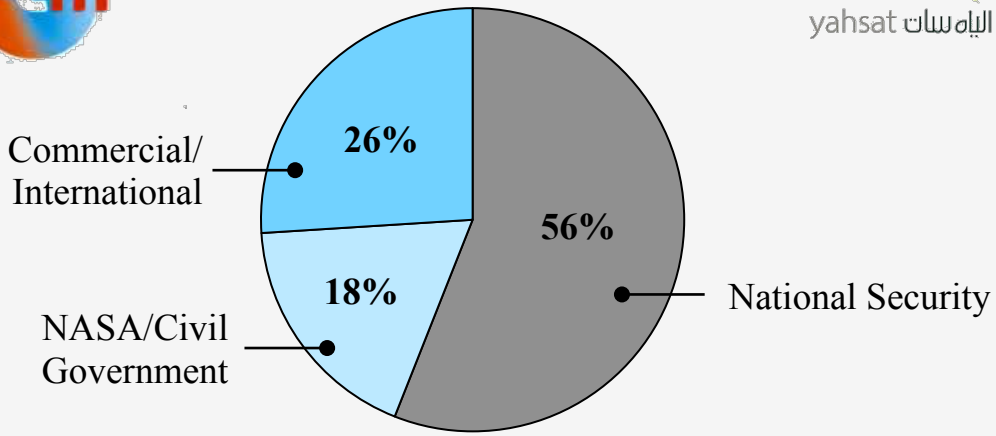
February 2015

Introducing the New Orbital ATK

- $4.5 Billion (2013 Pro-Forma Revenue) Global Aerospace and Defense Systems Company
- Innovative, Affordable Products for Government and Commercial Customers
  - Launch Vehicles, Propulsion Systems and Aerospace Structures
  - Missile Products, Defense Electronics, Armament Systems and Ammunition
  - Satellites, Space Components and Technical Services
- 12,500 Employees, Including 4,300 Engineers and Scientists
- R&D, Production and Test Facilities in 17 States

Major Customers and Market Segments



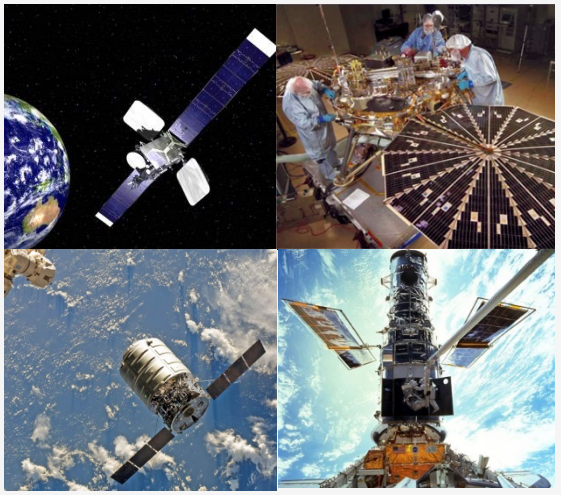


Approximate Revenue Distribution

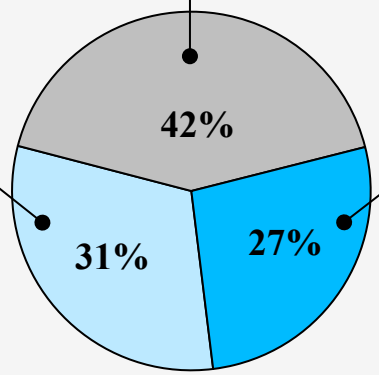
Three Operating Groups and 12 Product Lines

Flight Systems Group
- Space Launch Vehicles
- Rocket Propulsion Systems
- Missile Defense Systems
- Aerospace Structures

Defense Systems Group
- Tactical Missile Products
- Defense Electronic Systems
- Armament Systems
- Ammunition and Energetics



Space Systems Group
- Commercial Satellites
- Government Satellites
- Spacecraft Components
- Space Technical Services

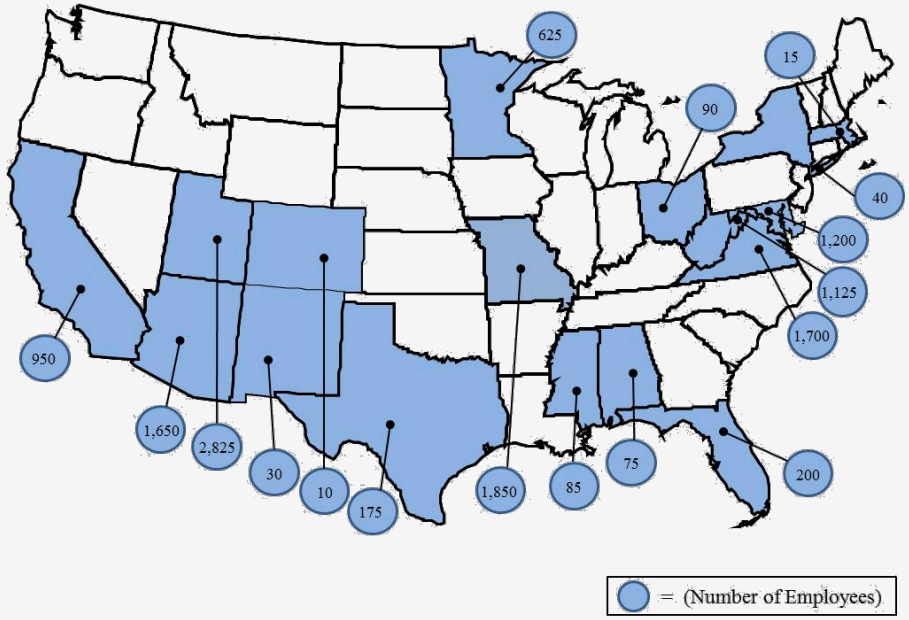


Approximate Revenue Distribution

Extensive Human and Physical Resources

- Over 12,500 Employees Dedicated to Aerospace and Defense Customers
  - 4,300 Engineers and Scientists
  - 7,250 Manufacturing and Operations Specialists
  - 1,100 Management and Administration Personnel

- Facilities in 17 States With Over 19 Million Sq. Ft. of R&D, Manufacturing, Test, Operations and Office Space
  - 6.1 Million Sq. Ft. Owned
  - 5.3 Million Sq. Ft. Leased
  - 8.1 Million Sq. Ft. Government Owned



A History of Innovation and Operations Excellence

Orbital ATK

Flight Systems

- First Private Developer and Operator of Space Launch Vehicles… More Than 85 Flown or in Production
- Leading Producer of Solid Rocket Propulsion Systems… Over 16,000 Motors Built to Date
- Primary Supplier of Long-Range Missile Defense Interceptors and Target Systems… More Than 300 Vehicles Built or Under Contract
- Innovator in Advanced Composite Structures Engineering and Manufacturing for Aerospace Applications

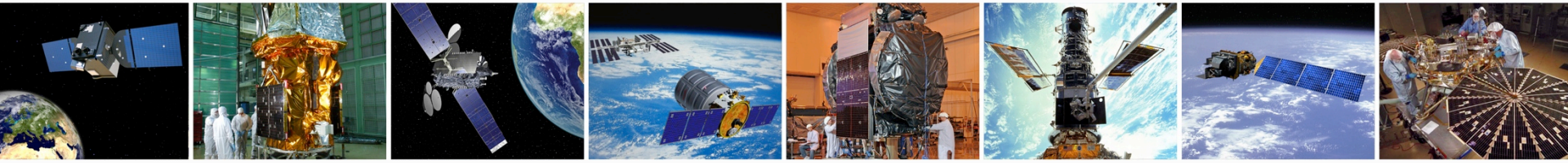
Defense Systems

- Pioneer in Tactical Missile Propulsion, Precision-Guided Munitions and Advanced Weapons
- World's Largest Manufacturer of Small- and Medium-Caliber Ammunition… More Than 8 Billion Rounds Produced in Last 5 Years
- Principal Supplier of Medium-Caliber Gun Systems for U.S. and NATO… 15,000-Unit Installed Base
- Leading Domestic Armament Facility Operator and International Co-Production Partner

Space Systems

- Major Builder of Satellites for Commercial and Government Customers… Over 165 Delivered and Another 95 in Production
- Pioneer in Human and Robotic In-Space Satellite Servicing and Logistics Systems
- Industry-Standard Supplier of Spacecraft Components and Subsystems… Products on More Than 800 In-Orbit Satellites
- Leading Operator of Small Research Rockets and High-altitude Scientific Balloons… 30 Missions Conducted Per Year

Space Systems Group



Space Systems Group Overview

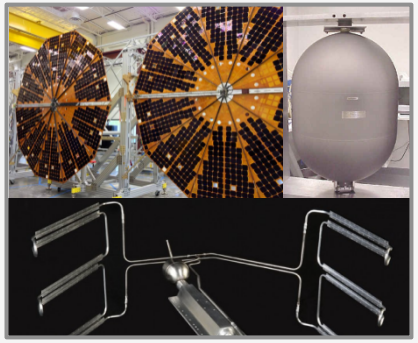
Commercial Satellites

Scientific Spacecraft

Human Space Systems

National Security Satellites

Advanced Space Systems



Space Components

Space Engineering Services

Research Rocket and Balloon Operations

- Annual Sales of About $1.2 Billion
- Workforce of Approximately 2,700 People
- Major Operations in Virginia, Maryland, California, Arizona, Texas and Utah

Space Systems Group (SSG) Business Lanes

Civil & Defense Programs
Jean Floyd

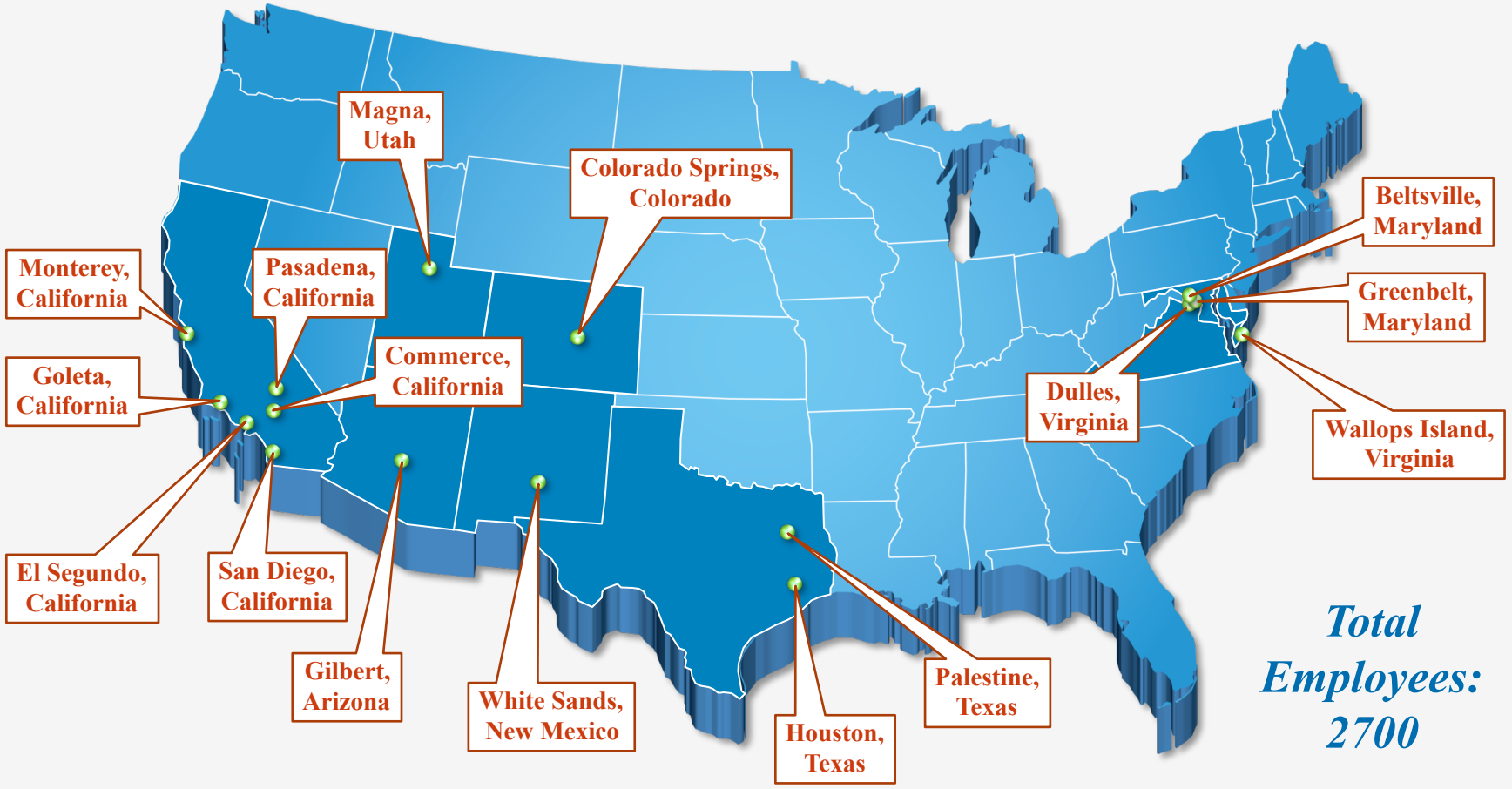
Commercial Satellites
Chris Richmond

Space Components
Dave Shanahan

Technical Services
John Pullen

Delivering Some of Orbital ATK's Most Innovative and Challenging Programs -
Frank Culbertson, SSG President

SSG Locations



SSG Has Operating Locations in 8 States

Orbital ATK Space System Capabilities

	LEO Systems			GEO Systems		
	Mini	**Small**	**Medium**	**Mini**	**Small**	**Medium**
Mission Capability	• 60 kg / 75 W Payload • 1-5 Year Life • 12-18 Month Delivery	• 550 kg / 750 W Payload • 1-5 Year Life • 16-36 Month Delivery	• 4,000 kg / 750 W Payload • 7-10 Year Life • 21-36 Month Delivery	• 100 kg / 1.5 kW Payload • 5-7 Year Life • 27-30 Month Delivery	• 500 kg / 5.5 kW Payload • 15-18 Year Life • 24-27 Month Delivery	• 800 kg / 8.0 kW Payload • 15-18 Year Life • 27-30 Month Delivery
Satellite Bus	**RapidStar-1**	**RapidStar-2** or **LEOStar-2**	**LEOStar-3**	**GEOStar-1**	**GEOStar-2**	**GEOStar-3**
Launch Vehicle	**Pegasus,** or **Minotaur I**	**Pegasus, Minotaur I, Minotaur IV** or **Minotaur C**	**Minotaur IV** or **Antares**	**Minotaur V** or **Antares (Future)**	**External Launch Vehicles**	**External Launch Vehicles**
Ground Software	**Spacecraft Control**	**Spacecraft Control**	**Spacecraft Control**	**Spacecraft Control**	**Spacecraft Control**	**Spacecraft Control**

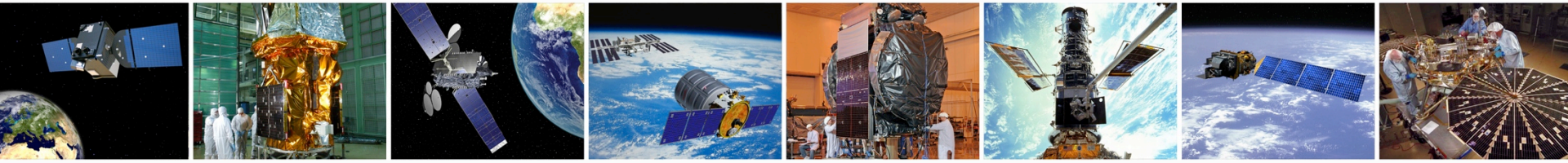
Orbital ATK Space System Capabilities

	Constellation	ESPA-Based Systems		In-Space Servicing	Exploration Systems	
	Micro	**Mini**	**Small**	**GEO**	**Human**	**Interplanetary**
Mission Capability	• 15 kg / 360 W Payload • 1-3 Year Life • 12-15 Month Delivery	• 250 kg / 500 W Payload • 1-5 Year Life • 22-24 Month Delivery	• 600 kg / 1.5 kW Payload • 1-7 Year Life • 22-24 Month Delivery	• 1,700 kg / 3.0 kW Payload • Rendezvous Capability • 6-15 Year Life • 21-36 Month Delivery	• 3,300-5,000 kg (Pressurized) • Rendezvous Capability • 6 month - 10 year • 24-27 Month Delivery	• 210 kg / 250 W Payload • Electric Propulsion • 7-10 Year Life • 36-42 Month Delivery
Satellite Bus	**MicroStar-1**	**ESPAStar-1**	**ESPAStar-2**	**Gemini**	**Cygnus**	**ExoStar**
Launch Vehicle	**Rideshare, Pegasus** or **Minotaur I**	**Antares** or **External Launch Vehicle**	**Antares** or **External Launch Vehicle**	**Minotaur IV** or **Antares**	**Antares** or **External Launch Vehicle**	**External Launch Vehicles**
Ground Software	**Constellation Control**	**Spacecraft Control**	**Spacecraft Control**	**Complete Ground Segment**	**Complete Ground Segment**	**Spacecraft Control**

Orbital: Baking in Mission Success

Safety&Mission Assurance

Discipline • Independence • Risk Management • Skilled Workforce • Learning Organization



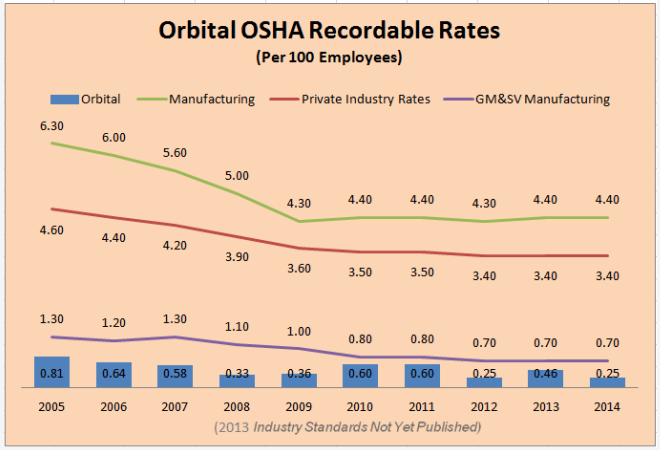
Mission Assurance Leads to Mission Success!

Mission Success – The achievement of specified performance requirements and the expectations of the users and operators in terms of safety, operability, suitability and supportability.

Mission Assurance – "The Disciplined application of general systems engineering, **quality,** and management principles towards the goal of achieving mission success, and, toward this goal, provides confidence in its achievement."

Aerospace Mission Assurance Guide

- Orbital's COTS and CRS missions to Orb-2 have been 100% Successful
  - Cygnus rendezvous and berthing activities highly successful
  - Disposal cargo successfully transferred
  - Cygnus reentry implemented safely and successfully
- Orbital's dedication to quality products has significantly contributed to mission accomplishment.
- Orbital's quality products led to three missions safely completed to the ISS and its crews.



Orbital's Industrial Safety Record has Surpassed Our Industry Peers for More Than a Decade

Quality Starts with Management

- Orbital's Quality Management System (QMS) is Third Party Registered
  - Third party registration and certified to ISO 9001:2008 and AS9100 Rev C
  - Standard business practices cover lifecycle of product development, build and delivery
  - Mandatory employee training includes: business ethics; safety; risk management; design and workmanship standards; etc.
  - Includes an internal audit system to monitor ISO and AS compliance
  - Overseen by a Continuous Improvement management team to improve and refine our business procedures

TABLE 4-1. QUALIT

QSP No.	Title	T
0100	Quality System Manual	Sr Dir Re
0200	Proposal Submission	Sr
0300	Contract Review	Sr
0400	Program Management	Pr
0500	Product Development	TS En Dir
0600	Procurement	Sr Pr
0700	Control of Customer Property	Su Ma
0800	Planning, Manufacturing, Integration, and Material Control	Su Ma Ma
0900	Delivered Product Sustainment, Mission Operations, & Maintenance	TS
1000	Inspection	TS an Su an
1100	Nonconforming Product	Su an
1200	Calibrated Equipment	Qu
1300	Document and Data Control	Co
1400	Continual Improvement	Sr Dir Representative

DNV

DNV BUSINESS ASSURANCE

MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 102859-2011-AQ-USA-ANAB, Rev. 2

This is to certify that

Orbital Sciences Corporation

at

45101 Warp Drive, Dulles, VA 20166 USA

See Appendix for Additional Locations for Multiple Site Certification Structure

has been found to conform to the Management System Standard:

ISO 9001:2008 and AS9100C
(technically equivalent to EN 9100:2009 and JISQ 9100:2009)

and has been audited in accordance with the requirements of:

AS9104/1:2012

Det Norske Veritas Certification, Inc. is accredited under the Industry Controlled Other Party (ICOP) Scheme.

This Certificate is valid for the following product or service ranges:

The managing of all business aspects for operating groups within Orbital Sciences Corporation. Each group is responsible for the technical and program management associated with design, procurement, manufacture, integration, test, operation, and servicing of a wide range of aerospace components, subsystems, systems, and services. Including, but not limited to: launch vehicles, space systems, satellites, ground stations, human space flight, and support services for Commercial, Defense, and Government/Civil customers

Initial Certification date: September 13, 2011

Place and date: Houston, Texas, December 04, 2013

This Certificate is valid until: January 15, 2015

for the Accredited Unit: DET NORSKE VERITAS CERTIFICATION INC., HOUSTON TEXAS

The audit has been performed under the supervision of

Mitchell L Williams
Lead Auditor

Robert L. Keys
Management Representative

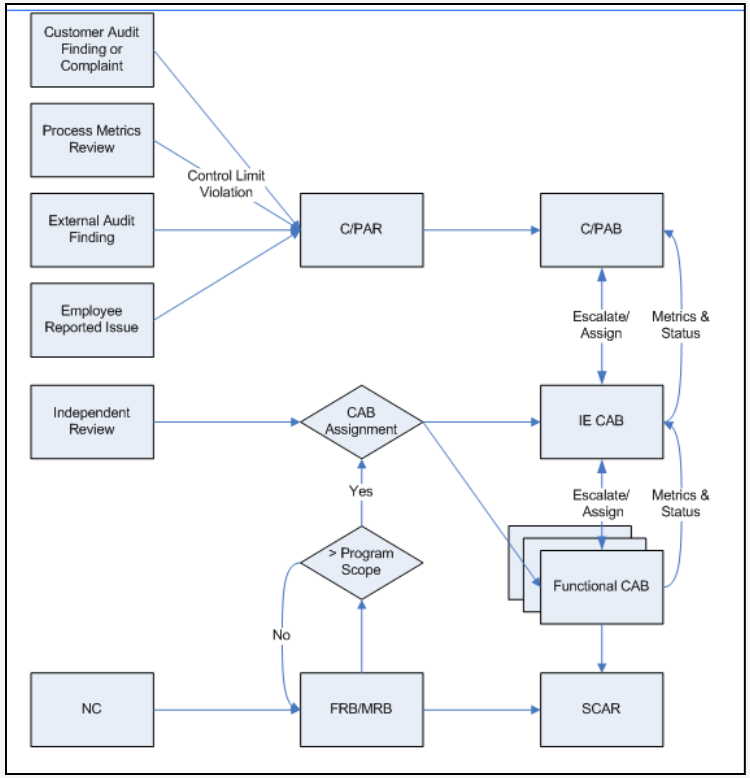
Lack of fulfillment of conditions as set out in the Certification Agreement may render this Certificate invalid.

ACCREDITED UNIT: DET NORSKE VERITAS CERTIFICATION, INC 1400 RAVELLO DRIVE, 77449, KATY, TX, USA, TEL: 281-396-1000, WWW.DNVCERT.COM

- Orbital is Actively Engaged within Industry
  - Member of American Society for Quality (ASQ)
  - Quality Leadership Forum (QLF)
  - Joint Audit Planning Committee (JPAC)
  - Aerospace Space Quality Improvement Council (SQIC)
  - Mission Assurance Improvement Workshop (MAIW)
  - Corporate member of the Mission Assurance Summit
  - Member of GIDEP

A Culture of Continuous Improvement

- Continuously Improving Our Processes
  - Non-Conformance Process Improves Flight Hardware/ Software (Internal and at Suppliers)
    - Managed by the Program in Material Review and Failure Review Boards
  - Corrective Action Boards (CAB) Broaden Perspective into Standards, Procedures and Processes
    - Managed by the Technical Operations Functional Managers in the Integrated Enterprise CAB
  - Demand for Supplier Improvement
    - Insight: Supplier Corrective Action Requests (SCAR)
    - Oversight: Strategic Supplier Improvement Plan (SSIP)
  - Corrective/Preventative Action Request (CPAR) is the Highest Priority and Impacting Improvement Action



FRB/MRB
- Containment
- Root Cause
- Corrective Actions
-Follow-up

Monitoring Quality

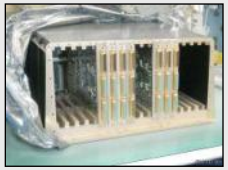
Design

Manufacture

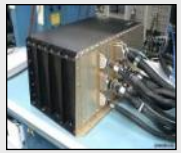
Manual Card Assembly

Card Test

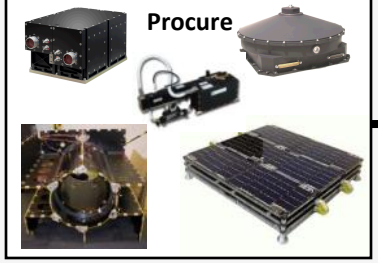
Box Assembly



Box Test (Includes Environments)



Procure



World-wide Supply Base

Space Vehicle (SV) Integration

SV Environmental Tests

EMI

Acoustic - Vibe

TVAC

SV Shipment

SV Launch Site Support

Mission OPS

Containment – Reducing CoPQ

Where the Defect was introduced

Where the Defect was found			Design	Vendor Level			Intermediate Level				Sub-Sys & System Level				Operational Level	TOTALS
			Engineering	Purch.	Vendor		MWC	BWC	HWC	ECWC	PWC	I&TWC - Mod Flow	I&TWC - SLF	Launch Site	Orbit	
	Design	Engineering														0
	Vendor Level	Purch														0
		Vendor			6											6
		Source Inspection				3										3
		RI / Stock					46									46
	Intermediate Level	MWC														0
		BWC														0
		HWC					1			2						3
		ECWC	3				4			12						19
	Sub-Sys & System Level	PWC	2				2				17					21
		I&TWC - Mod Flow	1				2			1		9				13
		I&TWC - SLF	1										6			7
		Launch Site					1							6		7
	Operational Level	Orbit														0
		TOTAL NCRs	6	0	6	3	56	0	0	4	12	17	9	6	6	0	125

Orbital's Internal Failure Analysis Laboratory


Focus Ion Beam/Scanning Electron Microscope


X-Ray Inspection

Core Competency in Failure Analysis

- Destructive Physical analysis
- Failure Analysis
- Prohibited Material Verification
- PCB Coupon Verification
- Materials Analysis
- Failure Simulations
- Well Equipped and Proven Technology
  - Focus Ion Beam/Scanning Electron Microscope
  - RAMAN Spectrometer
  - Dynamic & Static X-Ray
  - Particle Impact Noise Detection
  - Infrared and Optical Scopes and Cameras
- Highly Educated and Skilled Workforce

S&MA Institutional Practices

- Electrical, Electronic, Electromagnetic (EEE) parts
  - Selection from NASA EEE-INST-0002 and Orbital Preferred Parts List (PPL)
  - Compatibility with mission Total Dose and Single Event radiation requirements verified by test data
  - Traceability maintained to lot date code and/or serial number

- Materials selected from heritage programs and for verified compatibility with space environment
  - Vacuum stability, flammability, toxicity
  - Resistance to stress corrosion cracking
  - Cadmium, zinc and pure tin plating strictly prohibited – verified by lot sample inspection

- Process and workmanship standards based on high reliability NASA, MIL and industry standards
  - J-STD-001ES (Space Addendum) series for soldering, wiring, bonding
  - PWB design and fabrication to IPC standards
  - Strict ESD and FOD controls, with 100% training by engineering, assembly, test and quality personnel

Supplier Assurance & Control

Strong performance from our team members and suppliers is absolutely critical to the success of our Space programs

- Strong Supplier Achieved through:
  - Supplier Audits, Capability and Quality Surveys performed by a Cross-Functional Team
  - Benchmarking our Supplier requirements with other top Aerospace Contractors
  - Use of a Suppler Rating System, providing monthly reporting of quality and delivery performance
  - Responsiveness to any Supplier Corrective Action Requests (SCAR)
  - Managing, monitoring, and reporting to Orbital management the impact of supplier changes affecting facilities, management or processes
  - Reducing the Supplier Database for reduced risk and improved efficiencies
- Certified Supplier Program
  - Identifies top rated suppliers through past performance
  - Designates supplier's Quality Representative with authority to accept Orbital product
  - Orbital oversight maintained through mandatory inspection points (MIP) and metric reporting

Manufacturing, Integration, Test

- All flight hardware builds are to approved and CM released documentation
  - Assembly drawings and parts lists, with approved ECNs
  - Detailed work instructions
- Hardware identification, traceability, history
  - End Item Data Package (EIDP) provides configuration, traceability, nonconformance and acceptance results at all levels of assembly
- Receiving, in-process and final inspection/test points are clearly identified at all levels, and performed to documented and approved procedures
- Material Review Board (MRB) implemented for manufacturing anomalies, with participation of flight assurance and engineering
- Failure Review Board (FRB)
  - Conducted for all failures after start of functional testing
  - Chaired by program Flight Assurance Manager, with engineering, systems, I&T and program participation

Human Spaceflight

Resupplying Humanity's Outpost in Space

International Space Station Overview

- The International Space Station is the largest and most complex international scientific project in history. Led by the United States, the International Space Station draws upon the scientific and technological resources of 16 nations: Canada, Japan, Russia, 11 nations of the European Space Agency, and Brazil

- More than four times as large as the Russian Mir space station, the completed International Space Station will have a mass of about 472,000 kg. It will measure 356 feet across and 290 feet long, with almost an acre of solar panels to provide electrical power to six state-of-the-art laboratories.

- The station is in an orbit with an altitude of approximately 400 km with an inclination of 51.6 degrees. The orbit provides excellent Earth observations with coverage of 85 percent of the globe and over flight of 95 percent of the population.

- The ISS houses an international crew of 6.

International Space Station Overview

- Initial resupply of the ISS was primarily accomplished by the Space Shuttle and the Russian Progress autonomous resupply vehicle.
- With the retirement of the Space Shuttle, additional international partner resupply capabilities have been developed and demonstrated. These vehicles include the Japanese HTV and the ESA ATV.
- Resupply items include water, air, food, clothing, general operational supplies, spare parts, and scientific payload items
- Service also includes carrying away trash and other non-serviceable items for disposal during Cygnus destructive reentry
- Missions purchased on a per-mission basis, regardless of amount of cargo up and down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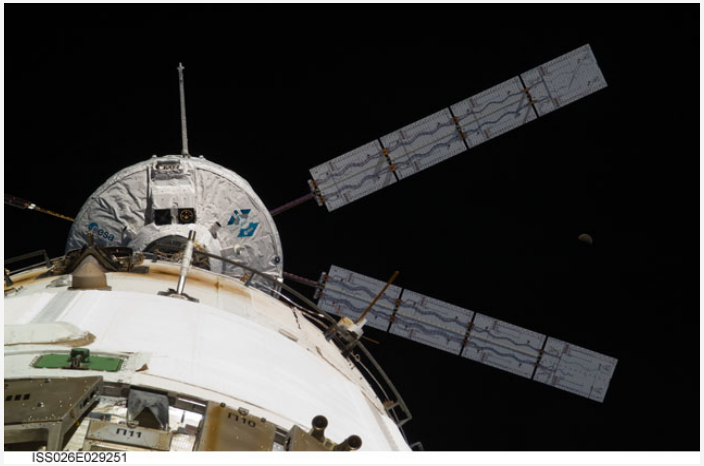
ISS026E029052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Low Earth Orbit Transfer Operations

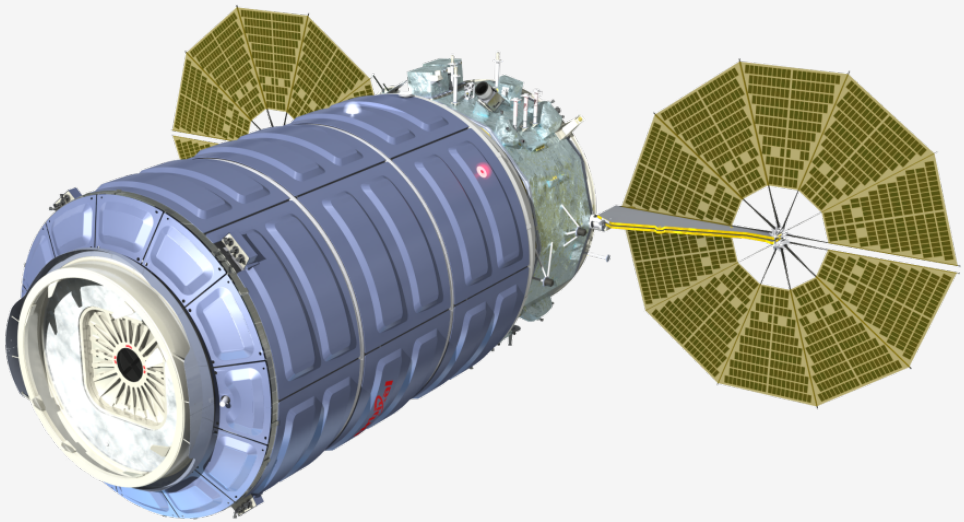
Drawing Upon Its 32 Years Of Satellite And Major Space Systems Development And Operations Experience, Orbital Sciences Corporation Has Embarked On A New Venture To Provide Low Earth Orbit Cargo Transfer Services To NASA's ISS Program

- **Under the joint NASA / Orbital Commercial Orbital Transportation Services (COTS) program, Orbital Developed the "Cygnus" Advanced Maneuvering Space Vehicle, Which is Designed to Meet the Stringent Safety Requirements for International Space Station (ISS) Operations.**
- **The Cygnus Spacecraft Provides Cargo Resupply to the ISS Program under the Cargo Resupply Services Contract**

Cygnus Overview

The Cygnus vehicle is evolving and currently has two configurations

Standard Cygnus



Enhanced Cygnus

- **Pressurized Cargo Module (PCM)**
  - Heritage: Multi-Purpose Logistics Module (ISS); ATV
  - Total Payload Mass: 2,000 kg (standard), 2700 kg (enhanced)
  - Pressurized Volume: 18.7 m^3, 27 m^3
  - Berthing at ISS: Node 2 Common Berthing Mechanism
- **Service Module (SM)**
  - Heritage: Orbital GEO and LEO missions
  - Power Generation: 2 Fixed Wing Solar Arrays
  - Power Output: 3.5 kW (sun-pointed)
  - Compatible with Antares launch vehicle

Low Earth Orbit Logistics Underway

Orbital COTS Program Successfully Completed

- Economically developed through Space Act Agreement
- 2 Major Space Operations completed
  - Antares Test Flight
  - COTS Demonstration Flight

Cygnus Has Begun Cargo Resupply to the ISS Program

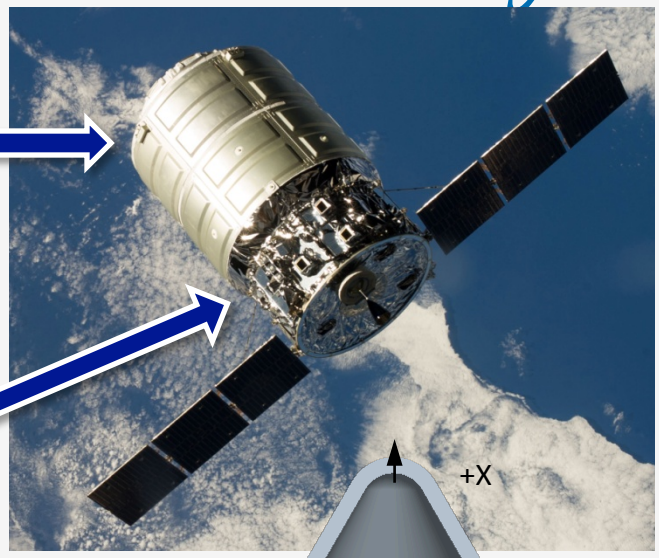
- Orb-1 Mission Completed on 2/19
- Orb-2 Mission Completed on 8/17
- 8 CRS Flights from 2014 to 2016

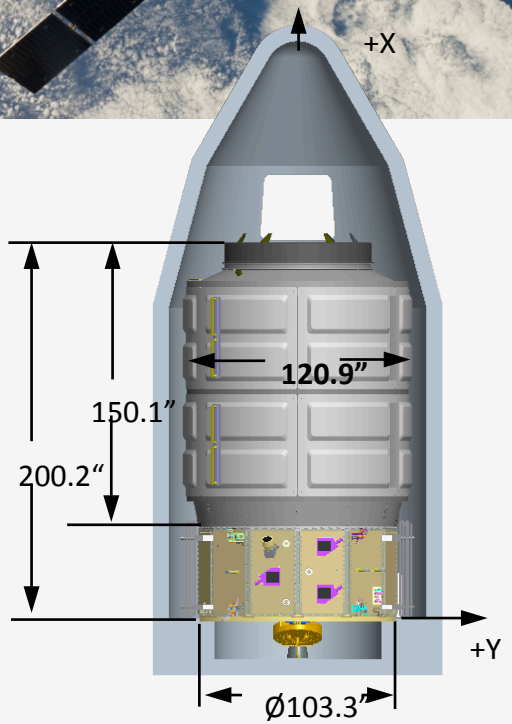
Cygnus Overview

Cygnus vehicle is comprised of two major modules

- **Pressurized Cargo Module (PCM)**
  - Heritage: Multi-Purpose Logistics Module (ISS); ATV
  - Total Payload Mass: 2,000 kg, 2700 kg
  - Pressurized Volume: 18.7 m3, 27 m3
  - Berthing at ISS: Node 2 Common Berthing Mechanism

- **Service Module (SM)**
  - Heritage: Orbital GEO and LEO missions
  - Power Generation: 2 Fixed Wing Solar Arrays,
  - Power Output: 3.5 kW (sun-pointed)
  - Propellant: Bi prop/Mono prop system
  - 32 thrusters in 3 independent strings
  - Quad-redundant computer architecture
  - Compatible with Antares





Antares Overview

Designed to Provide Versatile, Cost-effective Access to Space for Medium-Class Payloads

Currently Under Contract to Support 10 NASA International Space Station (ISS) Re-supply Missions

On-Ramped to NASA NLS-II Contract

On-Ramped to USAF OSP-3 Contract

EELV New Entrant Statement of Intent Accepted by USAF

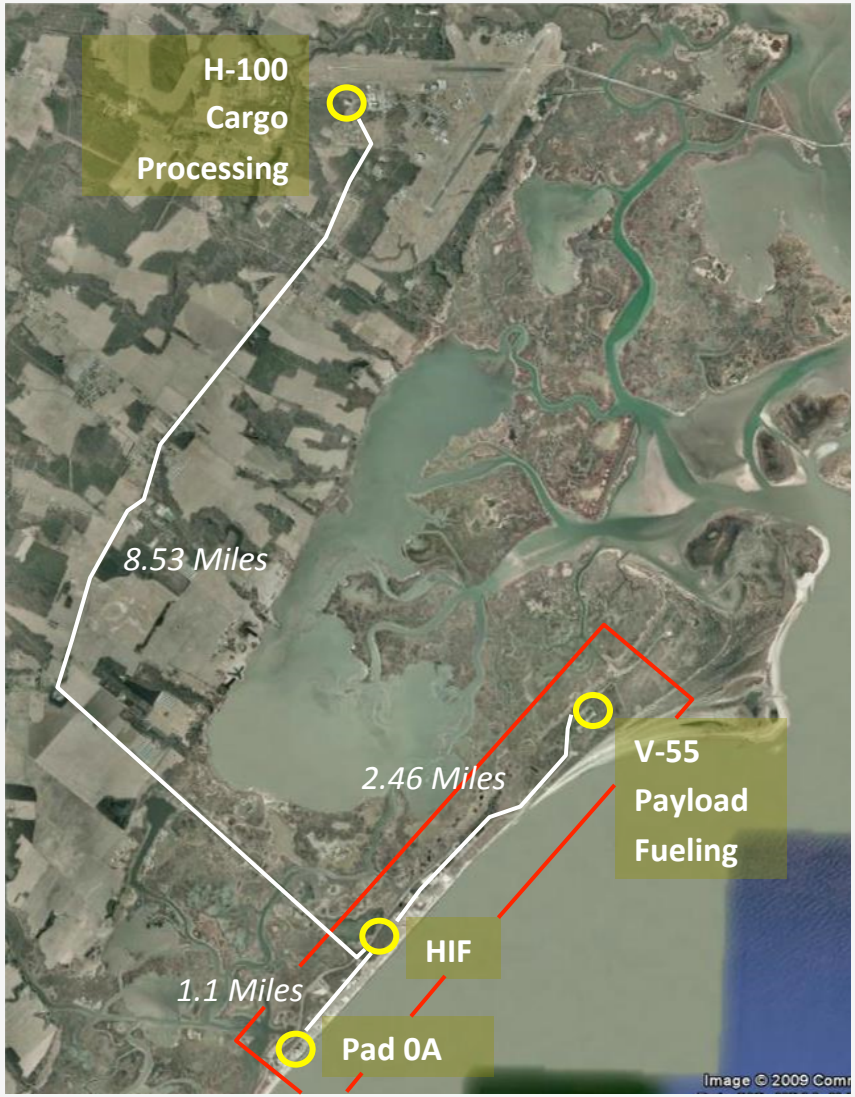
PAYLOAD FAIRING
- 3.9 meter diameter by 9.9 meter envelope
- Composite Construction
- Non-contaminating Separation Systems

STAGE 2
- ATK CASTOR® 30/30B/30XL Solid Motor with Active Thrust Vectoring
- Orbital MACH avionics module
- Cold-gas 3-axis Attitude Control System

STAGE 1
- Liquid Oxygen/RP-1 fueled
- Two AJ26 engines with independent thrust vectoring
- 3.9 meter booster derived from heritage Zenit design

VEHICLE PARAMETERS
- Gross Liftoff Mass: 290,000 kg
- Vehicle Length: 40 m
- Vehicle Diameter: 3.9 m
- Mass to ISS Orbit: 5000 kg Baseline
  6265 kg Enhanced

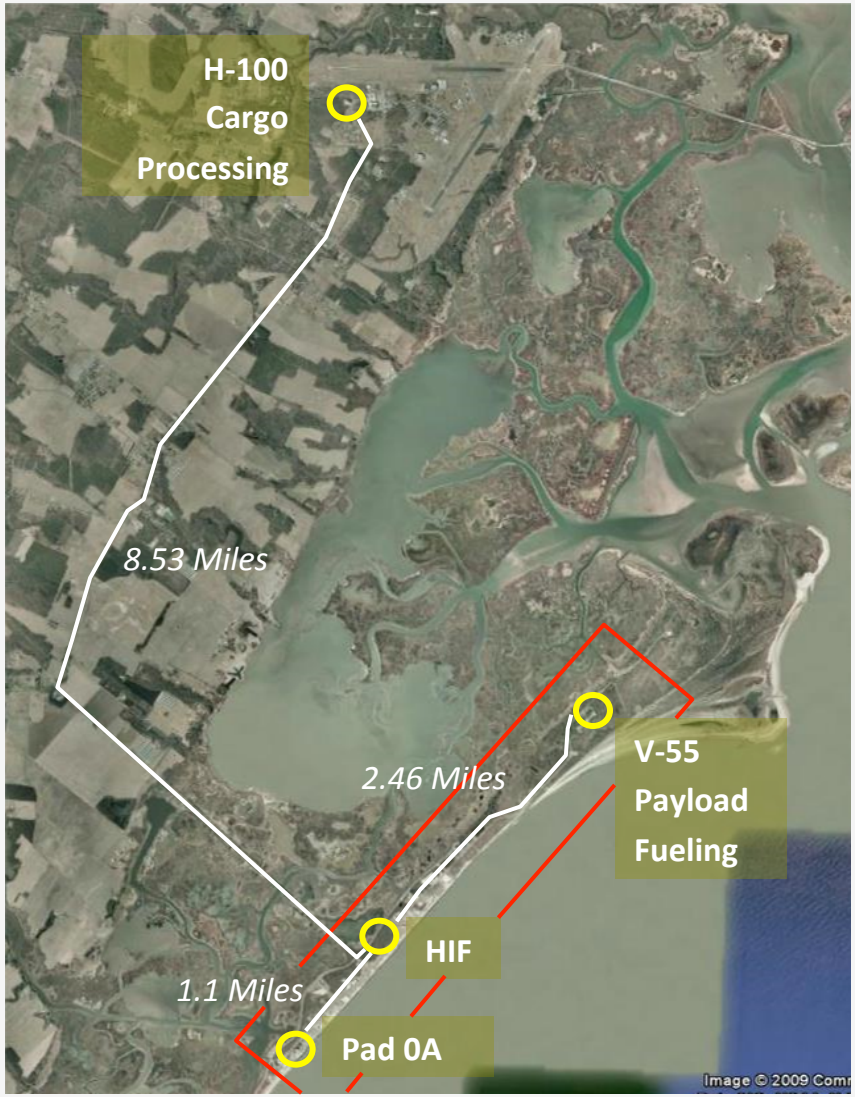
Antares Wallops Footprint



Cargo Loading

Final Cargo Installed – Hatch Closed

Antares Wallops Footprint



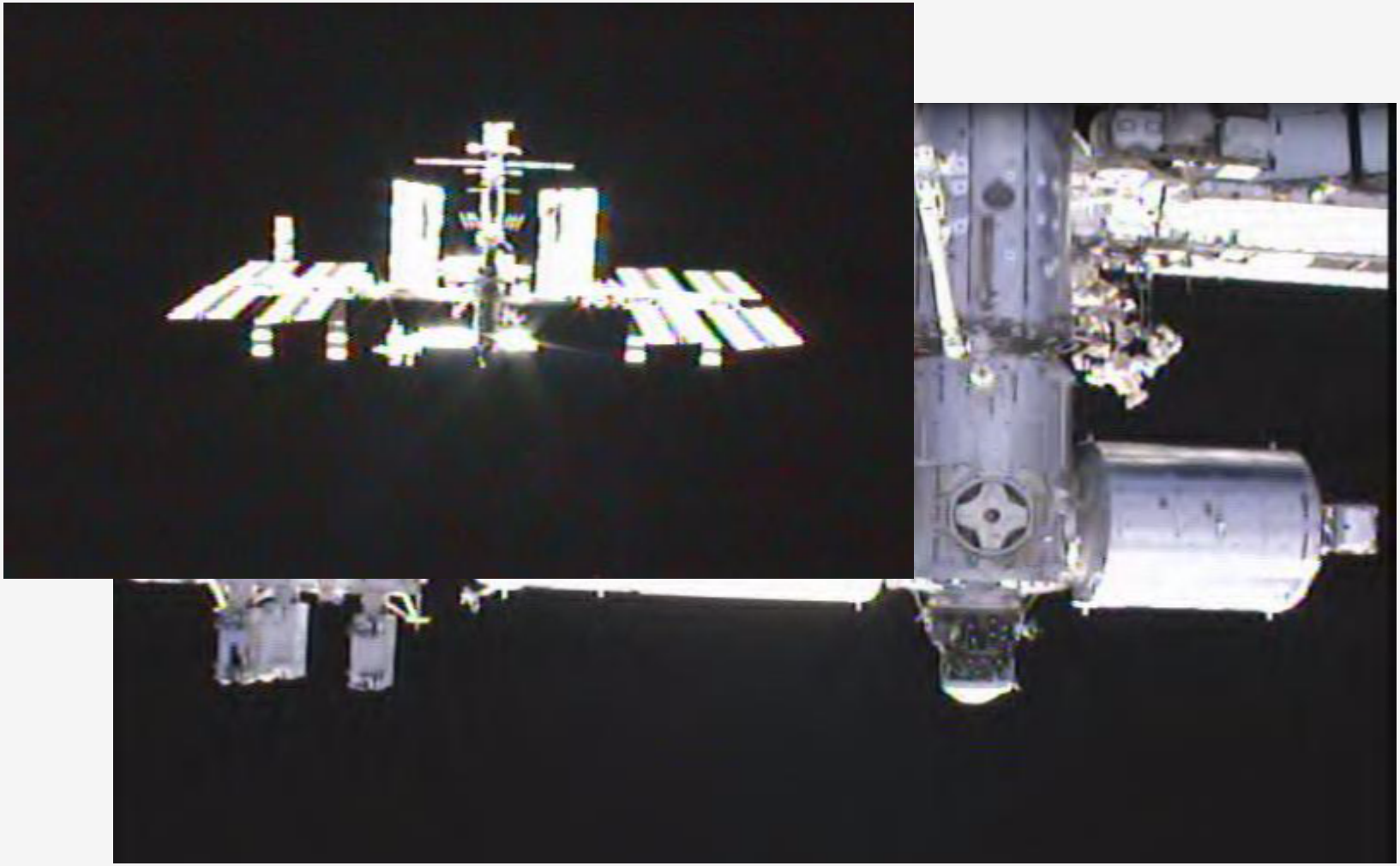
Fairing Installed

Rollout!

Antares on Wallops Launch Pad 0A

Orb-2 Liftoff

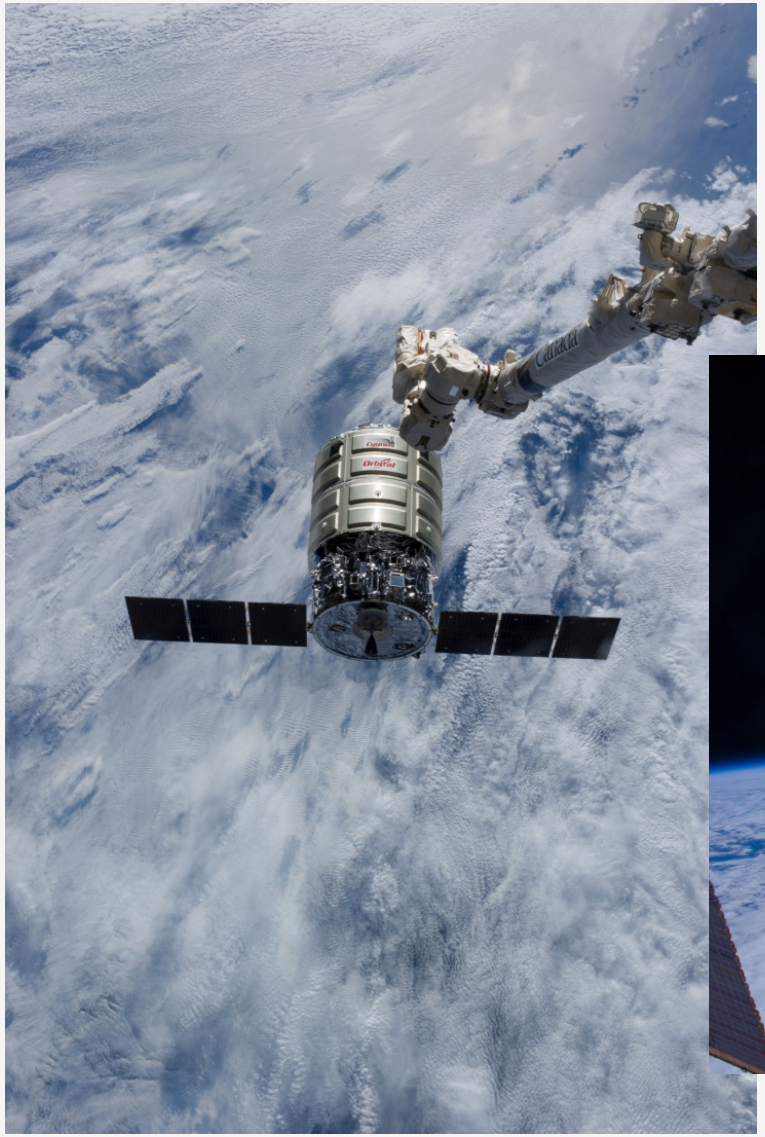
ISS from Cygnus - R-Bar Approach



Cygnus Far Field View

Cygnus Through the Window

Orb-2 Final Approach

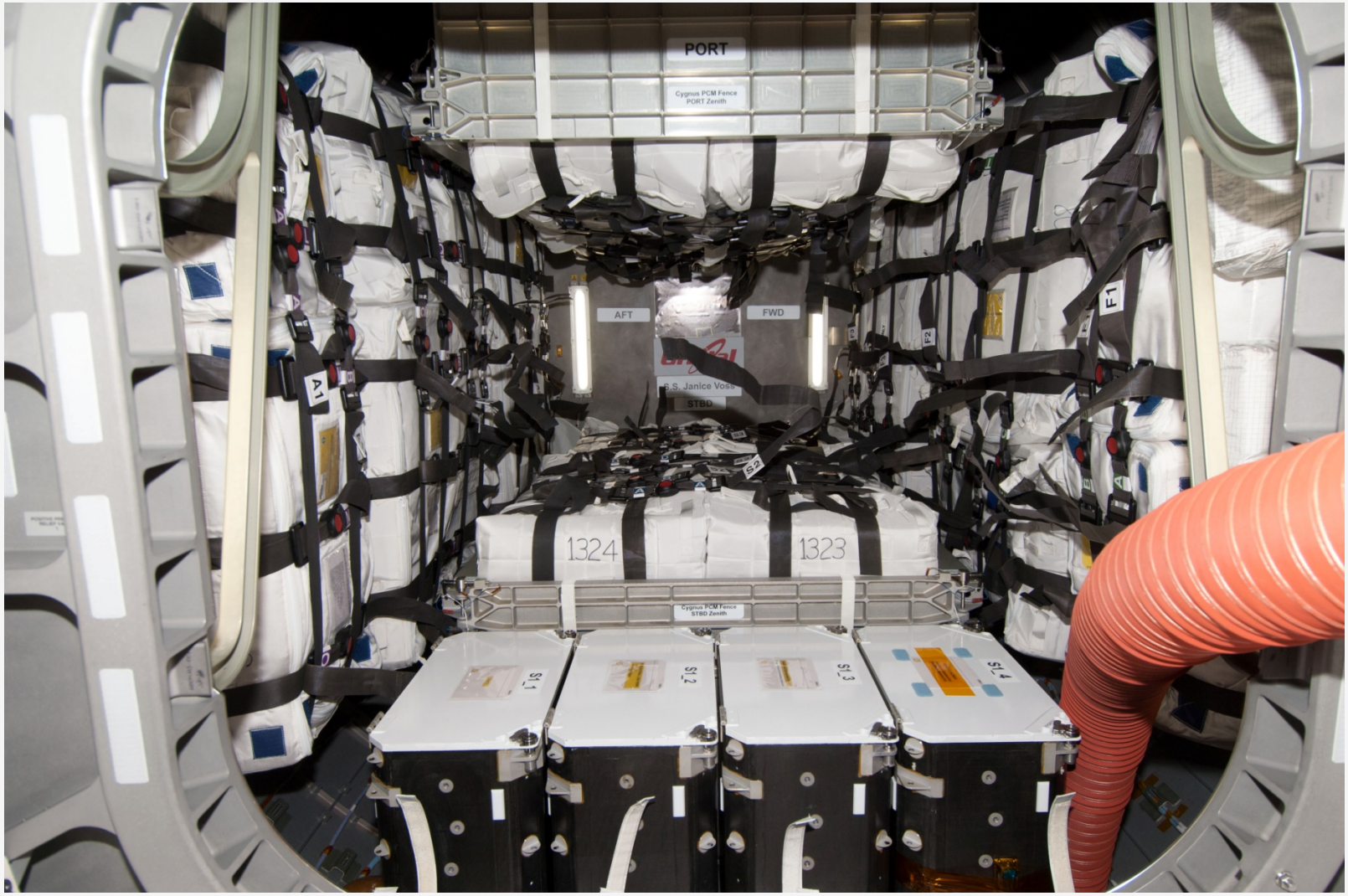


Cygnus Preparing to Grapple

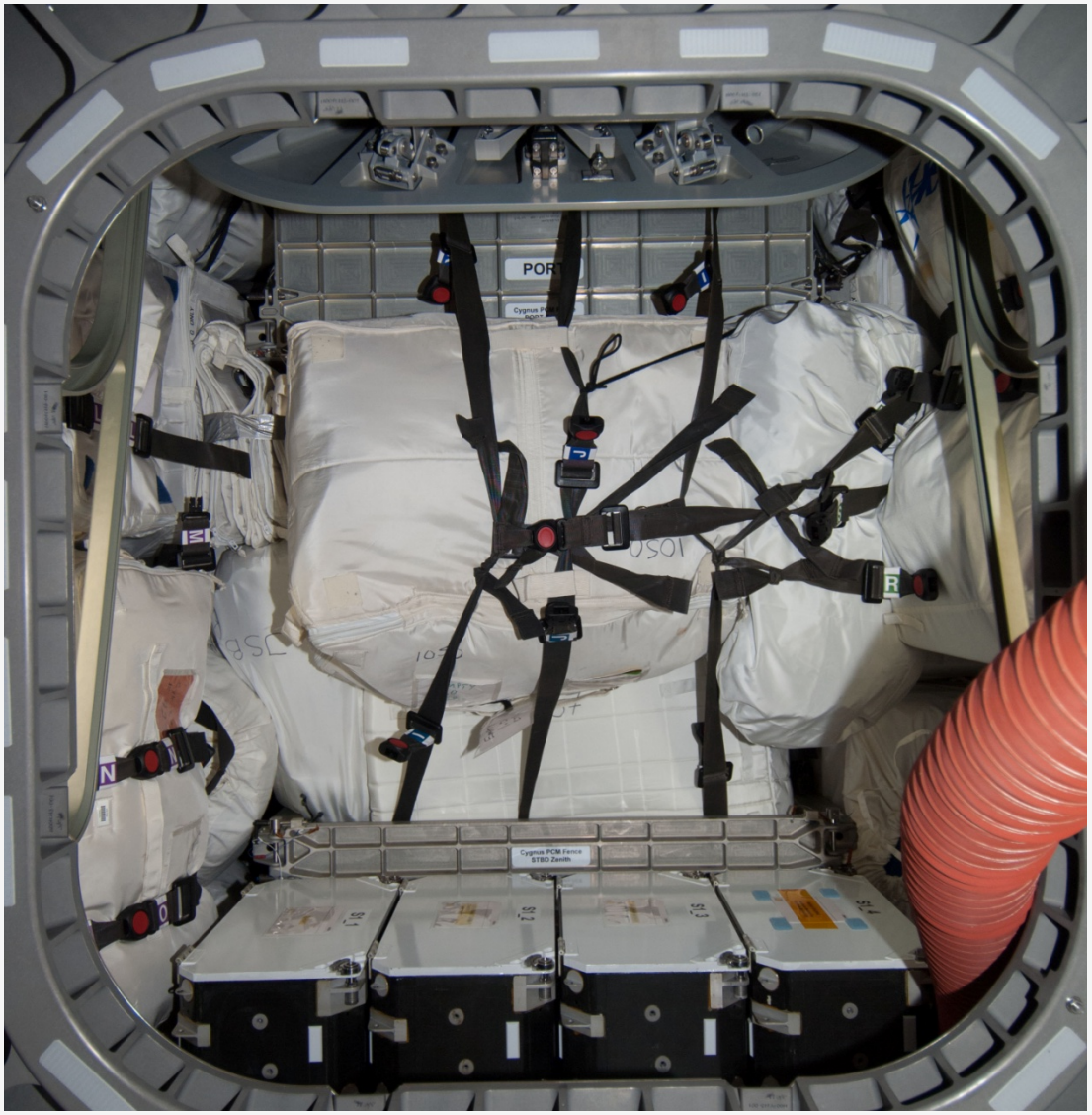
Cygnus Grappled

Orb-2 Berthed

Orb-2 Cargo Delivered

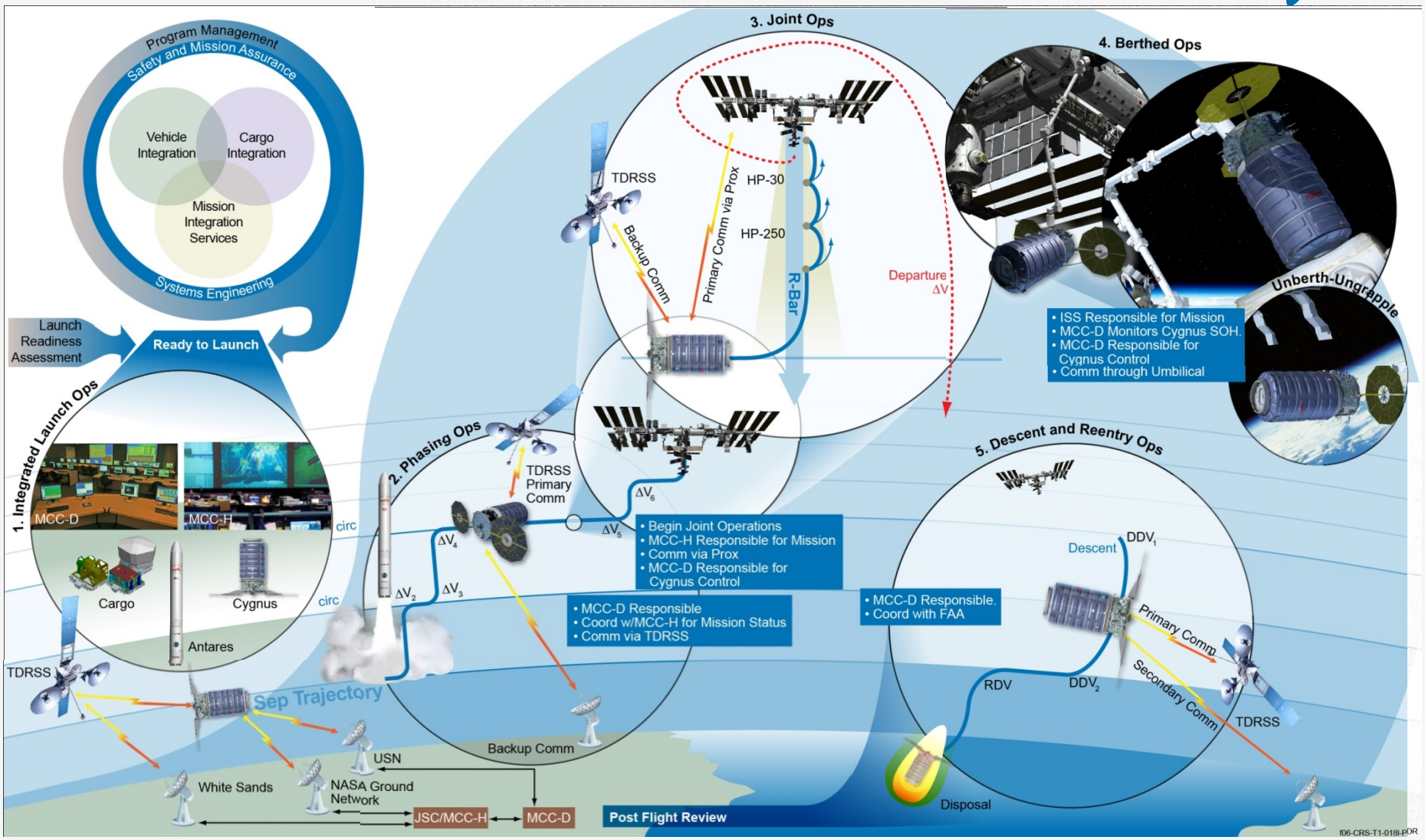


Orb-2 Disposal Cargo



Orb-2 Cygnus Re-entry

Journey to the ISS – One Wrong Move …



Cygnus Design Process "Bakes" In Success

- Well Established and Proven Processes/Performance (Launch Vehicle & Spacecraft)
  - Systems Engineering Produced Successful Initial Designs and Upgrades
  - Manufacturing and test of System Circuit Cards and Functional Boxes
  - Leveraging the Capabilities of a Global Supply Chain
  - Antares and Cygnus System Integration and Test
  - Assembly and Test at the Launch Site
  - Launch and On-Orbit Operations

- Vigilant and Independent Safety and Mission Assurance Function
  - Leads to High Confidence Mission Assurance and Proven Mission Success

- A Highly Involved Customer, NASA, Ensures User Expectations are Met
  - NASA's Oversight and Insight are Highly Evolved and Compliment Orbital Expertise
  - Expert Insight through COTS and CRS Programs
  - Independent Safety Review Panel required additional design requirements above those required for non-human space missions
  - Extensive verification activity to prove design works and is safe to complete mission successfully, and safely

NASA Insight and Oversight for Cygnus and Antares

- Insight
  - International Space Station Program Office
  - JSC Mission Operations Directorate
  - NASA Launch Services Program

- Oversight
  - JSC Safety Review Panel

- Our Mission Assurance Program includes rigorous Executive Readiness and Certification Reviews
  - Review anticipated risks and mitigations plans at program start
  - Review residual risks prior to shipment to the launch site.

COTS/CRS SMA—A Systems Approach

Safety and Mission Assurance approach to Orbital's Human Space missions emphasizes effective integration of systems engineering disciplines, quality, management are based on mature/disciplined processes for design, procurement, production, verification!

- Partnership with selected team members having strong experience in NASA human space missions
- Disciplined process for system requirements flow-down and verifications – supported by Cradle requirements management database
- Clear understanding of fault tolerant system designs and their implementation – supported by top-down system analyses and probabilistic risk assessment
- Strong interaction between S&MA, system engineering, and other engineering disciplines
- Firm baseline of proven design and process standards for flight hardware and software - refined during 29 years of successful NASA, DOD and commercial space programs
- Effective selection, monitoring and control of critical suppliers
- High Technology Readiness Level Components

COTS/CRS Safety Implementation Process

- Cygnus safety requirements defined in the COTS Interface Requirements Document (IRD), with specific requirements for control of Catastrophic and Critical hazards
  - Has been overriding consideration in Cygnus design trades, from inception of the program
  - Redundancy in critical hardware functions
- Follows "phased" safety review process with JSC/ISS Safety Review Panel (SRP)
- First Review (Phase I) for Orb-D1 mission conducted in February 2009, with 80% of the SRP's attention directed to the Cygnus "Collision" hazard report
- Orb-D1 Phase II safety review (for detailed design phase) was successfully completed in November 2009
- Cygnus Phase III safety review (for hazard control verifications) was successfully completed with SRP approval in May 2013
- Phase III updates conducted on each CRS mission to brief the SRP on design and hazard control updates, control re-verification results, and resolution of any mission anomalies
  - Orb-1 Phase III successfully complete November 2013
  - Orb-2 Phase III successfully complete March 2014
  - Orb-3 Phase III successfully complete October 2014

Quality is a Gift

- Our Business is Highly Complex
- **The Opportunity for Failure in this Market is Tangible**
- At Orbital, Quality is not Inspected-In, Its Built-In by a Vigilant Workforce

Orbital is Proud to be a Critical Link to the Ongoing Mission of the International Space Station