# Cygnus and ISS Cargo Resupply

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# Agenda

- Orbital Overview
- COTS and CRS Program Overview
- Current Program Status

# Orbital Overview

- Leading Developer and Manufacturer of Small- and Medium-Class Space Systems
  - 30-Year Record of Reliable, Rapid and Affordable Development and Production
  - Serving Customers in Commercial, National Security and Civil Government Markets
- Over 1,000 Satellites and Launch Vehicles Built or Under Contract for Customers
  - 200 Satellites and Space Systems
  - 165 Space and Strategic Launch Vehicles
  - 640 Target Vehicles and Sounding Rockets
- 3,700 Employees and 1.7 Million Square Feet of State-of-the-Art Facilities
- Revenues of About $1.5 Billion Expected in 2012
- Contract Backlog Totals $5.1 Billion for Delivery Through 2018
- Conservative Balance Sheet With Strong Liquidity

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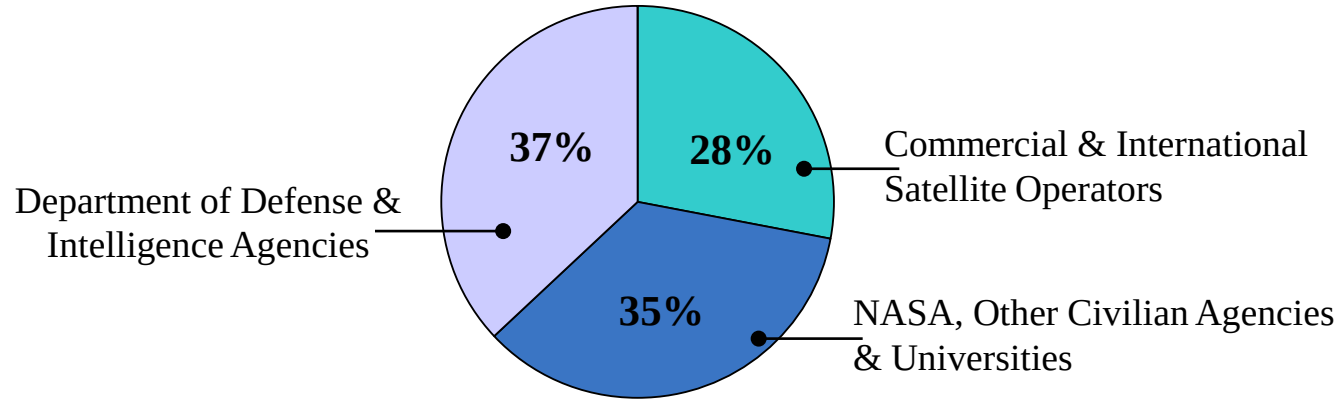
# Diversified Multi-Market Customer Base

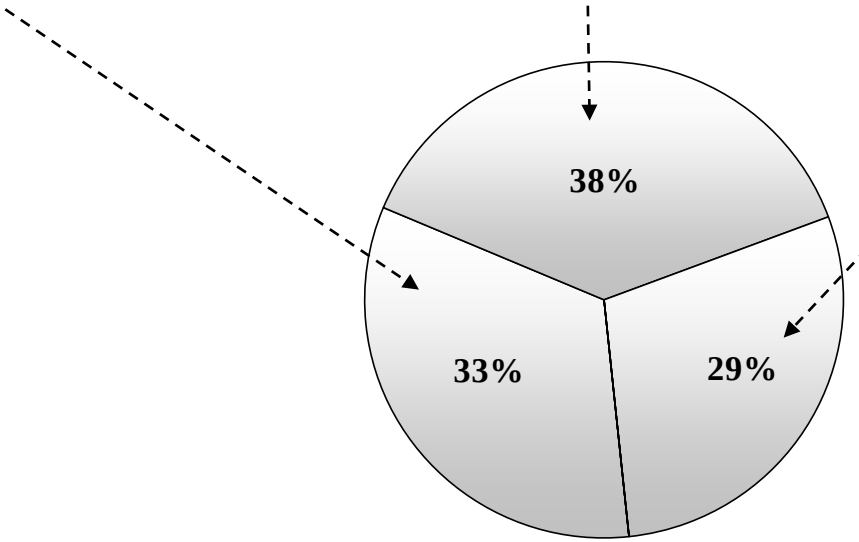

2011 Revenues by Customer Type

# Well-Balanced Business Segments

Launch Vehicles

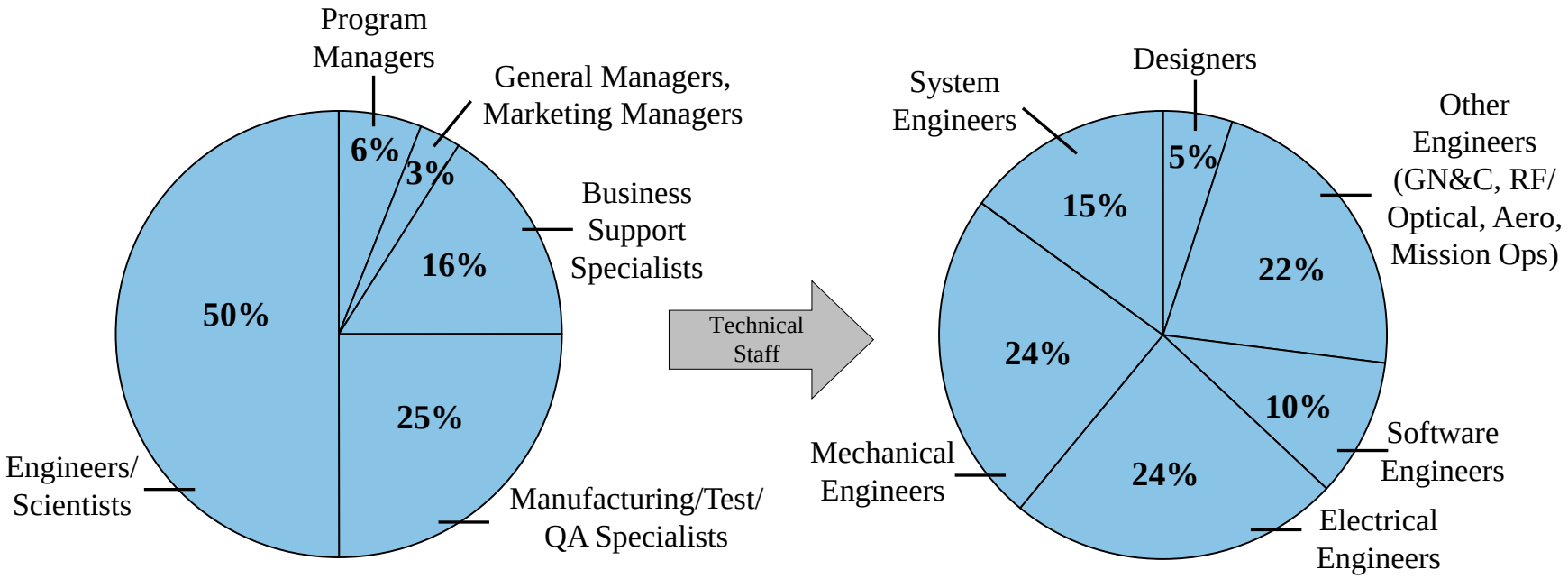
Satellites and Space Systems

Advanced Space Programs




2011 Revenues ~$1.4 Billion

# High-Caliber Engineering-Centric Workforce

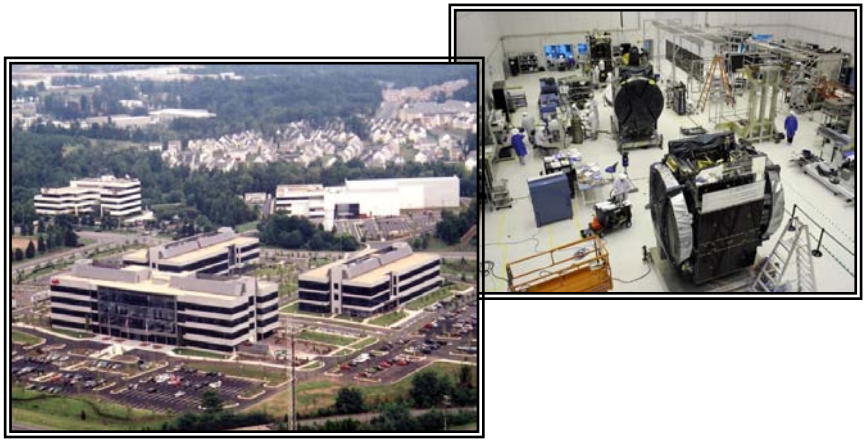



3,700 Employees*

1,850 Engineers/Scientists*

*As of January 1, 2012

# State-of-the-Art R&D and Production Facilities



**Dulles, Virginia**
• Headquarters and Satellite Development and Production
• 1,700 Employees

**Chandler, Arizona**
• Launch Vehicle Development and Production
• 1,300 Employees

**Gilbert, Arizona**
• Satellite Development and Production
• 300 Employees

**Greenbelt, Maryland**
• Space Technical Services
• 400 Employees

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# Over 725 Space Missions Since 1982*

69 Commercial Satellites

68 Government Satellites

40 Space Payloads

70 Space Launch Vehicles

185 Interceptor & Target Vehicles

301 Sounding Rockets

*April 1982-December 2011

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# Satellite and Space Systems Experience

**Commercial Satellites**

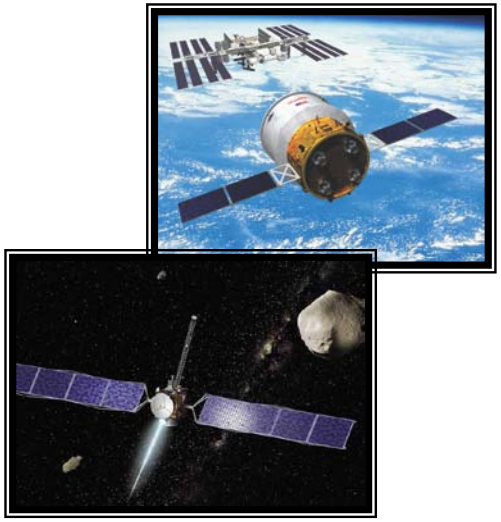
- GEO Communications
- LEO Communications
- LEO Imaging

**Mission Record**

- 69 Launches Since 1982
- 97% Mission Success

**Production Backlog**

- 9 Units in Backlog



**Science & Exploration Spacecraft**

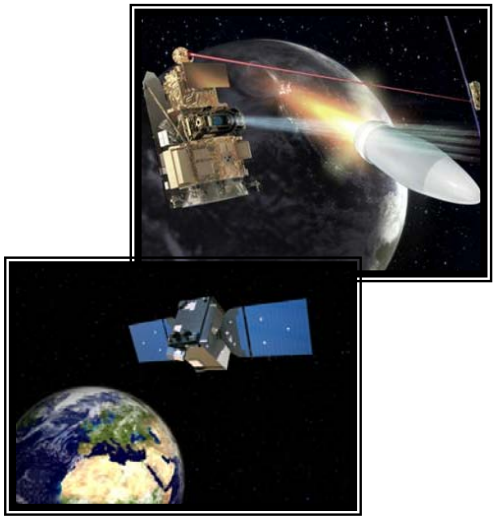
- LEO Earth & Space Science
- ISS Cargo Logistics
- Deep-Space Exploration

**Mission Record**

- 32 Launches Since 1982
- 96% Mission Success

**Production Backlog**

- 14 Units in Backlog



**National Security Satellites**

- LEO Missions
- GEO Missions

**Mission Record**

- 36 Launches Since 1982
- 97% Mission Success

**Production Backlog**

- 3 Units in Backlog

77 Satellites in Current Operations… Over 925 Satellite-Years of Experience

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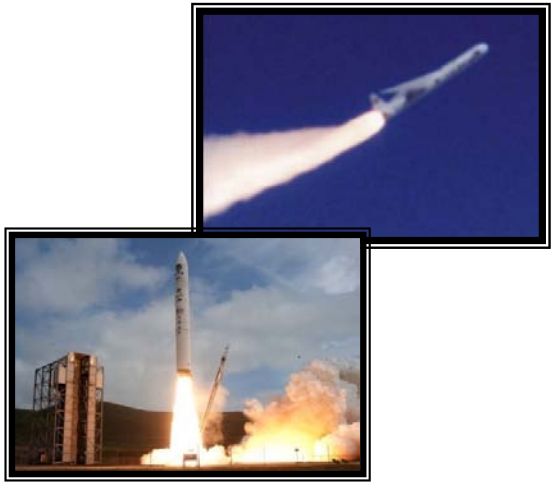
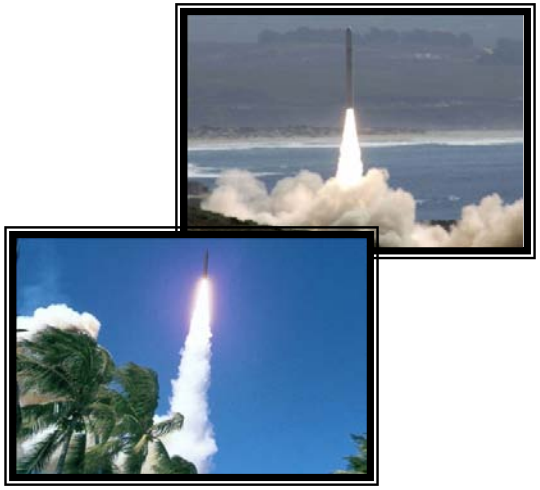
# Launch Systems Experience



**Space Launch Vehicles**
- Small Payloads (Up to 2 Tons)
- Medium Payloads (3 to 7 Tons)
- Special Purpose Vehicles

**Mission Record**
- 70 Launches Since 1982
- 92% Mission Success

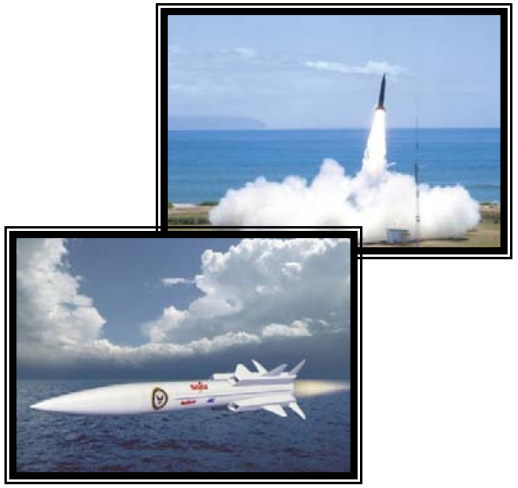
**Production Backlog**
- 1 Unit Delivered
- 19 Units in Backlog



**Strategic Launch Vehicles**
- Interceptor Vehicles
- Global Strike Vehicles
- ICBM/IRBM-Class Targets

**Mission Record**
- 22 Launches Since 1982
- 100% Mission Success

**Production Backlog**
- 40 Units Delivered
- 14 Units in Backlog



**Target Vehicles**
- Short-Range Targets
- Medium/Intermediate Targets
- Special Purpose Vehicles

**Mission Record**
- 160 Launches Since 1982
- 95% Mission Success

**Production Backlog**
- 28 Units Delivered
- 51 Units in Backlog

108 Launches With 96% Success in Last 10 Years

# Orbital's Cargo Delivery Program

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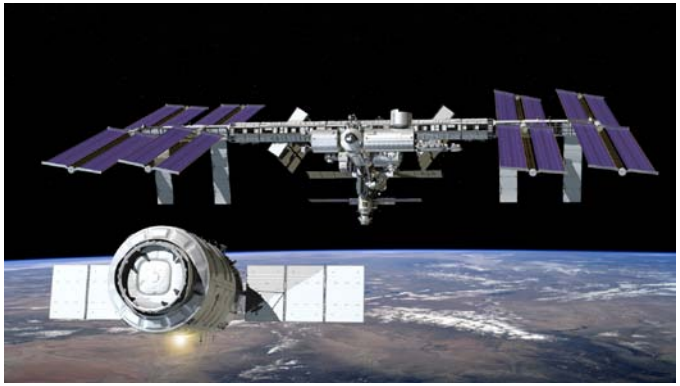
**Drawing Upon Its 30 Years Of Satellite And Major Space Systems Development And Operations Experience, Orbital Sciences Corporation Has Embarked On A New Venture To Provide Cargo Transfer Services To NASA's ISS Program**

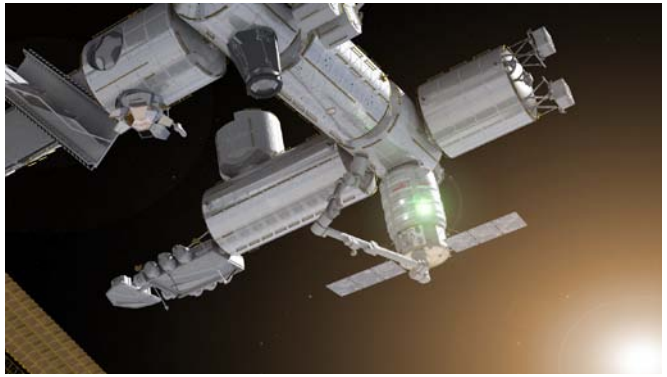
- Under the joint NASA / Orbital Commercial Orbital Transportation Services (COTS) Program, Orbital is Developing the "Cygnus" Advanced Maneuvering Space Vehicle, Which is Designed to Meet Stringent Safety Requirements for ISS Operations

- The Cygnus Spacecraft, with the Antares Launch Vehicle, Will Provide Cargo Resupply to the ISS Program under the Cargo Resupply Services (CRS) Contract

# International Space Station Overview

- ISS is in  an orbit with an altitude of 400 km with an inclination of 51.6 degrees. The orbit also 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.
- 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.
- Orbital Sciences is developing an ISS resupply capability for NASA and will operate that capability as a commercial service.
  - Orbital will leverage the success of the ISS partners along with our heritage of successful spacecraft development and operations
- 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. A competing system is being developed by Space X.





# Cygnus Cargo Resupply Vehicle Overview

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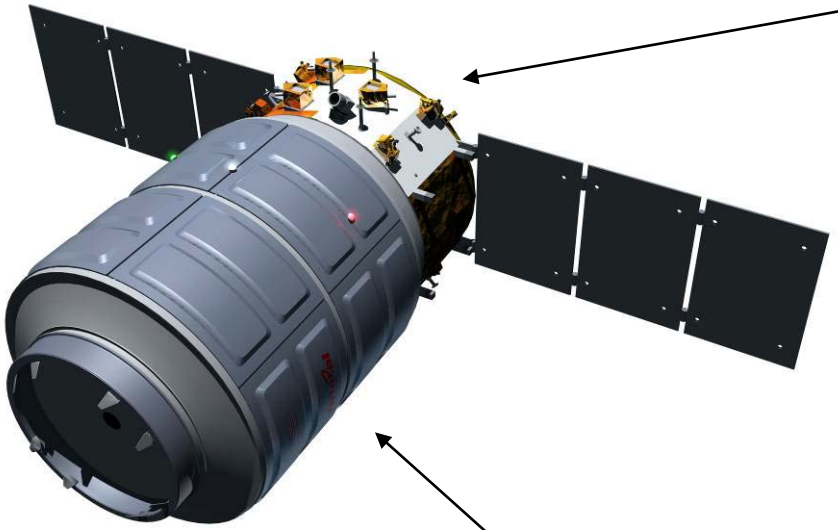
- The Cygnus vehicle is comprised of two major modules



•Service Module (Bus)

- •Provides all utility services to the cargo modules
- •Manages the autonomous rendezvous to the ISS
- •Provides required resources to allow the mission to be successfully completed
- •Structural interface to the launch vehicle and cargo modules
- •Manufactured at Orbital's Dulles facility

•Pressurized Cargo Module (payload)

- •Supports NASA Cargo that Requires a Pressurized Environment
- •Built by Thales Alenia

# Cygnus Mission Operations

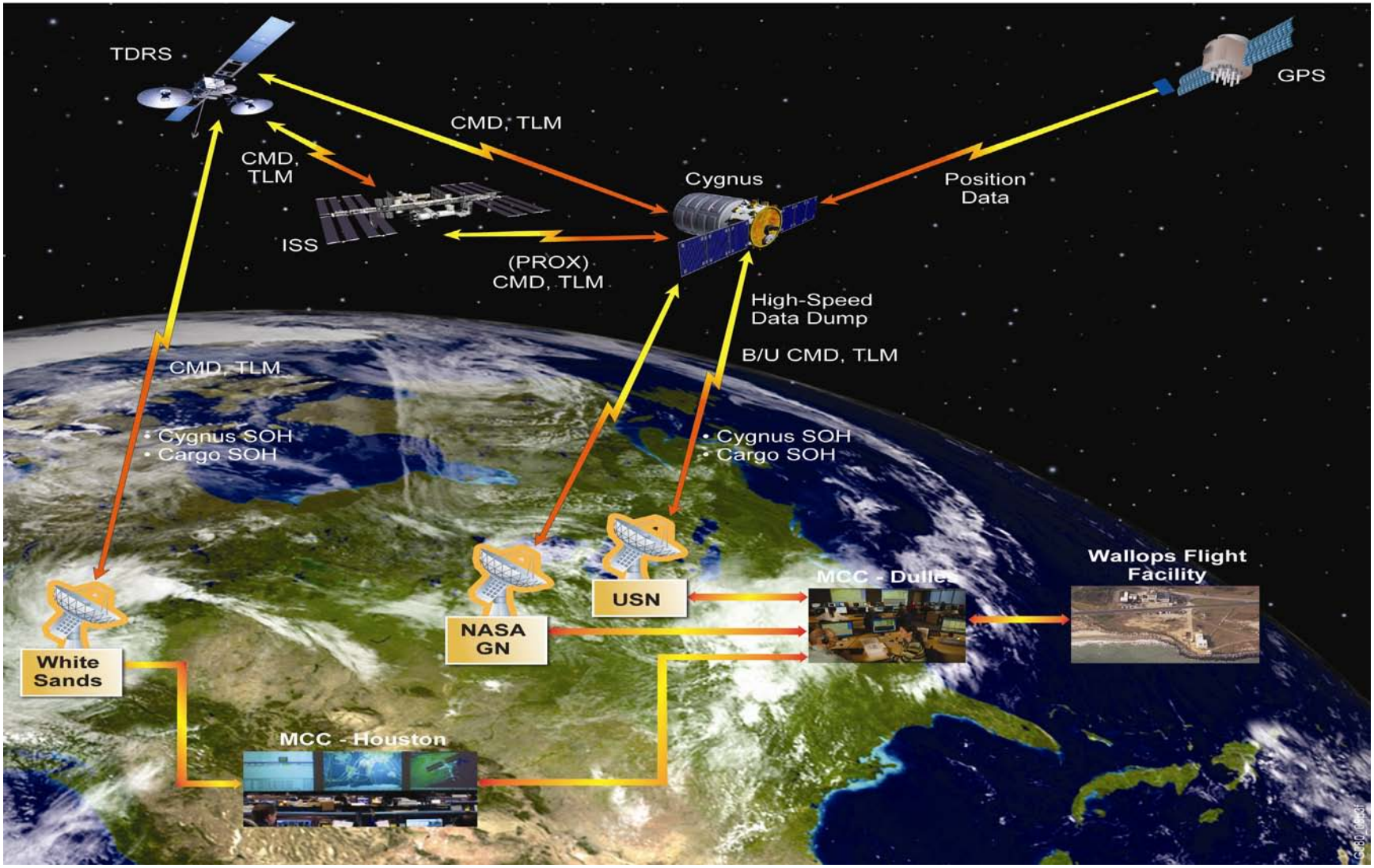
- Cygnus mission operations will be managed from Orbital's state-of-the-art Mission Control Complex in Dulles, Virginia, in concert with NASA's Johnson Space Center in Houston, Texas).

*Cygnus will be boosted into orbit by Orbital's Antares medium-class space launch vehicle*

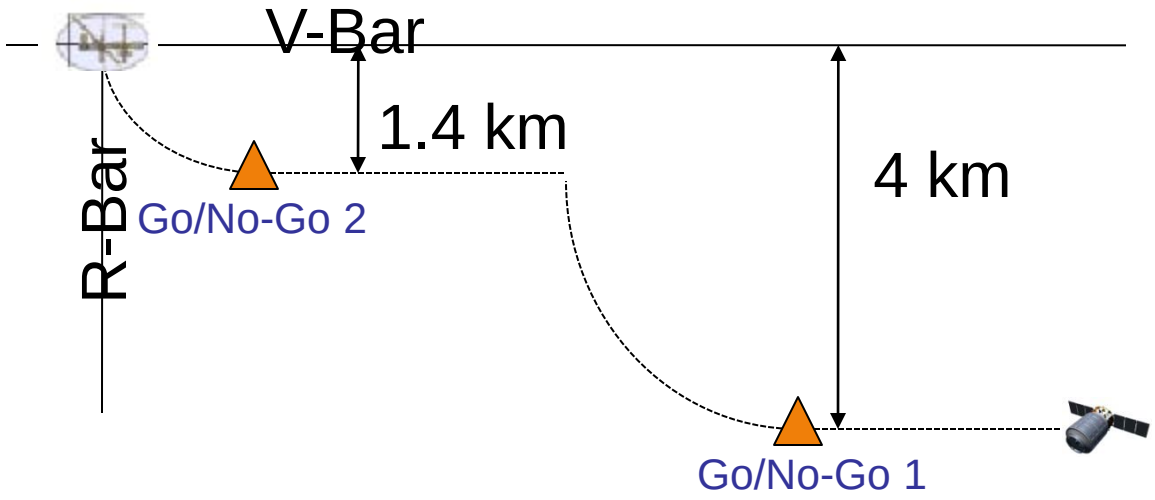
After being launched into low-Earth orbit by Antares, the Cygnus spacecraft has substantial maneuvering capability to transport it's payload from a low parking orbit to the ISS.

After the payload mission is complete, Cygnus is steered to a safe destructive reentry over the Pacific Ocean.

# Communication Paths



# R Bar Approach




- Cygnus uses an R-Bar approach to the ISS
  - Cygnus expects to have Prox Comm with the ISS from 23-50 km out on the 4 km co-elliptic
- Two “Go/No-Go” calls are planned during this period
  - Go/No-Go 1 allows Cygnus to go from a 4km to a 1.4 km coelliptic orbit
  - Go/No-Go 2 allows Cygnus to go to a Hold point 250m down the R-Bar

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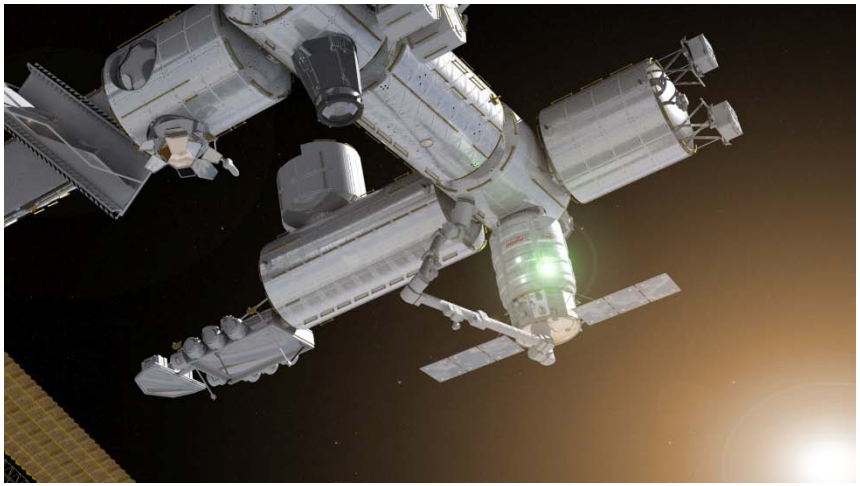
# Approach to Berthing


Japanese ATV Approach



Cygnus Approach is Similar to HTV

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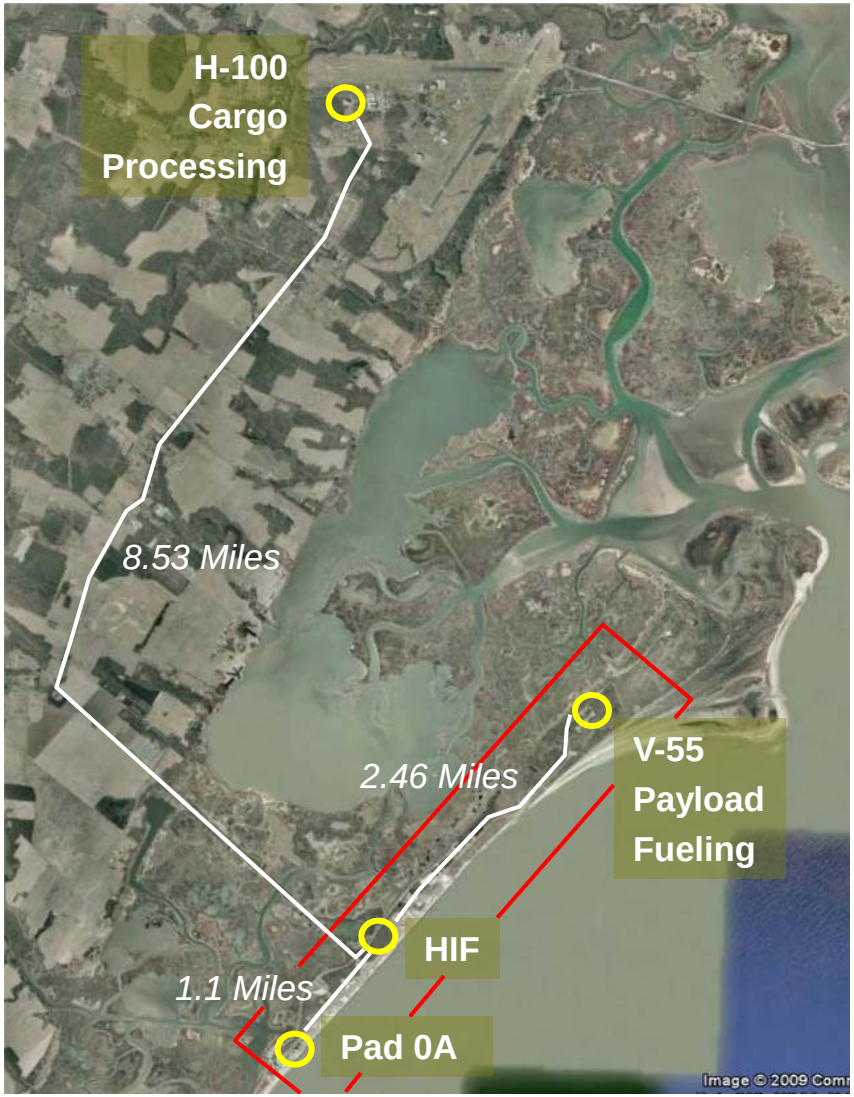
# Antares/Cygnus Wallops Footprint

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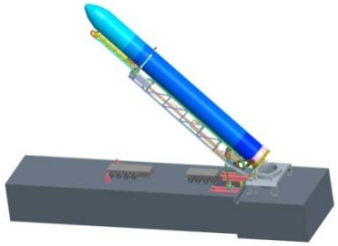
# Cygnus Hardware Processing Flow

Spacecraft Service Module (SM) Trucked from Dulles To Wallops
Pressurized Cargo Module (PCM) Shipped Direct to Wallops from Thales

SM and PCM Integrated and Tested in Wallops H-100 Payload Integration Facility

Cygnus Fueled in Wallops V-55 Fueling Facility

Cygnus Mated with Antares Launch Vehicle in Wallops HIF



Integrated Launch Vehicle Rolled Out to Pad and Erected on TEL "Strongback"

Launch Vehicle Fueled, Tested, and Readied for Launch

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# Antares Vehicle Overview

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

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

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

**STAGE 2**
- ATK CASTOR® 30/30B 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

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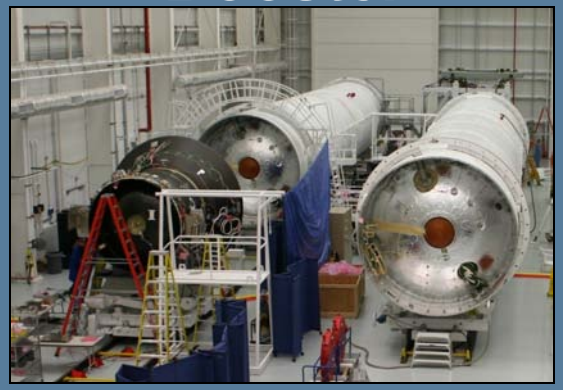
# Antares Hardware Status

## Booster



Hot Fire and Test Flight Boosters Being Processed @ Wallops

COTS Launch Booster Delivered

ORB-1 Launch Booster Tankage Complete

## Main Engine System

- ✓1st Four Engines Successfully Hot-fire Tested @ Stennis
- ✓ 1st Three Engines Delivered to Wallops
- ✓Hot Fire Test Engines Integrated into Engine Section

## Upper Stack

- ✓Upper Stack & Cygnus Pathfinder Complete
- ✓Upper Stack Integration @ Wallops
- ✓Avionics Testing Complete

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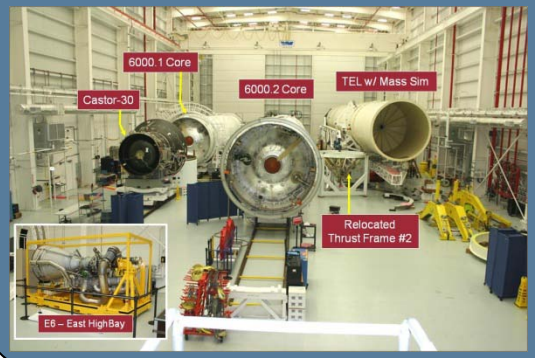
# Antares WFF Launch Site Development

## Horizontal Integration Facility

- ✓ Structure Complete
- ✓ Interior Complete
- ✓ Occupancy 3/11




## Launch Pad

- ✓Ramp & Flame Trench Complete
- ✓Tanks Installed
- ✓Deluge Tower Complete

## Infrastructure

- ✓ HIF GSE Delivered
- ✓TEL Complete
- ✓Transporters Available
- ✓TEL Pathfinder On-Going

# TEL Pathfinder Nov 2011 Featuring Rapid Retract and 2X Load Proof Test

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# Aft Bay Mated to Core for Pad Hot Fire


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# E7 ATP 17 Nov 2011

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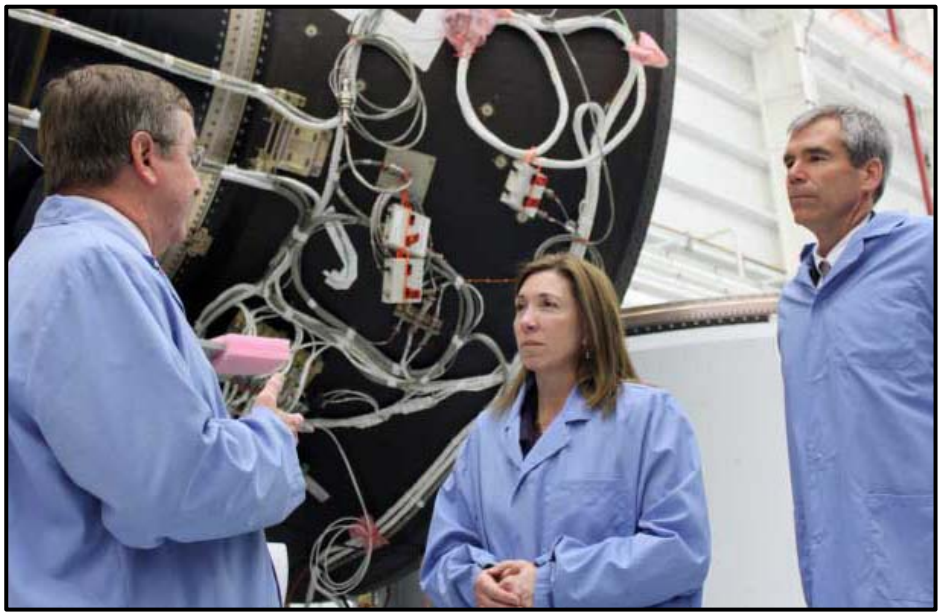
# Recent Visits by NASA HQ (L. Garver, M. Peck) to HIF



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# Wallops Launch Pad Nearing Completion

# Cygnus Service Modules in Test

# PCM 1 and PCM 2 at Thales Alenia

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# First Enhanced Module - PCM 4

# Pressurized Cargo Module at Wallops Flight Facility

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# Pressurized Cargo Module Loading

# Astronaut View Inside Loaded Pressurized Cargo Module

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# Questions?