Cygnus Beyond Low-Earth Orbit – Logistics and Habitation in Cis-Lunar Space

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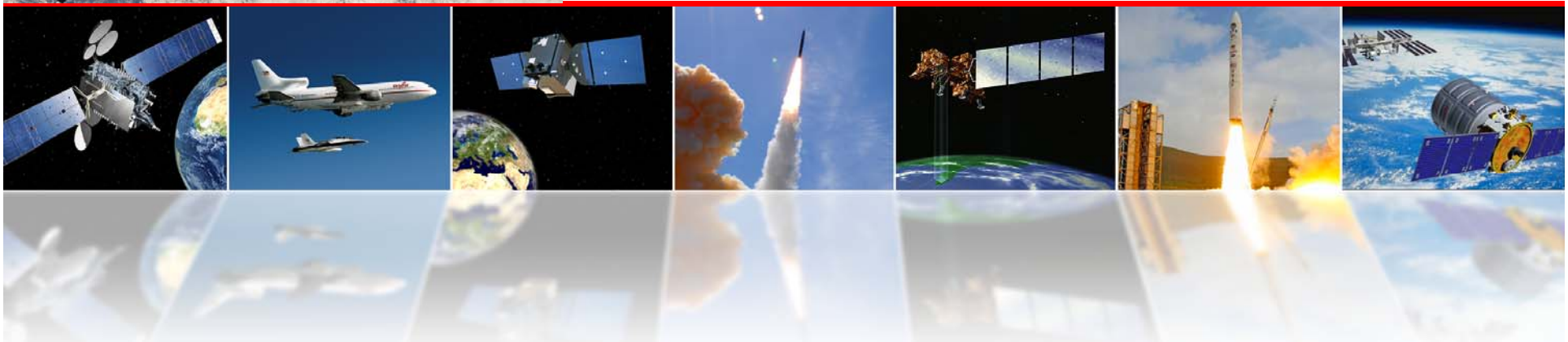

Outline

- Cygnus current capability for commercial resupply
- Cygnus future capability as an Exploration Augmentation Module
- Why Cygnus meets Global Exploration aims

Current Capability:
Low Earth Orbit Transfer Operations Underway

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- **Orbital COTS Program Successfully Completed**
  - ➢ Economically developed through Space Act Agreement
  - ➢ 2 Major Space Operations completed
    - Antares Test Flight
    - COTS Demonstration Flight

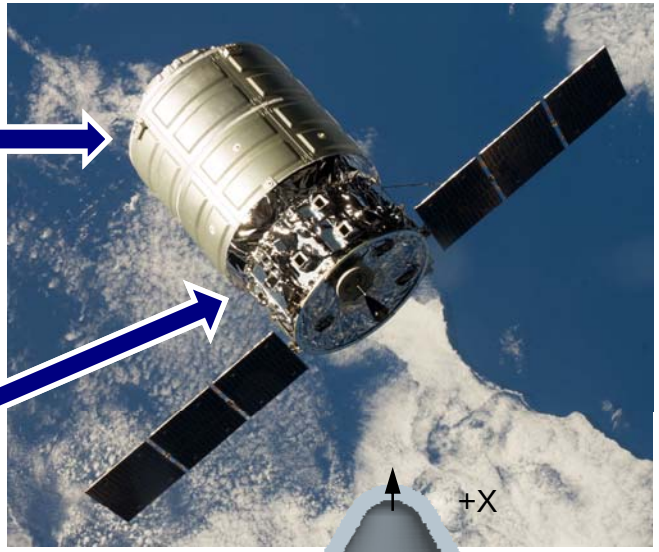
- **Cygnus Has Begun Cargo Resupply to the ISS Program**
  - ➢ Orb-1 Mission Completed on 2/19
  - ➢ Orb-2 Mission On Track for 5/6
  - ➢ 8 CRS Flights from 2014 to 2016

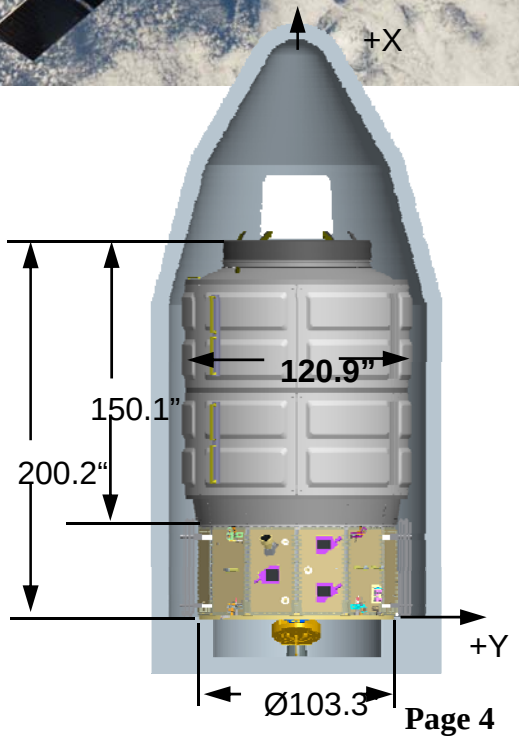
Cygnus Overview

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





Orb-D1 Cygnus on Approach

Orb-D1 Cygnus Grappled and Ready for Berthing

Orb-D1 Cygnus Berthed to the ISS

Cygnus Hatch Opening

Cygnus Crew Operations

Cygnus Crew Operations

Cygnus Separation and Re-Entry

Cygnus Future Capability – The Exploration Augmentation Module

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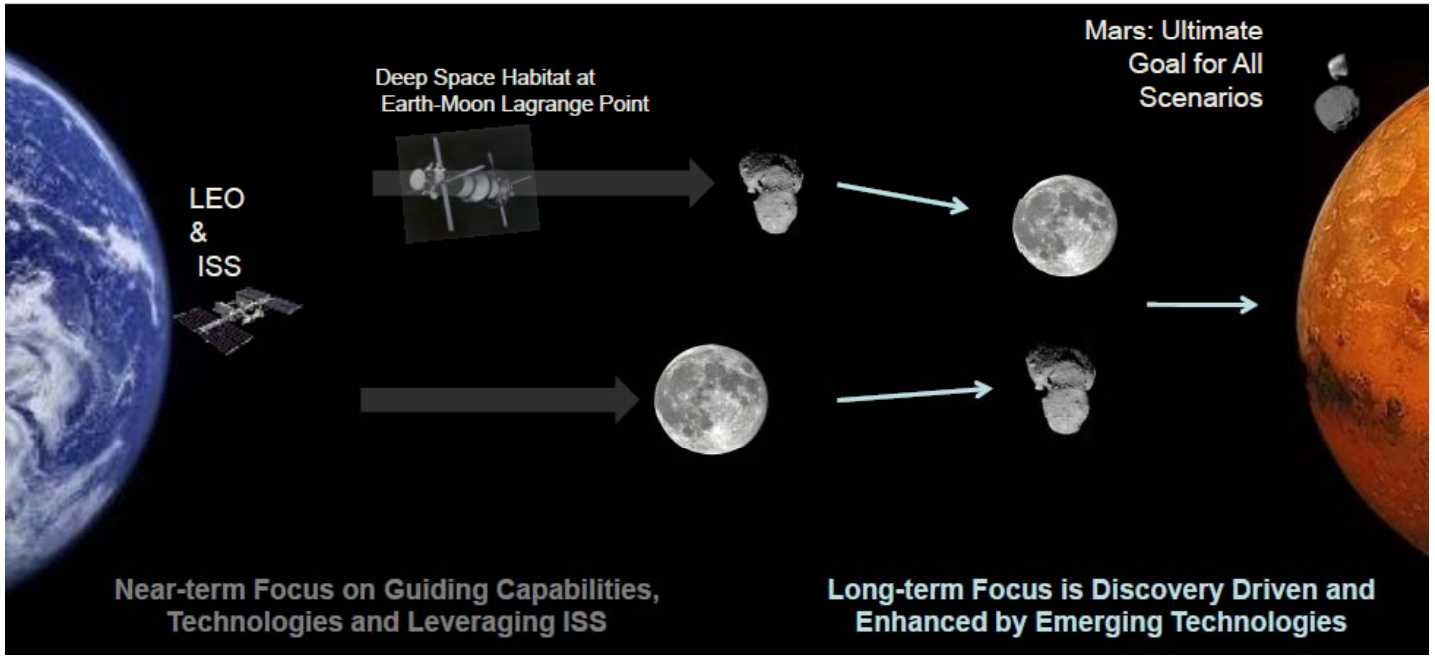
- **Orbital Sciences feels that Cygnus can be evolved to an Exploration Augmentation Module (EAM)**
  - To provide additional habitation capabilities and logistics requirements
  - To support more distant space destinations, providing essential services
  - To provide an affordable solution
  - To meet the aims of Global Exploration Strategy roadmap
- **The evolution of NASA human space capabilities from one program to another has historical precedence**
  - The Skylab, NASA's first space station, was derived from a Saturn V upper stage



Cygnus Missions for Exploration

- **Orbital's Cygnus Spacecraft Provides an Operational Capability That Is Available and Affordable In a Variety Of Applications Beneficial To NASA Exploration Missions Currently Under Development**
  - Can extend the duration of an Orion mission, either in Cis-lunar space or a high-altitude Earth orbit
  - Can provide a safe-haven at a distant destination
  - Can allow for early testing of systems required for Asteroid retrieval
    - Docking systems

- **A Cygnus EAM can provide space required for logistics, crew accommodations, crew medical requirements**

- **Cygnus EAM would be a modification of the existing module currently in production**
  - Supply chain already established
  - Non-recurring engineering completed

Candidate EAM Options

Cygnus can support a 4-person crew for 60 days while berthed to Orion

"Super" 4-Segment Configuration

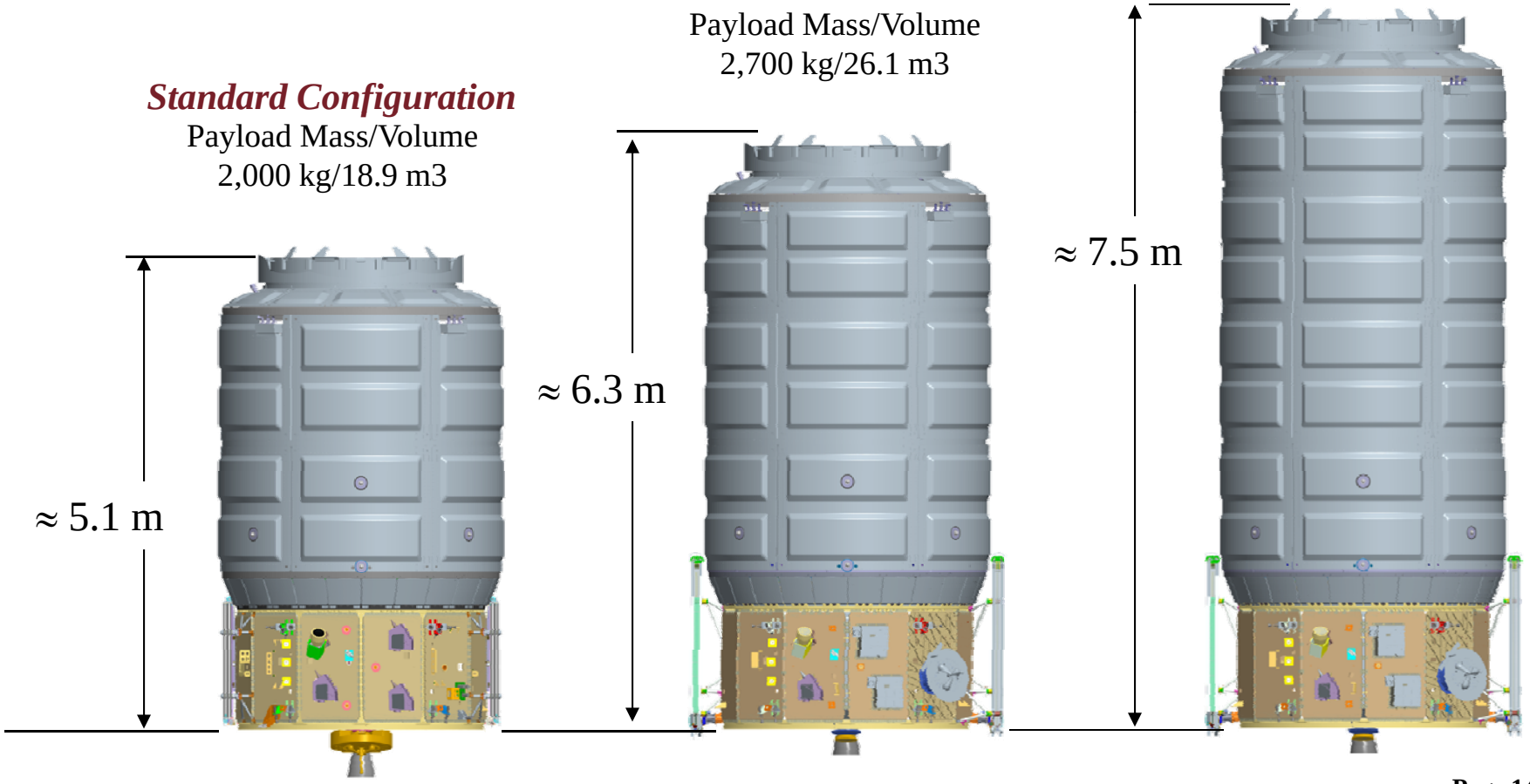
Payload Mass/Volume
3,400 kg/33.5 m3

Enhanced Configuration

Payload Mass/Volume
2,700 kg/26.1 m3

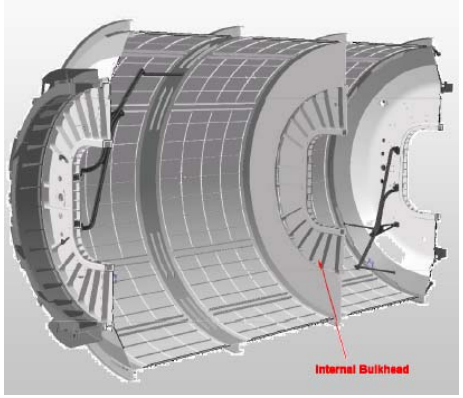
Standard Configuration

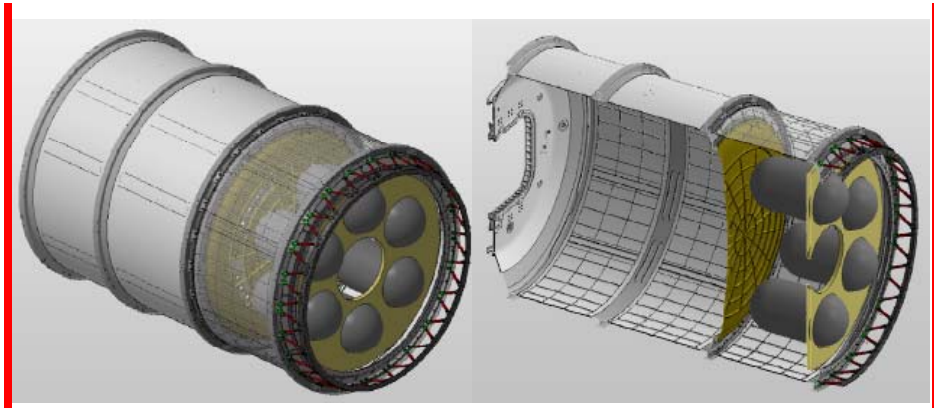
Payload Mass/Volume
2,000 kg/18.9 m3



Other EAM Topologies/Capabilities

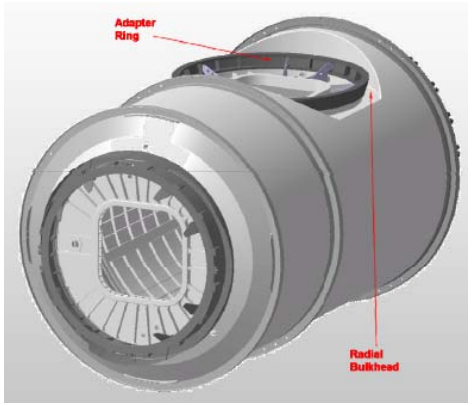
Internal Bulkhead



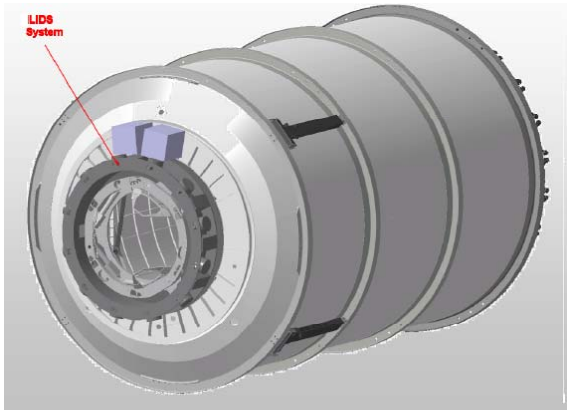


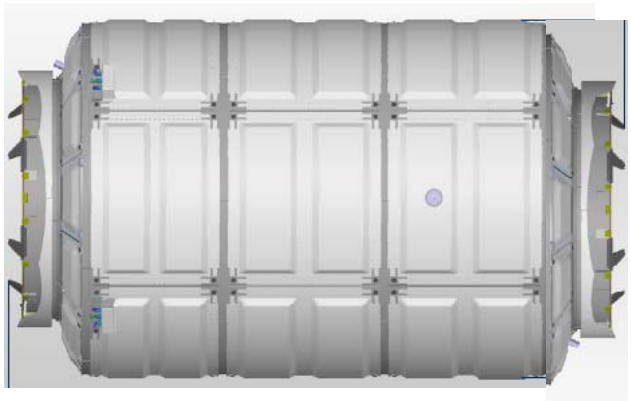
Hybrid Cygnus Pressurized Cargo Module with Unpressurized Gas/Water Storage

Side Hatch



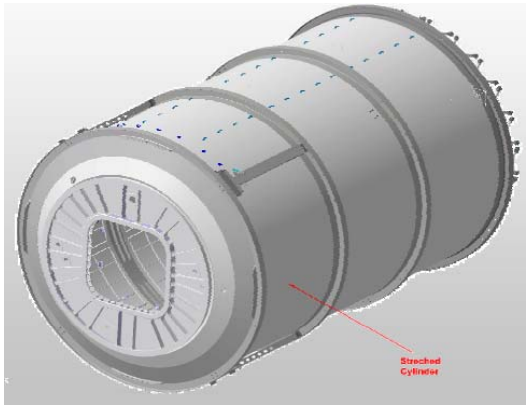
ILIDS Application





Cygnus Dual-Hatch Configuration

"Stretched" PCM



Candidate Cygnus Functions

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Structural Elements

Pressurized Module (PM)

- Habitable Volume
- Optical Viewing Port
- Life Support
- Thermal Control - Internal
- Crew Systems
- Waste Management
- Docking System

Service Module (SM)

- Electrical Power System
- Communications System
- Attitude/ Trajectory Control
- In-Space G&NC and Flight Computer
- Propulsion System
- Thermal Control - External

Cygnus Habitat Functionality

Supports/Enhances Deep Space Operations Through the Following

Internal capabilities

- Medical/Life Sciences Accommodations
- Mission Operations/Robotic Operations
- Habitat Operations
- Food Storage
- Hygiene Provisions
- Toilet

External Capabilities

- Storage for Water
- Storage for O2 and N2
- Storage for liquid waste
- Propulsion/Station-keeping capabilities
- Potential to be target or chaser for rendezvous

Cygnus System Facilitates Exploration Goals

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- **Affordability -** Evolutionary approach with utilization of existing space qualified systems and cargo missions to ISS, provides lower cost under tightening budget constraints

- **Early Schedule -** Utilization of existing capability provides opportunity for near-term mission support. Potential to "piggy-back" on currently planned CRS missions (8 missions through 2016)

- **Maturity / Reliability -** Cygnus heritage and redundancy provides reliability

- **Technology Advancement -** Cygnus utilization provides new technology risk reduction in flight environments

- **Flexibility -** Cygnus system elements are adaptable to evolving mission needs, goals and requirements

- **Partnership -** Involvement of Cygnus concepts in NASA Exploration assessments promotes commercial / NASA / international partnership

Exploration Cygnus Supports GER Objectives

- **Extends Human Presence** – Longer duration missions away from Earth
- **Develops Exploration Technologies and Capabilities** – Crew support technologies, ECLSS, more efficient logistics
- **Perform Science** – Human research beyond LEO, Lunar observation
- **Engage the Public** – More ambitious mission, additional elements
- **Stimulate Economic Expansion** – Inclusion of Affordable Additional elements
- **International Elements** - Cygnus EAM represents a US/International industrial collaboration, contributing to a joint international activity

Thank You

Graphic Credit – Lockheed Martin