

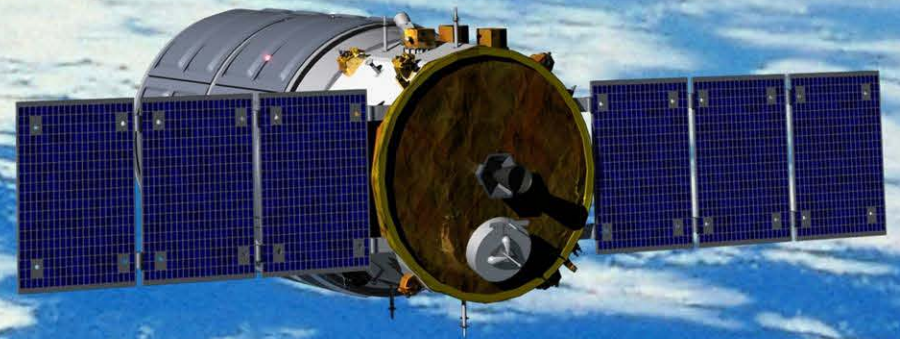


INNOVATION YOU CAN COUNT ON™

Satellite Servicing Utilizing Cygnus

Presented to the Spacecraft Servicing Workshop by

Warren Frick, Program Manager
Advanced Programs



Approved for public release, distribution unlimited
This document does not contain "technical data" as defined in the ITAR, 22 CFR 120.10.

Satellite Servicing



Approved for public release, distribution unlimited

Orbital Sciences Product Lines



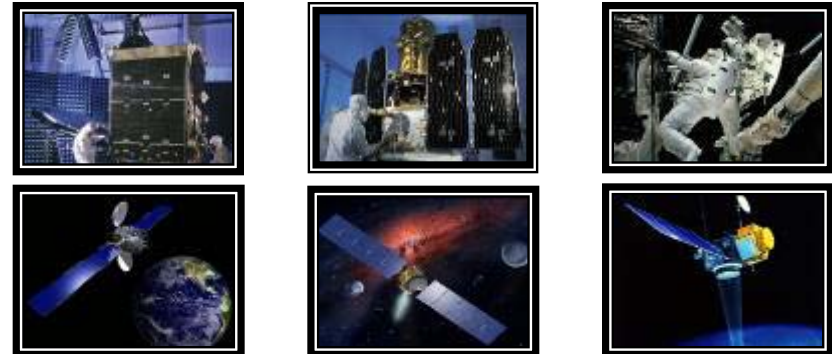
Launch Vehicles and Missile Systems



Space Launch Vehicles **Interceptor Launch Vehicles** **Target Vehicles/Missiles**

- 656 Launch Vehicles Developed, Built or Under Contract
- 97% Mission Success Achieved Over Last 10 Years (99 Vehicles)

Satellites and Other Space Systems



Communications Satellites **Scientific Satellites** **Other Space Systems**

- 179 Satellites/Space Systems Developed, Built or Under Contract
- 97% Mission Success Achieved Over Last 10 Years (70 Space Systems)

Advanced Space Programs



Advanced Launch Vehicles **Human Space Systems** **Military Satellites**

- 8 Major Advanced Space Systems Conceived, Prototyped or Under Contract to Develop Innovative Solutions Across All Sectors
- Involve Customer- and Company-Funded R&D and Limited-Quantity Production Programs to Demonstrate New Technologies

- Orbital's satellite servicing research is focused on our core competencies
 - Rendezvous and Proximity Operations (RPO)
 - Human satellite servicing as part of the Hubble Space Telescope (HST) Repair missions
 - Satellite design, development, fabrication, and flight
- As part of the Commercial Orbital Transportation Services (COTS) program, Orbital is building an extremely robust spacecraft called *Cygnus* that is capable of safe RPO near the ISS and will be operational in 2011, providing resupply services for 9 missions.
- With modest effort, *Cygnus* can be adapted to develop a multi-tiered satellite servicing system.

Cygnus Visiting Vehicle



- The Cygnus vehicle is comprised of two major modules

- Service Module

Provides all utility services to the cargo modules

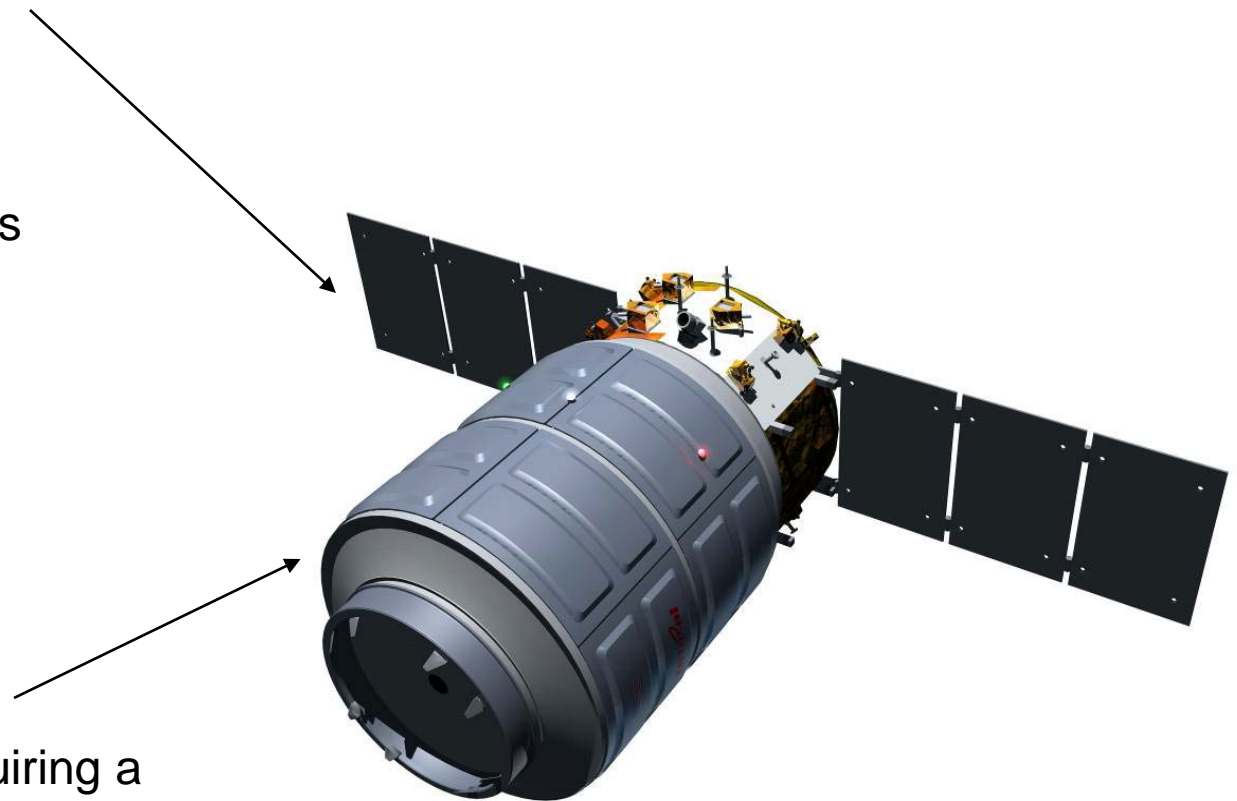
Manages the autonomous rendezvous to the ISS

Provides required resources to allow the mission to be successfully completed

Structural interface to the launch vehicle and cargo modules

- Pressurized Cargo Module

Supports NASA Cargo Requiring a Pressurized Environment



- By replacing the Pressurized Cargo Module with a multiple Degree Of Freedom (multi-DOF) arm, and a system to provide fixation to the target spacecraft, a Cygnus satellite servicing capability can be realized
 - This vehicle could replace spacecraft Orbital Replacement Units (ORUs) in a manner similar to that accomplished with the Orbital Express system
 - It could also add propulsion modules, a solid-fuel motor, electric propulsion modules, or other technologies for eventual controlled deorbit of a spacecraft at the end of its operational life
- Grappling would be accomplished with the multi-DOF arm derived from the DARPA FRENDA program or the NASA/DARPA Robonaut program



Satellite Refueling



- The robotic satellite servicing vehicle could also be expanded to become a Refueling Space Tug (RST)
 - By adding multi-DOF arms and a refueling adaptor to Cygnus, a Cygnus RST could be created to add maneuvering lifetime to older but operational vehicles
- Cygnus RST could rendezvous with a target, grapple it, and refuel it
- Cygnus RST could perform maneuvers to deorbit or reboost a target spacecraft to a safe orbit

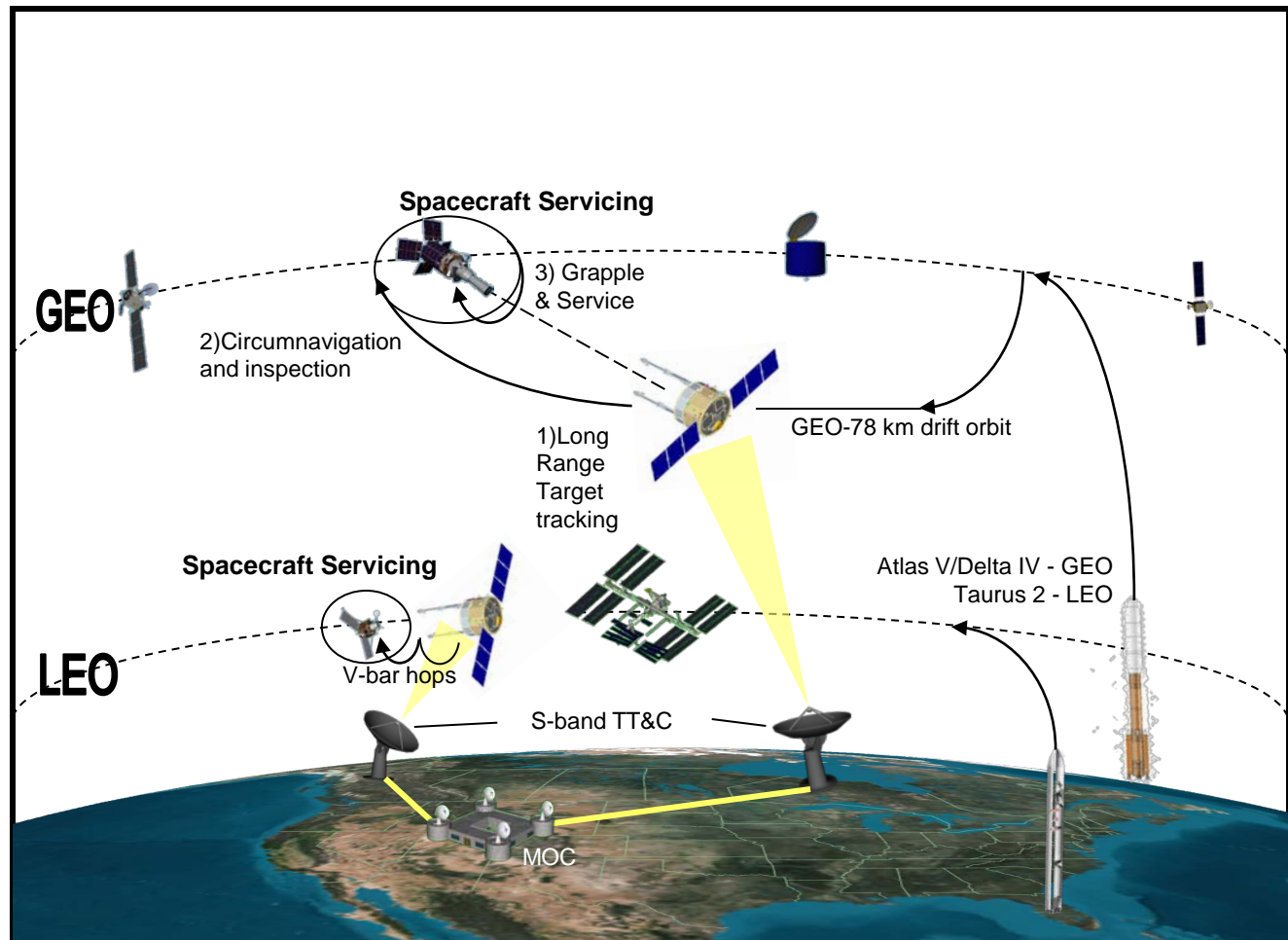


Satellite Servicing Con Ops



- Service Vehicle servicing LEO would be launched on a medium class launch vehicle, such as Taurus II

- Service Vehicle servicing GEO would be launched on a intermediate or larger launch vehicle, such as an Atlas V or Delta IV



Cygnus utilization for mission risk reduction

- The Cygnus with nominal avionics suite is multiply redundant and human-spaceflight compatible.
- The Cygnus Service Module has an large, modular payload capability to support a variety of servicing needs and has a large fuel capacity to support multiple approaches to the target spacecraft.
- Cygnus is currently being manufactured in a recurring manner that has programmatic support independent of satellite servicing.
- Cygnus RPO operations will be flight proven in the next two years

Programmatic response for this servicing concept could be very fast.

- The Cygnus and its Taurus II launcher are already under development, with an initial launch targeted for March, 2011.
- The DARPA FRENED robotic technologies have been demonstrated. Alternatives, such as Robonaut, have been utilized extensively in lab testing and in a planetary support role (Centaur) during field exercises.

Thank you for your attention!

