O.R.I.O.N.

Orbital Reuse through Innovative Operations Network

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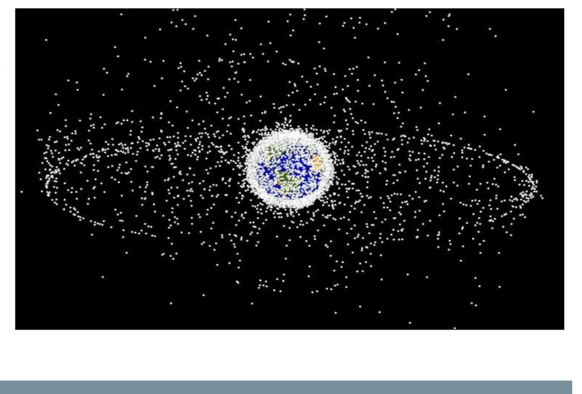
Mission Purpose

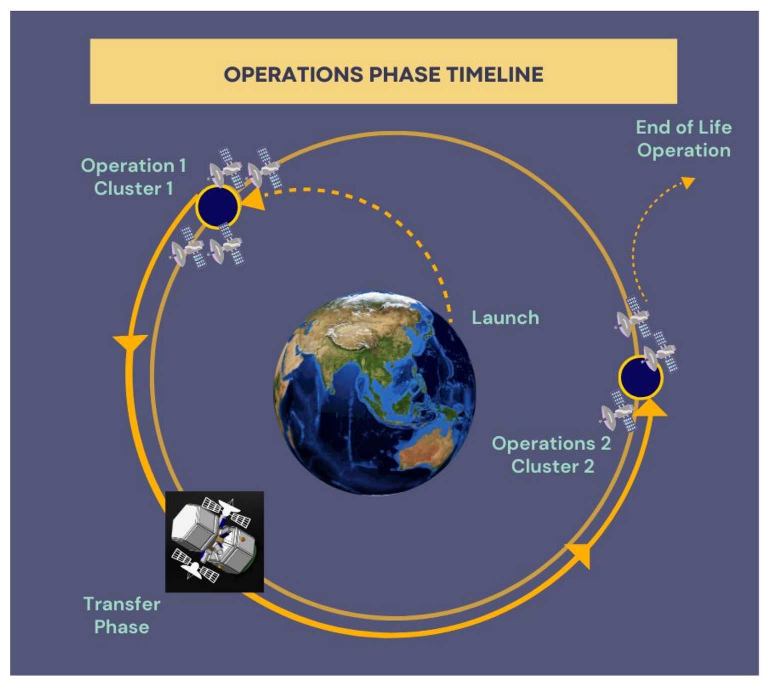
O.R.I.O.N aims to extend the operational lifespan of high-value GEO satellites while mitigating orbital debris. By deploying a modular in-space servicing and depot architecture, the mission enables autonomous repairs, in-orbit refueling, and debris tracking — all while reducing the need for costly replacements.

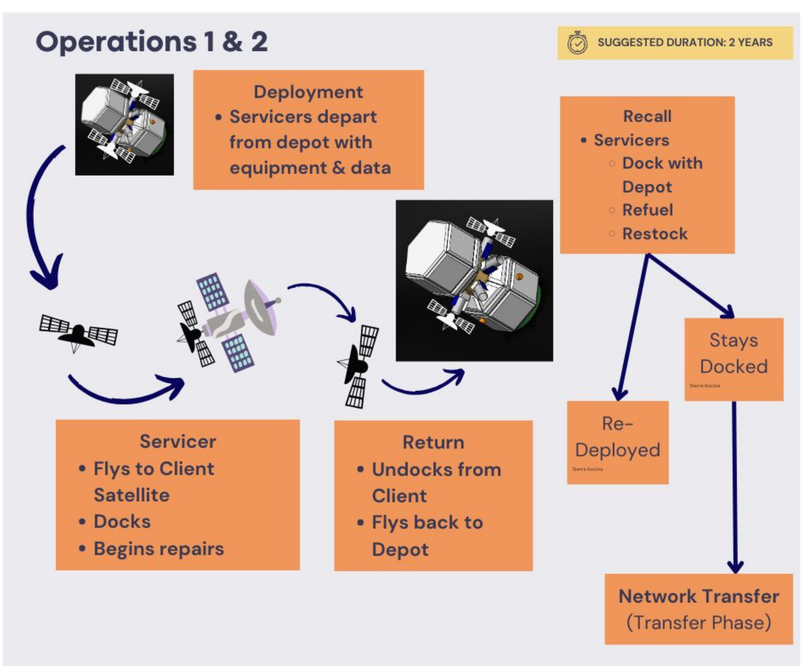


Mission Objectives:

- Perform solar panel upgrades and maintenance for operational GEO satellites
- Execute autonomous robotic servicing using ESPA-class satellites
- Enable on-orbit refueling and extend satellite life by up to 5 years
- Identify and track debris
- Relocate decommissioned satellites to graveyard orbits

Mission Timeline





Payload

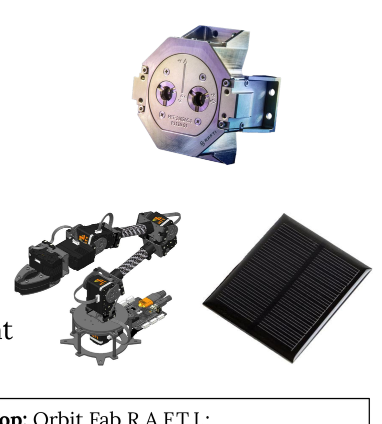
Docking Components:

Requirements:

- Resupply Servicer Satellites with consumables
  - Fuel (270kg)
  - Solar Cells (360 kg)

Solutions:

- Refueling
  - Orbit Fab R.A.F.T.I
- Solar Cell Replacement
  - ASTELAR robotic arm



Top: Orbit Fab R.A.F.T.I.; **Bottom Left:** ASTELAR robotic arm; **Bottom Right:** Replacement Solar Cell;

Debris Tracking Components:

Requirements:

- Wide Area Search: Visual/Thermal Sensors
- Orbital Data Acquisition: LiDAR

Component	Frequency	FOV	Resolution
Leonardo A-STR	10 Hz	16.4° x 16.4°	8.25 arcsec / 11.1 arcsec
Cosine HyperScout 2	N/A	31° x 16°	VNIR:16 nm; TIR: 1100 nm
LS MS06	1 Hz	40° x 120°	0.24° x 0.05°

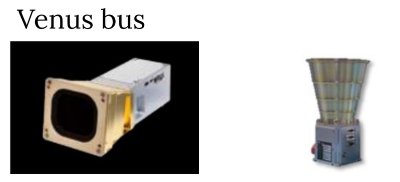
Guidance, Navigation, and Control

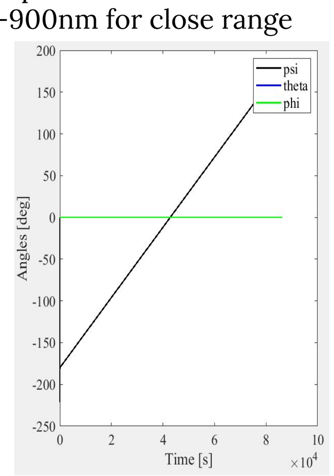
Servicer Requirements:

- Detect and track vehicles from 50 km
- Repair/upgrade 2-3 satellite solar panels
- Maintain a spectral range of 400-900nm for close range inspection

Servicer Solutions:

- 1 Mid Extension Neo Star Tracker (Left)
- Rendezvous and Docking Sensors (LiDAR)
- 6 ASTRO head cameras (Right) embedded within the X-Sat Venus bus





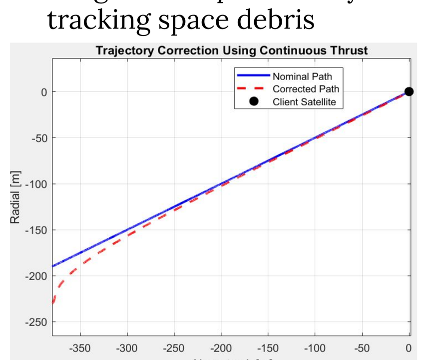
To determine the necessary orientation adjustments for the Servicer as it travels to each client satellite, the plot above models its change in Euler angles, $\phi\psi\theta$. This example will depict Servicer 1 traveling from the Depot to Client 1 and 2, at 97 and 92 degrees respectively.

Depot Requirements:

- Rendezvous with servicers, approach using close-proximity strategies, and docking
- Attitude and control systems for stabilization and orientation correction for docking
- Space Debris Tracking

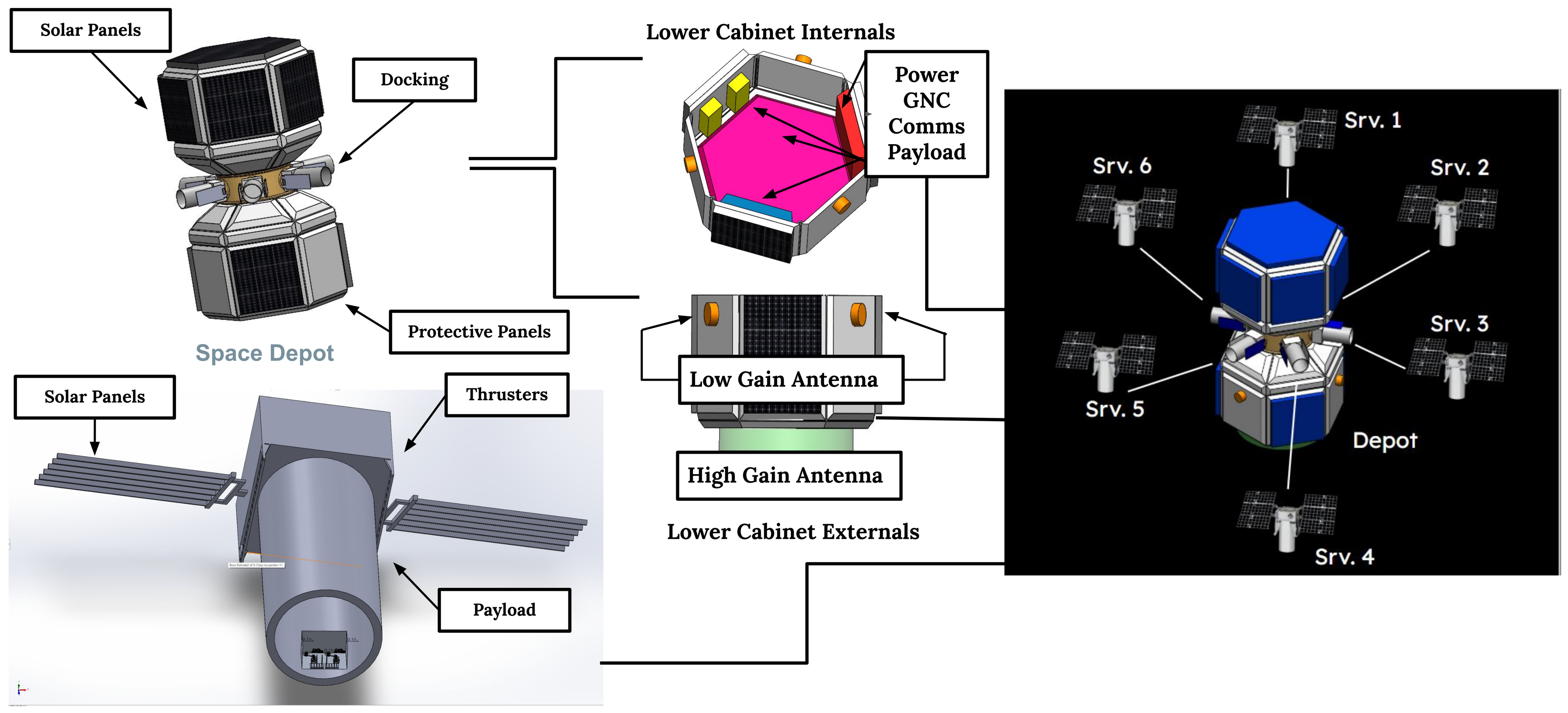
Depot Solutions:

- Sufficient star trackers, gyroscopes, and sun sensors for orientation
- Reaction wheels and RCS thrusters for guidance and attitude adjustments
- Usage of complementary sensors for detecting and tracking space debris



This graph shows the servicer using continuous thrust to approach the client satellite with an initial position and velocity error.

Depot and Servicer Configuration



Servicer: X-Sat Venus Class (BlueCanyon Tech)

Depot Trajectory

Requirements:

- Insert into 35,786 km circular GEO (≤0.1° inclination, ≤0.01 eccentricity).
- Phase 35° ahead of target within mission-defined timeline.
- Less than 3 km/s total ΔV for mission operations.
- Reach final position within ±0.1° longitude of target point.
- Tolerate launch errors (Δa ±10 km, Δe ±0.005, Δi ±0.1°); maintain comms & eclipse limits.

Analysis:

- Trajectory analysis was performed using MATLAB to model GEO insertion a 2° inclination change and a 35° phasing maneuver.
- Candidate trajectories were evaluated based on ΔV, transfer time, and fuel constraints to meet mission demands.
- The final profile balanced efficiency and mission goals, with body-fixed frames generated from cartesian state vectors.

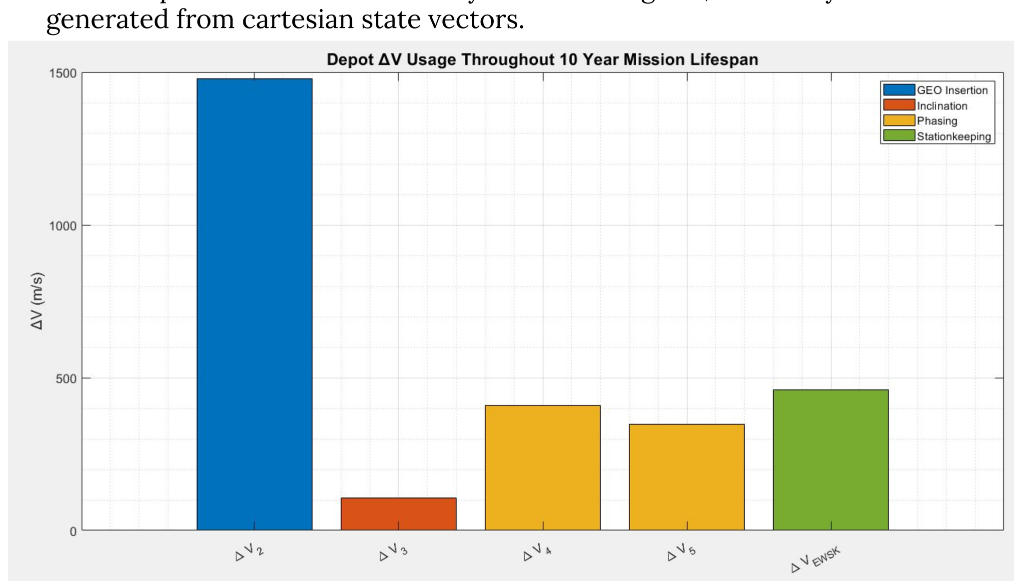


Fig 1. Depot ΔV Required

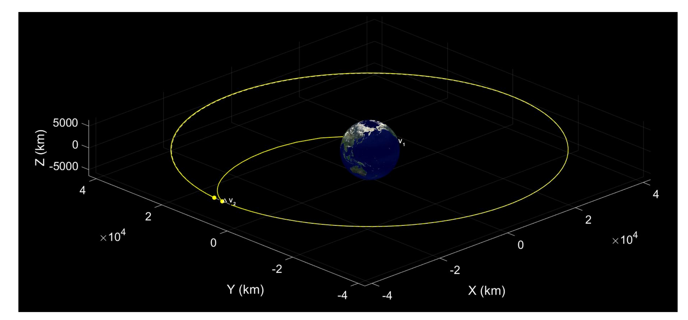


Fig 2. Hohmann Transfer Trajectory - ΔV Required: 1478.03 m/s

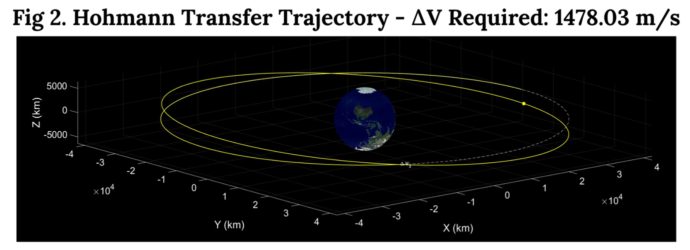


Fig 3. Plane Adjustment Trajectory - ΔV Required: 107.33 m/s

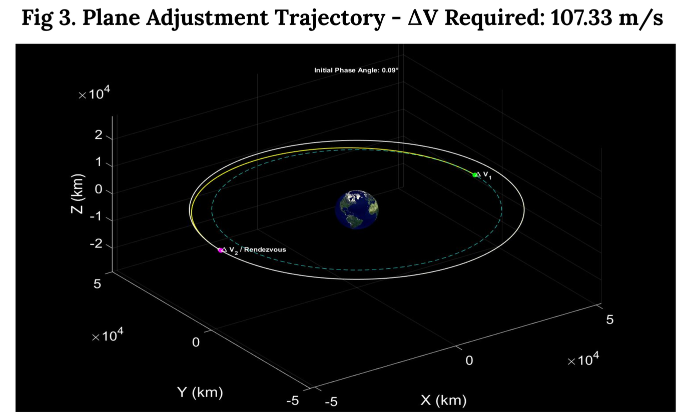


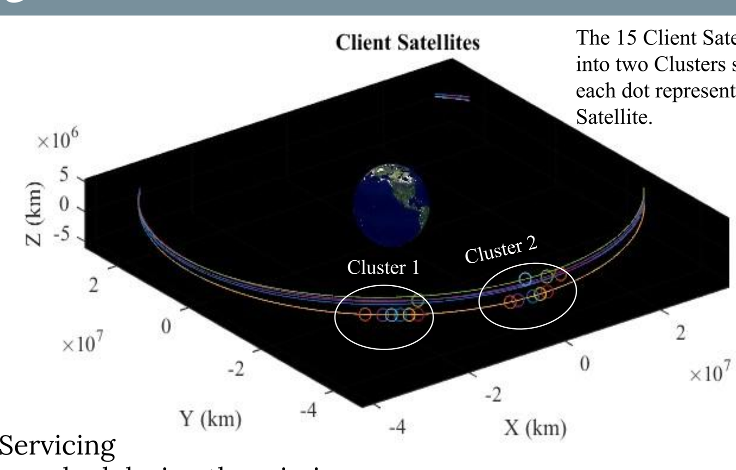
Fig 4. Phase Shift Trajectory - ΔV Required: 756.40 m/s

Servicer Trajectories

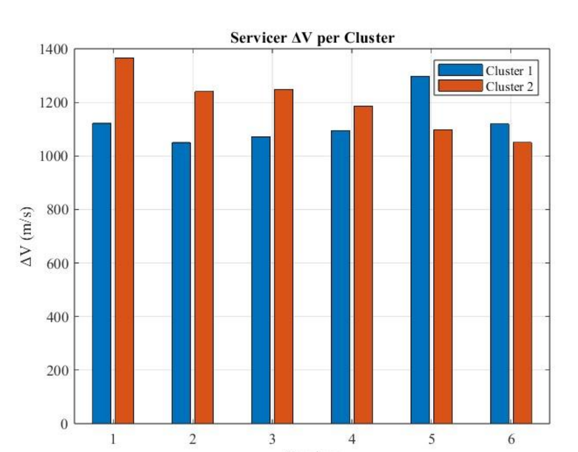
Objectives: Rendezvous with all 15 Intelsat Galaxy Satellites
Requirements: Use less than 7000 m/s before refueling:
In each cluster, a servicer must travel to and from

- 1 Inclined Satellite or 2 not Inclined Satellites

Upon arrival, each Servicer must have enough fuel to perform docking & rendezvous maneuvers
Each Servicer is refueled in between Clusters



The 15 Client Satellites fall into two Clusters seen above, each dot representing a Client Satellite.



Servicers must perform:

- Hohmann Transfer
- Inclination change
- Phasing Change

Each Servicer was assigned a Servicing Route to ensure all clients are reached during the mission.
Analysis was performed using MATLAB determining all transfers are under 1,400 m/s, meeting our requirements

Servicer	1	2	3	4	5	6
Cluster 1	1.218	1.0499	1.071	1.0934	1.2976	1.1194
Cluster 2	1.3663	1.2403	1.2471	1.1863	1.0984	1.0502

Structures and Thermal

Requirements (Structures):

- F.S. > 2.25
- Load Factor ~ 6g
- Primary Lateral Mode > 10Hz
- Primary Axial Mode > 25Hz

Solution:

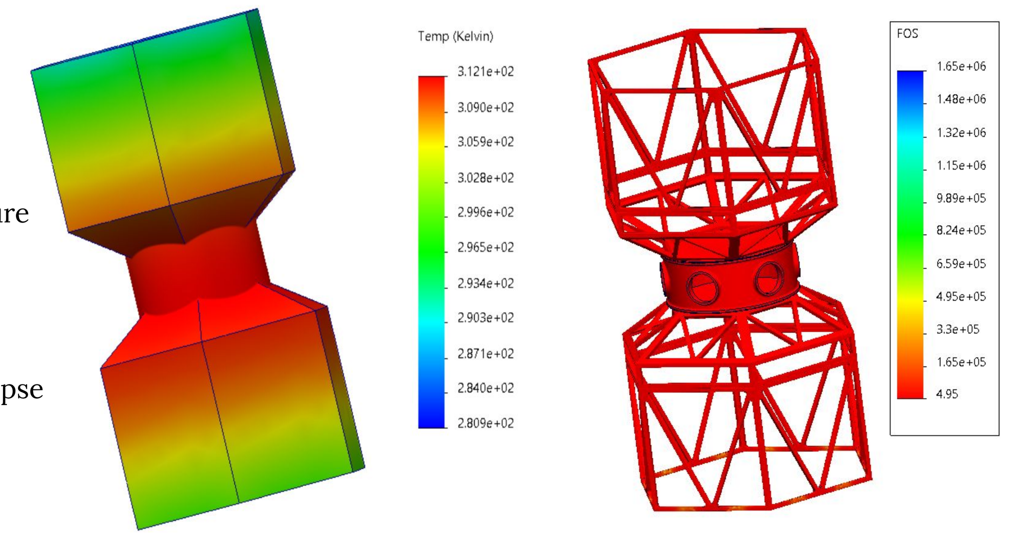
- Aluminum Frame Load Bearing Structure
- CF-Al Honeycomb Sandwich panels

Requirements (Thermals):

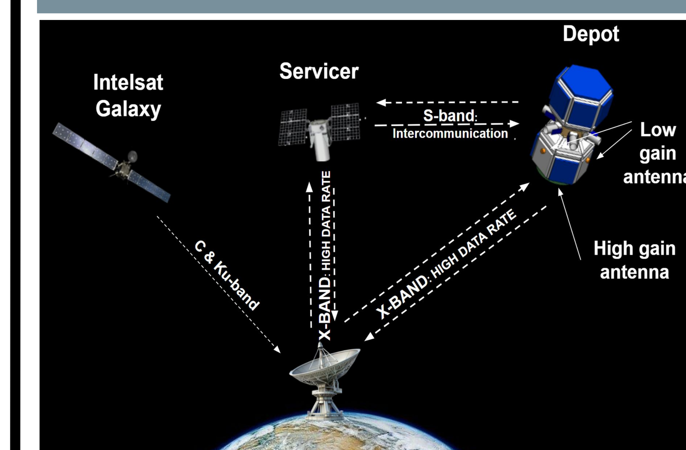
- Avg. Temp. ~ 300K
- Temperature Gradient ~ 0-30K
- Maintain Temp through 72 min Eclipse

Solution:

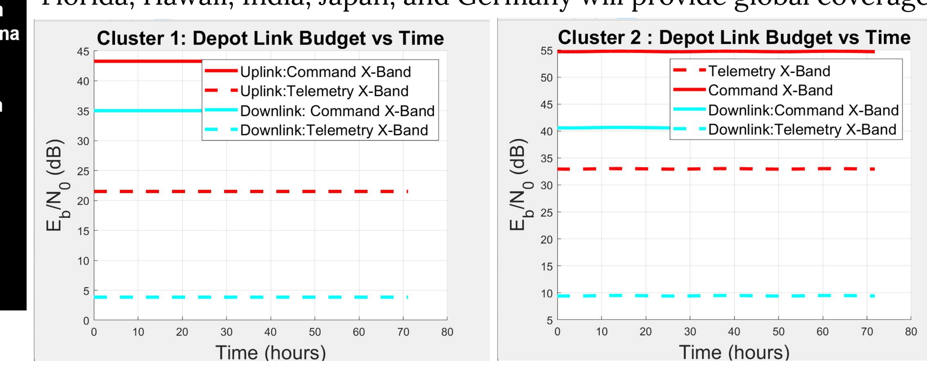
- Passive Thermal Control
- Chemglaze A276 White Paint



Communications

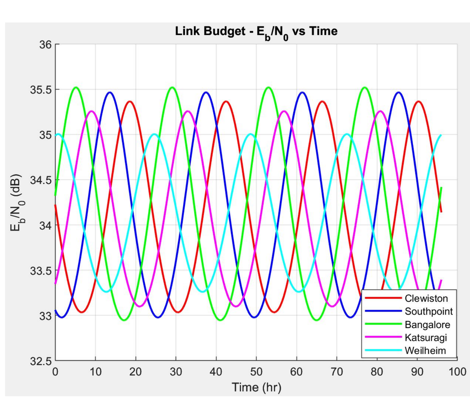


Requirements: To support real-time operations for bidirectional relay, with data rates on the high end totaling 21 Mbps.
Solution: A network of five ground stations, operated by SSC—located in Florida, Hawaii, India, Japan, and Germany will provide global coverage.

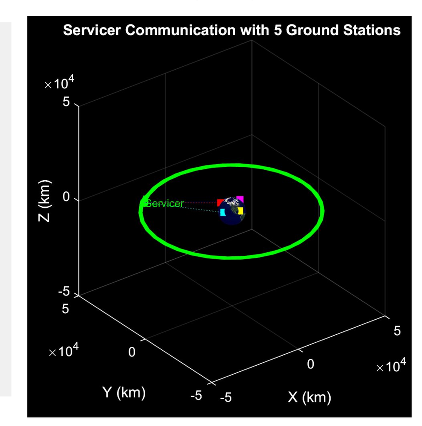


The Depot is also equipped with a 0.031 m² high-gain phased array antenna- Earth pointing and a 0.0019 m² low-gain patch antenna.

Subsection	Data Rate Required
GNC w/ Supporting systems in Payload	0.5-2.5 Mbps
Real-time Video Transmissions	1-8 Mbps
Real-time Communication	6-10 Mbps
Debris Tracking **after** Compression	10-50 Mbps



Servicer to Grounds in X-Band



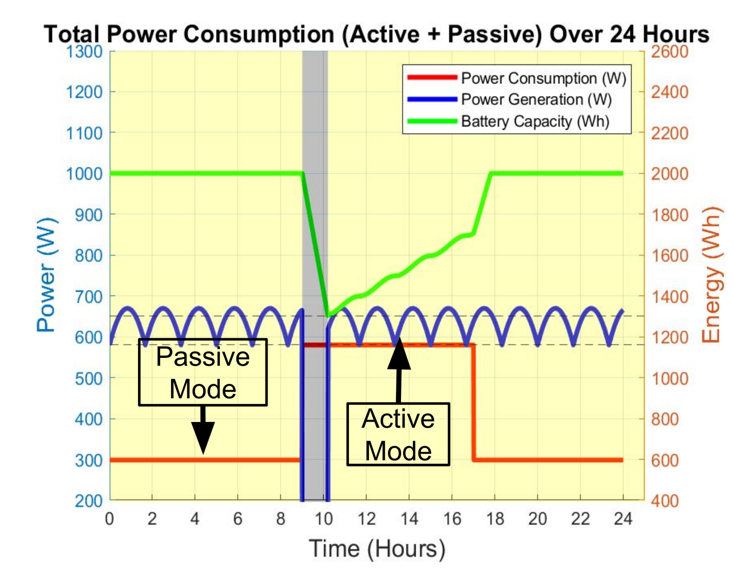
Power

Requirements:

- Generate enough power to support Depot system demands
  - 2 Operating Modes
    - Passive: Space Debris Tracking Operations (298.4 W)
      - GNC, Payload, Communications, Propulsion
    - Active: Docking + Space Debris Tracking Operations (580 W)
- Surplus to recharge depleted batteries even under max load
- Store enough power to conduct docking operations during eclipses

Solutions:

- Generation:
  - 6 x 1.85 m^2 GaAs solar panels
    - 3 Secondary panels
- Storage:
  - 2 x 1,000 Wh Li-Ion batteries



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