

SPACE DRONE™ Adaptable Servicing Spacecraft

ESA Clean Space Industrial Days 2018

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Effective Space Solutions

Pioneering last-mile logistics in space

- Space is the last untapped commercial frontier - we are building last-mile logistics services in space that will power this new economy
- Fleet of SPACE DRONE™ spacecraft to position, maintain, monitor and guarantee space assets
 - GEO & LEO Satellite Servicing
 - Active Debris Removal (ADR)
 - Logistic support of space exploration

Phase one deployment: Extending the life of GEO satellites in orbit

- SPACE DRONE™ spacecraft acts as an external 'jet-pack' to the host satellite
- Two SPACE DRONE™ spacecraft servings two host satellites starting 2020.

Current Servicing Market

- On Orbit Services is a rising potential market in GEO and in LEO orbits
- Baseline technologies are similar for Post Mission Disposal (PMD) and Active Debris Removal (ADR) missions
- Missions include
 - Life extension
 - Inspection and repair
 - Refueling and transport
 - Satellite Servicing Vehicle (SSV) Concept within ESA's Clean Space Initiative

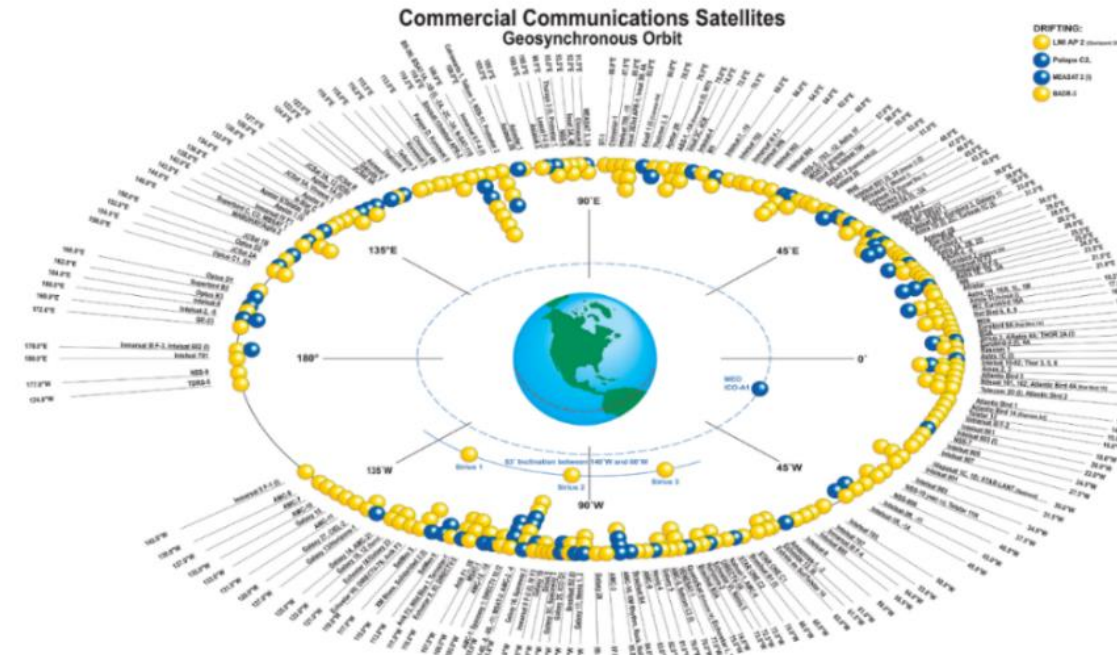
Servicing & ADR in GEO

GEO Total available market

- >400 commercial communication satellites
- >50 NATO-friendly governmental satellites
- ~15 years of service (each, by design)
- ~25 decommissioned annually due to 'end-of-fuel', otherwise operational

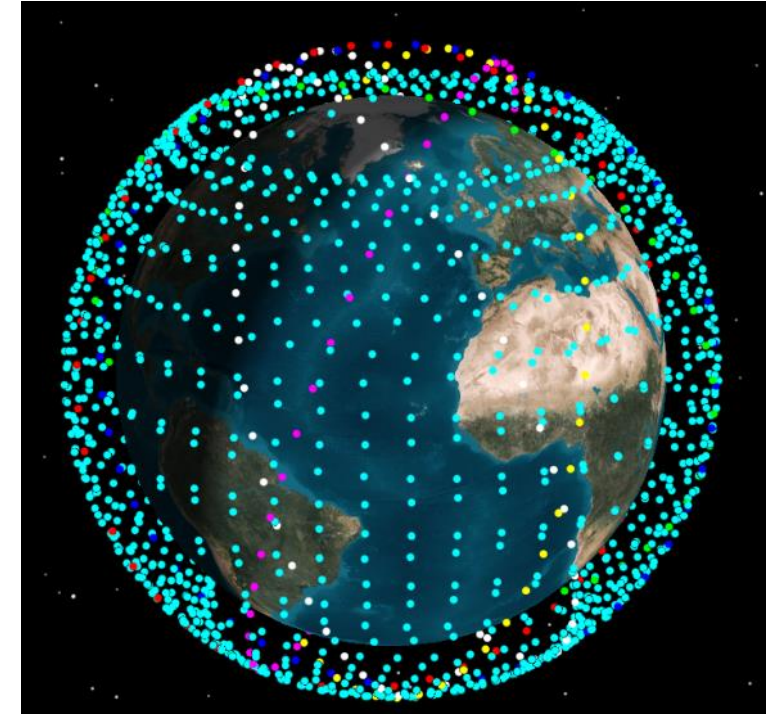
GEO debris

- ~ 4 malfunctioned satellites drifting a year
- 735 satellites drifting near GEO (as of 2017)



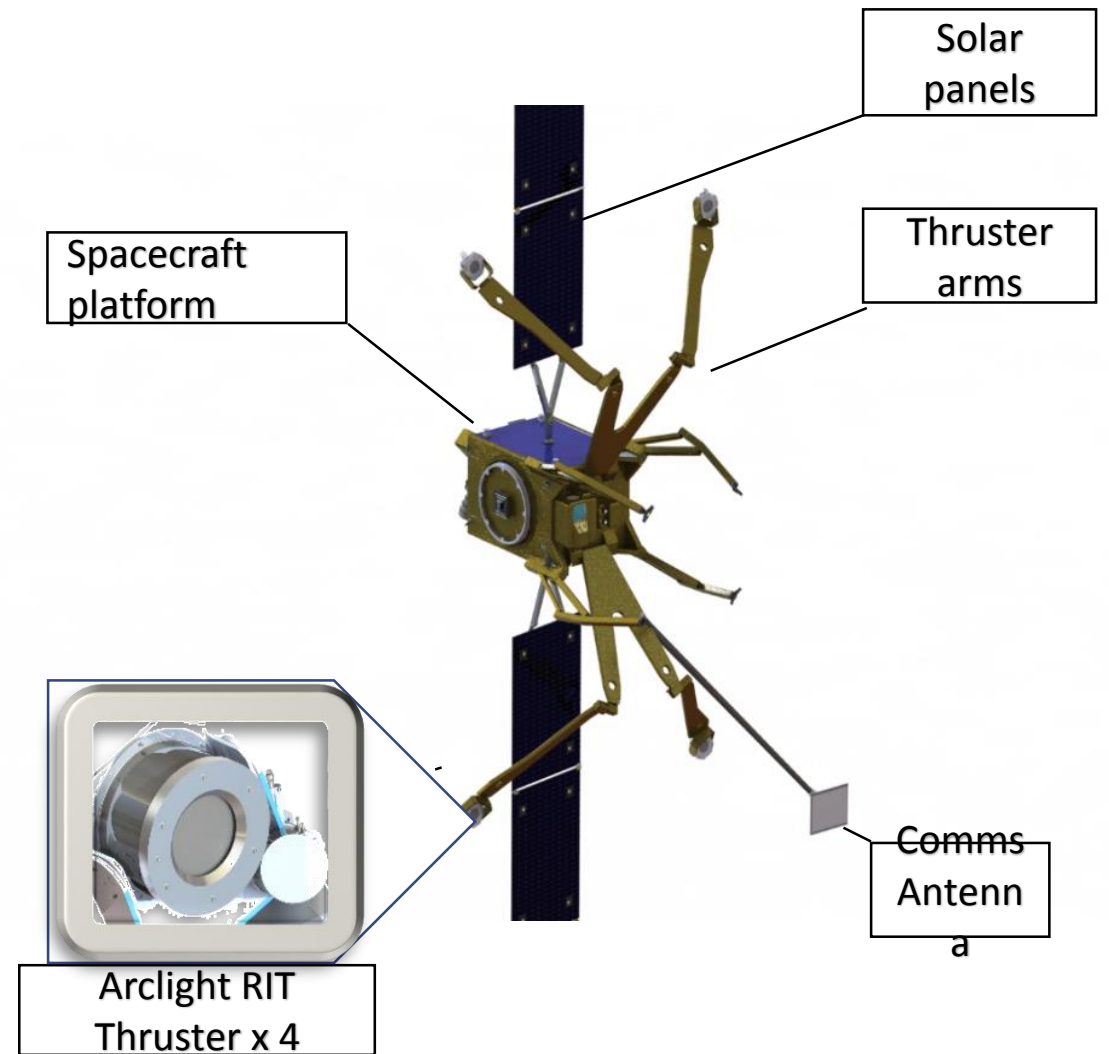
LEO Mega Constellations & ADR

- Rise in mega constellations: OneWeb, Telesat, SpaceX, LeoSat ...
- On orbit servicing and post mission disposal strategy is essential
 - High reliability success rate (99%-95%) is required in the Post Mission Disposal (NASA/ESA)
- Services can include
 - Post Mission Disposal (PMD), especially for single-thread designs
 - Transfer to and from parking orbits
- Multiple missions required by each constellation



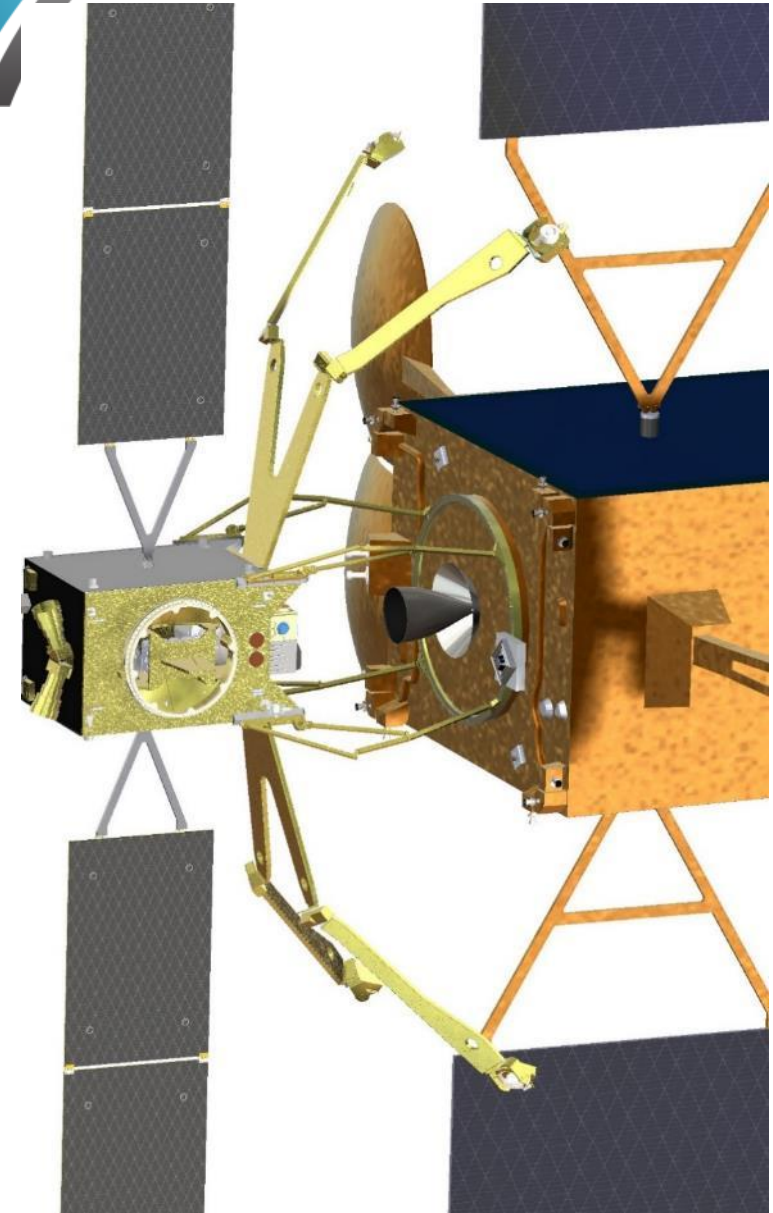
SPACE DRONE™ SPACECRAFT

- Small spacecraft design
- Launch Mass - 400kg
- In-Orbit Service Life - 15 years
- Ride share using Grand ESPA ring
- Host adapter ring compatibility 937/1194/1666mm diameter
- Host satellites ranging from 1500kg - 4000kg



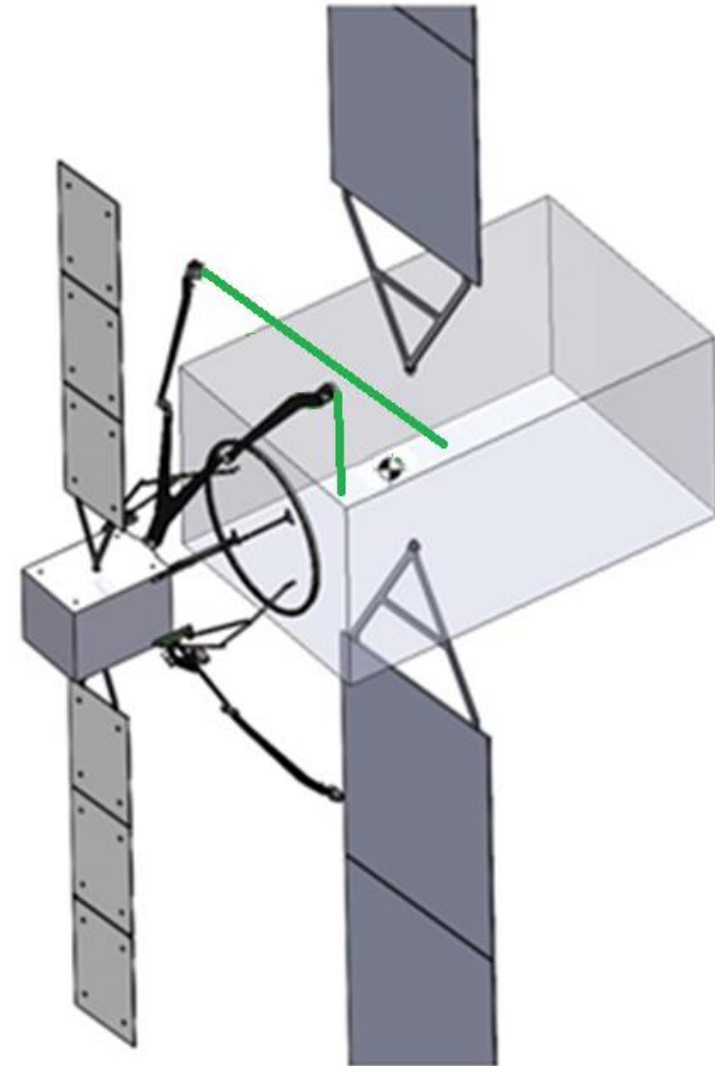
SPACE DRONE™ Spacecraft Missions

- All Electric Orbit Raising
- Multiple Rendezvous & Docking
- Tandem Operations
 - ✓ Station Keeping
 - ✓ Attitude Control
 - ✓ Relocation & deorbiting
 - ✓ Orbit and inclination correction
 - ✓ Bringing into use (BIU)

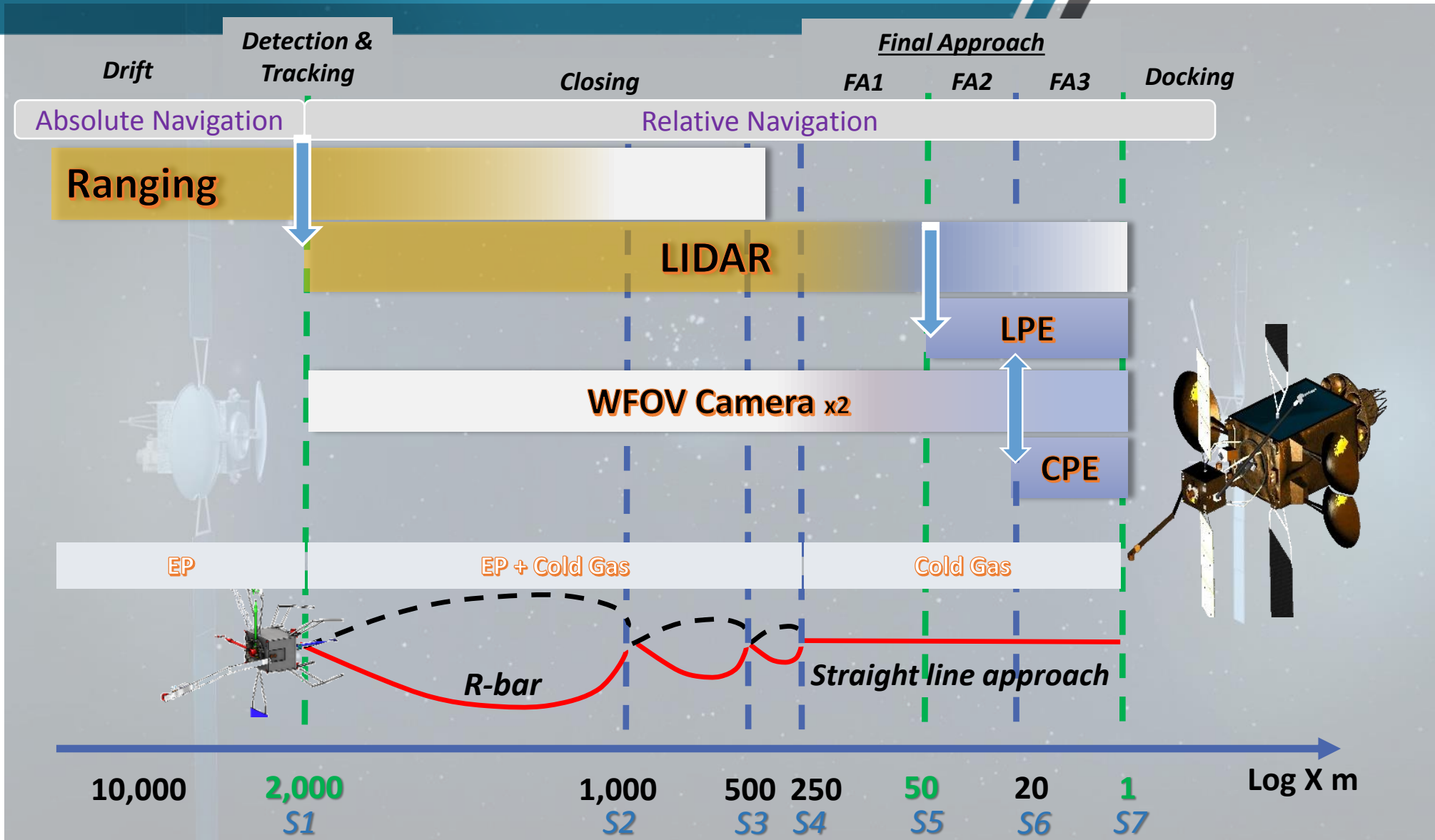


Tailoring the Design

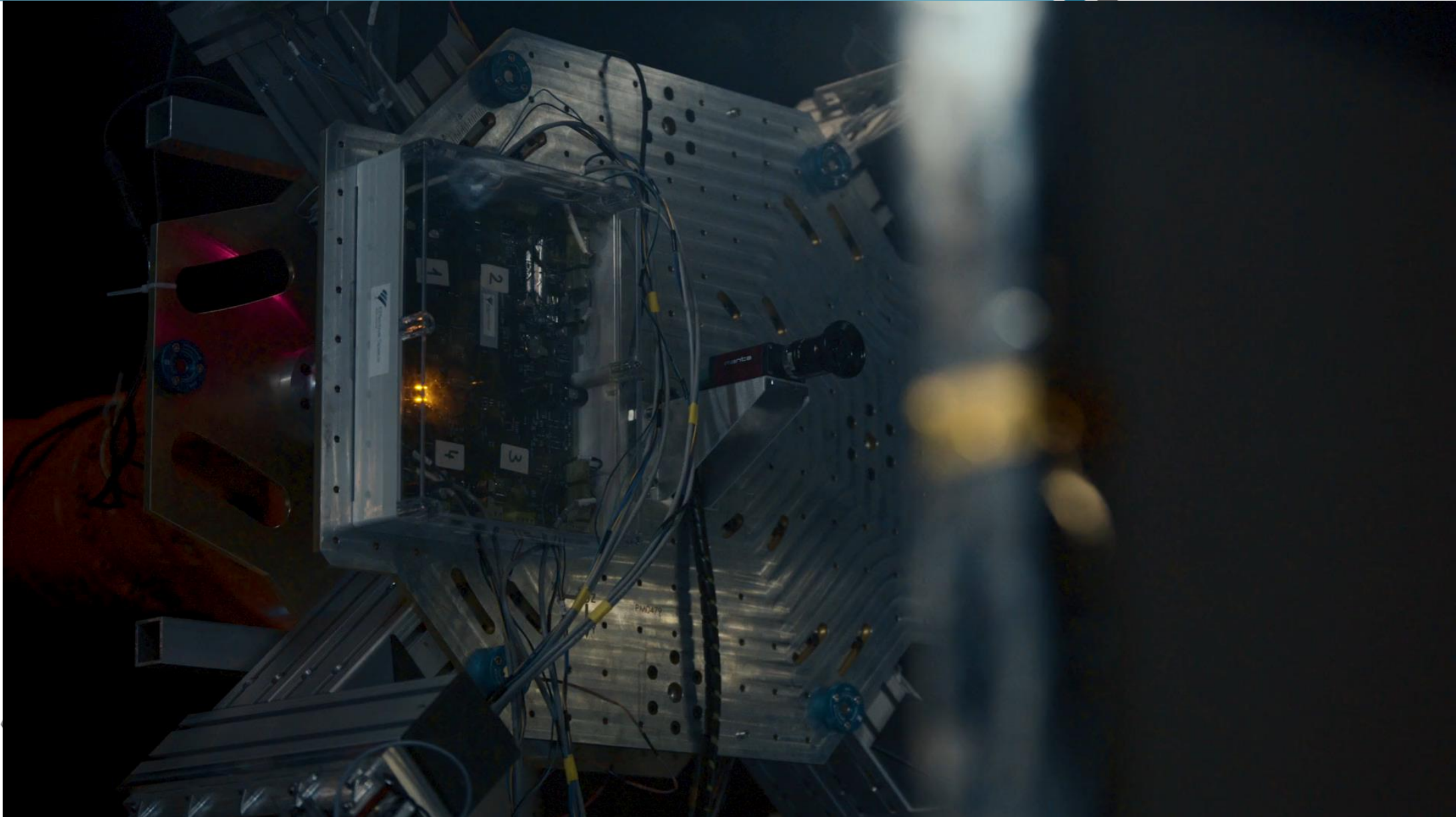
- Proprietary method for attitude control and station keeping of the joint stack (patent pending)
- 4 plasma thrusters on 4 thruster steering arms
- Redundancy – all mission objectives can be met with failure of one thruster, one thruster arm or one Thruster Control Unit
- Optimizing Satellite and Algorithm design while considering shadowing and momentum management constraints



Rendezvous and Docking (RvD) Approach

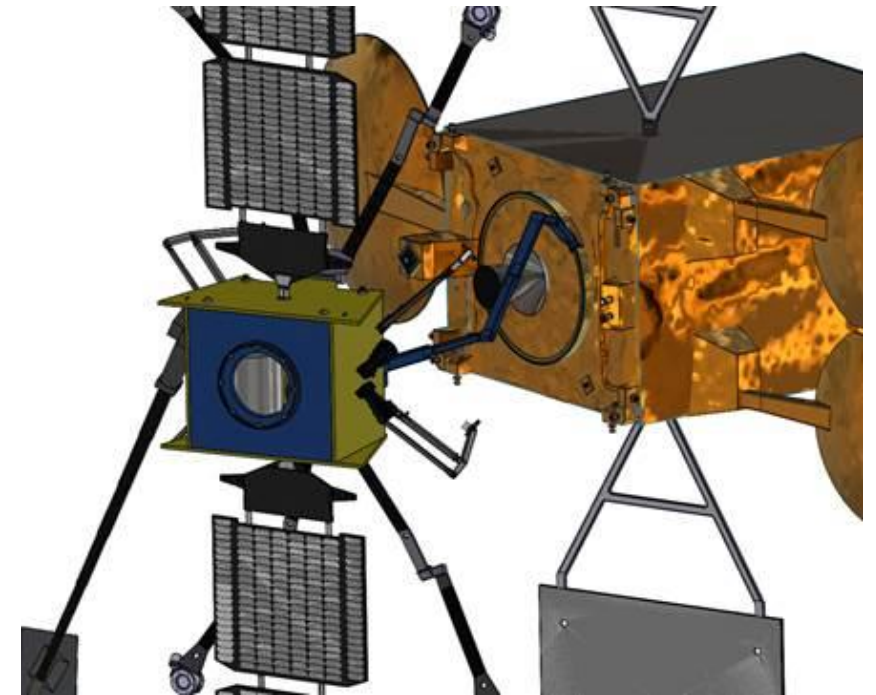


Test Campaign Proof of Concept



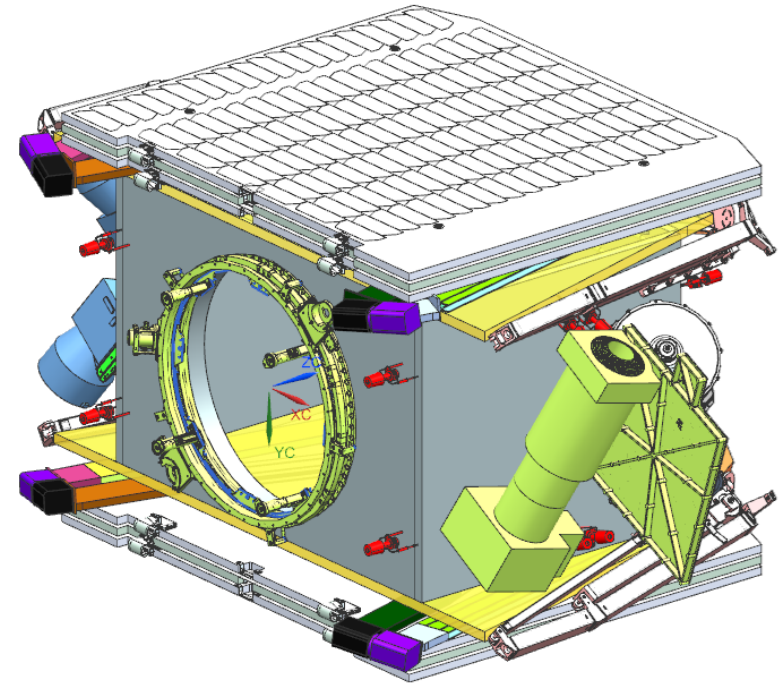
Adapting the Space Drone™ Spacecraft

- SPACE DRONE™ spacecraft concept, can be modified for ADR
- Maintaining a large recurrent part of the system and operations
- First two SPACE DRONE™ spacecraft will provide in-orbit validation opportunities for major elements of the ADR design
- Operations & ground segment will gain heritage for Servicing and ADR



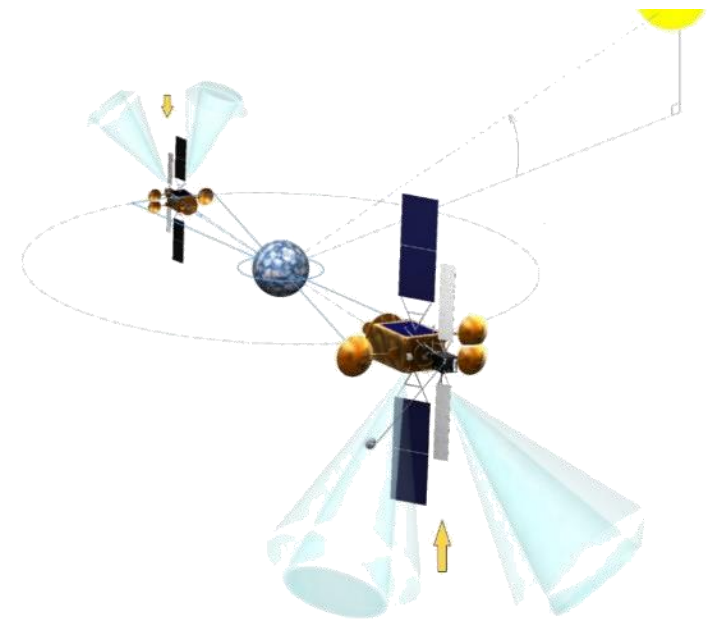
TEST CASE: SPACE DRONE™ Spacecraft in LEO

- Solution for mega-constellation deorbit management
 - Average mass of removed objects is 200kg
 - Orbital Transfer and disposal orbit using electric propulsion
 - RvD & Detumbling using chemical propulsion
 - Disposal orbit below 350 km
- The ADR mission calls for at least 10 ADR runs to be performed by a single drone
- Provides cost effective solution for large-scale deorbiting of constellation satellites



Summary

- SPACE DRONE™ spacecraft is a semi autonomous satellite, capable of multiple docking and servicing of GEO satellites
- SPACE DRONE™ spacecraft platform suited for LEO Active Debris Removal and Post Mission Disposal
- Provides cost effective solution for large-scale deorbiting of constellation satellites
- Heritage for technologies and service operations by 2020 with the first servicing SPACE DRONE™ spacecrafts.





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solutions

SPACE DRONE™ Adaptable Servicing Spacecraft

Thank you for listening!

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