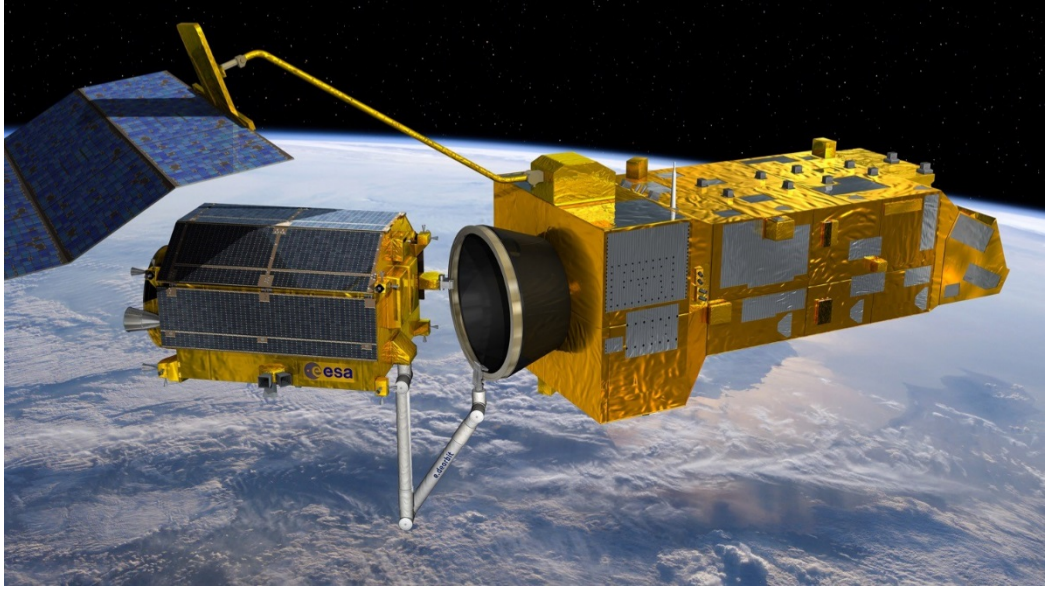
e.Deorbit and the Space Servicing Vehicle

Clean Space

23/10/2018

Active Debris Removal

e.deorbit



➔ MISSION GOAL

To remove an ESA-owned heavy debris from 800-1000 km (near polar region).

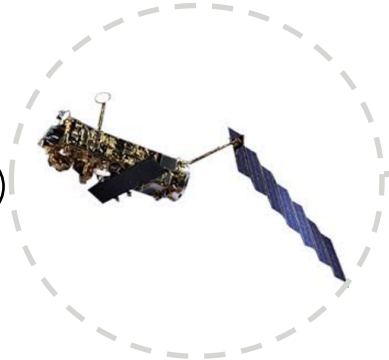
e.Deorbit Mission Scenario

JAN 2024
LAUNCH VEGA-C

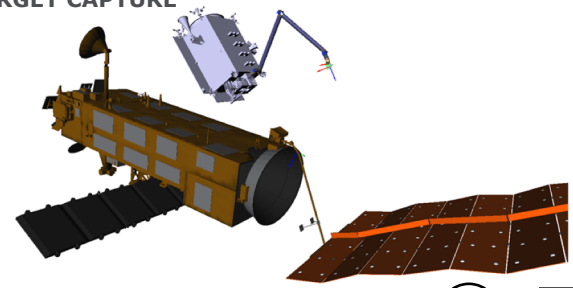
JAN 2024
COMMISSIONING AT 300 KM CIRCULAR ORBIT

JAN 2024
TRANSFER AND PHASING TO TARGET ORBIT

FEB 2024
RENDEZVOUS AND TARGET INSPECTION



MAR 2024
SYNCHRONISAION & TARGET CAPTURE



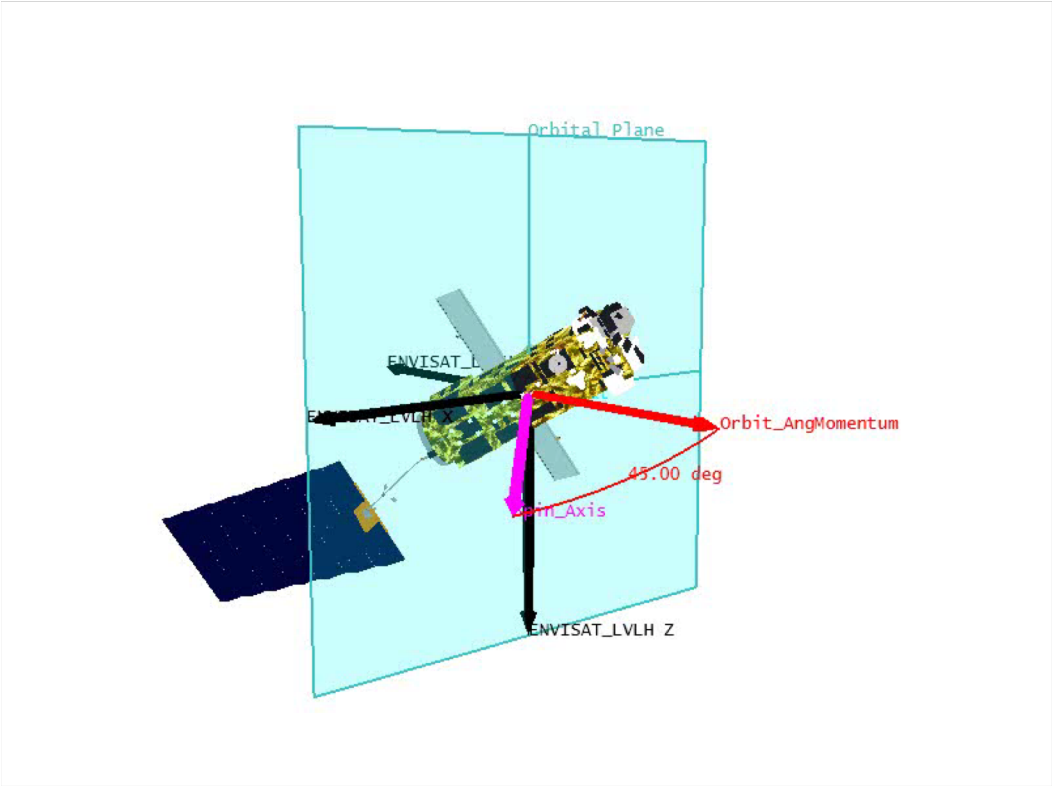
MAR 2024
STABILISATION

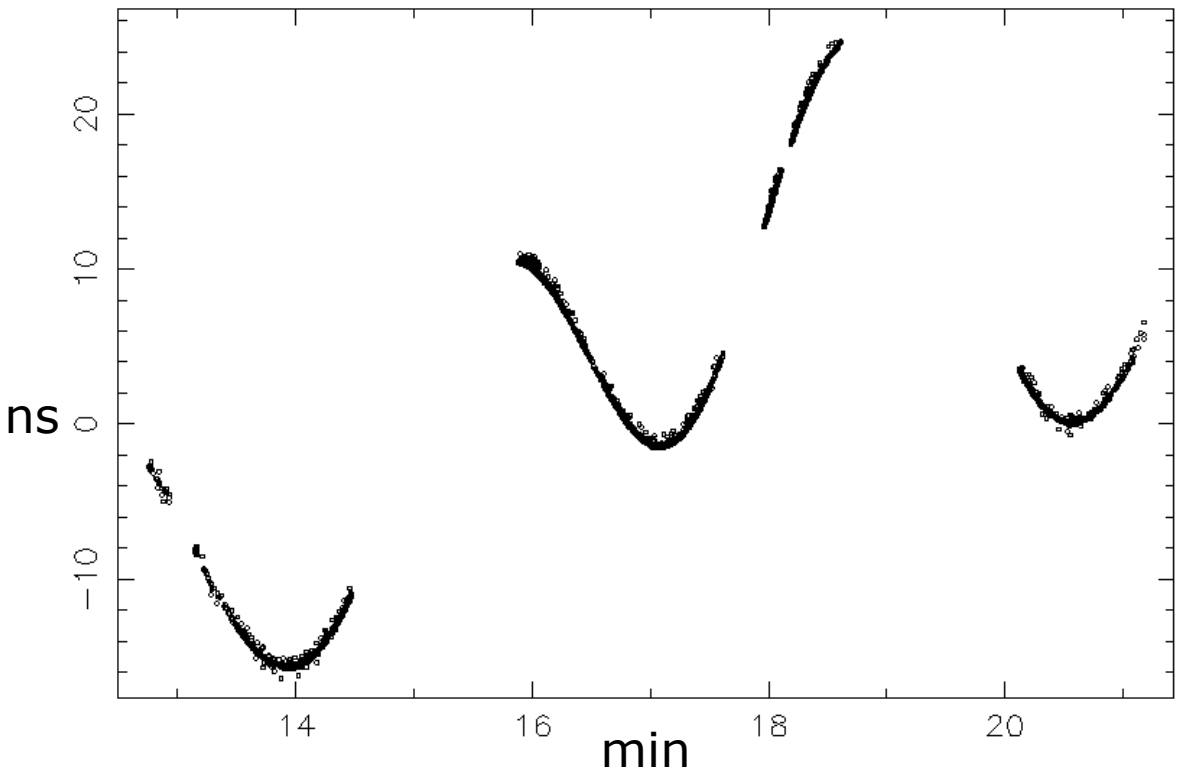
APR 2024
DISPOSAL

Mission Challenges

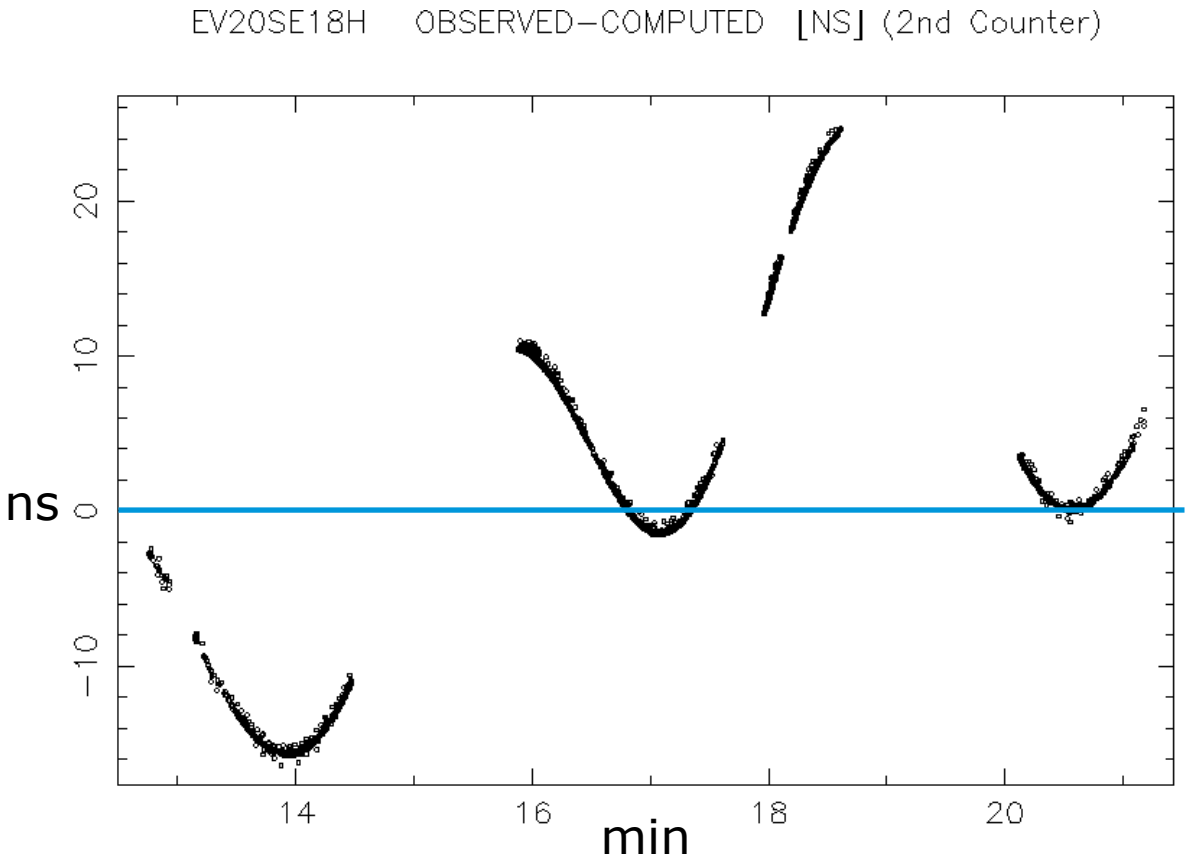
1. Synchronised Flight
2. Collaborative Control of Robotics/GNC
3. Uncooperative Capture
4. Safety (Comms vs. Autonomy)
5. Stack Control and Disposal

ENVISAT Attitude Update



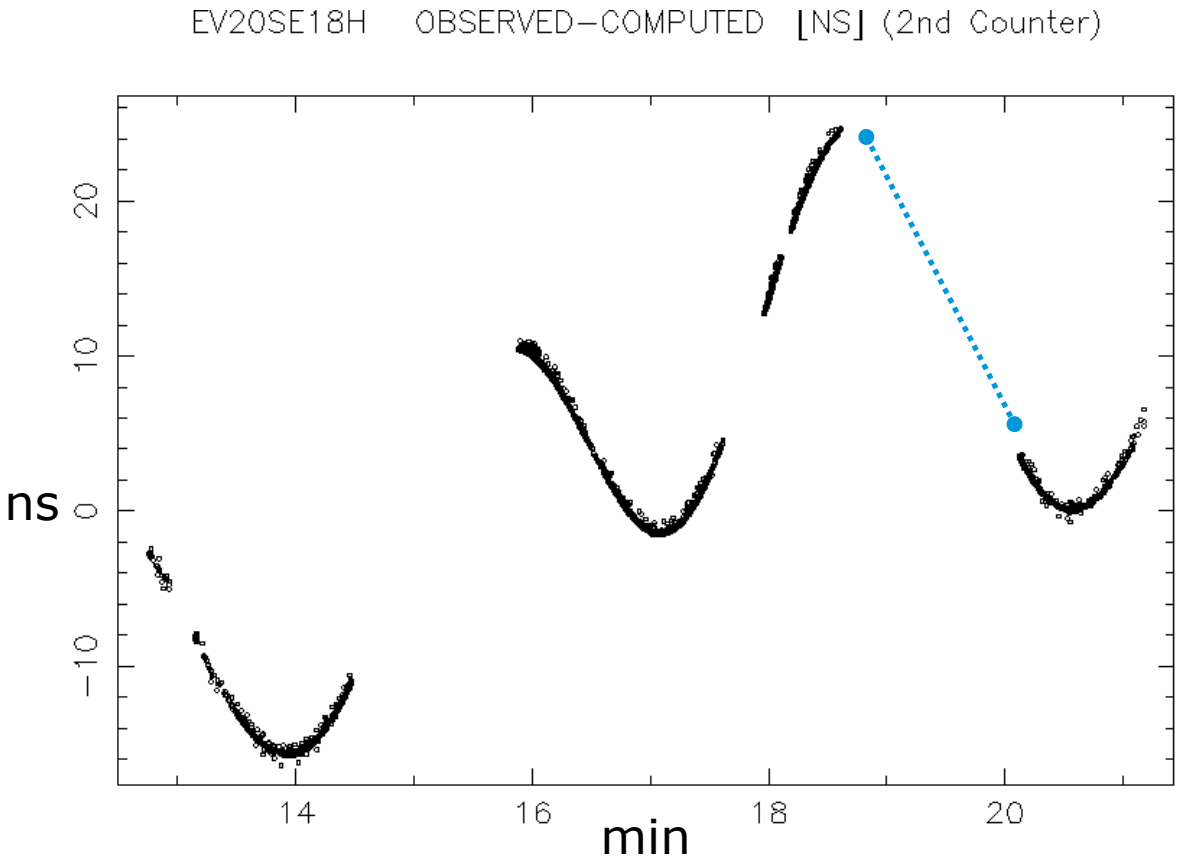


Credits: AIUB 20th of September



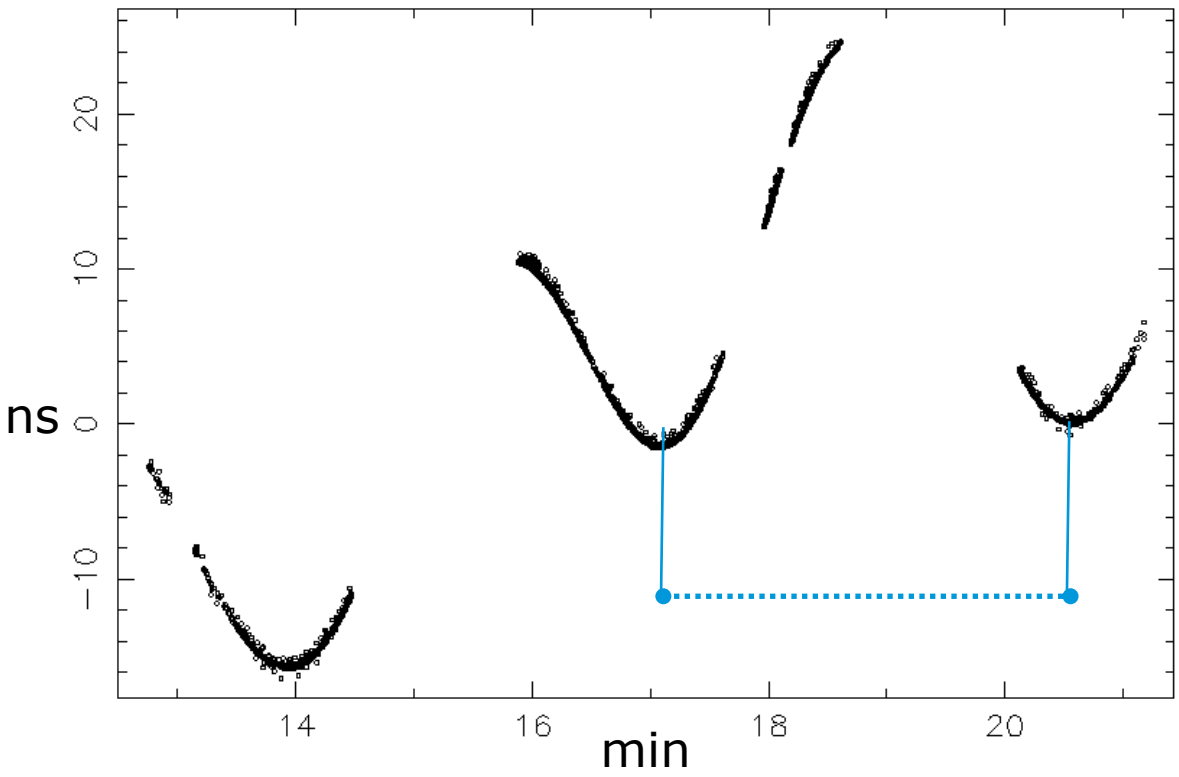
Expected Position

Credits: AIUB



Gaps in Observation ➔ Possibly due to tumbling motion

Credits: AIUB



Period of 190s

Credits: AIUB

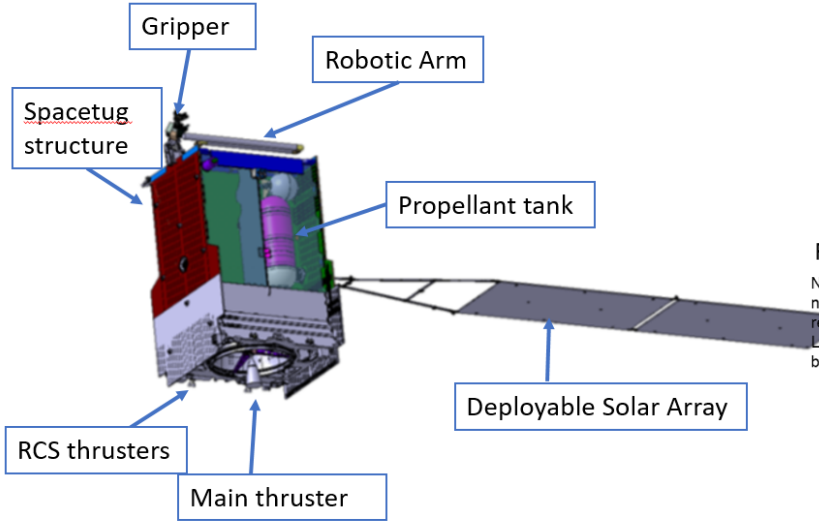
Active Debris Removal - e.Deorbit

	2014	2015	2016	2017	2018
e.Deorbit System	Phase 0	Phase A	Phase B1		Consolidation Phase
	Completed	Completed	Completed		On-Going

➔ e.Deorbit Consolidation Phase

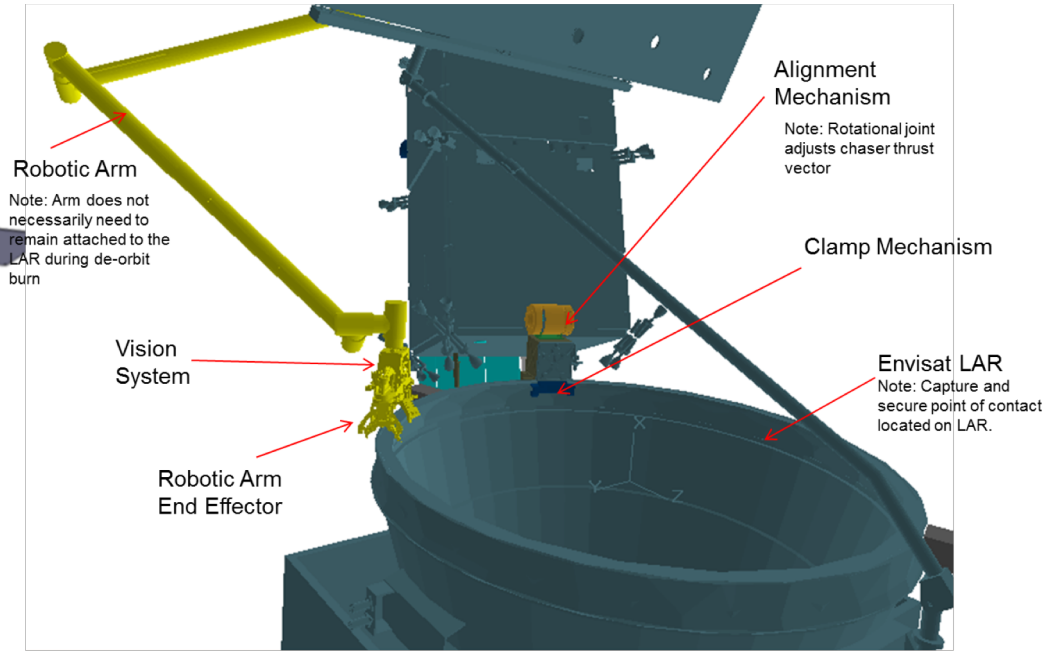
A bridge between Phase B1 and Phase B2, with the objective to study the synergies with e.Deorbit and the Space Servicing Vehicle / Space Tug

e.Deorbit Consolidation Phase

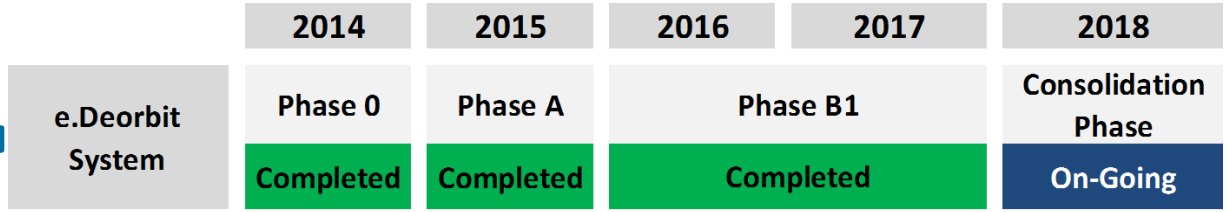


Total Wet Mass	2977 kg
Dry Mass	2025 kg
Propellant	952 kg

Capture system



Clean Space – Active Debris Removal and Servicing



2018 Space Servicing Vehicle CDF Study - Complete

2018 Request for Information

Space Servicing Vehicle – CDF Pre-Phase A

AIRBUS DEFENCE & SPACE

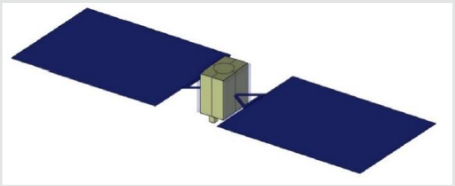
arianeGROUP

elv An Avio Group and ASI Company

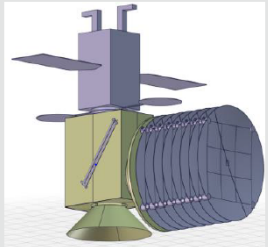
OHB

ThalesAlenia A Thales / Finmeccanica Company Space

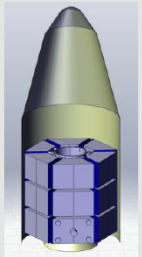
Mission Scenario 1
Deep Space Gateway Tug



Mission Scenario 2
Antenna Assembly
for GEO S/C



Mission Scenario 3
Megaconstellation
ADR



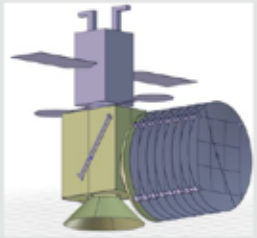
Space Servicing Vehicle – CDF Conclusions

Conclusions:

1. Synergies in Technologies
2. Different System Designs Required

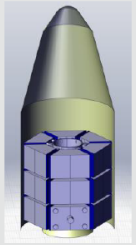
➔ Follow-On Activities

Mission Scenario 2
Antenna Assembly
for GEO S/C



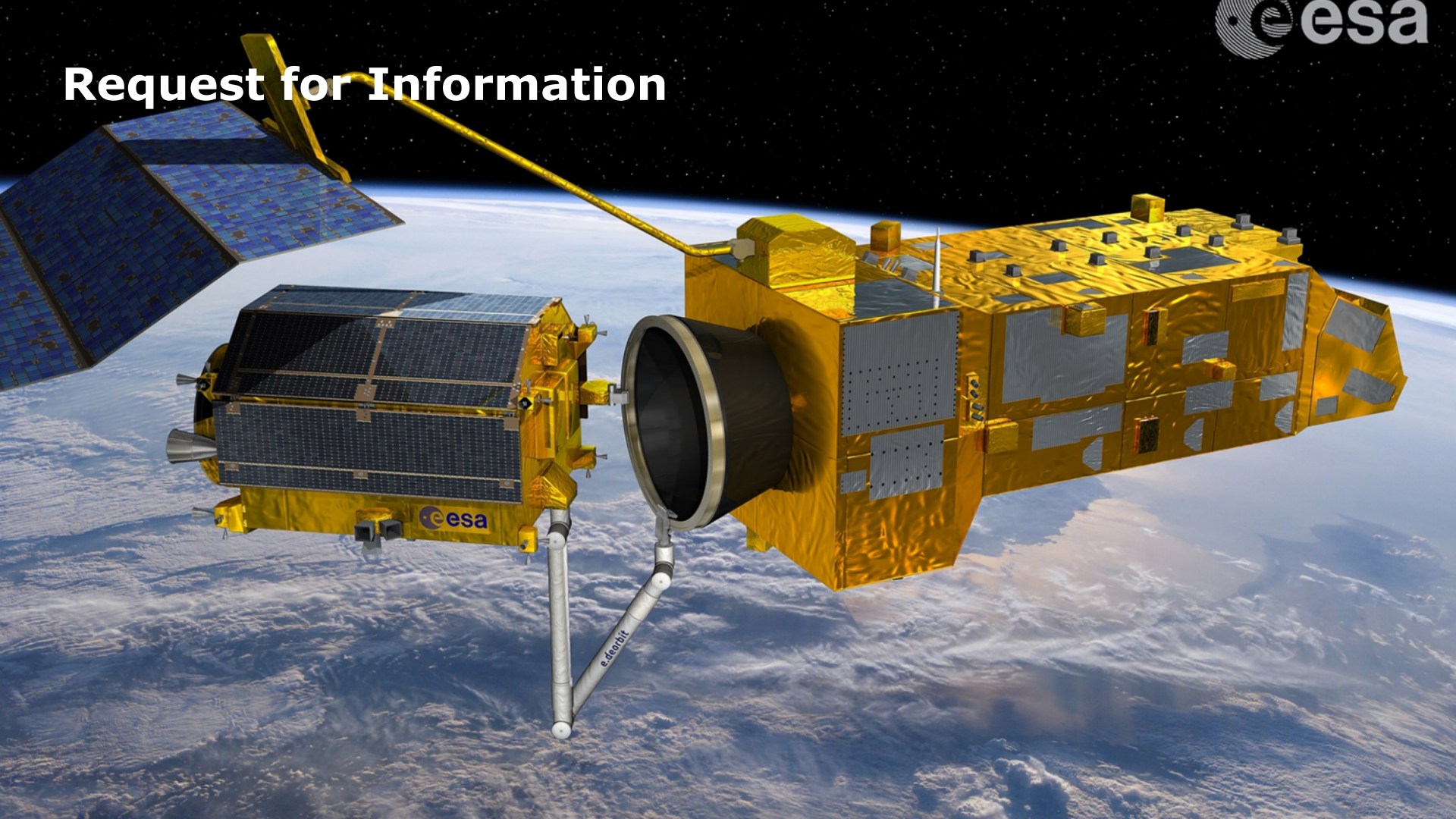
- On-Orbit Antenna Assembly
- Servicing Platforms in GEO

Mission Scenario 3
Megaconstellation
ADR



- Megaconstellation Phase A

Request for Information



RFI ➔ Objectives

This initiative addresses three objectives:

- to perform the removal of ESA satellite(s) as a precursor of in-orbit servicing;
- to demonstrate technologies, functions and operational know-how to perform other in-orbit services; and
- to achieve the above by means of service contract(s) to provide an opportunity to space industry to enter into this new space market.

RFI ➔ Mission Statement

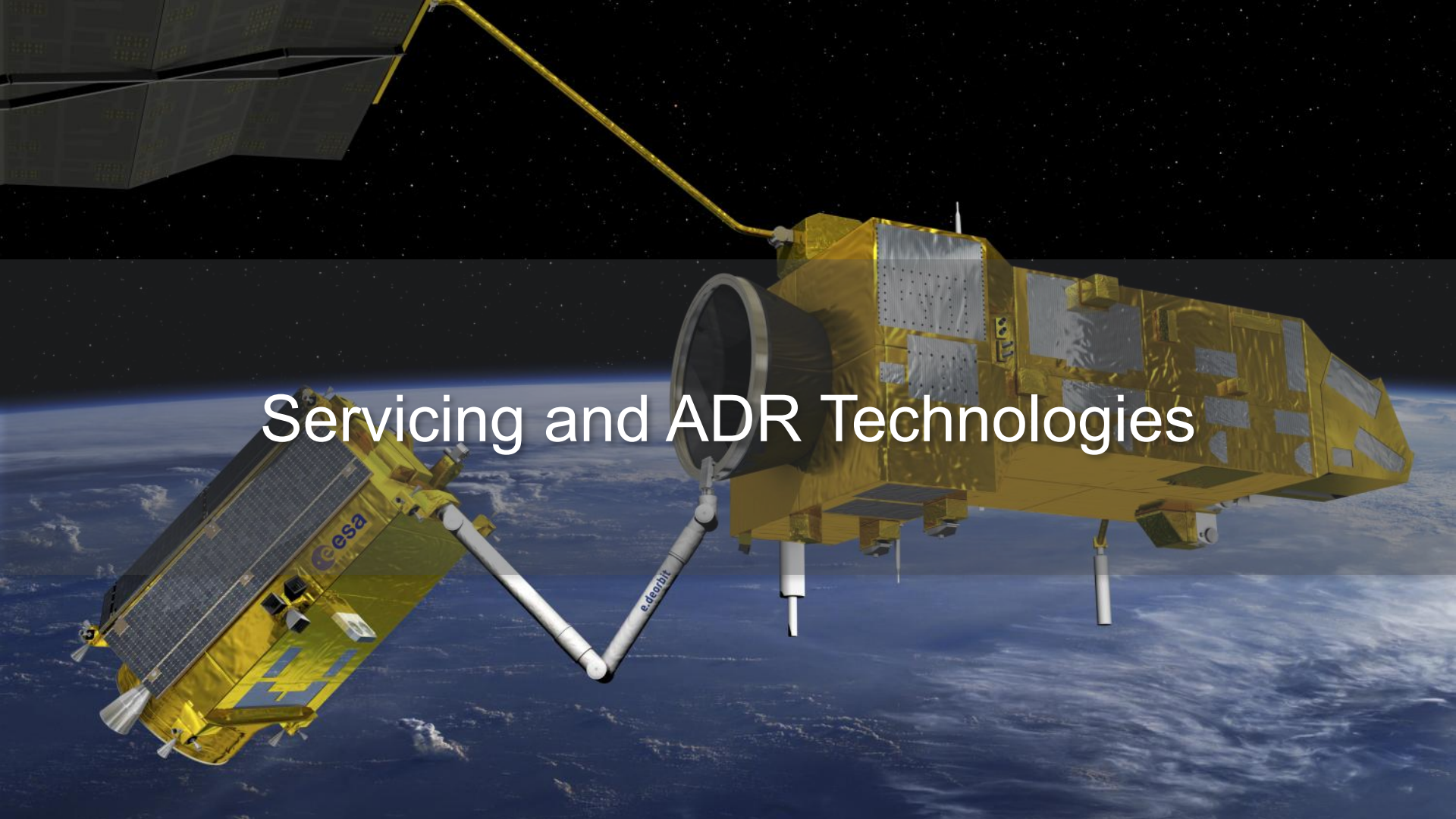
Mission Statement

Perform the removal from orbit of an ESA-owned satellite(s) in execution of service contract(s) placed by ESA and demonstrate capabilities and technologies for in-orbit servicing

RFI ➔ Mission Requirements

MIS-01	Remove from orbit ESA-owned satellite(s) with a total mass larger than 100 kg at least 5 years prior to its/their natural re-entry*
MIS-02	Demonstrate feasibility of critical technologies enabling other in-orbit TBD servicing opportunities
MIS-03	Provide a robust business model for in-orbit servicing activities beyond the service provided to ESA
MIS-04	Comply to space debris mitigation requirements stated in RD.1

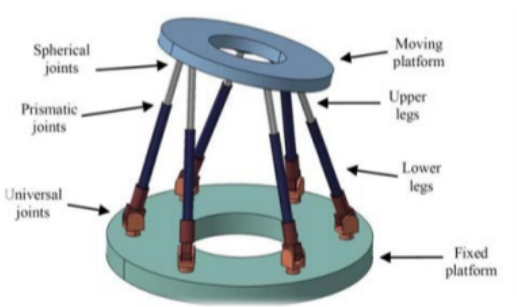
* list of satellites published



Servicing and ADR Technologies

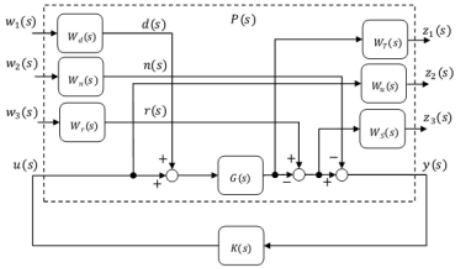
Continuing ADR / SSV Technologies

3.3 M€ in TRP / GSTP Technology Developments on-going

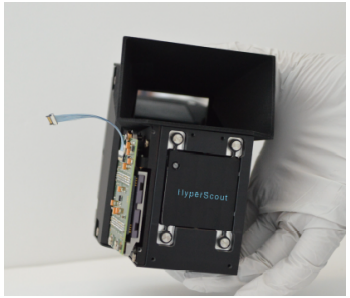


6-Degree of Freedom Gripper Platform
Credits: Hellenic Technology Robotics

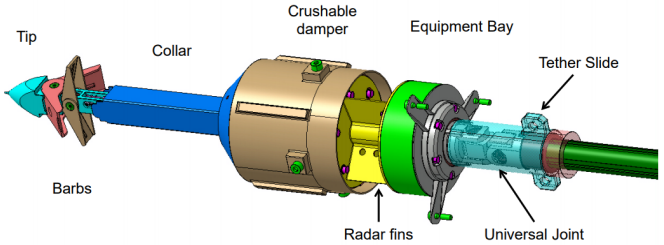
Tether



Combined Control
Credits: GMV



Multi-Spectral Camera
Credits: Cosine



Harpoon Development
Credits: Airbus

2018 / 2019 +

Activity Title	Target Prog.	Total Budget	Year	Status
Space Servicing Vehicle Robotics Subsystem - Phase 1 (RENEGADE)	GSTP	€7,000,000	2018	Approved
e.Inspector Phase A	GSTP	€250,000	2019	Planned
Space Servicing Vehicle Robotics Subsystem - Phase 2	GSTP	€5,500,000	2020	Proposed
Space Servicing Vehicle Pre-Development of Algorithms	GSTP	€400,000	2019	Proposed
Space Servicing Vehicle Multispectral Camera	GSTP	€800,000	2019	Proposed
Space Servicing Vehicle Stereo Camera	GSTP	€800,000	2019	Proposed

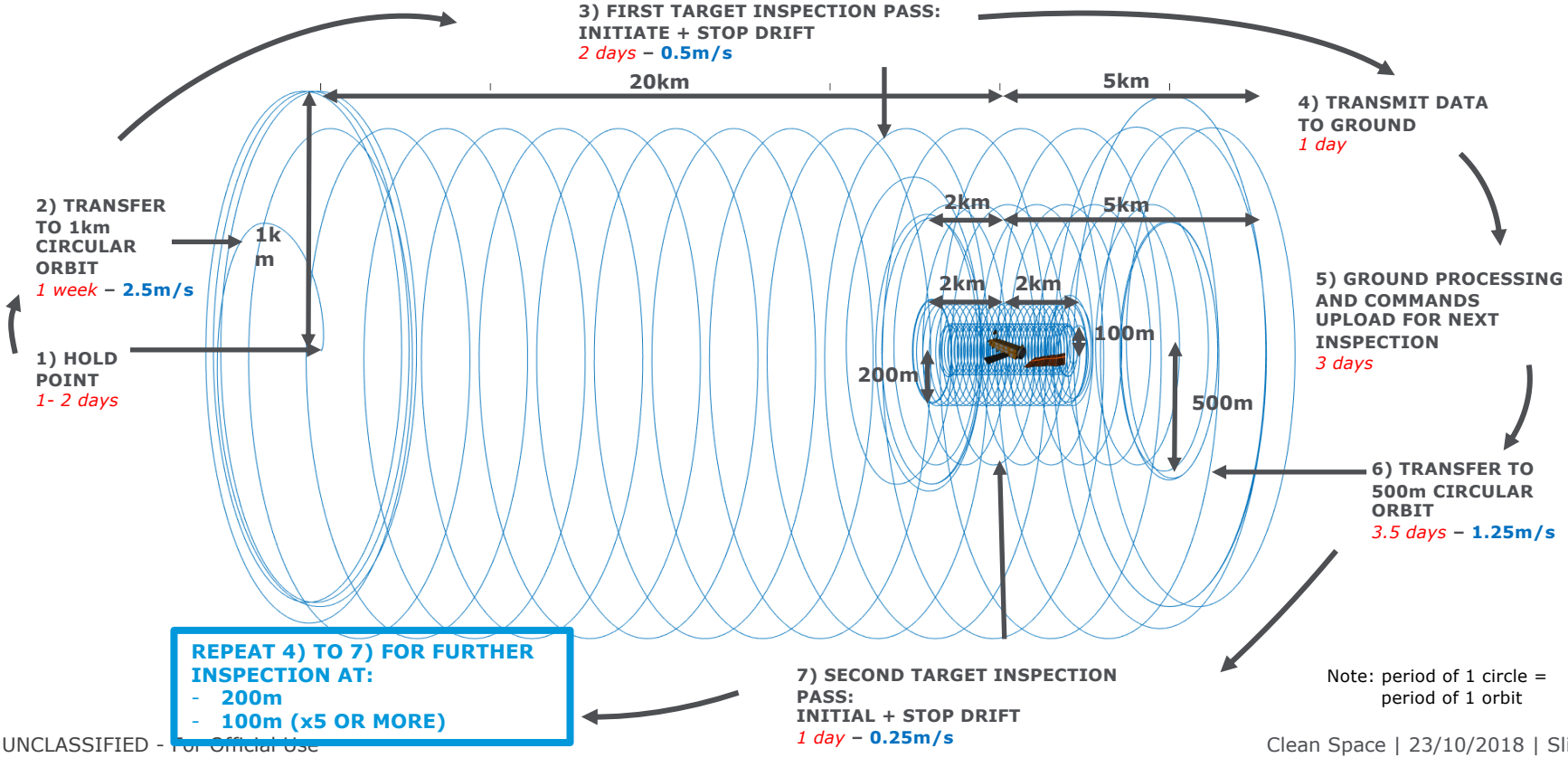
e.Inspector

➔ Mission Objectives

R-MIS-1: Image ENVISAT in its current status

R-MIS-2: Use obtained images for the verification and validation of a Space Servicing Vehicle GNC sensors

Inspection Timeline – EP to ENVISAT

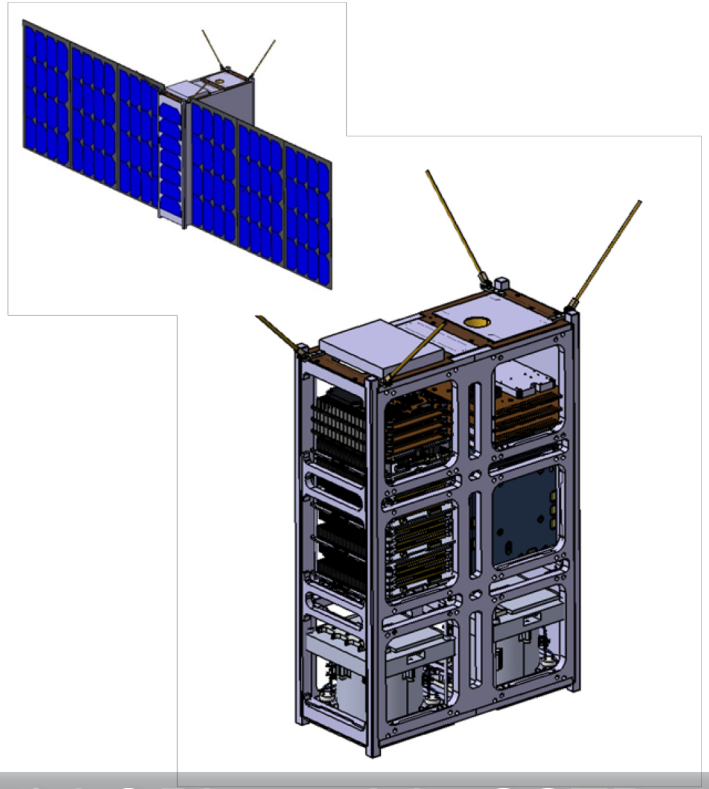


e.Inspector Summary

Subsystems:

- **Communications**: UHF (housekeeping) and S-band (payload data) (1 antenna, 1 transceiver of each)
- **Data-handling**: 1 CubeSat computer, 1 FPGA, 1 power board
- **Power**: 1 PCDU, Battery, 1 Body Mounted 3U SA, 2 SA wings of 3x6U
- **Mechanisms**: 2 HDRM, 12 Hinges
- **AOCS**: GPS rcvr, 6 SAS, IMU, 3 MT, 1 Rel Nav Imager, 3 RW, 1 STR
- **Thermal Control**: 45 Temp sensors, 15 Heaters, BP, MLI, OSR
- **Propulsion**: 2 FEEP systems

Cubesat Dispenser Type: ISIS – 6U



Proposed as a 250 k€ Phase A in GSTP

Design for Removal

esa
European Space Agency

Following the failure of a satellite…

1. Track the satellite orbit, and characterize the attitude – *implement retroreflectors, radar corner reflectors*
2. Launch an ADR satellite & perform the rendezvous and approach – *implement RF tags, 2D-3D markers*
3. Stabilise the satellite – *shortcircuit the magnetorquer*
4. Capture the satellite – *integrate a capture interface*

Planned for the future Copernicus Programme.

Design for Removal – ITT for Mechanical Interface

Design for Removal - Passive Mechanical and Rendezvous Interface for Capture after End-of-Life (PRINCE)

PRINCE shall include the following elements developed to TRL 3:

- Passive interface on the target satellite including the mechanical interface to facilitate capture and the navigation supports (e.g. 2D / 3D markers)
- Mechanical interface on the space servicing vehicle (e.g. the gripper at the end of a robotic arm)

The output: Interface Control Document to be provided to EO

150 k€ Open Competition (ITT Closure - 7 weeks)

Scope

Objective:

- Provide technical input for a future discussions on design principles / requirements for safe close proximity operations

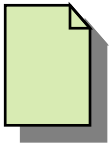
Benefits:

- Support industry through technical guidance and identification of potential licensing methods
- Capture of knowledge
- Protection to the orbital environment and other assets
- Enable international engagement

Large Space Integrators

Working Group

Robotics	Propulsion	Safety
Legal	Quality	ATV Operations
GNC	Systems	Operations



Output:
Technical input for a future design principles document

2019 Industrial Activity ≈ 400 k€

Activity Summary

System:

- RFI – Q4/18 or Q1/19
- TBC - Servicing Provisions for GEO Satellites (ARTES) – ’19 [600k€]
- TBC - On-Orbit Assembly (ARTES) – Q4/18 [250 k€]
- TBC - Megaconstellation Phase A (ARTES) – Q1/19 [350 k€]

Technology:

Robotics for Space Servicing Vehicles: Renegade ITT Closed [7M€]

GNC Space Servicing Vehicles:

- 4 x activities in GSTP Workplan [10 M€]
- e.Inspector Phase A Proposed [250 k€]

Design for Removal: 1 x mechanical interface/robotic (open) [150 k€]

Close Proximity Operations: Q1/Q2 ’19 [400 k€]

Don’t Forget the Lab Tours