e.Deorbit and the Space Servicing Vehicle

Clean Space

23/10/2018
Active Debris Removal

MISSION GOAL

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

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 20°th of September
Gaps in Observation ➔ Possibly due to tumbling motion
Period of 190s

Credits: AIUB
Active Debris Removal - e.Deorbit

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

Capture system

- **Total Wet Mass**: 2977 kg
- **Dry Mass**: 2025 kg
- **Propellant**: 952 kg
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

Mission Scenario 1
Deep Space Gateway Tug

Mission Scenario 2
Antenna Assembly for GEO S/C

Mission Scenario 3
Megaconstellation ADR
Conclusions:
1. Synergies in Technologies
2. Different System Designs Required

Follow-On Activities

- On-Orbit Antenna Assembly
- Servicing Platforms in GEO
- 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.
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

<table>
<thead>
<tr>
<th>MIS-01</th>
<th>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*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIS-02</td>
<td>Demonstrate feasibility of critical technologies enabling other in-orbit TBD servicing opportunities</td>
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<td>MIS-03</td>
<td>Provide a robust business model for in-orbit servicing activities beyond the service provided to ESA</td>
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<tr>
<td>MIS-04</td>
<td>Comply to space debris mitigation requirements stated in RD.1</td>
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</tbody>
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* 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

Multi-Spectral Camera
Credits: Cosine

Tether

Combined Control
Credits: GMV

Harpoon Development
Credits: Airbus
<table>
<thead>
<tr>
<th>Activity Title</th>
<th>Target Prog.</th>
<th>Total Budget</th>
<th>Year</th>
<th>Status</th>
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<tbody>
<tr>
<td>Space Servicing Vehicle Robotics Subsystem - Phase 1 (RENEGADE)</td>
<td>GSTP</td>
<td>€7,000,000</td>
<td>2018</td>
<td>Approved</td>
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<tr>
<td>e.Inspector Phase A</td>
<td>GSTP</td>
<td>€250,000</td>
<td>2019</td>
<td>Planned</td>
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<tr>
<td>Space Servicing Vehicle Robotics Subsystem - Phase 2</td>
<td>GSTP</td>
<td>€5,500,000</td>
<td>2020</td>
<td>Proposed</td>
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<tr>
<td>Space Servicing Vehicle Pre-Development of Algorithms</td>
<td>GSTP</td>
<td>€400,000</td>
<td>2019</td>
<td>Proposed</td>
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<tr>
<td>Space Servicing Vehicle Multispectral Camera</td>
<td>GSTP</td>
<td>€800,000</td>
<td>2019</td>
<td>Proposed</td>
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<tr>
<td>Space Servicing Vehicle Stereo Camera</td>
<td>GSTP</td>
<td>€800,000</td>
<td>2019</td>
<td>Proposed</td>
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</tbody>
</table>
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**

1) **HOLD POINT**
   - 1-2 days

2) **TRANSFER TO 1km CIRCULAR ORBIT**
   - 1 week – 2.5m/s

3) **FIRST TARGET INSPECTION PASS:**
   - INITIATE + STOP DRIFT
   - 2 days – 0.5m/s

4) **TRANSMIT DATA TO GROUND**
   - 1 day

5) **GROUND PROCESSING AND COMMANDS UPLOAD FOR NEXT INSPECTION**
   - 3 days

6) **TRANSFER TO 500m CIRCULAR ORBIT**
   - 3.5 days – 1.25m/s

7) **SECOND TARGET INSPECTION PASS:**
   - INITIAL + STOP DRIFT
   - 1 day – 0.25m/s

**REPEAT 4) TO 7) FOR FURTHER INSPECTION AT:**
- 200m
- 100m (x5 OR MORE)

**Note:** period of 1 circle = period of 1 orbit
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

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

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