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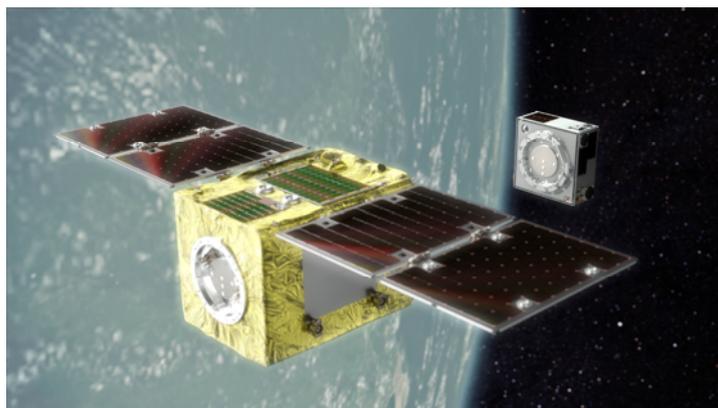
## ELSA-d プロジェクト ステータス-打ち上げに向けて-

### ELSA-d End-of-Life Debris Removal Mission: Preparing for Launch

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ELSA-d (End of life service by Astroscale - demonstration) は軌道上で故障した衛星を取り除くための非協力接近捕獲の主要技術を実証するミッションです。全ての環境試験と機能試験が完了し、射場への輸送準備が整いました。また、迅速かつ円滑にミッションを完遂できるよう、異常対応も含めた運用訓練も実施しております。当プロジェクトの最新ステータスとこの前人未至のミッションをこの先数ヶ月でどのように実施するかを示します。

The ELSA-d (End of Life Services by Astroscale-demonstration) mission will demonstrate the key technologies for non-cooperative rendezvous and docking for defunct and satellites which have come to their end-of-life. All environmental and functional tests are complete and the spacecraft is ready for shipment to the launch site. In addition, intensive operation training has been conducted in order to achieve the mission and to be prepared for any off-nominal incidents. In this presentation, we would like to show the latest status of ELSA-d and how this novel mission will be conducted as we prepare for launch.







**ELSA-d End-of-Life Debris Removal Mission:  
Preparing for Launch**

February 26<sup>th</sup>, 2021

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ELSA-d Project Manager  
Seita Iizuka

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## Key Business Markets



Services	End of Life (EOL) “Don’t add any more debris”	Active Debris Removal (ADR) “Remove debris that is already there”
Potential Customers	Constellations, Private Satellite Operators	Governments, International framework
Client Objects	<ul style="list-style-type: none"> <li>- Satellites that have failed in orbit or reached end of operational lifetime</li> <li>- 50~500kg</li> </ul>	<ul style="list-style-type: none"> <li>- Environmentally critical objects</li> <li>- 500kg+ (up to tonnes)</li> <li>- Existing debris</li> </ul>
Rationale	<ul style="list-style-type: none"> <li>- Protect operational service</li> <li>- Manage regulatory and reputational perspectives</li> </ul>	<ul style="list-style-type: none"> <li>- Demonstrate commitment to orbital sustainability</li> <li>- Assure spaceflight safety for all operators</li> </ul>
Global Responsibility		
Model	Unprepared approach and capture	Unprepared approach and capture
Astroscale provides	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">Servicer</div> <div style="border: 1px solid black; padding: 2px;">Mission licensing</div> <div style="border: 1px solid black; padding: 2px;">Customized insurance</div> <div style="border: 1px solid black; padding: 2px;">Ground segment &amp; operations</div> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <div style="border: 1px solid black; padding: 2px;">Universal DP</div> <div style="border: 1px solid black; padding: 2px;">Retro-reflector</div> </div>	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">Servicer</div> <div style="border: 1px solid black; padding: 2px;">Mission licensing</div> <div style="border: 1px solid black; padding: 2px;">Customized insurance</div> <div style="border: 1px solid black; padding: 2px;">Ground segment &amp; operations</div> </div>

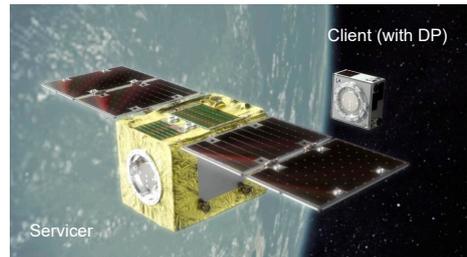
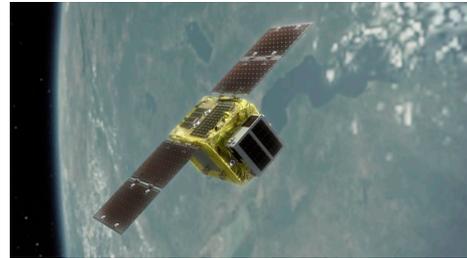


## ELSA-d – An Overview

First unprepared rendezvous & docking mission in the world!

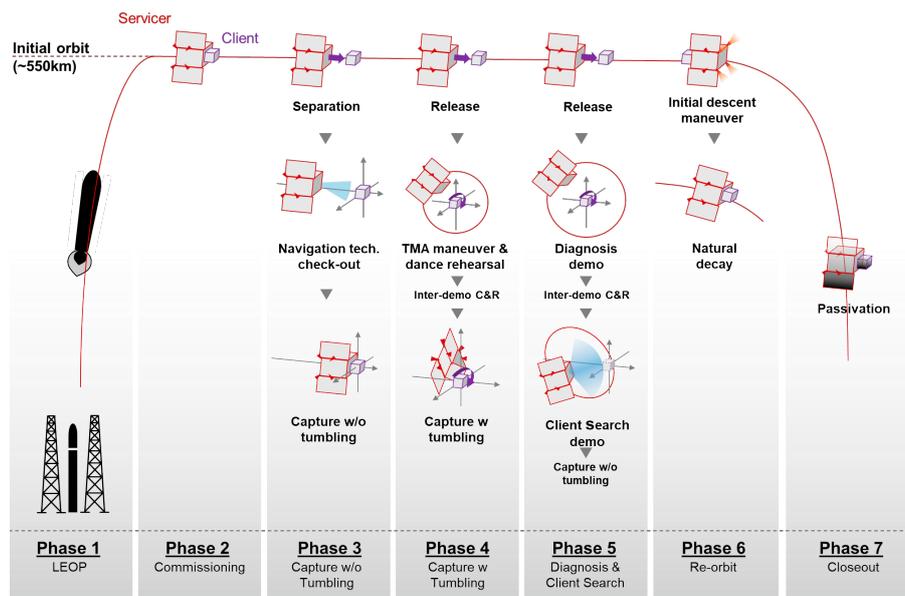
### Key Mission Details

- Servicer: 175 kg
- Client: 17 kg with docking plate (DP)
- DP allows prepared servicing of client using proprietary magnetic capture system.
- Launch in March 2021
  - Signed with Glavkosmos / GK Launch Services, Soyuz 2
  - SSO (500-600 km), LTAN 10.30-11.00.
- Full phases of operations that would be necessary for a full EOL service, including client search, inspection, capture, re-orbit and de-orbit.



ELSA-d Mission Concept

## ELSA-d – CONOPS





## ConOps Video

<https://youtu.be/HCWxdK7l0hI>

## ELSA-d – Key Capabilities – I



**End-to-end Rendezvous Solution** including far and short-range approach

- GNC processors (GNC command, sensor handling)
- Usual complement of attitude sensing e.g. star trackers, attitude control e.g. RWs and position sensing e.g. GPS
- Specialist rendezvous: ranging system, night navigation cameras (wide and short angle), day cameras, range finders, illumination device

**Safety Evacuations and Passively Safe Trajectories** fully executed in mission

- Collision avoidance (passive and active abort)
- Movement to evacuation point
- Protected safety ellipse
- Manual experiment abort
- Protected critical functions (including de-orbit)
- Safety critical computing: FDIR and safety tasks
- Architectural redundancy
- High-fidelity ground-based simulation

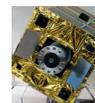
**Docking Plate (DP)** to enable unprepared removal

- Designed with constellation customers in mind.



**Magnetic Capture** of non-tumbling & tumbling clients

- Capture system is designed to extend and retract and allow multiple captures and releases.





## ELSA-d – Key Capabilities – II

**Autonomous Flight Software** targeting roughly ECSS Level-3 autonomy

- Event-based autonomous operations
- Execution of on-board operations control procedures
- Only intermittent communication with ground stations (No satellite relay communication)

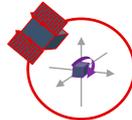
**Re-orbit, De-orbit and passivation capabilities**

- Green propulsion system with high ISP and compatibility to small launch vehicles



**Advanced Operational Capabilities**

- Demonstration of client search capability.
- Fly-around inspections of client with operator assessment.



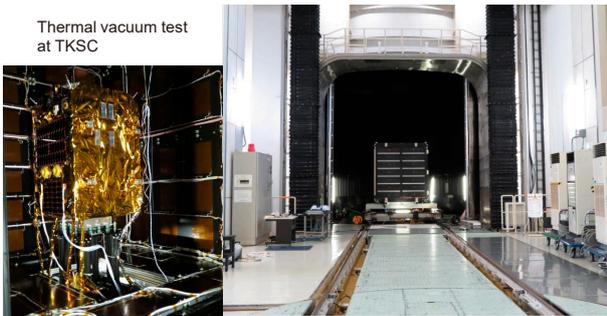
**In-orbit Servicing Ground Segment** designed specifically for EOL / ADR.



## ELSA-d – AIT / V&V – I

- Environmental tests (Thermal vacuum, EMC, Acoustic, Vibration) have been completed at Tsukuba Space Centre in late 2019 / early 2020
- No significant issue has been observed and all tests have proceeded as planned
- All tests have been conducted efficiently with limited personnel (less than ten engineers have handled the tests including 24-hour shift during the thermal vacuum test )

Thermal vacuum test at TKSC



EMC test at TKSC



Acoustic test at TKSC

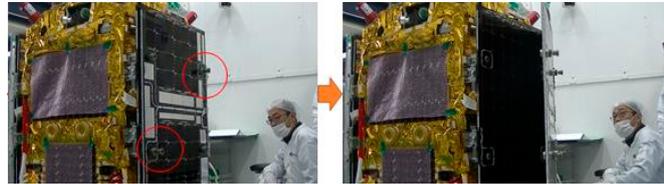


Vibration test at TKSC



## ELSA-d – AIT / V&V – II

- Various function tests have been completed for the last eight months both in Servicer and Client
- The number personnel staying at the office has to be restricted due to COVID-19. IT technologies such as remote access and teleconference have utilised as much as possible
- ELSA-d would be operated by Astroscale UK office. Connectivity tests between the UK control centre and the actual satellites have been conducted repeatedly.
- Validation of operation procedures and operation training are ongoing, connecting both the UK and the JP office



Solar panels deployment test

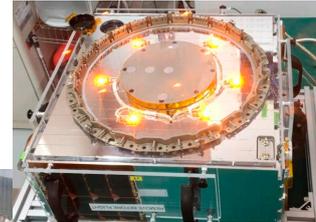
Client's function test



Ground support equipment used for Servicer's test



UK – JP interface tests & Operation training



RCS (thruster) function test



## ELSA-d – AIT / V&V – III

ELSA-d is now ready for the shipment and the launch!





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