

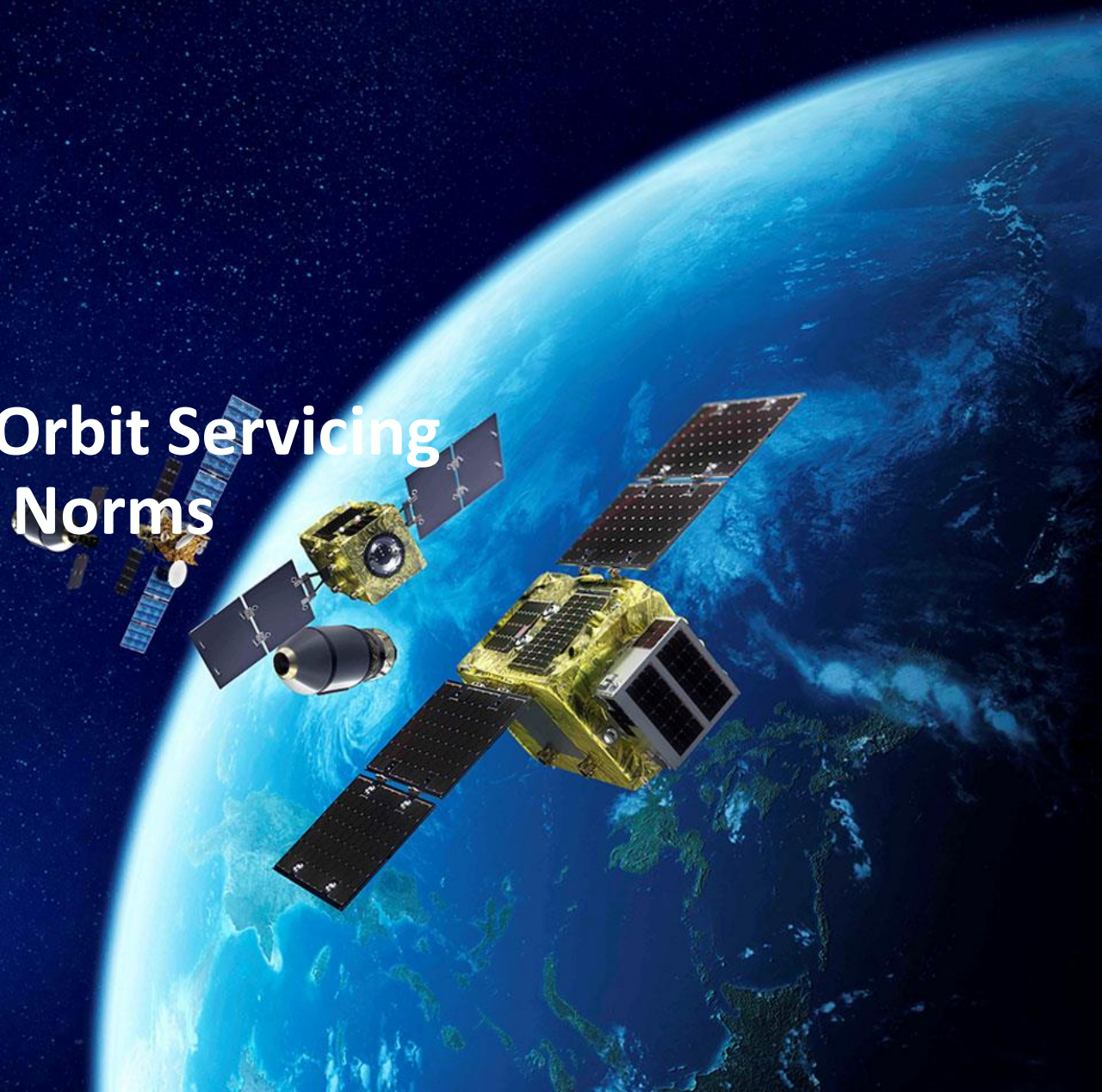


Space Sustainability: The Advent of Commercial On-Orbit Servicing and Immediate Need for Space Norms

UNOOSA Legal Subcommittee - Technical Presentation

Astroscale Holdings Inc.

April 17, 2024



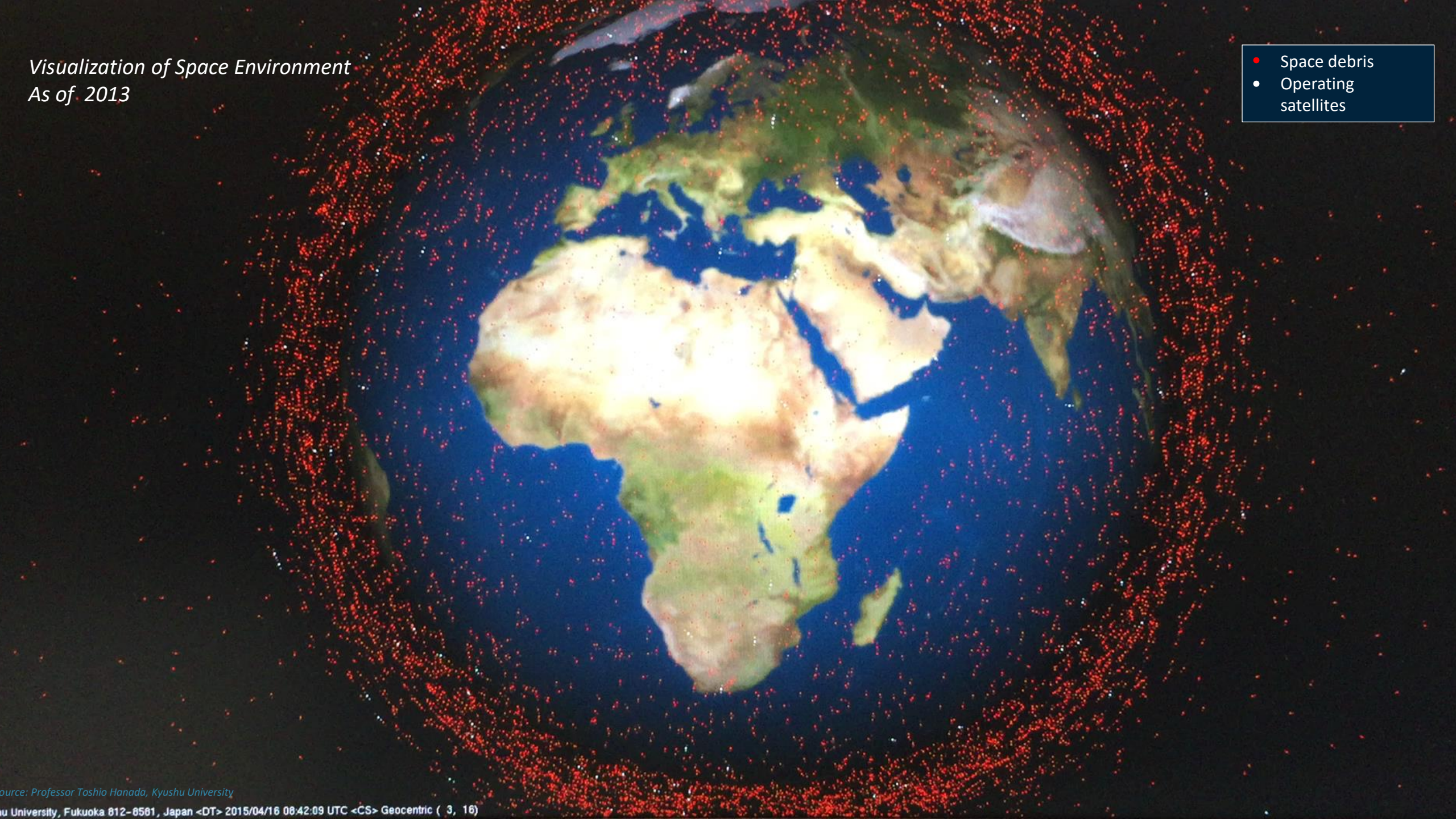


Space Environment and On-orbit Servicing (OOS)



*Visualization of Space Environment
As of 2013*

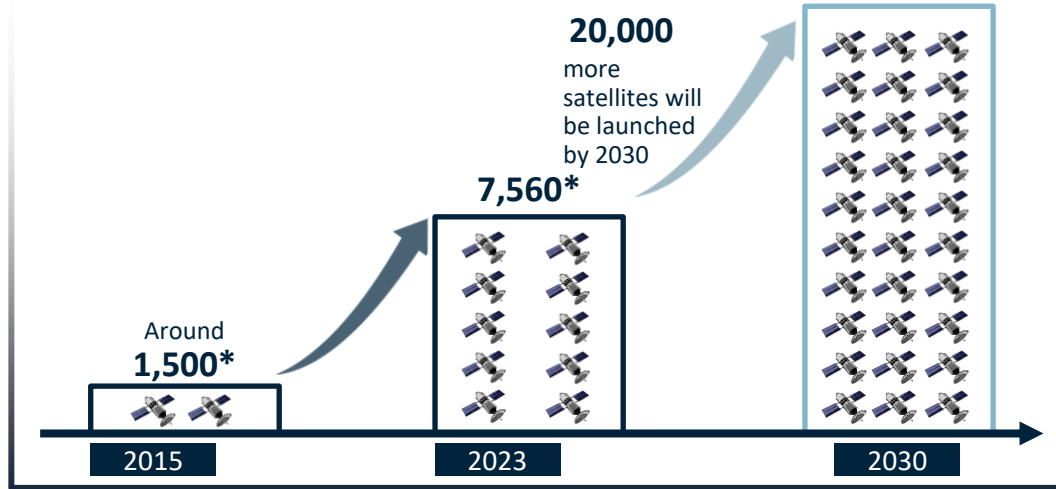
- Space debris
- Operating satellites





Unsustainable Orbits are Driving up Risks

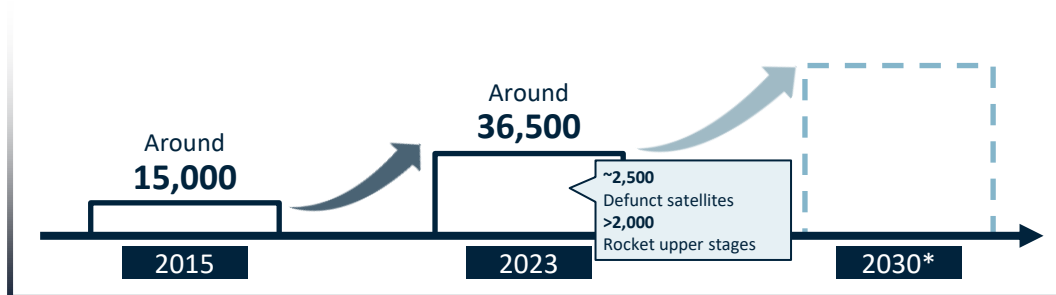
Number of Satellites in Space



Source: UCS Satellite Database(2023), Space News(2023)"Industry report: Demand for satellites is rising but not skyrocketing", U.S. Government Accountability Office (2022)"Large Constellations of Satellites"

* Number of satellites at the end of 2015 and in May 2023

Amount of Debris in Space (>10cm)

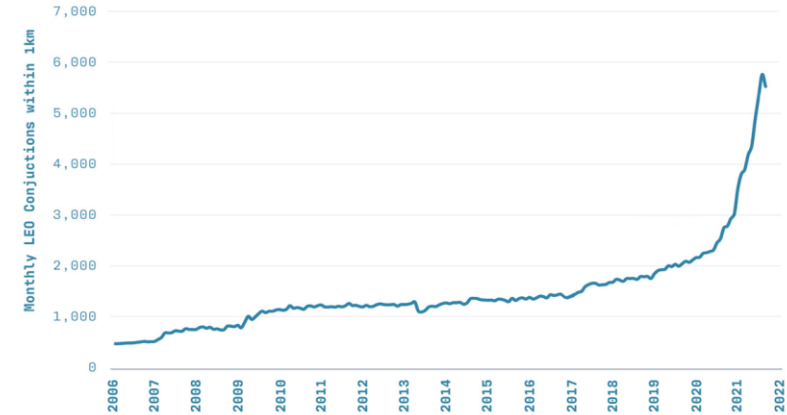


Source: European Space Agency, ESA Space Environment Report.

* Dot box for 2030 is for illustration purposes only.

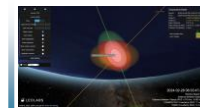
Conjunction Trend for Low Earth Orbit (LEO)

Number of near-misses between satellites and debris within 1km (2006-2022)



Source: The Center for Space Standards & Innovation at COMSPOC, with the Space Data Association, "Evaluation of LEO Conjunction Rates Using Historical Flight Safety Systems and Analytical Algorithms" (October 2021)

Near-misses between two large objects



7th time between Jan.2022-Mar.2024 with a miss distance of less than 20m between two intact, non-maneuverable objects (debris)*1

Increasing number of collision avoidance maneuvers by Starlink



2023 2H
Once every 11 minutes
(6 times/hr) *2

2028 Projected
Once every 16 seconds
(228 times/hr) *3

*1: Based on information provided by LeoLabs. "A dead Russian spacecraft almost collided with a NASA satellite. The crash could have sent 7,500 bits of debris rocketing around Earth." Business Insider. *2: "Starlink close encounters decrease despite ever-growing number of satellites." SPACE.com. *3: Hugh Lewis, a professor of astronautics at the University of Southampton, assuming prior 18 months' growth rate continues

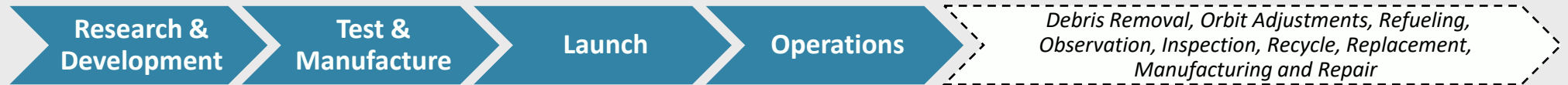
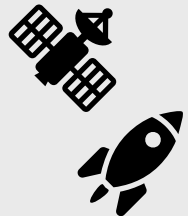


OOS is Key to Sustainable Use of Space

Logistics / Energy / Communications / Infrastructure Value Chain



Spacecraft Value Chain

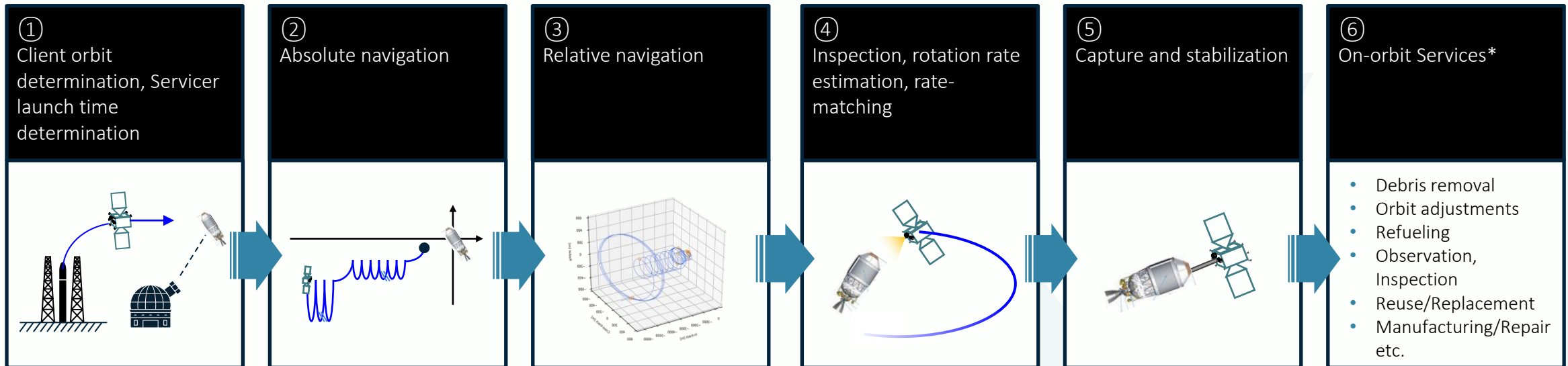


On-orbit servicing

RPO Technologies for Unprepared Objects is Key for OOS



Rendezvous and Proximity Operations Technologies



** Some of these are in the conceptual stage and include services that have not yet begun development.*



Astroscale: Pioneering the Future of Space Sustainability

VISION

Safe and sustainable development of space for the benefit of future generations.

MISSION

Develop innovative technologies, advance business cases, and inform international policies that reduce orbital debris and support long-term, sustainable use of space.



Introduction to Astroscale



7 Active Global Offices



570+ Diverse Team Members



Influential Global Leadership



In-House Development & Operations

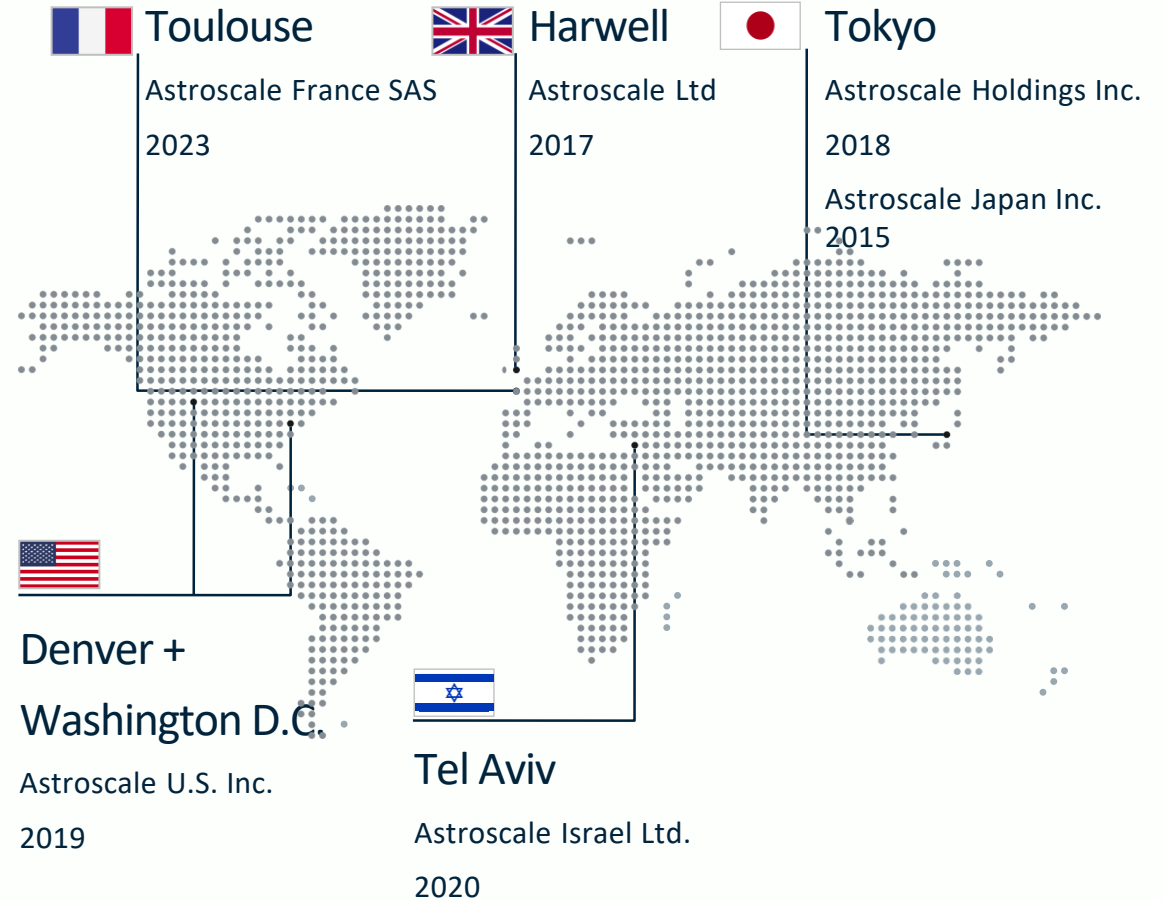


30+ Awards



\$383M Raised¹

¹ Represents total amount of equity raised up to Series G, showing the amount as of March 2024.



ELSA-d: Proving Commercial OOS Capabilities



ELSA-d

Launch: March 22, 2021

Mission: Successful demonstration of core RPO technologies in orbit (navigation, sensors, magnetic capture, software) and operations on the ground (fault detection, isolation & recovery, ground segment).

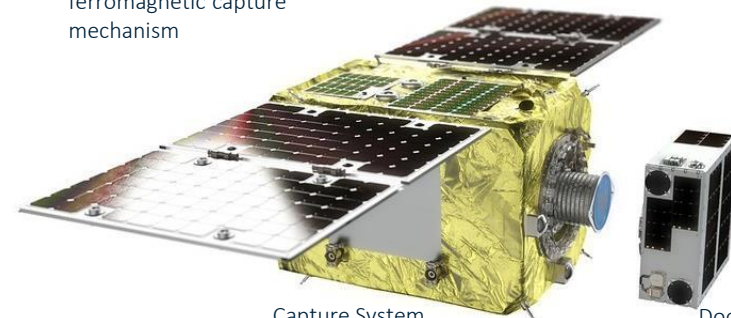
Status: Mission complete. Servicer and client are de-orbiting and will re-enter atmosphere **within 5 years**.

Servicer (175 kg)

Satellite equipped with a sensor suite, RPO technologies, & a ferromagnetic capture mechanism

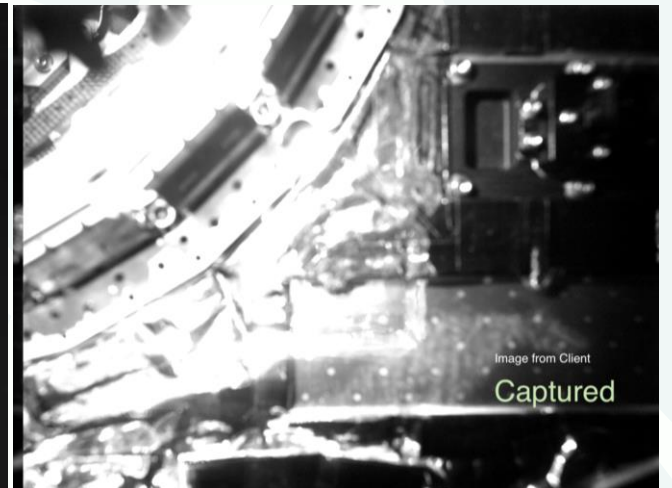
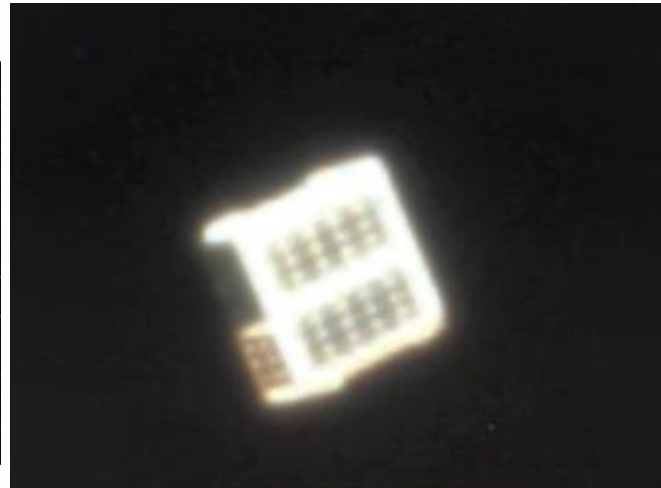
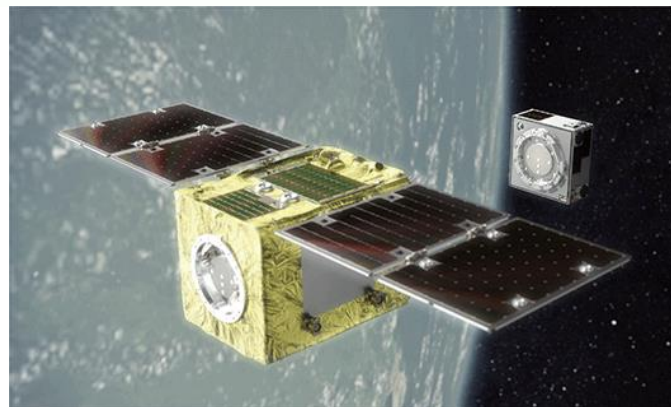
Client (17 kg)

Replica debris/defunct satellite equipped with ferromagnetic docking plate & unique fiducial pattern



Capture System
Magnetic capture system
Extends towards client

Docking Plate
Magnetic capture point



ADRAS-J: Proving Commercial OOS Capabilities



ADRAS-J

Launch: February 18, 2024

Mission: The first ever mission by a commercial company to rendezvous, approach and characterize an upper stage rocket body in orbit. Groundbreaking demonstration of RPO technologies for a paying customer.

Status: Successful launch and satellite check-out. Currently approaching client.



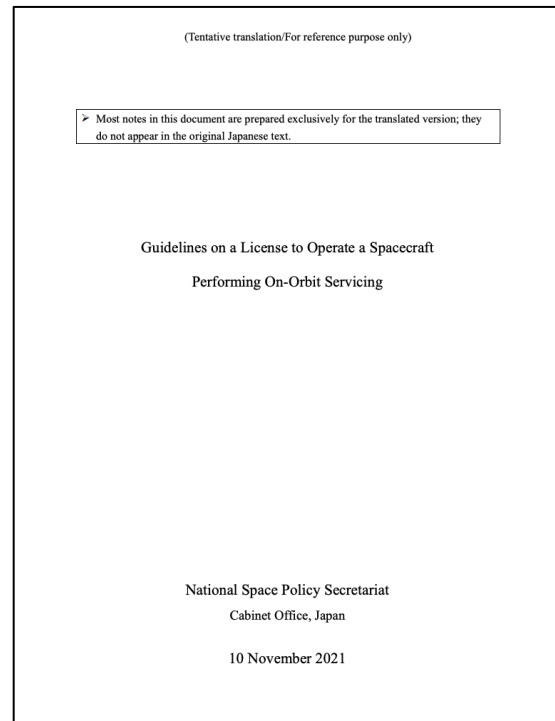
Best Practices and Standards for OOS



ADRAS-J followed “Japan’s guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing” that showed best practices and standards for safe and transparent RPO operations.



Guidelines by Cabinet Office, Japan
[guideline_oosgl.pdf \(cao.go.jp\)](https://www.cao.go.jp/guideline_oosgl.pdf)



Major Requirements

- Justifiability of purposes as a lawful business conduct
- Subsystems necessary for the safety
- Operations and maneuvers plan necessary for the safety
- Transparency of the safety and justifiability

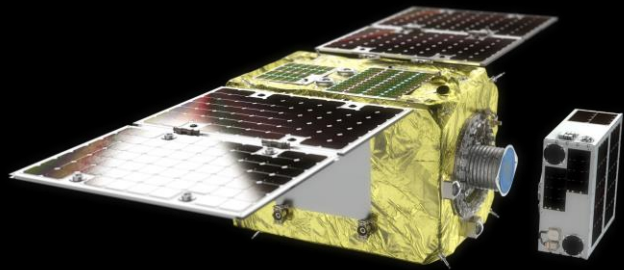


PMissionJapan Vienna @JapanMissionVie · 2月13日

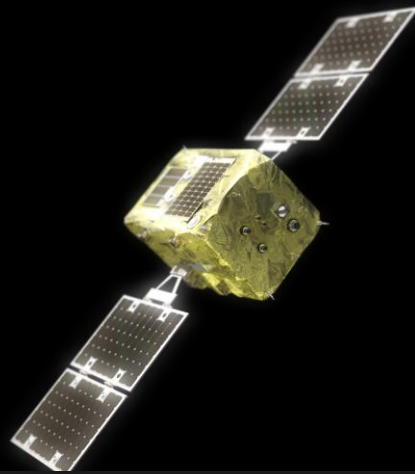
On 6 February, at the LTS workshop during #STSC, Ms Iwamoto of #Astroscale_JP presented Astroscale's efforts for on-orbit servicing, including the Active Debris Removal project, and touched on Japan's guidelines for ensuring the safe and transparent operation of such services.



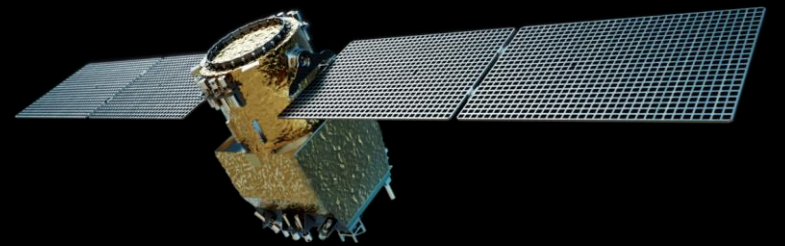
A representative from Astroscale Japan presented CRD2 program and OOS guidelines at the UNCOPUOS LTS workshops in February 2024



ELSA-d



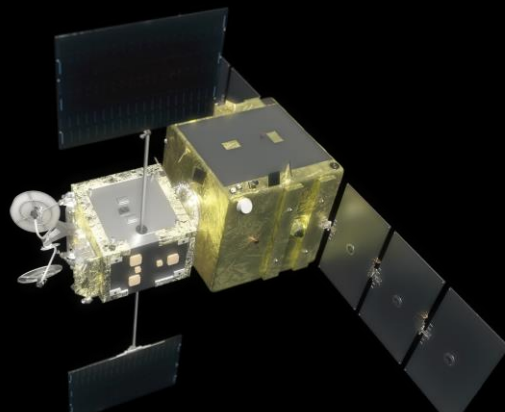
ADRAS-J



APS-R



LEXI-P

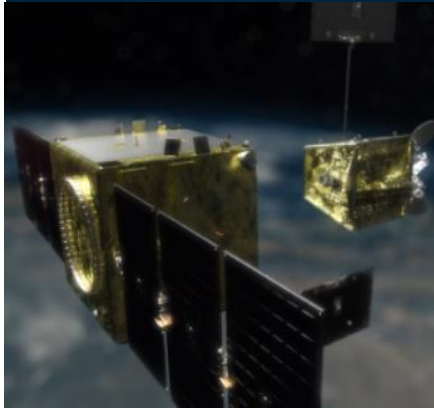


ELSA-M



COSMIC

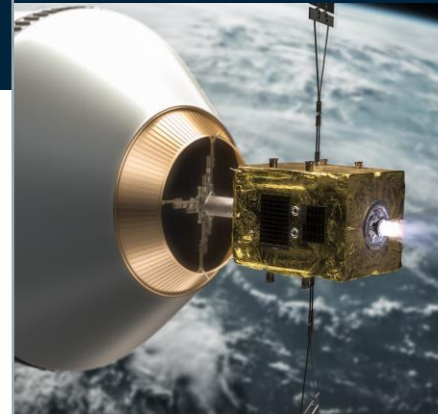
Our Missions Cover Multiple Orbits and Serve Numerous Types of Customers



EOL

End-of-Life Services

Mission: Prevent Future Debris
Objects: Satellite Constellations
Client: Commercial and Government



ADR

Active Debris Removal

Mission: Remove Current Debris
Objects: Defunct Satellites and Rockets
Client: Government



LEX

Life Extension Services

Mission: Orbit adjustment, refueling
Objects: GEO Satellites
Client: Commercial and Government



ISSA

In-Situ Space Situational Awareness

Mission: Observe Orbital Environment
Objects: Space Environment and Potential Risks
Client: Government



Our Expectation for Global Actions for Space Sustainability

Environmental Changes

- **Deteriorating space environment**
- **Advancing commercial OOS capabilities**
- **Emerging rules to regulate satellite operators and policies to promote OOS**

Immediate and Further Actions

1. Industry, states, and global organizations must take action:

A) Industry:

- Develop, demonstrate, and mature innovative OOS technologies.
- Validate value propositions and drive discussions on best practices and standards.

B) States:

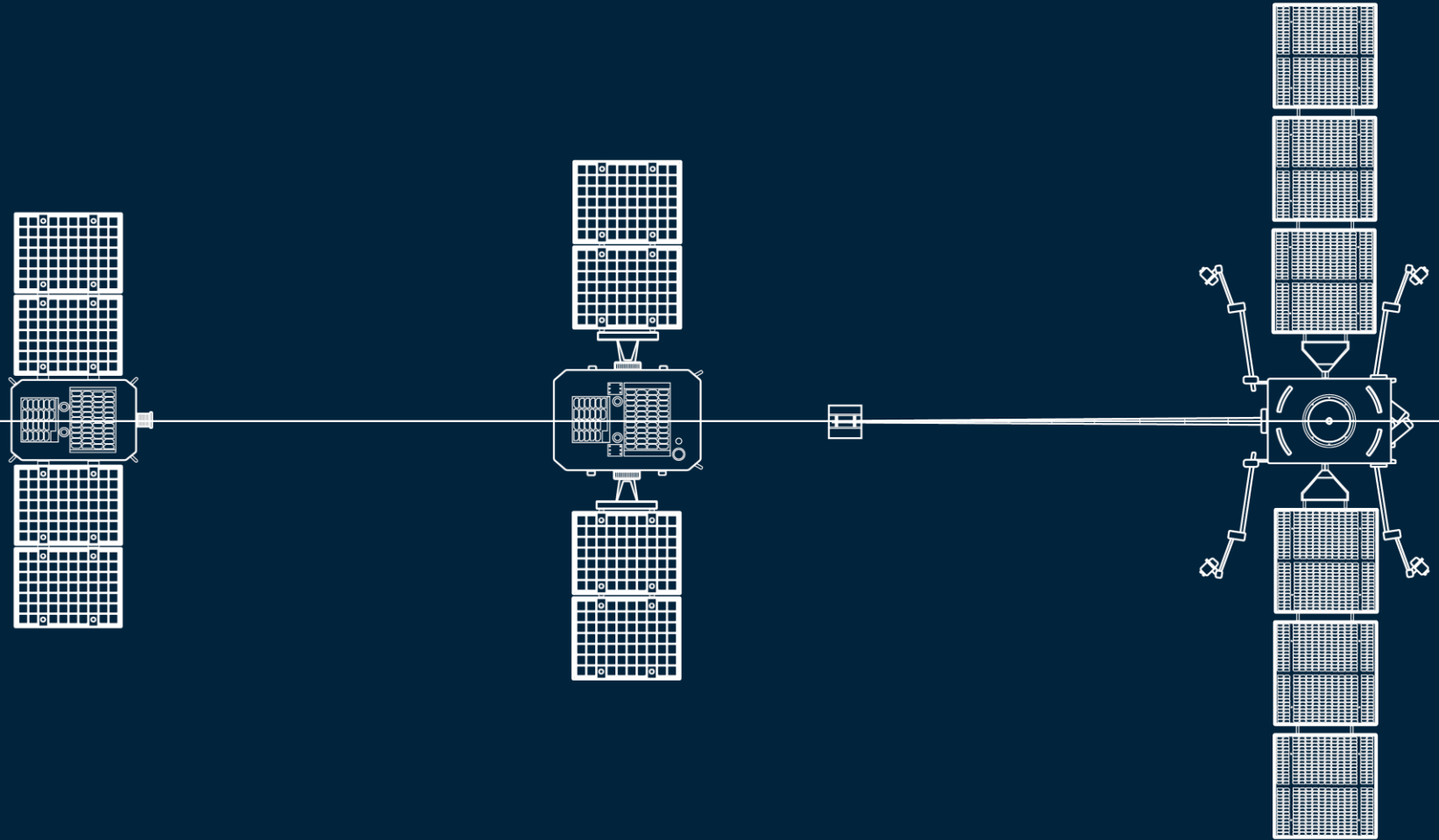
- Allocate budgets to support advanced R&D.
- Implement regulations and establish space policies and architectures leveraging OOS for a circular economy in space.

C) NGO/IGO:

- Generate consensus-based, non-binding rules on space sustainability and debris mitigation and remediation.

2. Regulatory and legislative action items should encompass the following:

- Facilitating the sharing SSA (Space Situational Awareness) data to enhance SSA capabilities
- Requiring satellite operators to deorbit all satellites at the end of their life
- Requiring states to remove existing debris critical to space environment



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