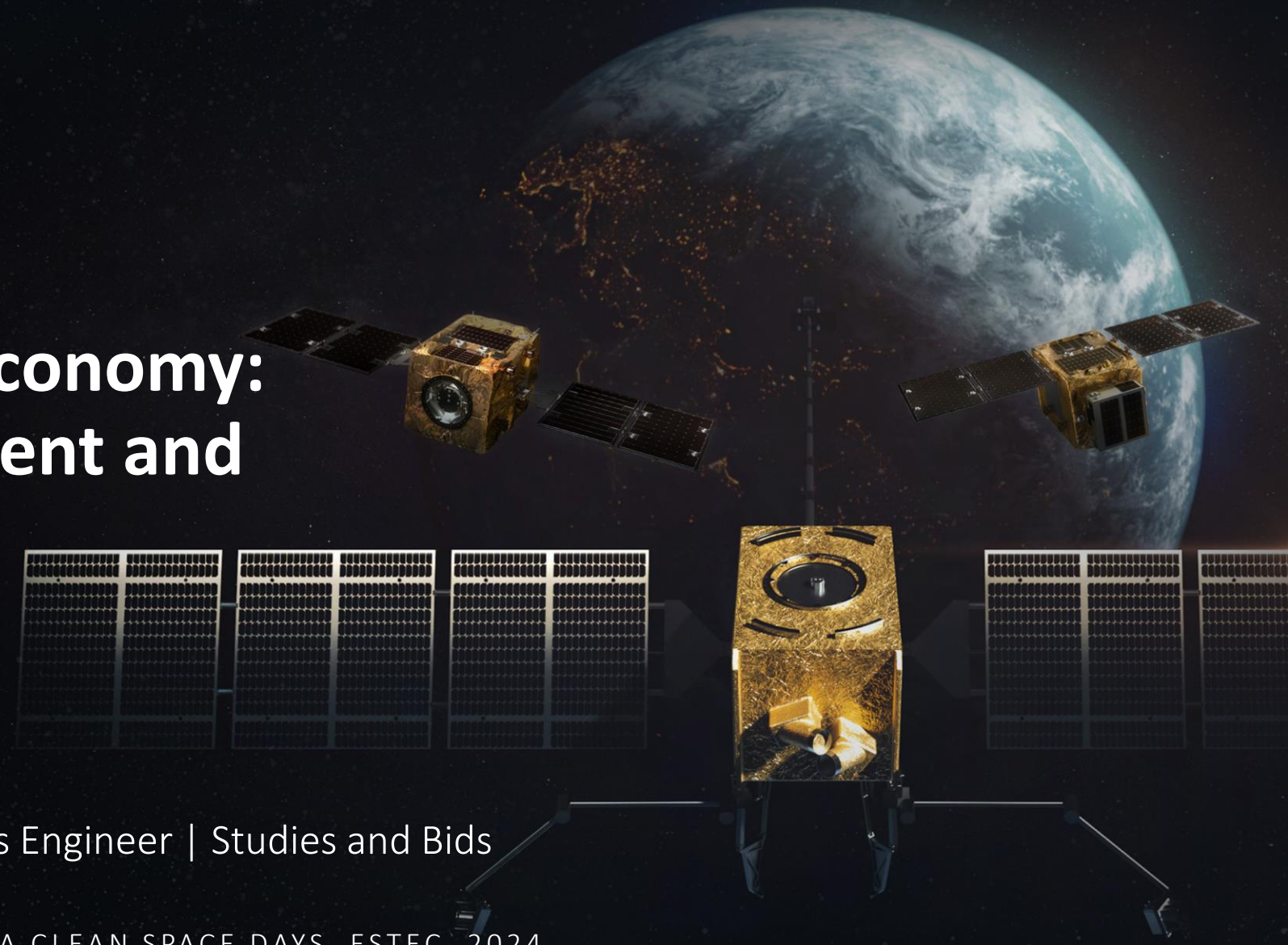
Astroscale

Towards a Circular Economy: Satellite Refurbishment and Upgrading Services



Presenter:

Dr. Adrian Dumitrescu – ASUK Systems Engineer | Studies and Bids

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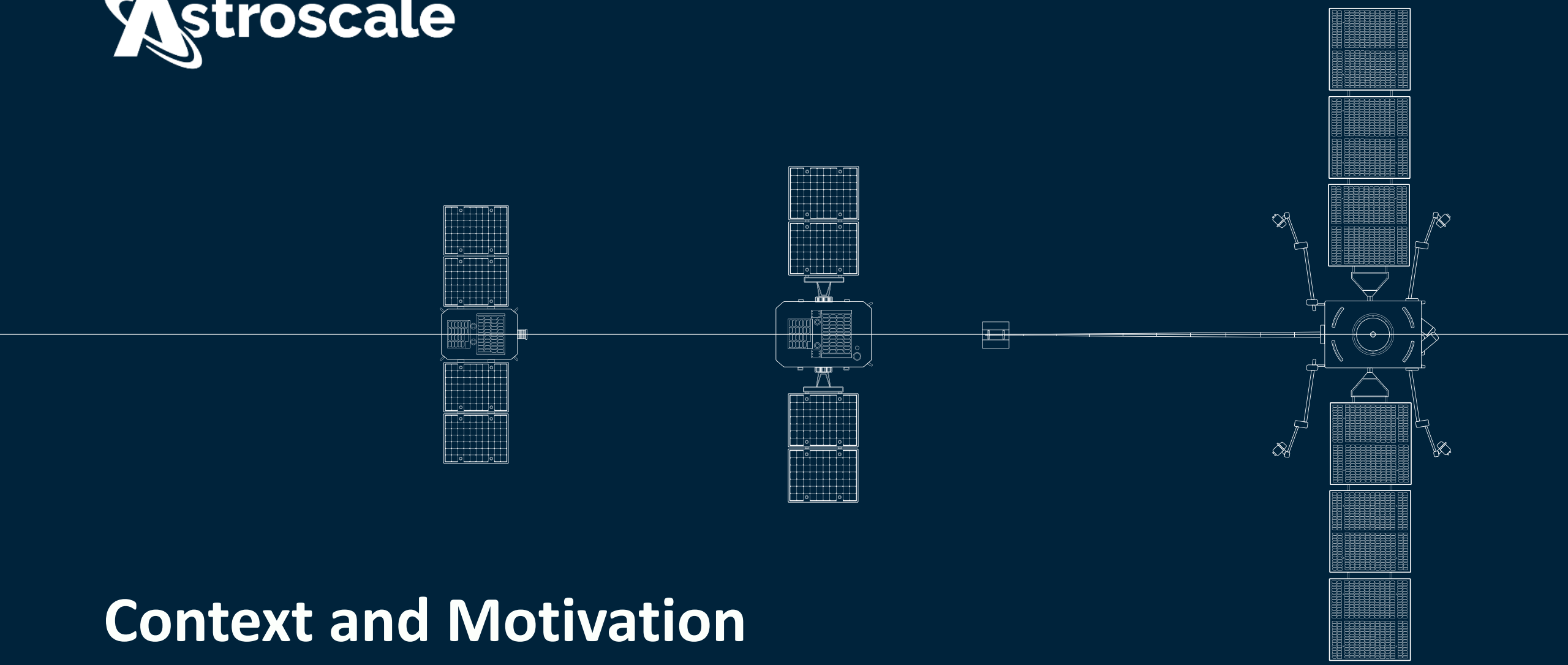


Context and Motivation

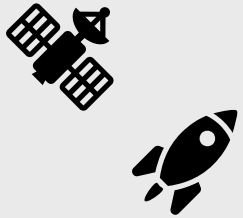
Context and Motivation

No commercial industry on Earth is built on single use and disposal. The Space industry still is.

Logistics / Energy / Communications / Infrastructure Value Chain

Research & Development → Test & Manufacture → Sales → Operations → **Post-sales Servicing and Support (Repair, Inspection, Maintenance, Disposal)**

Spacecraft Value Chain



Research & Development → Test & Manufacture → Launch → Operations → *Debris Removal, Situational Awareness, Life Extension, Orbit Adjustments, Refueling, Maintenance and Repair*

In-Orbit Servicing

Context and Motivation

- ESA has noted that a market for in-orbit activities is both expected and desirable.
- Servicing, rendezvous, assembly, refurbish, manufacturing, and recycling are all part of the future of the space economy.
- Astroscale sees refurbishment and upgrading as a promising next step towards an in-orbit economy, bridging the technology gap to manufacturing and recycling.
- Refurbishment and upgrading are also two areas where Astroscale can leverage experience with current platforms under development, such as COSMIC.

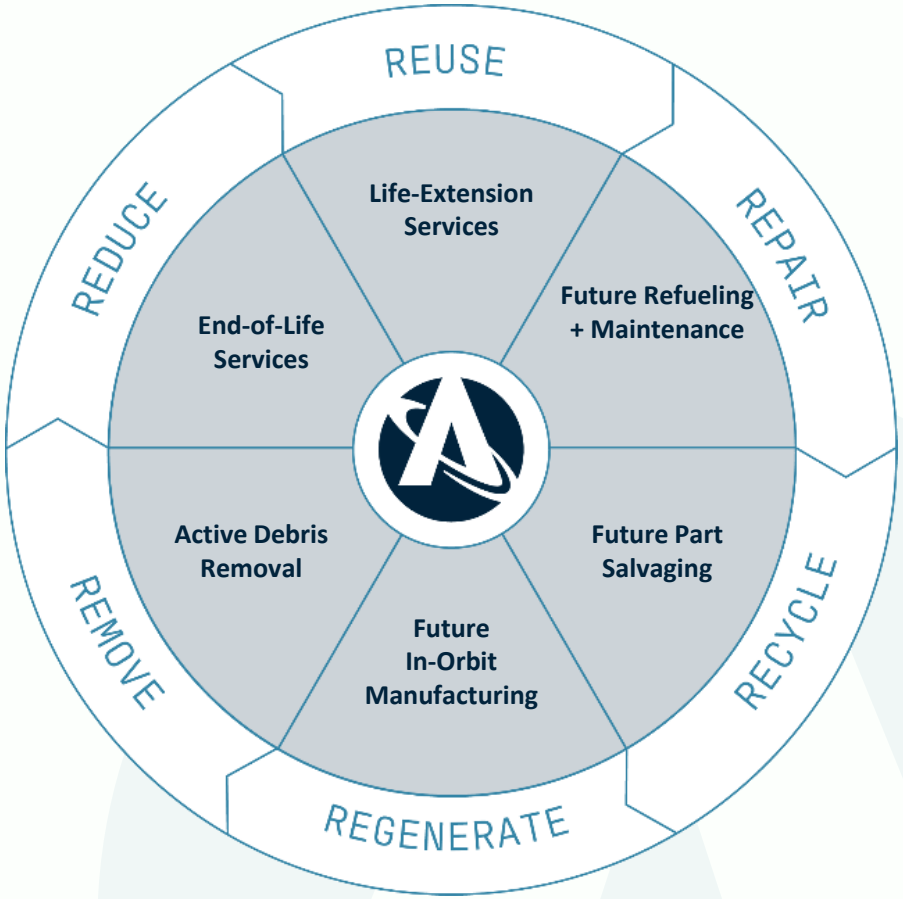


Fig. 1. Astroscale's circular space economy proposition

Context and Motivation

- Refurbishment, upgrading and repair are terms that are being used frequently in this context.
- Refurbishment mainly refers to swapping out a damaged component with a new one.
- Upgrading mainly refers to replacing a component with another component that has better capabilities.
- Repair is a step further from both and it does not necessarily imply any exchange of hardware, but a direct manipulation of hardware found on the client.

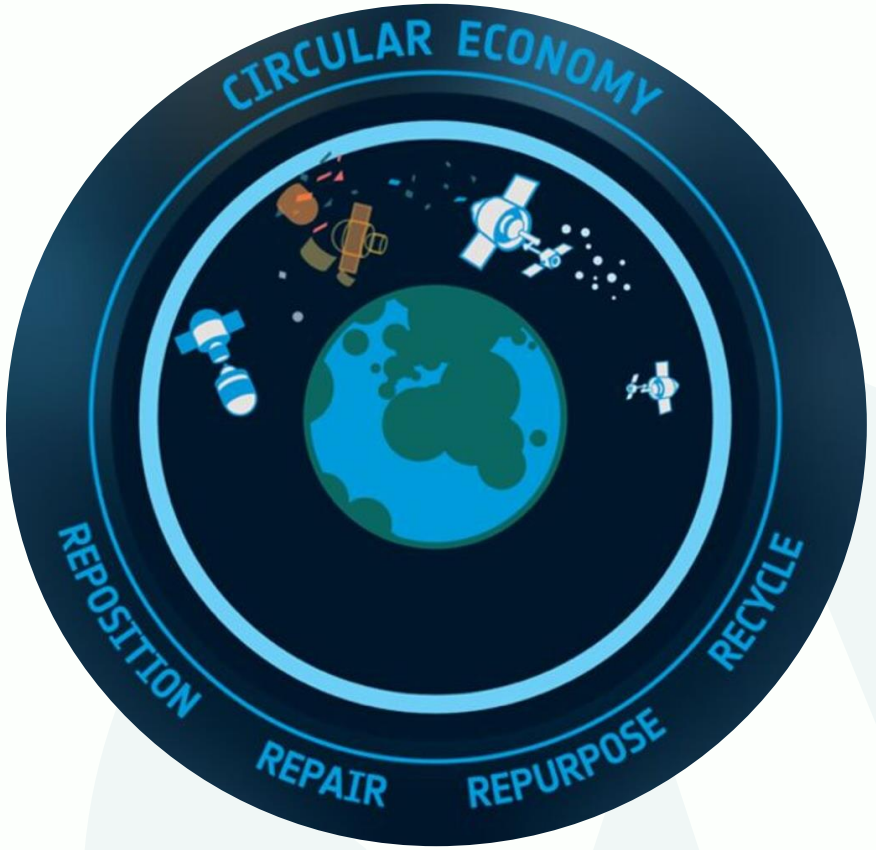


Fig. 2. ESA circular economy cycle

Context and Motivation

- All current generation spacecraft payloads, be they Earth Observation, comms or navigation, require significant processing capability.
- The complexity of on-board processing is determined by the availability of space-qualified hardware.
- Computing hardware continues to develop quickly c.f. Moore's law and new architectures such as quantum computing and neuromorphic processors are also being developed.
- Therefore, it is desirable to be able to replace satellite processors within 3-5 years from launch, as they are replaced and upgraded for Earth bound electronics.

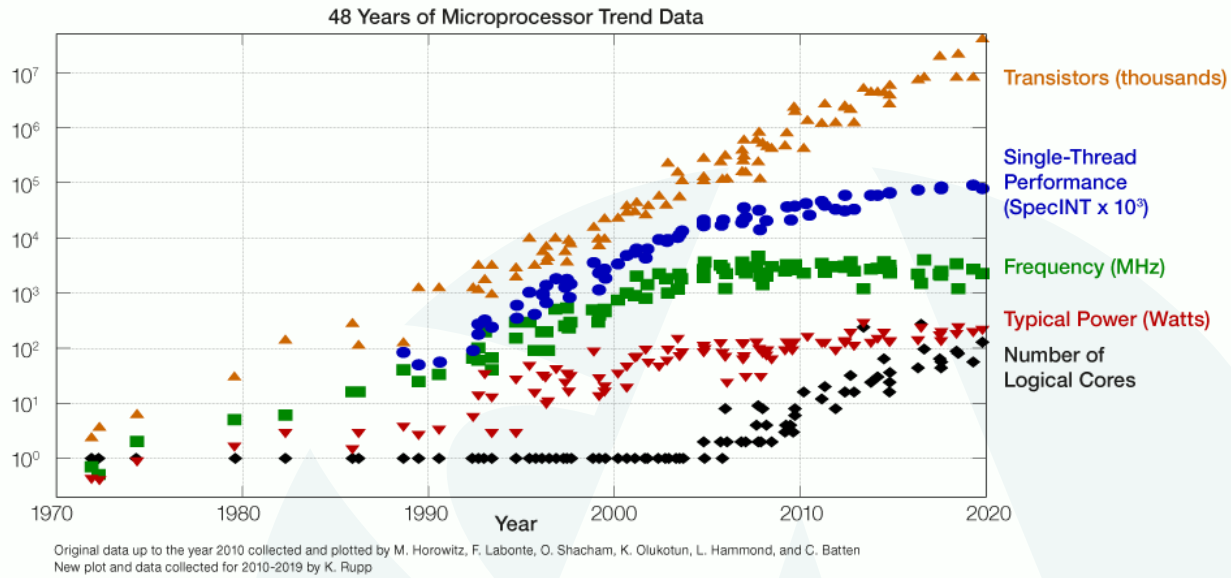


Fig. 3. Processing power evolution since 1970
Source: Man Group – Bending Moore's Law

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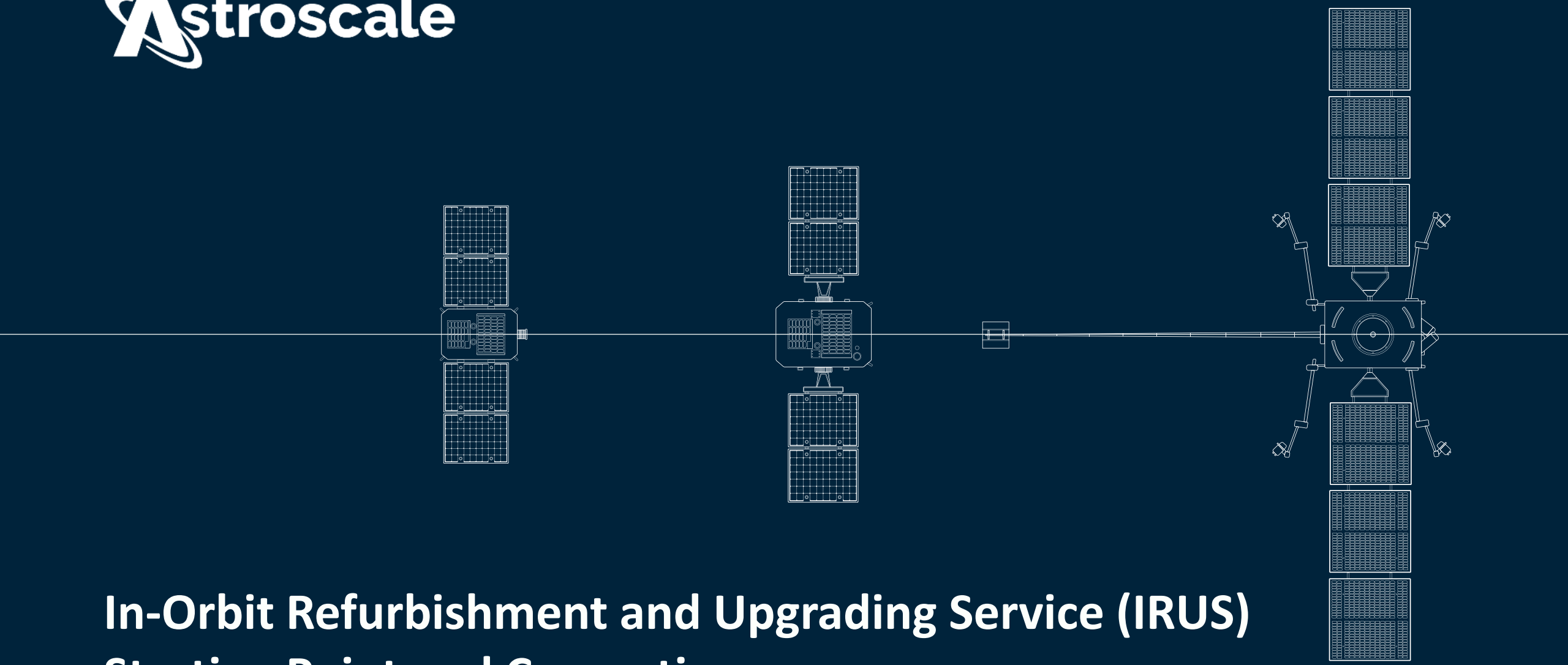

In-Orbit Refurbishment and Upgrading Service (IRUS)
Starting Point and Consortium

Starting Point

- Astroscale is focused on building on the experience in developing In-Orbit Servicing (IOS) platforms to enable more complex servicer-client interactions such as those involved in refurbishing.

- The COSMIC platform, currently in development post PDR with UKSA, is a solid starting point for an upgrading mission given its robotic arm capture system and its ability to interact with tumbling space assets.

- In developing the IRUS servicer, Astroscale will continue to advance core technologies which will underpin future IOSM missions, namely RPO, docking, and robotic manipulation.

Fig. 4. A rendition of the COSMIC servicer docking a client

Consortium

- A central element to both the technological and commercial feasibility of the refurbishment and upgrading service is identifying potential clients who are not only willing to pay for the service but are willing to design their platforms to be serviced in the first place.
- To this end, Astroscale UK (ASUK) is partnering with In-Space Missions (ISM) who will design a serviceable client and will provide a constellation roadmap, and with DHV Technology who will help refine the business plan.

Fig. 5. A summary of the IRUS consortium

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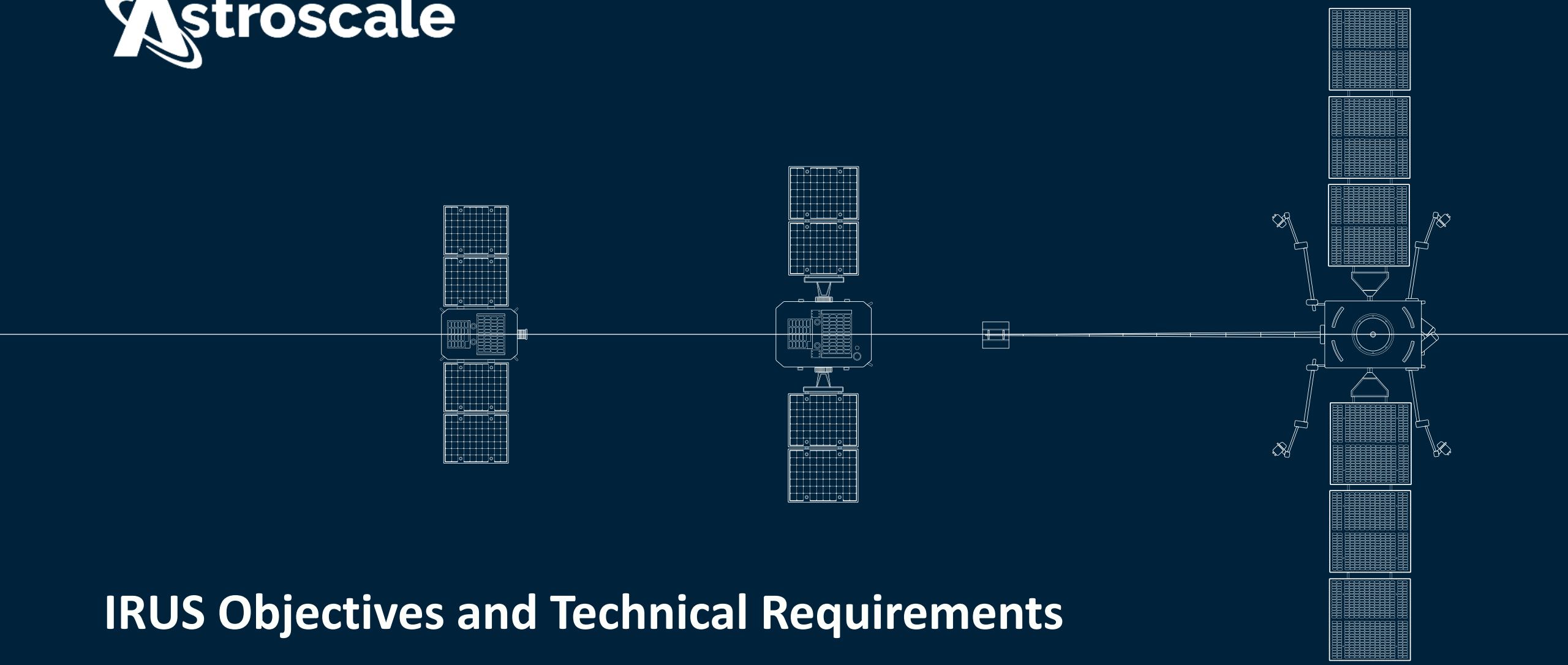

IRUS Objectives and Technical Requirements

IRUS Objectives

Service Level Objectives

Develop a **technically** and **economically** viable CONOPS that enables **refurbishment of multiple clients** in the context of future commercial constellation services.

Mature the **business model** considering the full lifecycle costs of refurbishment and upgrading services developing the **future circular space economy**, including market analysis, pricing policies, and commercial feasibility.

Define an **initial interface** that will enable a **standardised docking** approach between the servicer and the client.

Servicer Spacecraft Objectives

Develop an initial servicer spacecraft design that enables **targeted component refurbishment and upgrading** of the client spacecraft, leveraging relevant design considerations from the COSMIC platform.

Define a set of **functional requirements** and **operational constraints** for a robotic arm that features a **compatible standardised end-effector** that can be used for future refurbishment and upgrading missions.

Client Spacecraft Objectives

Develop an initial **client spacecraft** design focused on specific containerised units that enables **targeted component upgrading** by a robotic servicer.

Define an initial mechanical, electrical and thermal **interface** between the client spacecraft bus and the **containerised subsystem.**

IRUS Objectives

- The IRUS concept comprises a servicer spacecraft that can move around a prepared client satellite, potentially as part of a constellation, replacing subsystems one-by-one.
- These subsystems range from swappable containers with processor units or batteries to swappable solar cells/panels.
- Astroscale will investigate the upgrading of these subsystems with ISM as a baseline end-customer and further extend the business case with DHV, to broaden the scope of future missions.
- ISM will focus on narrowing down the most promising upgradeable spacecraft components, while also developing a container design, including an initial interface definition.

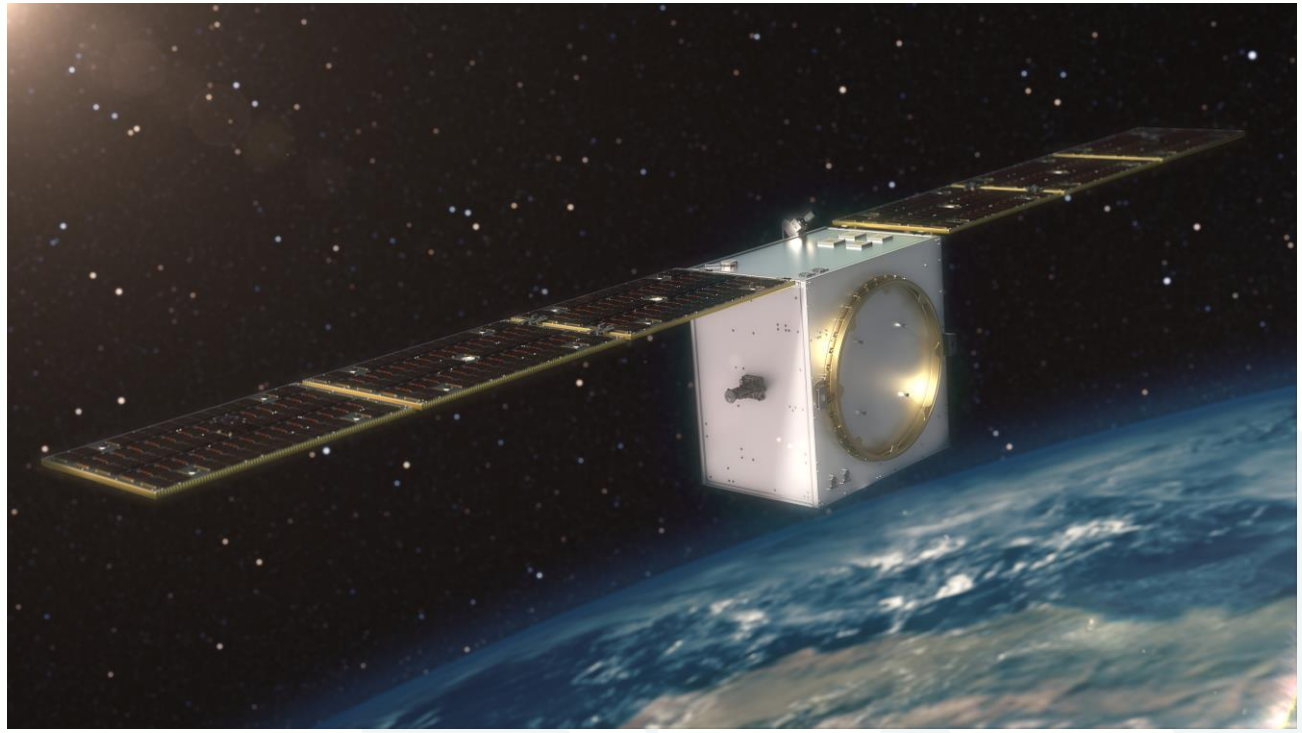

Fig. 6. ISM's Faraday Dragon Rideshare Service platform

IRUS Mission Requirements

1. Service multiple clients with a single servicer.
2. The servicer shall feature a container storage system for replacement units.
3. The servicer shall feature an end-effector compatible with the containers on both sides.
4. The servicer shall upgrade at least one functionality on the client.
5. The client shall integrate a swappable container design for at least one component type.
6. Each client serviced shall be cooperative.

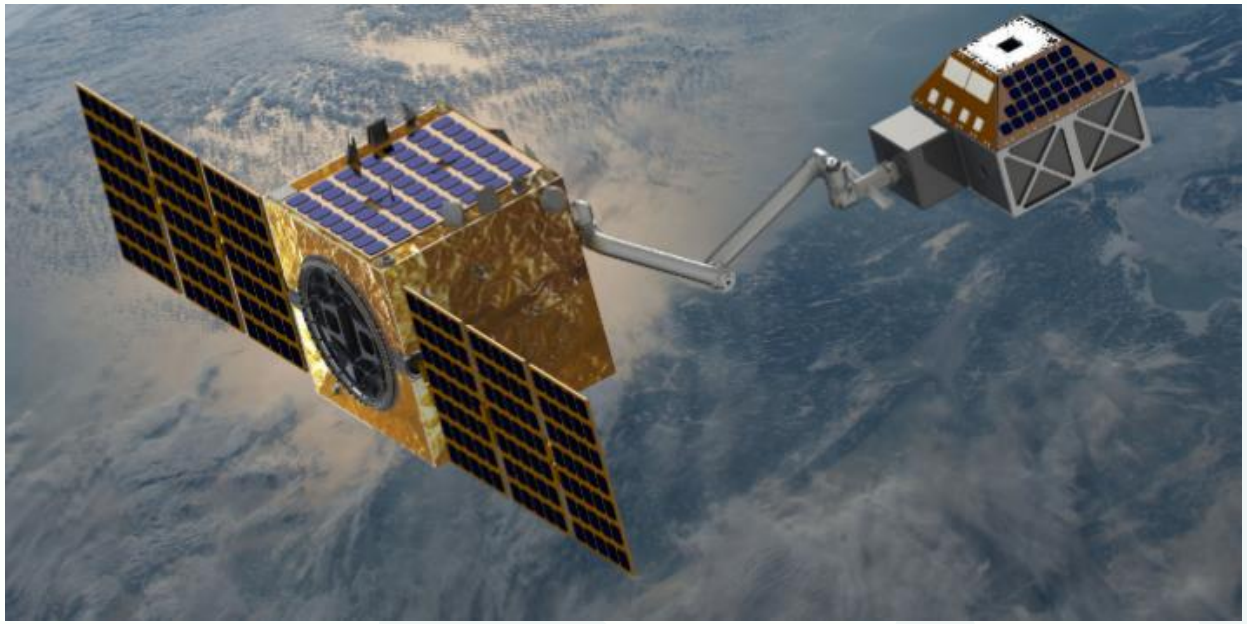

Fig. 7. A rendition of the ASUK servicer replacing a client unit

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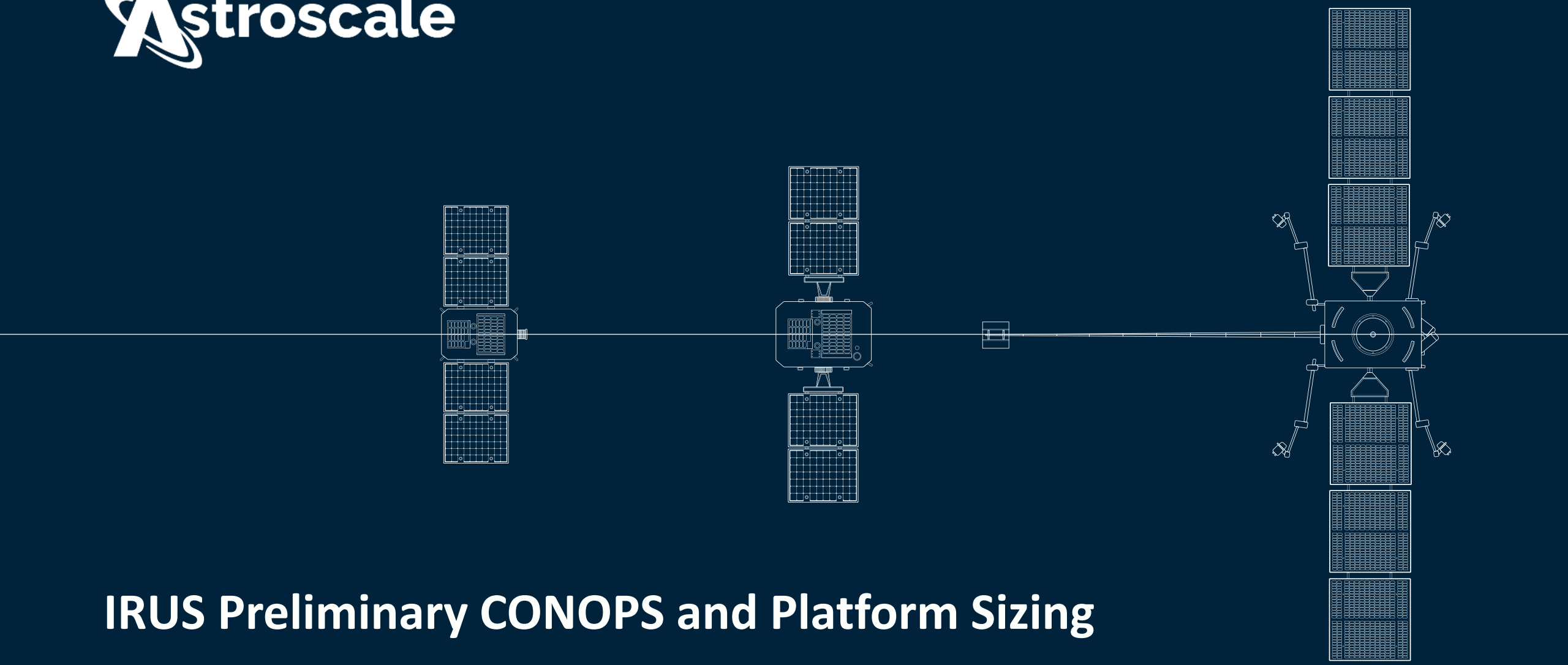

IRUS Preliminary CONOPS and Platform Sizing

IRUS CONOPS

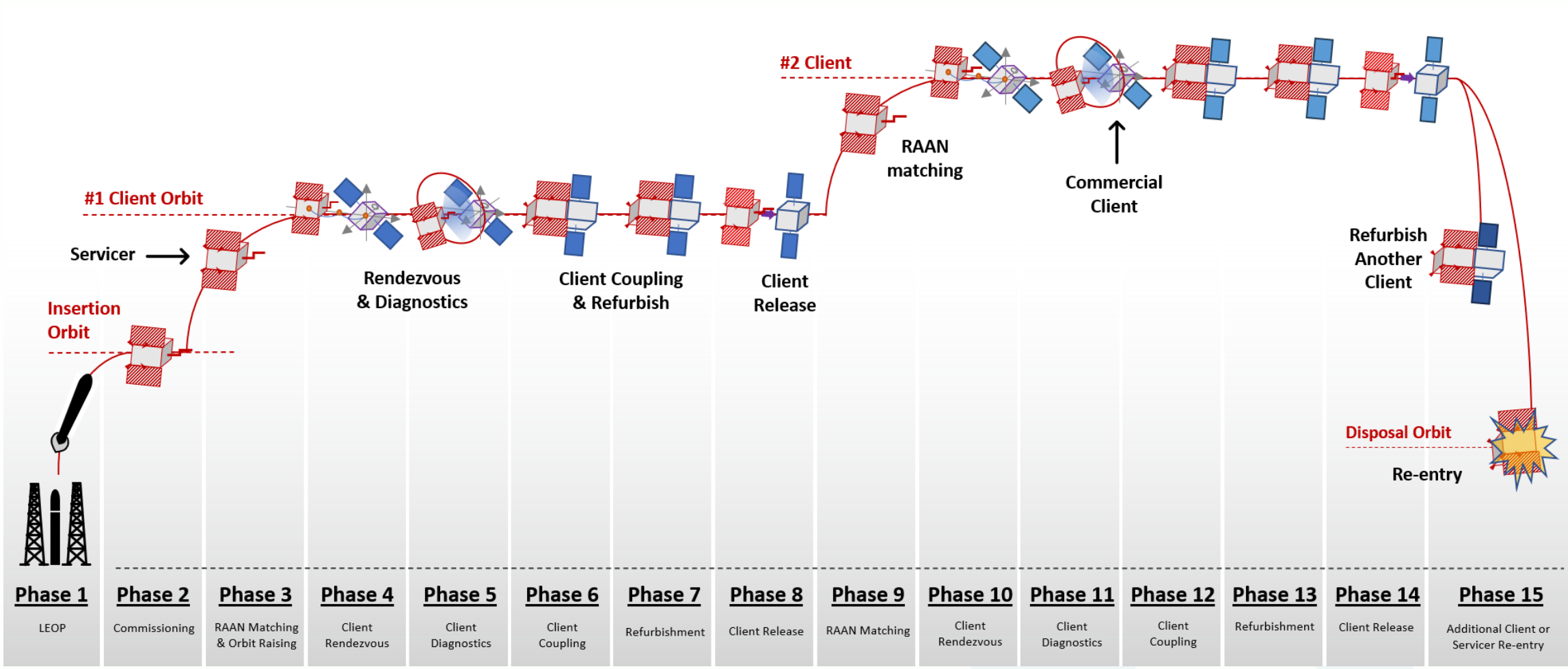

Fig. 8. A first iteration of a refurbishing mission CONOPS

IRUS CONOPS

- There are a few critical aspects to define in order to refine the mission CONOPS:
  - The number and size of clients to be serviced.
  - Their relative orbit altitudes, inclinations and Right Ascension of the Ascending Node (RAAN).
  - The expected client angular rate at docking.
  - Th expected duration of the refurbishment activity.

- This information will provide the details needed to size the servicer and especially the propulsion system.

- Inclination changes are very costly in terms of delta V, while RAAN matching can be achieved through a combination of propellant use and orbit drift.

Video showcasing the RPO sequence for an ELSA-M type servicer

IRUS Platform Sizing

- The servicer is expected to be in the 700 kg mass range with a rough size of 1.5 m per side.

- Depending on the relative orbits of the clients, the servicer is likely to rely on a combination of Electric and Chemical Propulsion that provide the capability for both efficient orbit matching and high energy manoeuvres.

- While the servicer will be based on the COSMIC platform, it will be different in a few key ways:
  - Added capability for container accommodation.
  - The need to have two attachment points to the client instead of one.
  - Different requirements on the docking system and on the refurbishing manipulator.
  - Potential requirement for direct communication to the client spacecraft.

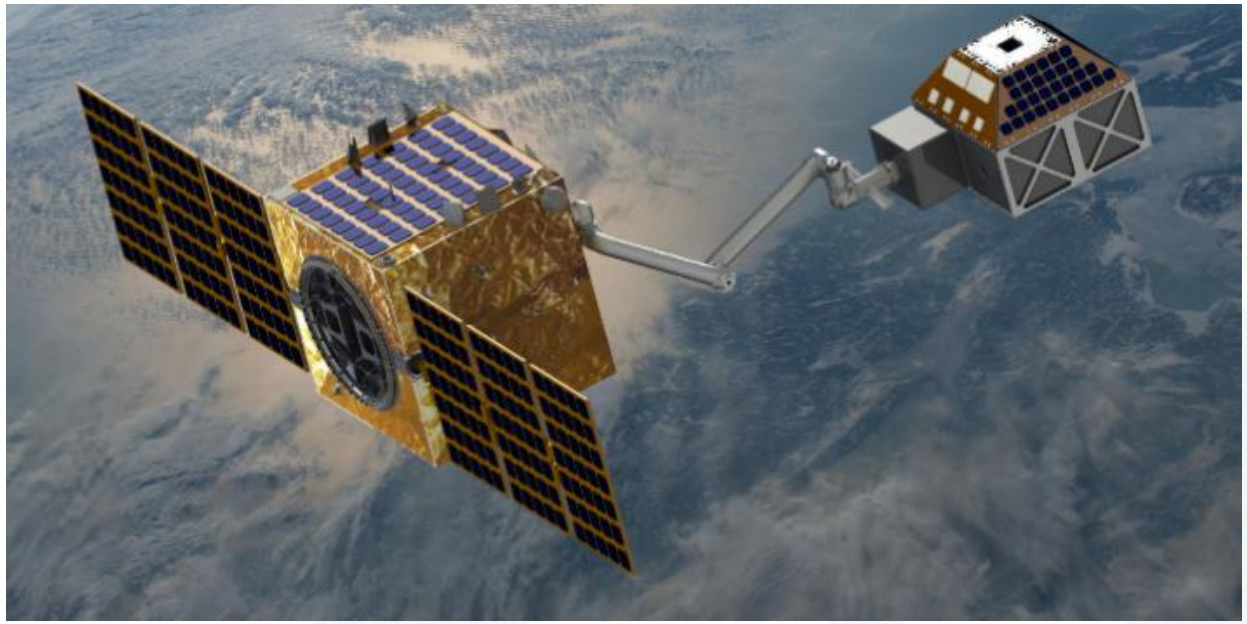

Fig. 9. A rendition of the ASUK servicer replacing a client unit

IRUS Client Sizing

- For an ISM spacecraft to be serviced, the existing platform design will need to be modularised to enable upgrading.
- The structural design of the client could feature permanent containers and modules with a rail system that allows the modules so slide in and out of a container.
- For power and data transfer, wireless and inductive interfaces could be used to connect the modules. A connectorized approach is also considered when high throughput is necessary.

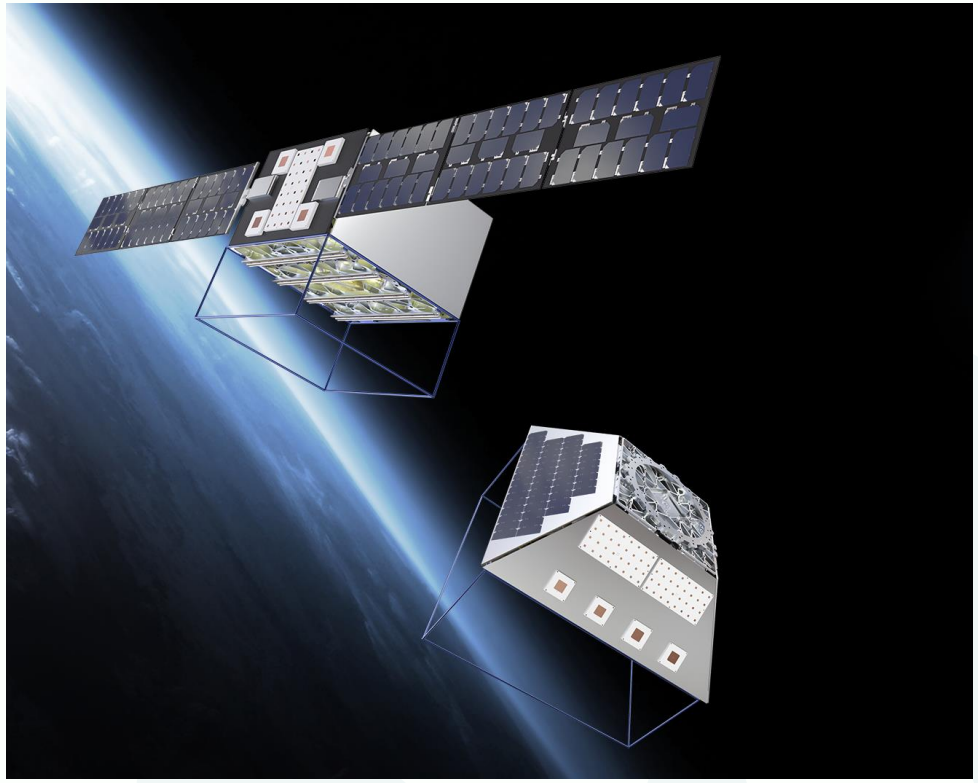

Fig. 10. ISM Rideshare platforms

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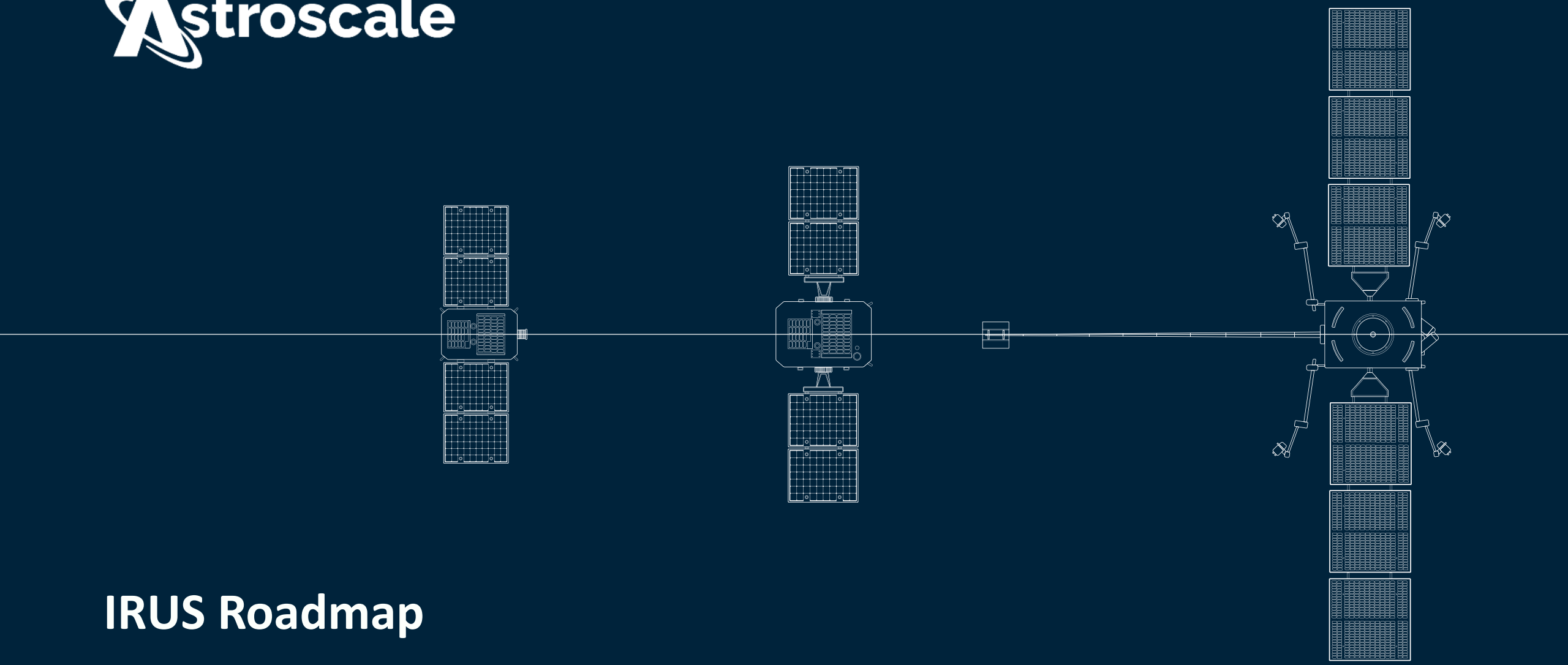

IRUS Roadmap

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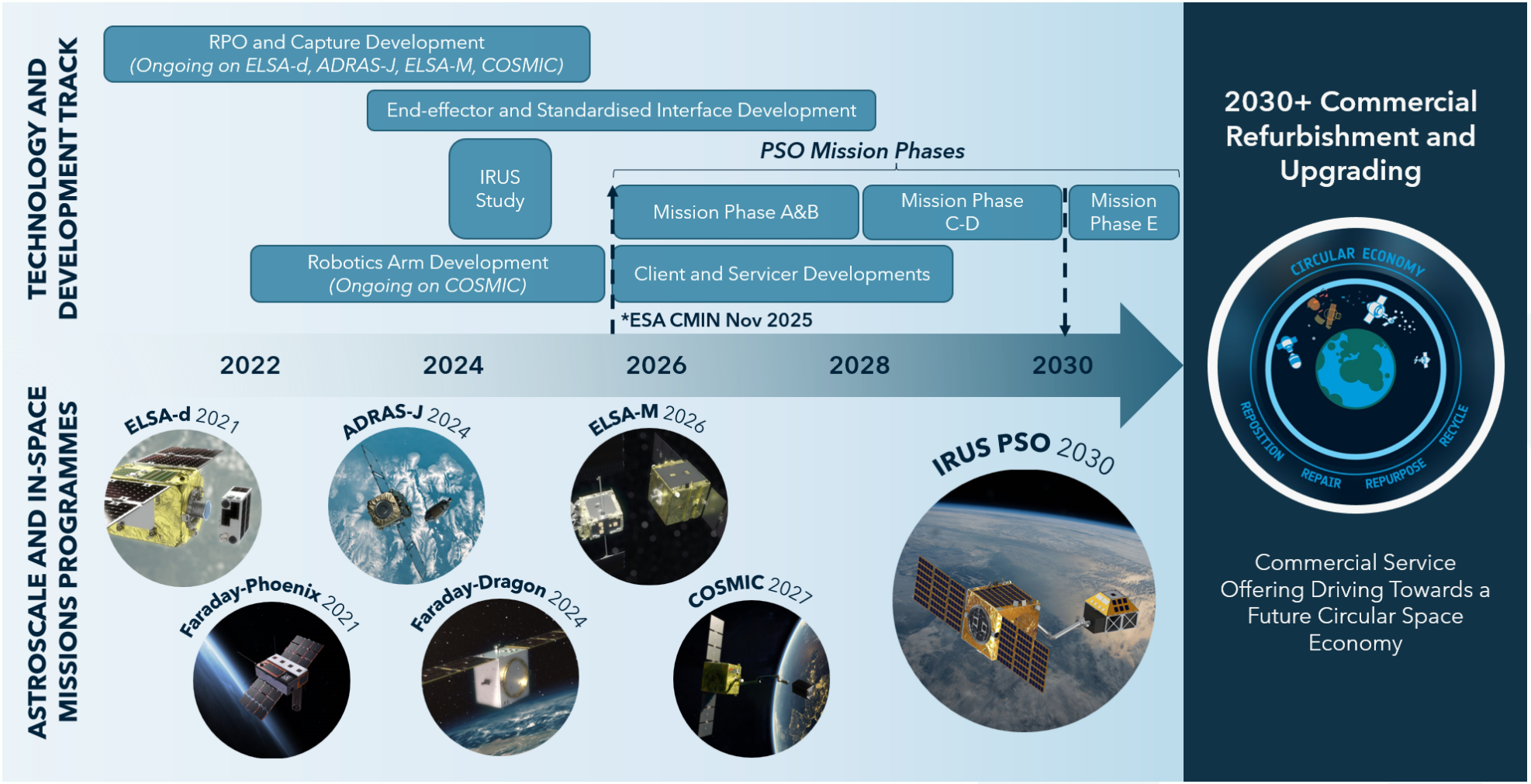
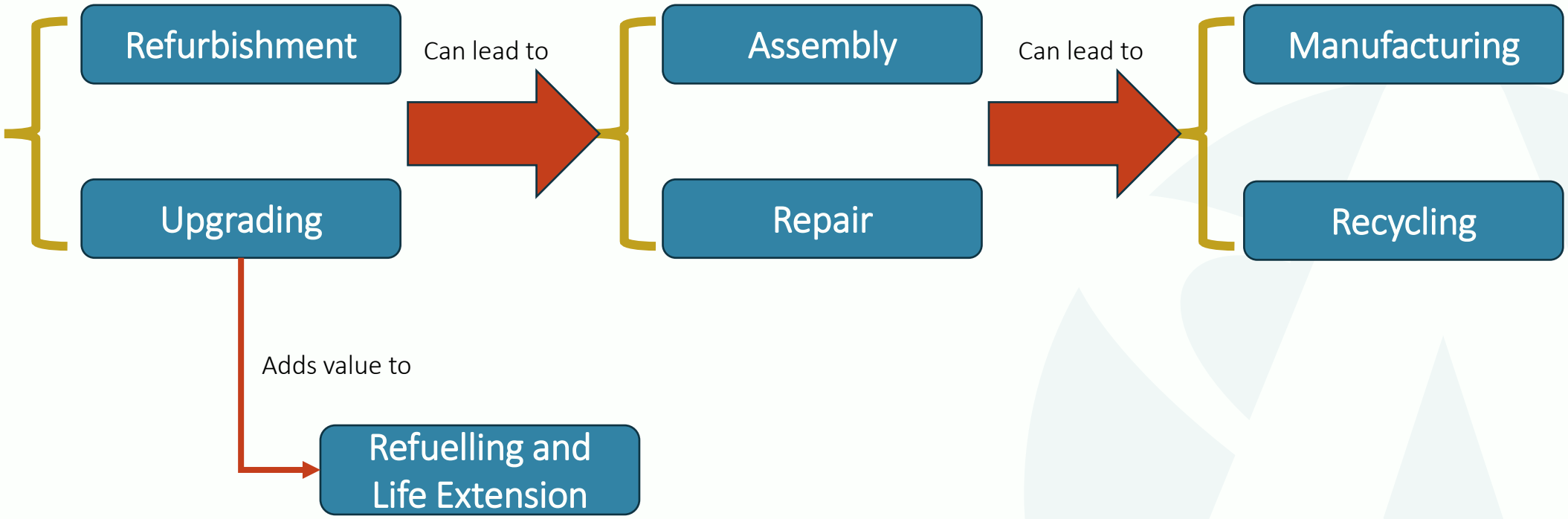


Fig. 11. A roadmap including a Preliminary Service Offering (PSO) that highlights the parallel Astroscale and ISM developments

IRUS Roadmap

Refurbishment and upgrading can add value to refuelling and life extension services, while leading into areas such as in orbit assembly and repair. Ultimately, this can all progress towards in orbit manufacturing and recycling, truly tying this work to the pillars of a Circular Economy in Space!



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Thank you for your attention!
Q&A time!

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