Astroscale

esa

Leading the development of LEO Refuelling

Keeping legacy missions flying and enabling the future of commercial and sustainable LEO IOS services

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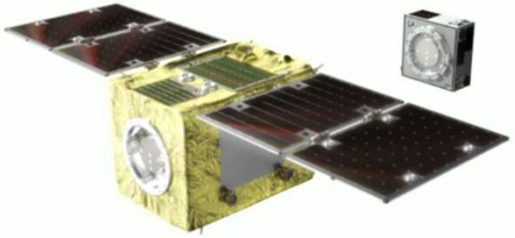
NammoMDA

ThalesAlenia Space
a Thales / Leonardo company

gmv
INNOVATING SOLUTIONS

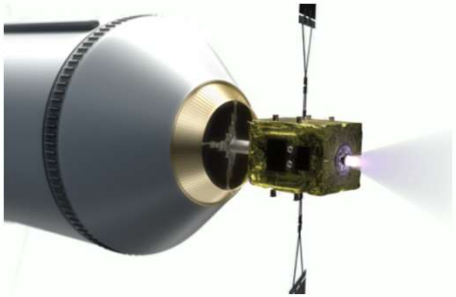
Company Vision and Services

Astroscale is developing innovative and scalable solutions across the spectrum of on-orbit servicing, while creating a sustainable foundation for the growth of the space economy in the process



End-Of-Life *for defunct satellites pre-engineered for servicing*

Life Extension *to keep GEO satellites in operation after fuel depletion*



Active Debris Removal *of large, non prepared threatening debris currently in orbit*

In Situ Space Situational Awareness / Inspection *to diagnose and characterise objects*

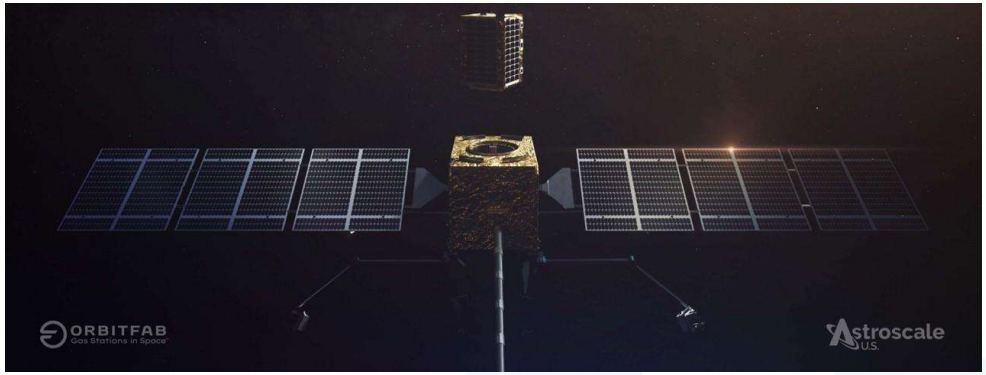
Refuelling Landscape

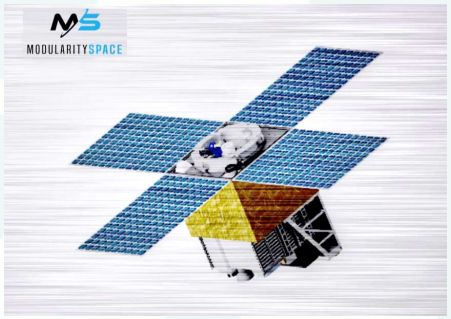
GEO Refuelling and Life Extension missions are under development, e.g. Astroscale, Orbit Fab, Northrop with high value GEO clients.

LEO Refuelling is less studied, but has potential to service two key markets:

- Large LEO Clients (typically large remote sensing satellites)
- The growing IOS market (modular craft, space tugs, In-Space Logistics, debris removal, etc.)

Astroscale is developing a family of LEO servicers (ELSA) and is well positioned to realise this service.





LEO Refuelling by Astroscale will keep legacy missions flying and enable the future of commercial and sustainable LEO IOS services

LEO Refuelling Value Proposition

Refuelling in LEO ***is a critical component to unlocking the In-Orbit Services*** *and a driver of the IOS economy. Refueling will enable other key IOS services and is key technology to future growth.*

REDUCE LAUNCH MASS

EXTEND OPERATIONAL AND REVENUE GENERATING LIFETIME

GIVE FLEXIBILITY TO THE OPERATORS

INCREASING VALUE DUE TO COLLISIONS AVOIDANCE DEMAND

OPENS UP NEW CONCEPT OF OPERATIONS

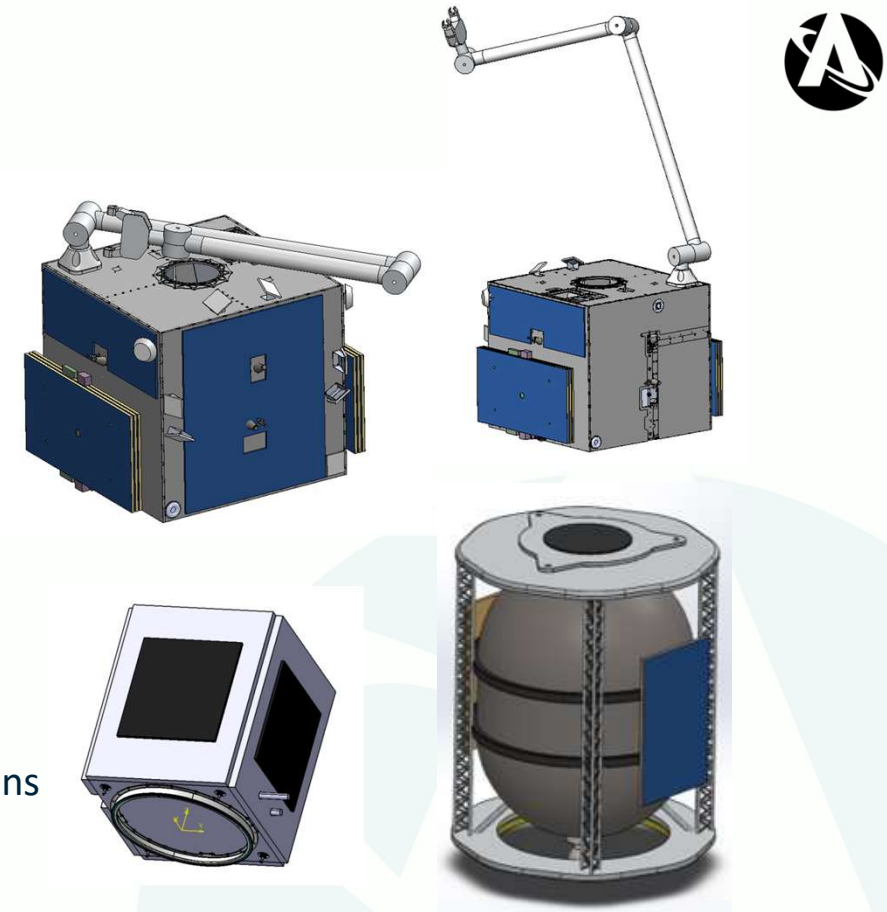
DEMONSTRATE RESPONSIBLE BEHAVIOUR

Concept Overview

The Refuelling Service consists of two key Space Segment Elements

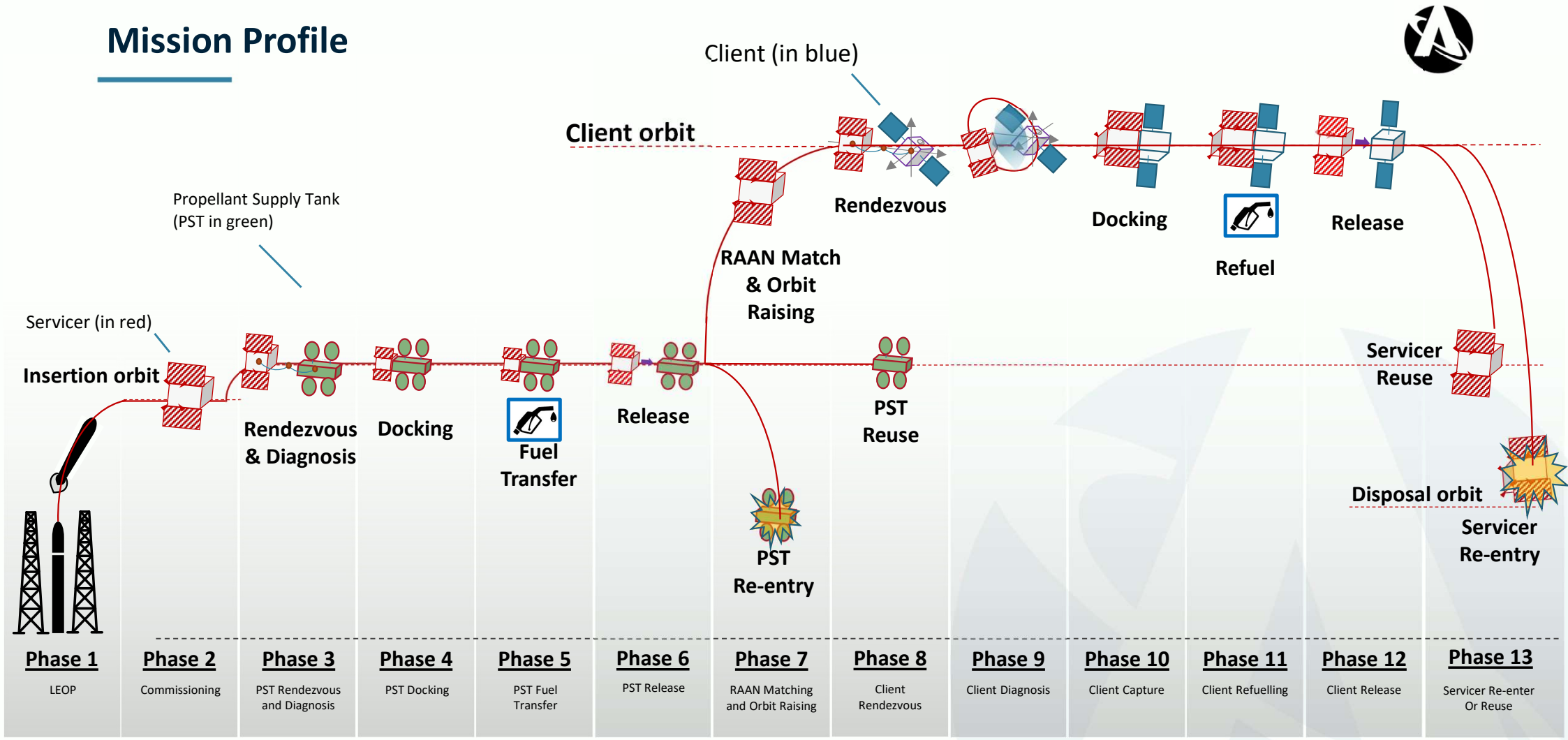
- **Refuelling Servicer** is a modified version of ELSA-M with the addition of:
  - Robotic arm and manipulator
  - Refuelling subsystem to enable refuelling

- **Propellant Supply Tanks (PST)** are simple spacecraft that provide a fuel source and a mix of sizes are likely for final commercial service infrastructure
  - Large multi-use tanks to support multiple refuelling missions
  - Smaller tanks for targeted refuelling



The servicer, using Astroscale's advanced Rendezvous and Proximity Operations (RPO) capabilities, collects fuel at a depot and delivers it to a client

Mission Profile



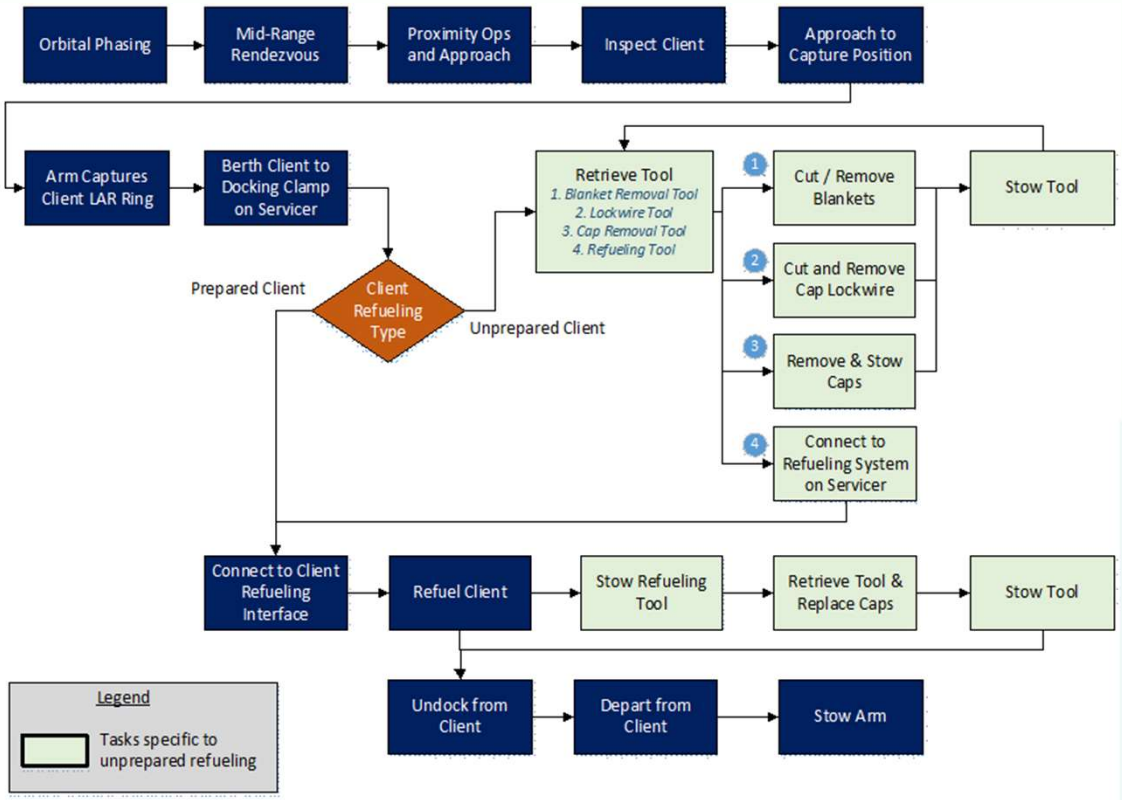
Technical Considerations

- **Mission durations** are at least **8 years**, typically able to **refuel 2-4 clients** per mission (depending on relative orbits).
- Initially, the system will refuel client satellites with **monopropellant hydrazine** using and **one or more propellant supply tanks** to replenish the servicer

Expertise already existed in our consortium to deal with **prepared interfaces** to support **future clients**.

During this phase, we have focussed on examining how to refuel **unprepared satellites** to also support **legacy clients**, i.e. by accessing the fill and drain valves and prepared client interfaces.

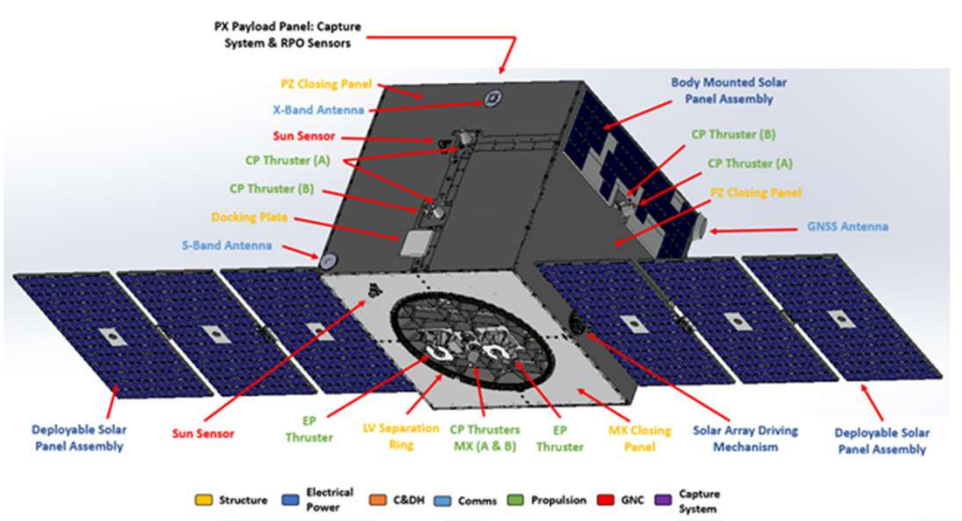
ESA ASSIST Fuel Coupling



Mission Design - Refuelling Servicer

The refuelling mission would strongly leverage our ELSA-M heritage to ensure a low-risk and cost effective system

- The servicer is a **modified version of ELSA-M**
- ELSA-M is designed to provide **End-of-Life (EOL) services for multiple prepared clients**, fitted with Docking Plates.
- Astroscale has been working with **OneWeb**, for **over 4 years** and have recently **secured funding to design and manufacture the ELSA-M** servicer working with OneWeb, the European Space Agency and UK Space Agency through the Sunrise programme
- IOS Refueling Servicer capable of refuelling satellites at commercially viable price



ELSA-M Servicer (as presented in 2021 IAC paper)

ELSA-M Adaptations

Key areas that would need to be developed on ELSA-M for the refuelling variant are as follows:

- Addition of a **robotic arm** and a **docking and capture mechanism**.
- An upscaling on the ELSA-M **structure**, **power subsystems** and **AOCS actuators** to facilitate the new robotic arm.
- Updates to the **GNC** and **AOCS** to reflect new operations.
- **Refuelling adaptations and components**.

Study Consortium

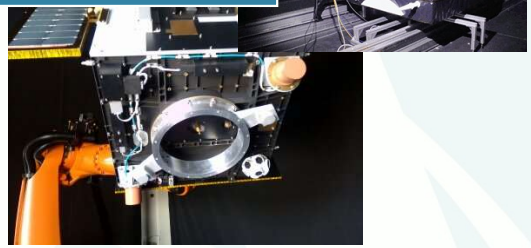
Astroscale Ltd. – Prime, Servicer Lead, Service Provider and Ground Segment Lead

Thales Alenia Space – Propellant Supply Tank and Potential Intermediary Customer

Nammo – Fuel transfer Mechanism and Refuelling Interfaces (knowledge of customer interfaces)

MDA – Robotics for Servicing/Manipulator Arm and Capture/Docking Mechanism

GMV – Test Bed Development and GSE

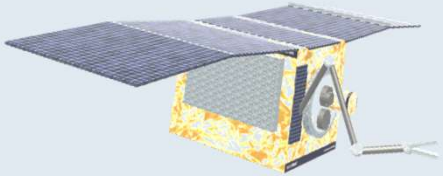


Existing unprepared large LEO satellites

Primarily institutional missions and large EO clients

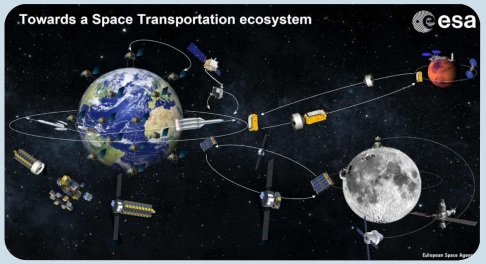
Future prepared large LEO satellites & IOS vehicles

Adoption of refuelling interfaces in institutional and commerical missions



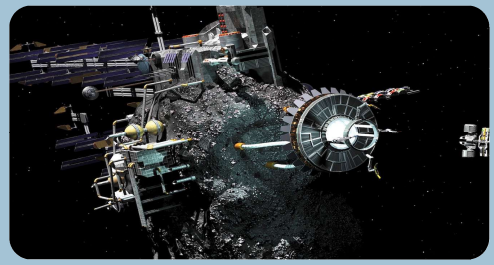
Space Transportation ecosystem

A large infrastructure with multiple fuel depots of different sizes



In-orbit Manufacturing

In-orbit satellite production and established large scale in-orbit infrastructure.



2022 2025 2028 2030

Nascent market and expected to mature by 2030

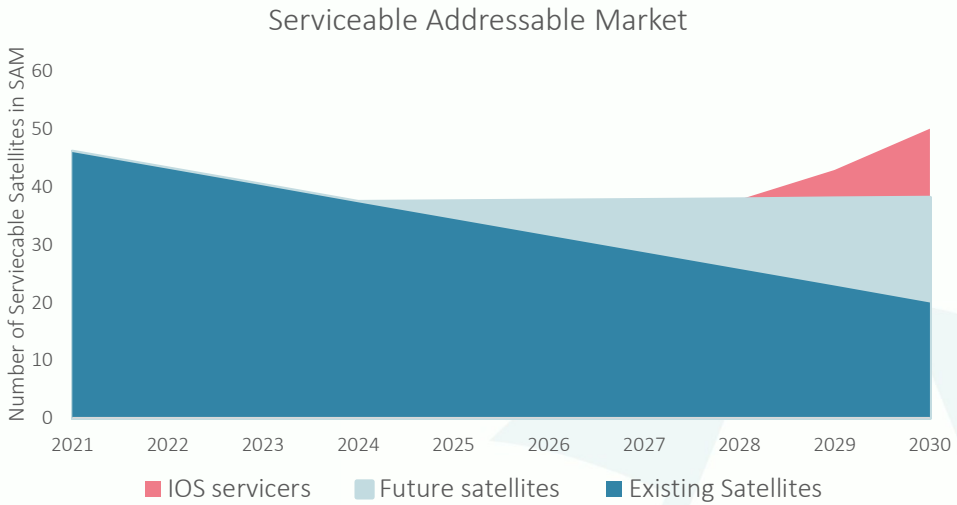
Market Analysis

Target Customer:

1. Existing unprepared large LEO satellites
2. Future prepared large LEO satellites
3. In-orbit servicing vehicles

Demand from customers

Large LEO providers signal interest in refuelling services in LEO and numerous IOS service providers have announced that their vehicle will be prepared for refuelling and the ability to refuel is crucial to their business case

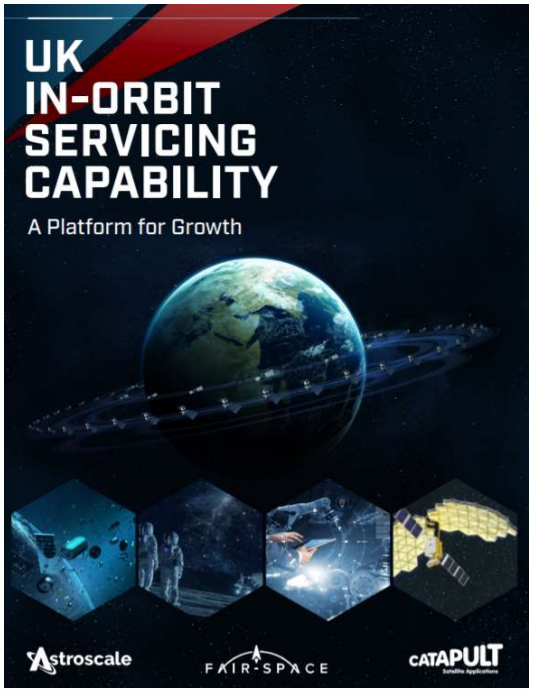


NSR's In-Orbit Services Report Projects $14.3 Billion in Revenues as Non-Geo Constellations Grow Demand

NSR's *In-Orbit Services: Satellite Servicing, ADR, and SSA, 5th Edition (IoSM5)*

Leading the development of LEO Refuelling

"As the race to launch Non-GEO Satellite Constellation grows, thousands of satellites are set to launch through the coming decade growing demand for IoS" – NSR's *In-Orbit Services: Satellite Servicing, ADR, and SSA, 5th Edition (IoSM5)*



*"We **welcome all efforts, public and commercial,** in debris removal and **on-orbit servicing** activities and undertake to encourage further institutional or industrial research and development of these services."* – G7 nations commit to the safe and sustainable use of space

Preliminary timeline for initial IOS refuelling development targets a **launch before 2027** for the proposed first of kind service.

Developing our capabilities and building towards **full commercial refuelling services by late 2020s / early 2030s.**

By average

990

satellites to be launched

every year by 2028

Source: Euroconsult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