

Space Circular Economy

Knowledge Exchange Webinar

Antonio Caiazzo and Calum Turner
On behalf of ESA Cleanspace Team

30/01/2025

- 10:00 - 10:20 CET **ESA Introduction** Antonio Caiazzo
- 10:20 - 10:40 **Astroscale** Adrian Dumitrescu & Nina Wyniawskij
- 10:40 - 11:00 **Growbotics** Chris Brunskill & Rob Brennan-Craddock
- 11:00 - 11:20 **Kinetik** Maximo Roa
- 11:20 - 11:40 **Thales Alenia Space** Gautier Durand
- 11:40 - 12:00 **ESA Wrap-up** Antonio Caiazzo/Calum Turner

ESA Moderators



Ross Findlay
Systems Engineer
Concurrent Design Facility



Antonio Caiazzo
Systems Engineer
Clean Space Office



Calum Turner
Systems Engineer
Clean Space Office

ESA's Vision for a Space Circular Economy

Antonio Caiazzo, on behalf of the ESA Cleanspace Team

30/01/2025



Zero Debris Approach

By 2030



Implement a **net zero pollution** strategy for objects in space, by consistently and reliably removing them from valuable orbits around Earth immediately after they cease operations



By 2050



Circular economy in space:
Assembling, Manufacturing, Recycle

**Current focus: Paving the way for a
Circular Economy in Space**

Enabling technologies for in-orbit manufacturing, refurbishing and recycling



IOS
globally

USA

- Northrop Grumman MEV-1, MEV-2 launched in 2019/2020 (*AOCS-takeover of GEO sats*)
- Northrop Grumman next generation servicer (MEP incl. pods) by 2024
- NASA's OSAM-1 (*refueling, NASA cancelled it*) and OSAM-2 (*additive manufacturing, concluded*)

China

- Shijian-21 apparently captured COMPASS-G2 in GEO in Jan 2022 (*debris removal*)
- The State Council Office of the PRC released a White Paper in January 2022 for Space Activities from 2022-2025 with an emphasis on IOS

Russia

- Launched an inspection mission in GEO in 2017

Japan

- Launch of ADRAS-J (*in-orbit inspection*) and inspection of the target (H-IIA R/B)





Europe is Behind

Verification of In-Orbit Servicing outside Europe

Technical and commercial verification of in-orbit servicing has been demonstrated

e.g. Intelsat & Optus procuring/implementing IOS services from a service provider

Potential Loss of European Market Share

US based IOS service providers are proposing solutions to European operators, answering the growing need for life extension & EOL services, representing a loss of European market share.

→ IOS has been technically and commercially verified outside Europe

→ ESA and European industry need to act now to establish future IOS activities

ESA activities - 5 Elements of IOS

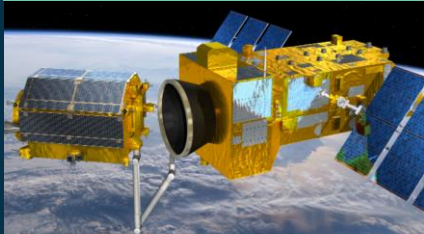
Mission Implementation



Purpose: To implement Near Term IOS Opportunities:

- ADR and IOS Missions
- In-Space Transportations Missions

In-Orbit Servicing System Studies



Purpose: To Define Long-Term In-Orbit Servicing Missions:

- Assembly
- Manufacturing
- Refurbishment
- Recycling
- Refueling

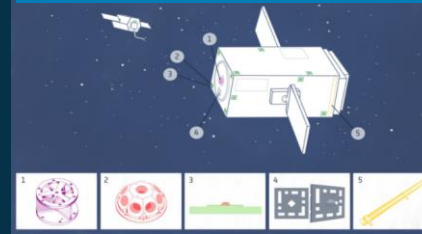
Technology Developments



Purpose: To prepare technologies for future IOS mission concepts:

- Capture systems
- Rendezvous and close-proximity equipment
- Test Facilities

Standardized Servicing Interfaces for Future Platforms



Purpose: To prepare future ESA missions:

- Capture interfaces
- Rendezvous markers
- Requirements
- Refueling interfaces

Safe Close Proximity Operations



Purpose: To derive a methodology for ensuring sustainable close-proximity operations:

- Guidelines
- Handbook
- Verification Tools



In-Orbit Servicing, Assembly and Manufacturing Working Group mapping activities across the Agency

IOS Vision

In-Orbit Servicing

DEBRIS REMOVAL



ClearSpace-1 (S2P)



ELSA-M (CSC)



CAT-IOD (S2P)

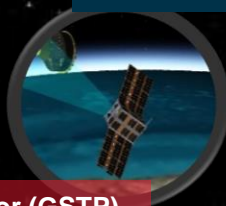


ERASE (ESA-EUM)

RENDEZVOUS & DOCKING



InSPoC-1 (STS)



e.Inspector (GSTP)

2026+

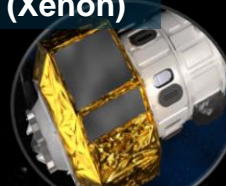
ADR and In-Space Transportation Preparation & Missions

REFILLING (Cryogenic)



InSPoC-2 (STS)

REFUELING (Xenon)



ESPRIT - ERM (HRE)

AOCS TAKEOVER



RISE (S2P)



ENCORE (S2P)

2030+

IOS Preparation & Missions

ON-BOARD INTELLIGENCE



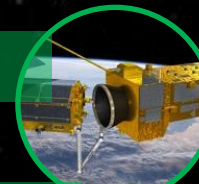
InSPoC-3 (STS)

STORAGE



InSPoC-4 (STS)

REFURBISHMENT



MANUFACTURING



RECYCLING



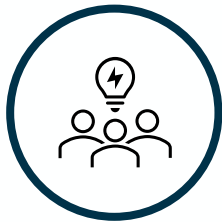
2035+

Circular Economy Preparation & Missions

Missions

Space Circular Economy Campaign

Motivation



- Build consensus for priorities on circular economy activities in the short-medium term
- Objective is to build case for procuring future activities



- Build consortiums and lobbying
- Prepare proposals for the next Council of Ministers in 2025

Current studies – Space Circular Economy system studies

ESA is funding 4-5 new 100 k€ studies to investigate mission concepts for future circular economy space systems capable of providing **on-orbit refurbishment, manufacturing, and recycling** in Earth orbit. A campaign to gather proposals was launched on the OSIP platform in January this year.



Refurbishment is the servicing of an existing satellite by replacing current aged or non-functional parts by new equivalent ones.



Manufacturing is the manufacture of s/c parts on-orbit starting from raw material and/or basic components coming from Earth and/or from on-orbit recycling.



Recycling is the capacity to process materials/parts already in space, from old spacecraft or space debris, into usable raw material for the manufacturing of new equipment/parts

Selection Criteria



Relevance for circular economy in space



Novelty and disruptive potential



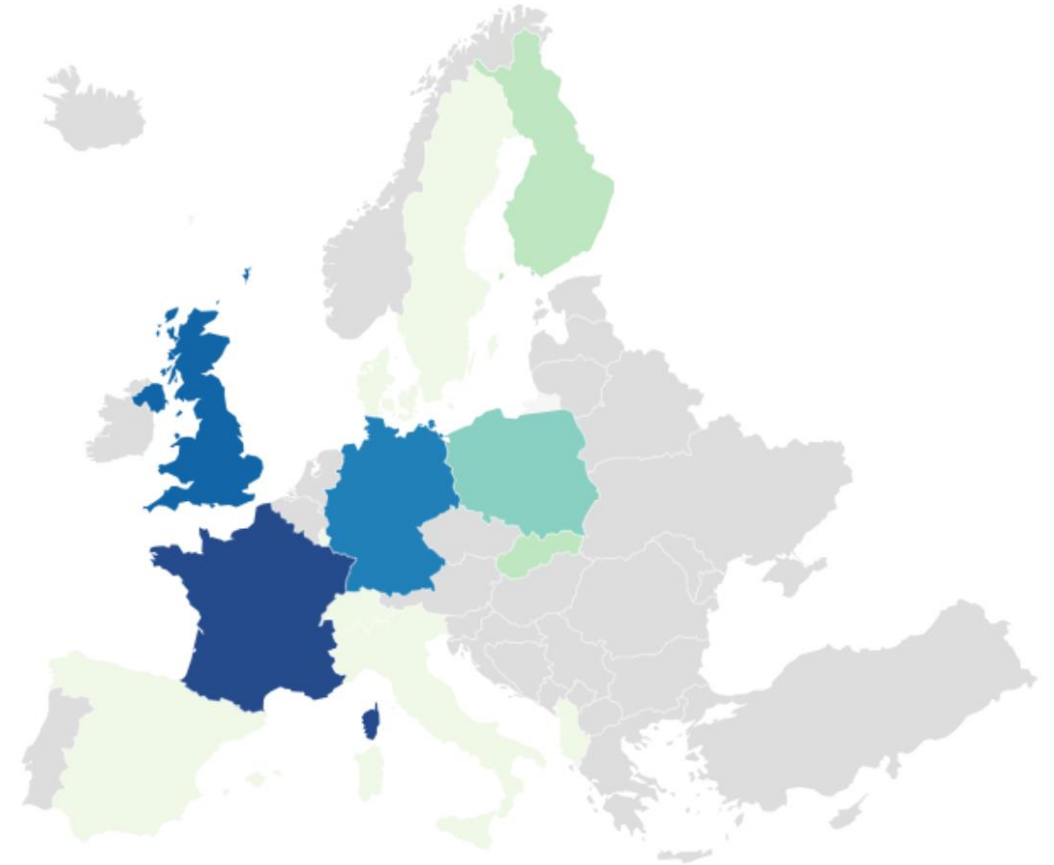
Technical and programmatic feasibility

Space Circular Economy Campaign – Submissions

- **36 ideas received** from 13-member, cooperating, or associate states
- **10 proposals** requested for the second round
- **4 proposals** accepted for industrial contracts

Number of Ideas Submitted

Ideas submitted to ESA's System Studies for the Circular Economy in Space OSIP campaign.



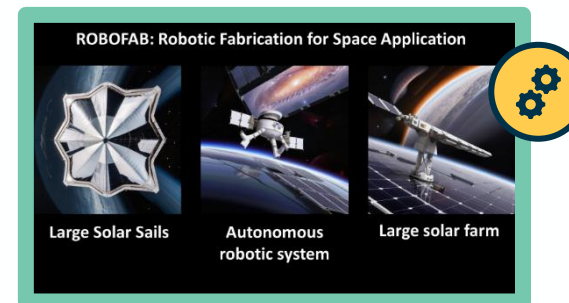
OSIP Campaign Summary	
Member or Contributing State	Number
Poland	3
Slovakia	2
United Kingdom	7
France	9
Finland	2
Germany	6
Italy	1
Canada	1
Spain	1
Sweden	1
Switzerland	1
Denmark	1
Luxembourg	1

Space Circular Economy Campaign – Proposals

Selected proposals: 4 activities started in September 2024.



Astroscale (UK)
Satellite Refurbishment and Upgrading Services for Orbital Sustainability



KINETIK Space (DE)
Robotic Fabrication for Space Applications

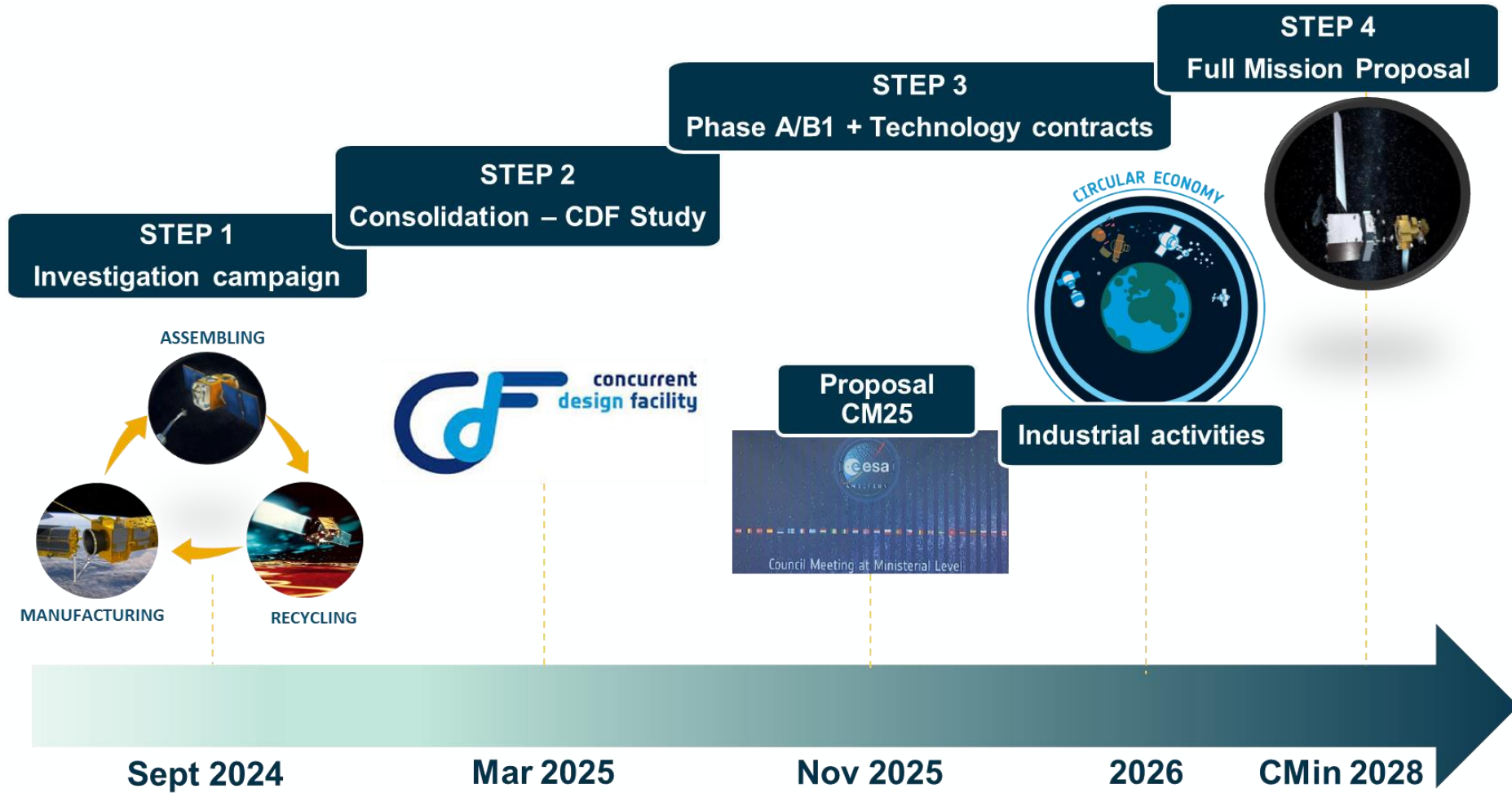


Growbotics (UK)
LOOP: commercial refurbishment mission of a spacecraft in GEO



Thales Alenia Space (FR)
Recycling Space Plant

Roadmap for Space Circular Economy



CM25 : 2 phase A/B1 ADRIOS follow-up missions + technology maturation – 5-10M€
CM28 : phase B2 - E mission proposal

Thank you!

