SPACE SCAVENGERS

MANAGED RECYCLING ORBIT OPERATED AS A MULTI-AGENT SYSTEM

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Circular Economy in Space

Space scAvengers entered the space industry to create **sustainable, long-term solutions** for debris management and in-orbit servicing

Inspired by the circular economy model where waste becomes a resource, leading to reduced launches from Earth and in-orbit sustainability

ESA's Open Space Innovation Platform (OSIP)

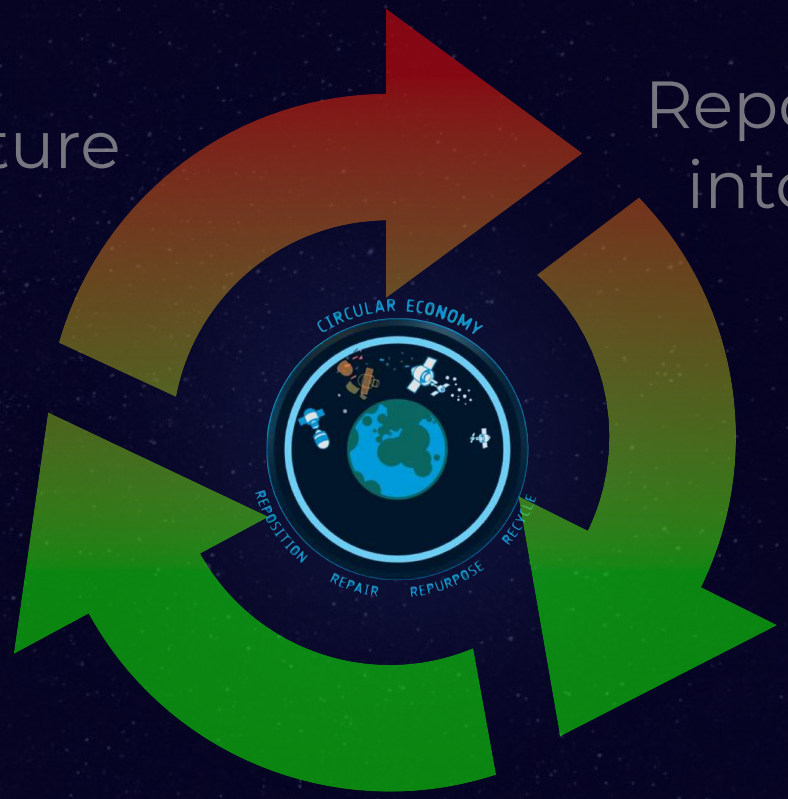
Proposal selected as part of the **System Studies for the Circular Economy in Space** initiative

Idea: Managed Recycling Orbit operated as a Multi-Agent System

Objectives

Develop a mission concept that integrates **space debris capture, repositioning, and recycling** in a dedicated orbital zone using **multi-agent systems**

Engage stakeholders and identify future use cases for in-orbit recycling



Idea: Managed Recycling Orbit operated as a Multi-Agent System

Consortium

Space scAvengers	Mission design, payload, GNC algorithms, and simulation
Telespazio Germany	Business model, ground segment and operations services
Czech Aerospace Research Centre	Satellite platform definition and specification

Space scAvengers

TELESPAZIO
a LEONARDO and THALES company

CZECH AEROSPACE RESEARCH CENTRE

Integration with InsPOC3 “Onboard and shared Intelligence"

Synergy with ESA’s program on close proximity operations, expanding from simple rendezvous to full autonomous recycling

Three Pillars of the Managed Recycling Orbit Concept

Dedicated Orbital Zone

Managed Debris Constellation

Multi-Agent Cooperative Systems

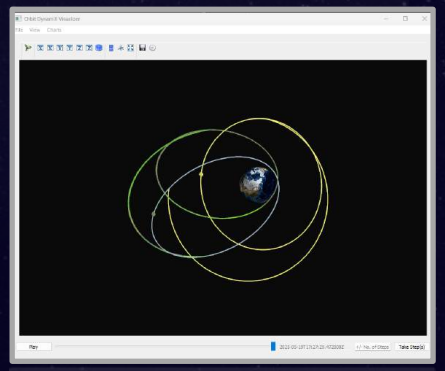
+ Ground-based Junkyard Orbit Operator

Transforming waste into **cooperative objects** for future reuse

Dedicated Orbital Zone

Dedicated Space for Debris

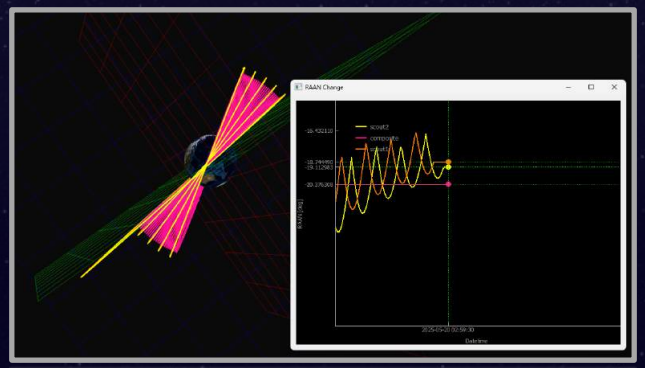
A specific orbital zone where debris is collected, processed, and recycled, creating a sustainable environment for debris management



Managed Debris Constellation

Repurposed Debris as a Resource

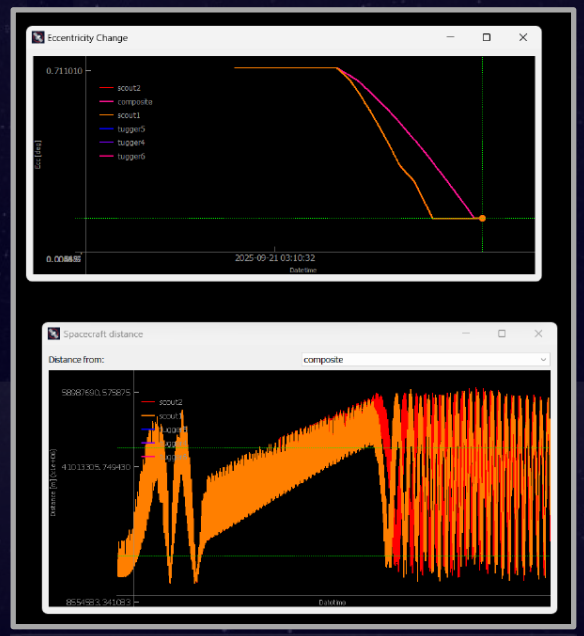
Managed constellation of defunct objects serves as the infrastructure for future space operations, enabling in-orbit manufacturing and construction



Multi-Agent Cooperative Systems

Autonomous Debris Management

Multi-agent spacecraft autonomously capture, transform, and reposition debris, enhancing operational efficiency and safety in space



Ground-based Junkyard Orbit Operator

Earth-based Control Hub

The Junkyard Operator manages and optimizes the entire debris handling process, supporting future services like in-orbit repairs and satellite recycling

CONOPS

Space debris

f.e. rocket body upper stage (ESA-A; EPS L9; ...)

MAS Fleet - Swarm Squad composed of Micro-satellites with various functions

Scouts

Inspection and GNC support

Vultures

Uncooperative / unprepared debris capture; In case of prepared debris, Dockers can be used

Tuggers

High delta-V / high mass transfers

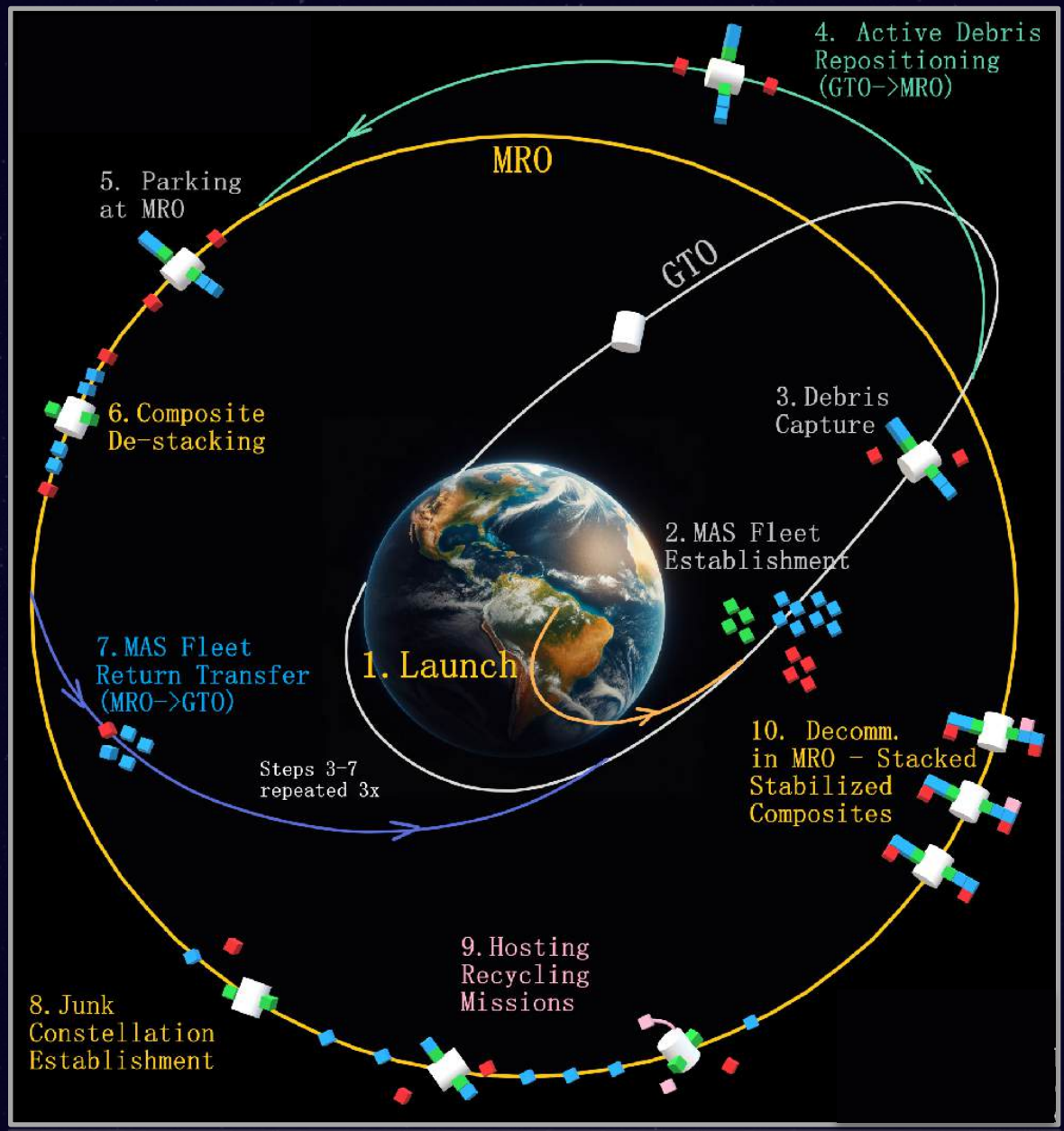
MAS Agents are capable to create stacks through docking.

Vultures remain connected to debris to secure cooperativness and prepardness of the composite

The new European FEEP propulsion system with gas propulsion system preliminary selected and evaluated as feasible solution.

Client Chaser

During hosted recycling mission



Enabling Technologies

Platforms

Microsatellite platforms with **hybrid propulsion systems** (electric + cold gas) provide high versatility, allowing efficient debris capture and repositioning

Modular, enabling agents to work cooperatively

Payloads

Robotic arms and **capture mechanisms** for handling debris, coupled with advanced sensors for precise manipulation

Sensors: LiDAR, cameras for real-time debris tracking and **collaborative perception**

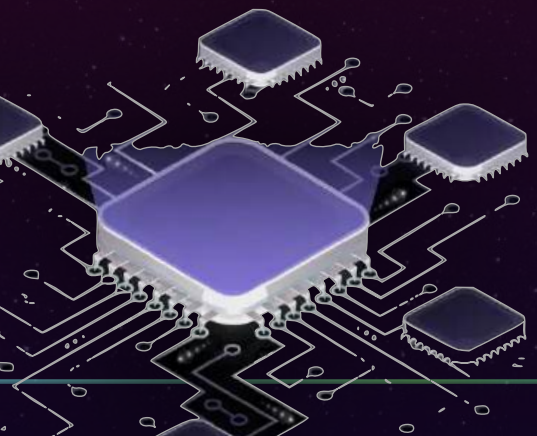
Ground Segment

Ground segment using predictive **simulation tools** for mission planning and real-time telemetry systems

existing

emerging

Shared Intelligence



Distributed intelligence for real-time decision-making

Supported by supervized autonomy and telemetry

Enabling Development

Simulation Environment for Collaborative Space Mission Planning

Access and Usability

Web based access

Comprehensive **Documents Library**

Marketplace for Spacecraft Components

real parts such as buses, propulsion systems, robotic arms, sensors ...

Matchmaking System

find and connect with compatible space systems and services

Advanced Mission Planning and Analysis

Mission Analysis based on **CONOPS**

AI Assistance

help with mission setup and results analysis

Contact Dynamics

contact physics between spacecraft

Orbital Physics

Close Proximity Operations (CPO)

tools for simulating spacecraft rendezvous and docking maneuvers

Control Algorithms Training

integrated machine learning and AI for GNC for collaborative missions

Simulation and Integration

Digital Twin Creation

SW-Centric Mission Preparation

Multi-Agent Systems

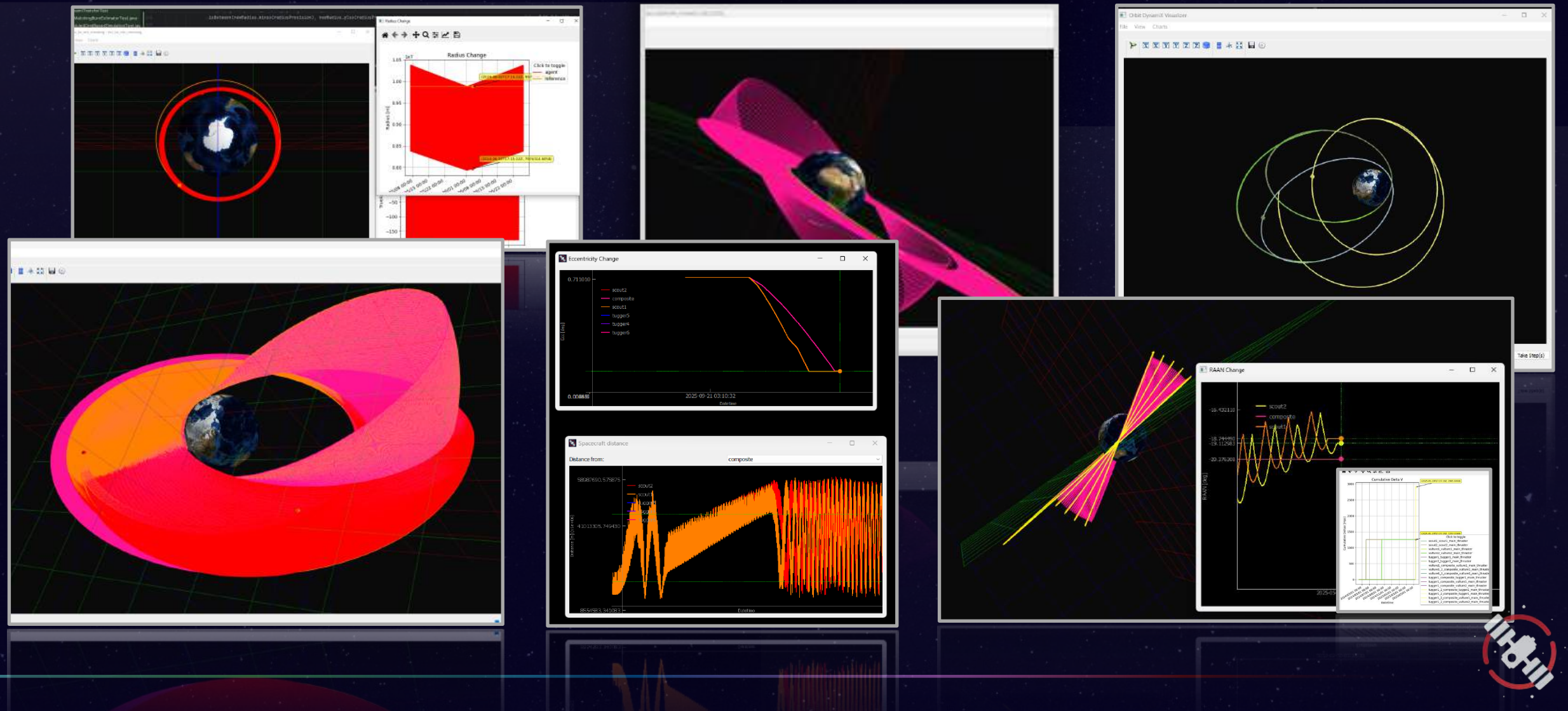
HW In-the-Loop Simulations

Shared Intelligence

collaboration between multiple spacecraft

Enabling Development

Simulator and Platform for Space Mission Planning



… a little **Call for Action**

WE INVITE COMPANIES INTERESTED IN IN-ORBIT SERVICES TO

JOIN US

AND HELP SHAPE FUTURE
OF COLLABORATIVE MISSION PLANNING

- **Share** your **spacecraft capabilities** and **functional details**
- **Contribute your expertise** in satellite technologies
- **Bring your spacecraft solutions** to multi-agent system
- **Co-create** next-generation in-orbit services with our innovative platform
- **Participate in trials and be an adopter of in-orbit servicing missions planning**

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Unlocking

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