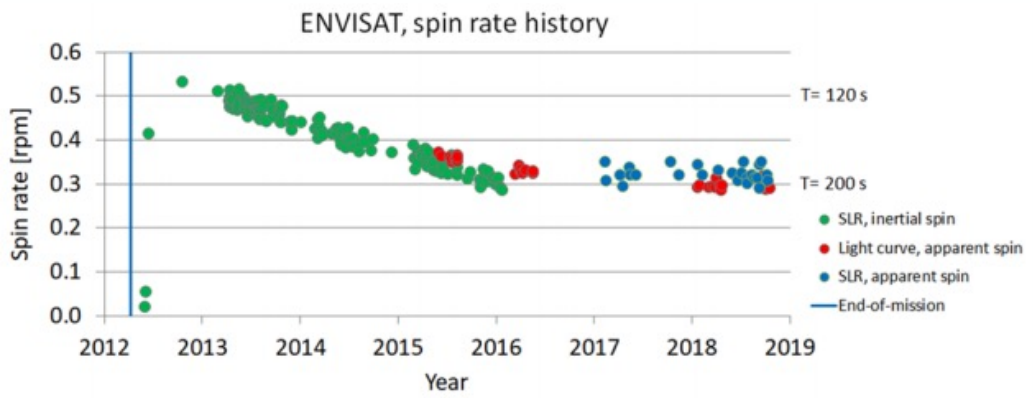
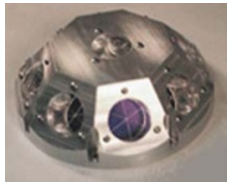
Introduction
ESA's Design for Removal

Estefanía Padilla on behalf of Clean Space

Active Debris Removal is Challenging…

Debris objects spin



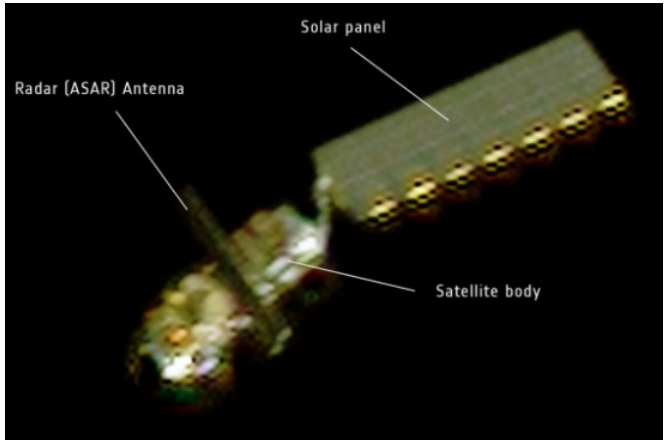


ENVISAT Retroreflector

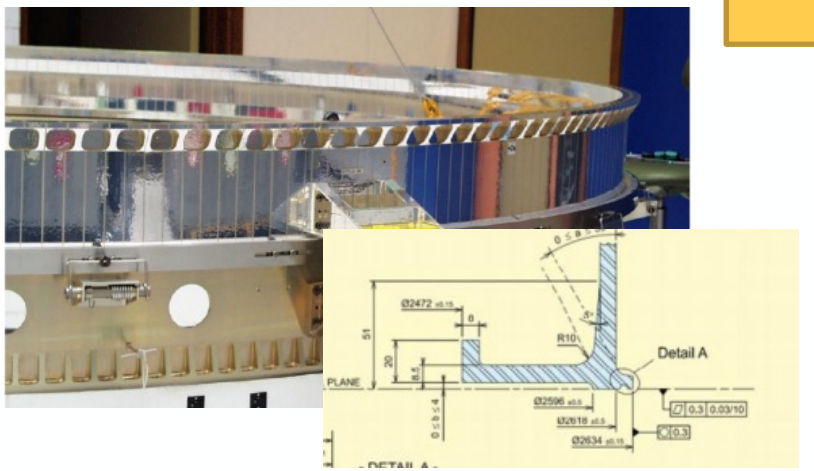
Why?

Without D4R, each satellite ADR solution would be different

Debris is not designed for capture



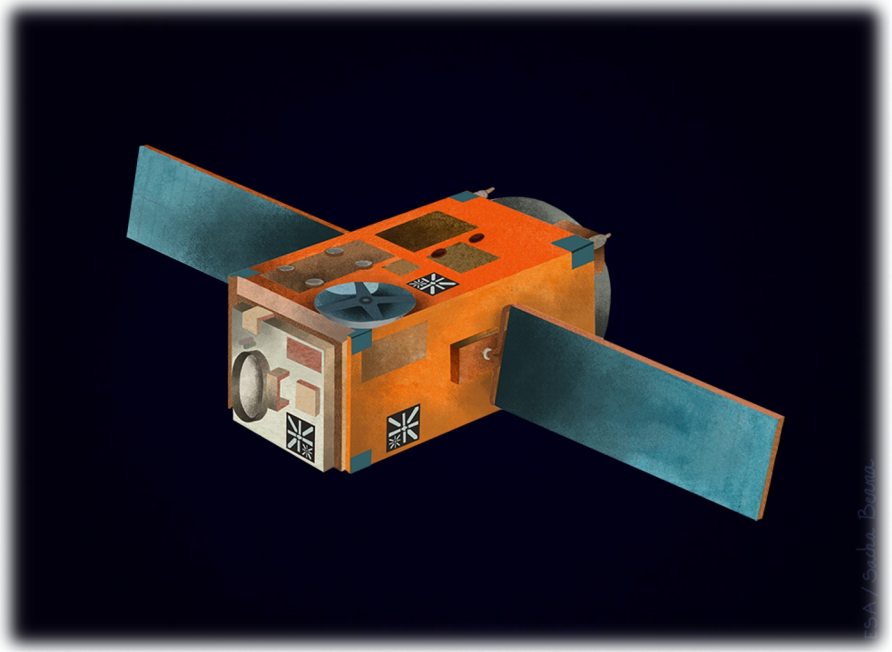
Capture interfaces



Ease removal by external servicer and decrease associated costs

What is a standard interface for D4R?

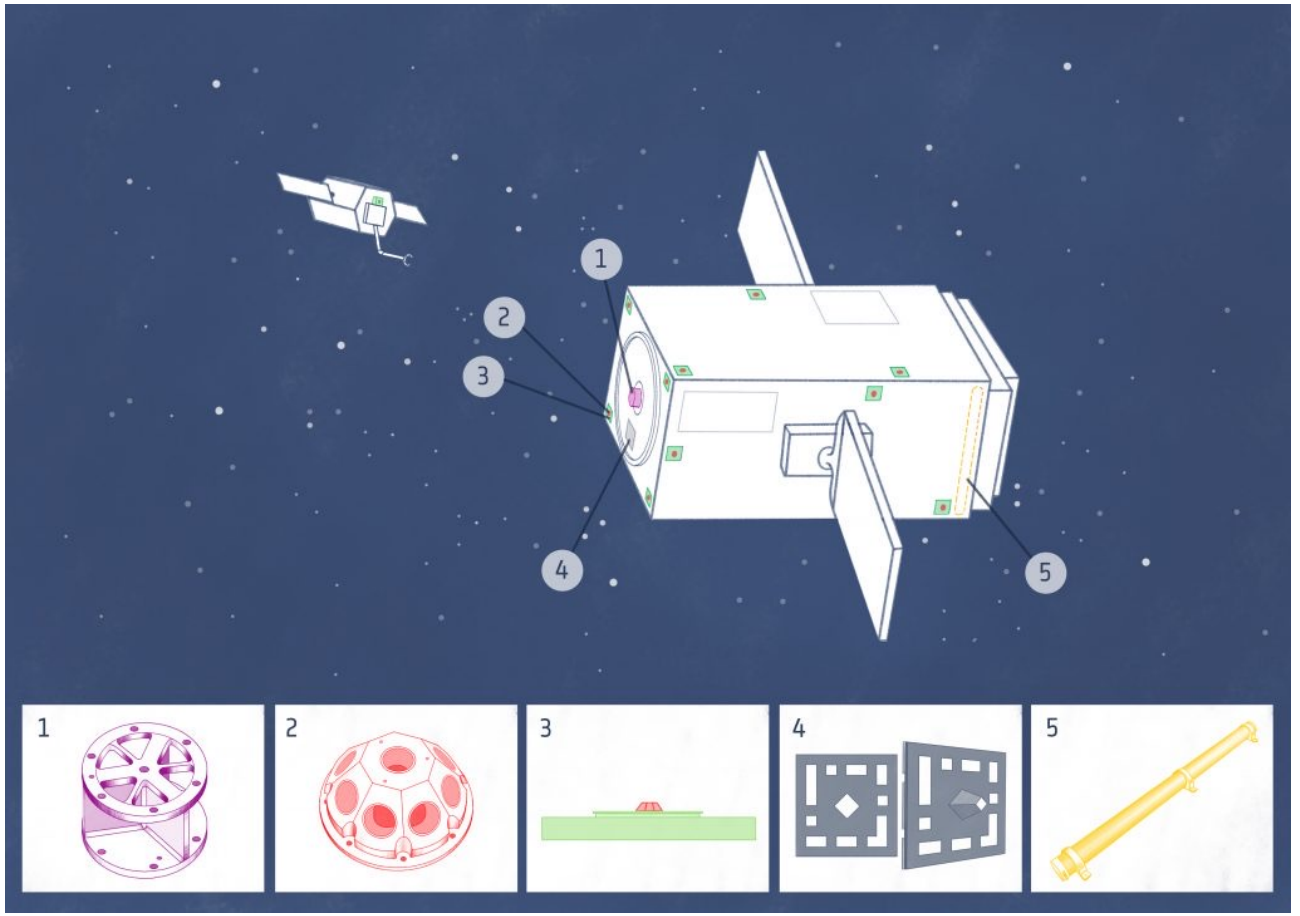
A D4R solution shall cover different aspects



What?

- Capture
- Relative navigation for rendezvous
- Attitude reconstruction from ground
- Detumbling

ESA solution for controlled re-entry

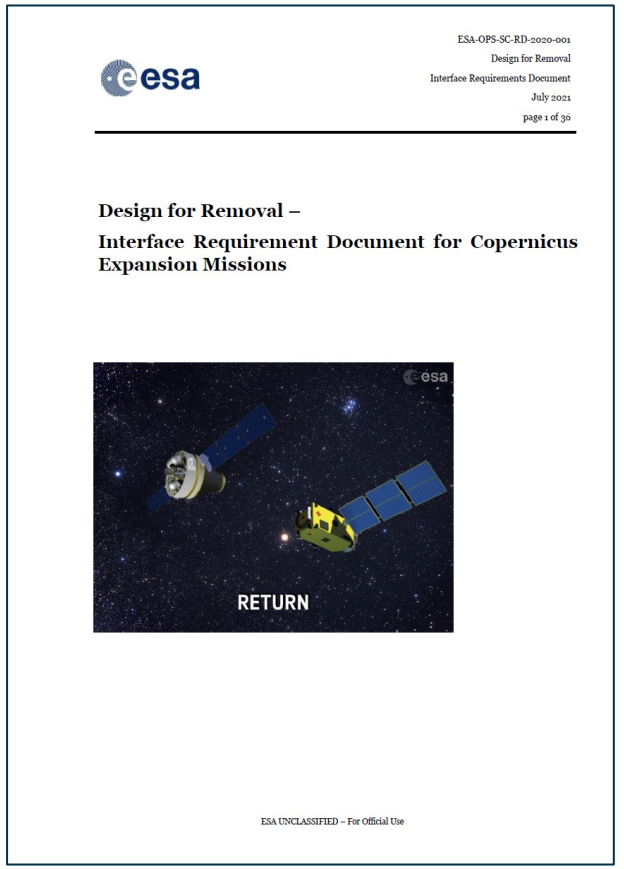


How?

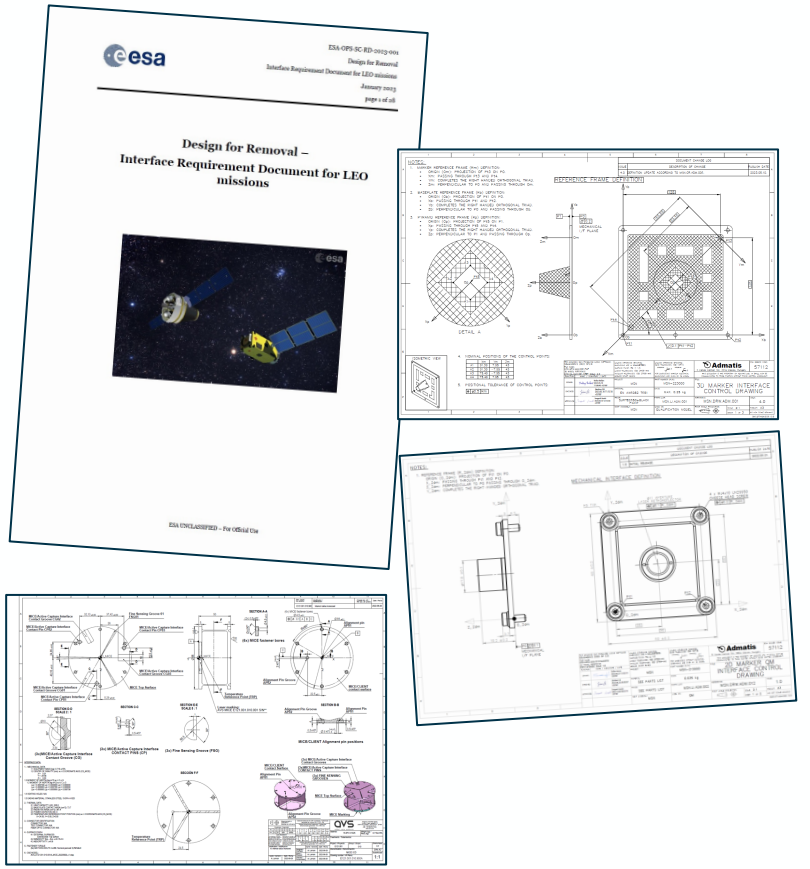
1. Mechanical Interface for Capture
2. Retroreflectors to support attitude determination from ground
3. 2D Markers to support rendezvous
4. 3D marker to support the final metres of rendezvous and the visual servoing of the capture system
5. Detumbling through short-circuited magnetorquers

ESA has developed an **Interface Requirements Document** as interface with the system

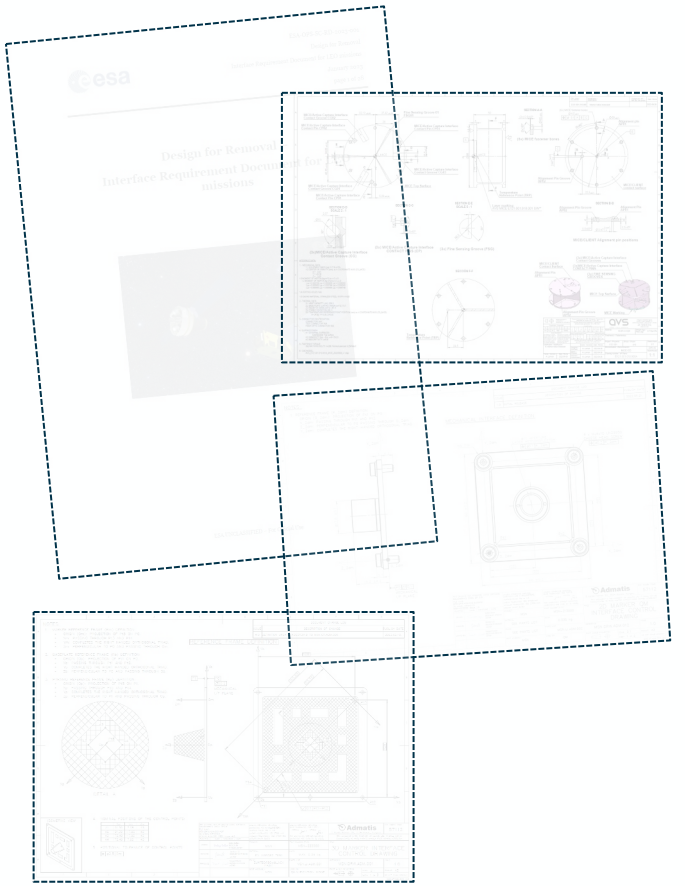
Interface Requirements Document



First D4R IRD for Copernicus Expansion Missions released in 2020



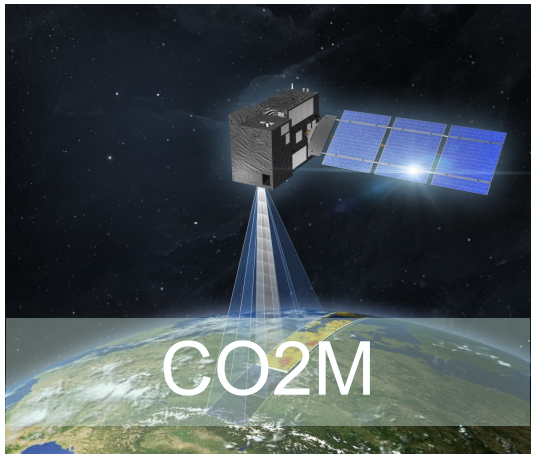
Second D4R IRD for LEO missions released in 2023
MICE, 2D marker and 3D marker ICDs



Future D4R IRD data-package releases for other applications

ESA solution for controlled re-entry

The developed standard interface is being integrated in future Copernicus Expansion missions (EO missions)



D4R is part of the Zero Debris approach
It will be included in the ESA Space Debris Mitigation Standard (ESSB-U-ST-007), which is planned to be published in November

New D4R activities

NEW CONFIRMED ACTIVITIES

- ❑EOL passive detumbling service for removal of not operative satellites in LEO/MEO/GEO orbits
- ❑Standardised De-orbit Interface Definition for LEO Satcom-class Spacecraft
- ❑Phosphorescent Markers to Support Navigation
- ❑Phase A of In-Orbit Demonstration of Standard Interfaces for End-of-Life Capture and Removal (CAT-IOD)
- ❑Capture Payload Bay Detailed Design and Verification (CAT-EM)

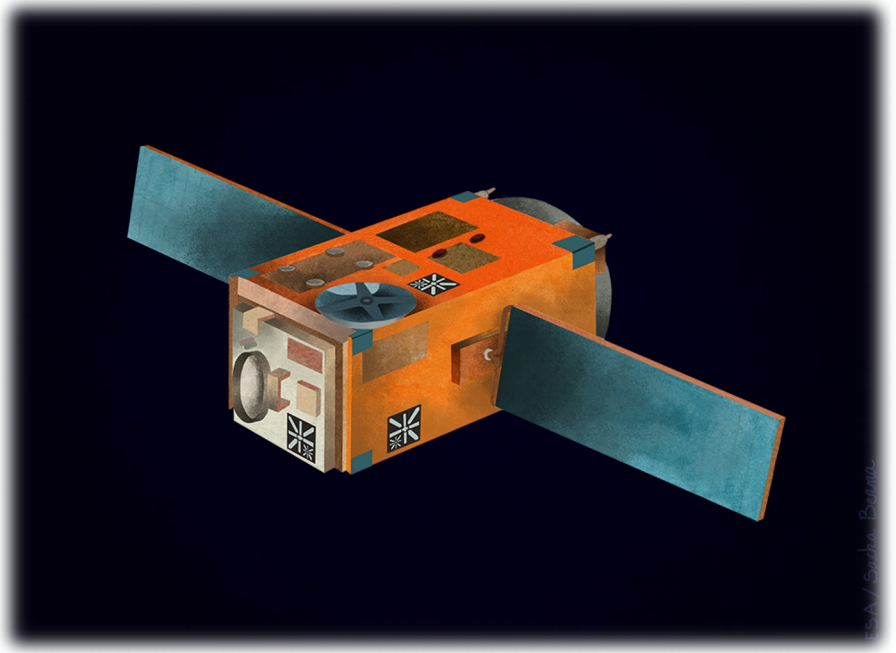
NEW PLANNED ACTIVITIES

- ❑Markers to Support Navigation – Second Generation Definition
- ❑Reflector-based Attitude Detection System (RADS) – Follow-up

Conclusions and next steps

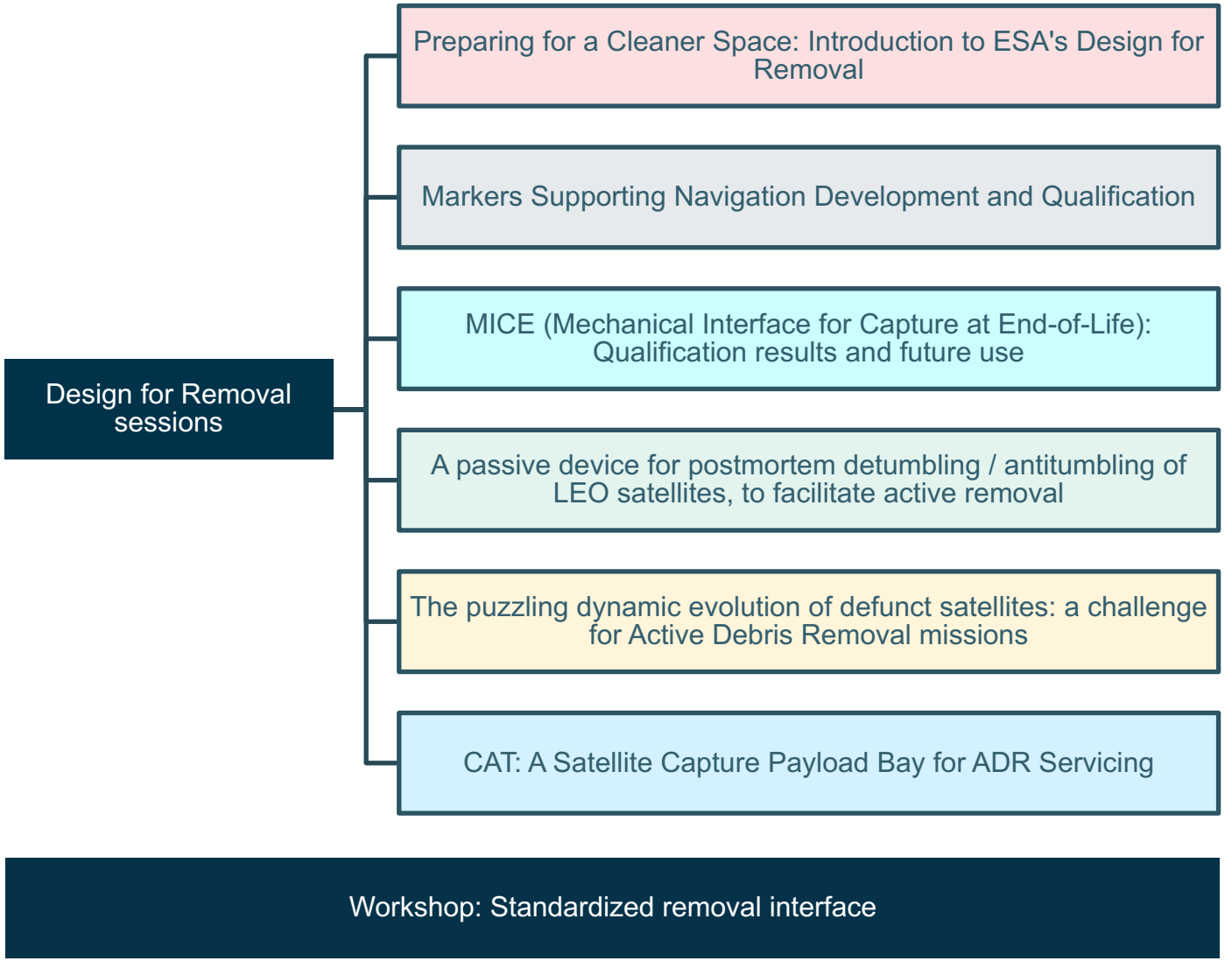
- D4R is part of the **Zero Debris approach**
- It will be included in the ESA Space Debris Mitigation Standard (ESSB-U-ST-007)

- 1st generation standard interface optimised for controlled re-entry has been developed and implemented in 4 Earth Observation Missions
- Interface Requirements Document has been developed to gather the interface requirements with the system and is available under request



- Next steps:
  - In Orbit Demonstration of the 1st generation D4R technologies
  - Development and demonstration of the correspondent capture payload (e.g. CAT activity)
  - 2nd generation D4R technologies
  - Standard removal interfaces needed for small satellites and constellations (uncontrolled re-entry)
  - Standard removal interfaces needed for LEO, MEO and GEO

Agenda


Design for Removal sessions
Preparing for a Cleaner Space: Introduction to ESA's Design for Removal
Markers Supporting Navigation Development and Qualification
MICE (Mechanical Interface for Capture at End-of-Life): Qualification results and future use
A passive device for postmortem detumbling / antitumbling of LEO satellites, to facilitate active removal
The puzzling dynamic evolution of defunct satellites: a challenge for Active Debris Removal missions
CAT: A Satellite Capture Payload Bay for ADR Servicing
Workshop: Standardized removal interface

Thanks for your attention!