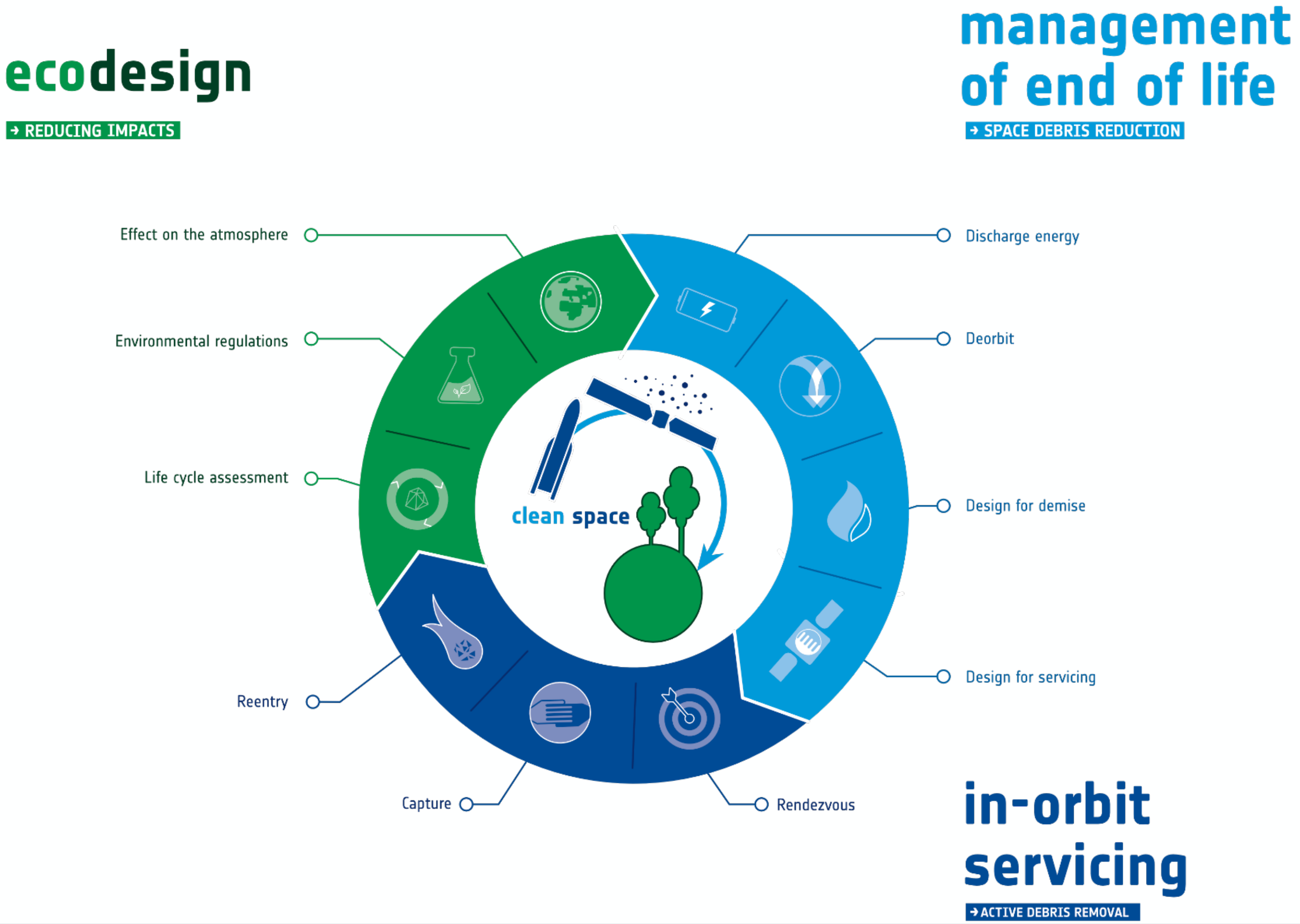
Space Debris Mitigation
Current Challenges & Future Solutions

22/09/2021

Management of End of Life: Scope

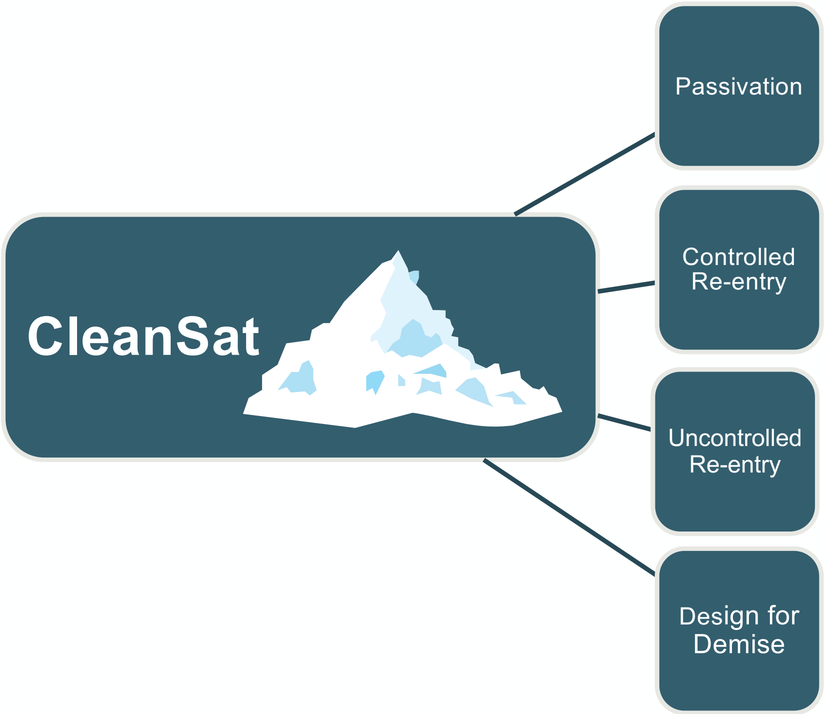


Space Debris Mitigation (SDM): Objectives

- Spaceflight shall be **safe** and compatible with the **sustainable use of outer space**
- The **proliferation of space debris** shall be **constrained**
- Access to space to **remain available for all**

ISO 24113:2019(E) - Space systems — Space debris mitigation requirement

CleanSat: General presentation



CleanSat initiative started in 2016

Aim → to develop and integrate new technologies for End-of-Life in future LEO missions.

Proactive and coordinated approach with suppliers, integrators and ESA working together.

Foster **innovation and competitiveness** of European products to answer to EoL new needs.

CleanSat achievements: Passivation

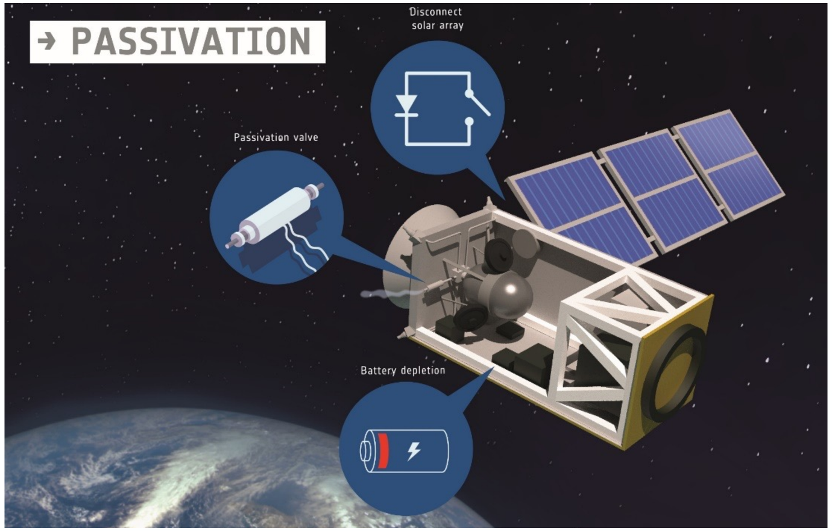
The lack of passivation is still today the main source of fragmentation events in orbit

Lessons learnt

- Importance of permanently discharging the batteries
- Relevance of propellant residuals

Developments

- Characterization of batteries failure modes
- PCDU integrated passivation
- Propulsion passivation valves (pyro and SMA)



How do we cope with system failures in orbit ?

Clean Space Industry Days
Passivation
21/09 @ 14:00-15:40

CleanSat: Deorbit systems

The EoL deorbit of satellites paramount to reduce the probability of catastrophic in-orbit collisions

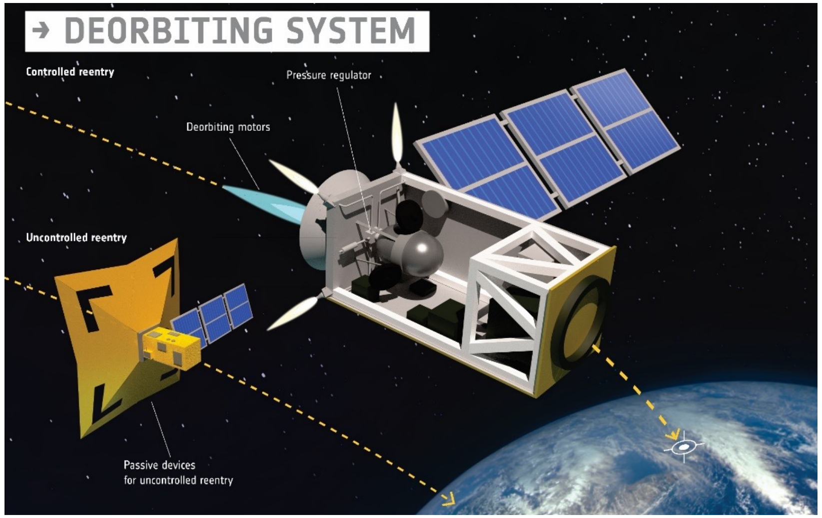
Lessons learnt

- Controlled reentry is costly and complex
- Lack of modularity and high demise uncertainty

  → Early decision on deorbit strategy

Developments

- Drag augmentation devices
- Solid Rocket Motors for deorbit & Propulsive deorbit kit



With the increase of traffic will the allowed time in protected orbits be reduced?

Clean Space Industry Days

Passive De-orbit Devices	Controlled Re-entry
23/09 @ 09:30-11:00	23/09 @ 11:30-13:00

CleanSat: Design for Demise

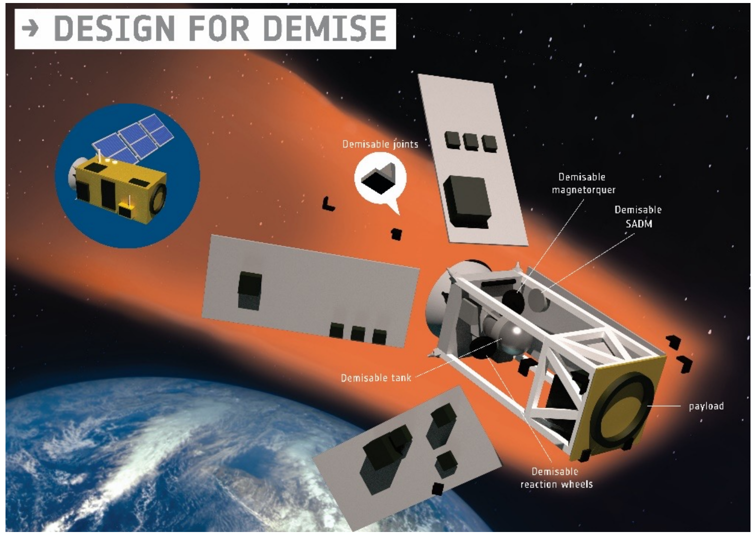
Design for Demise is a recent technical domain with many uncertainties

Lessons learnt

- Models development & validation is lengthily and costly
- (Optical) Payloads often take most of casualty risk budget
- Needs to be considered from very early in the design

Developments

- Demisable S/C equipment: Tanks, MTQs, RWs, SADM
- Early break-up & containment technologies
- First worldwide guidelines for demise analysis and testing (DIVE)

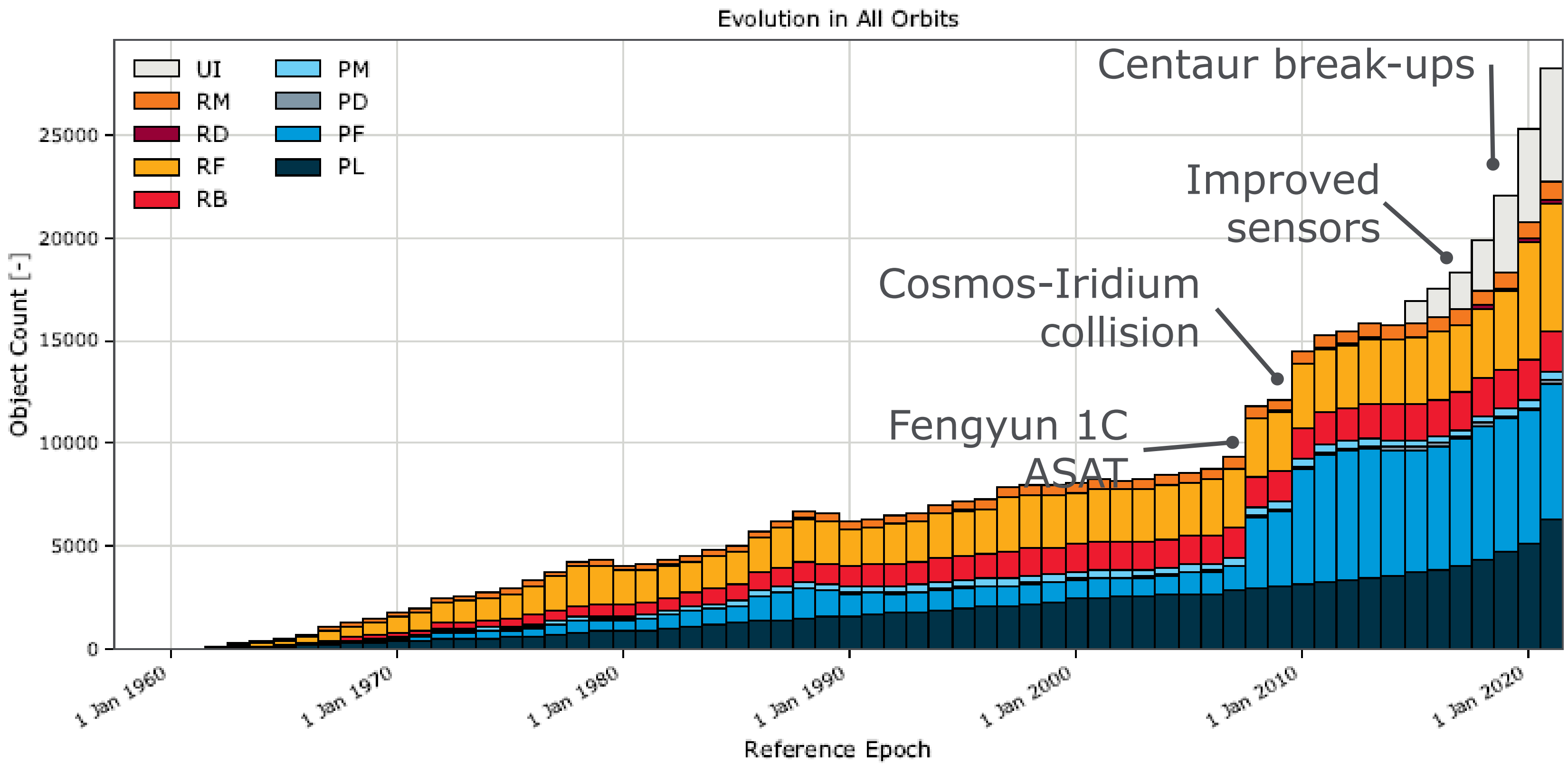


How to consolidate Design for Demise approach and integrate it in future missions?

Clean Space Industry Days

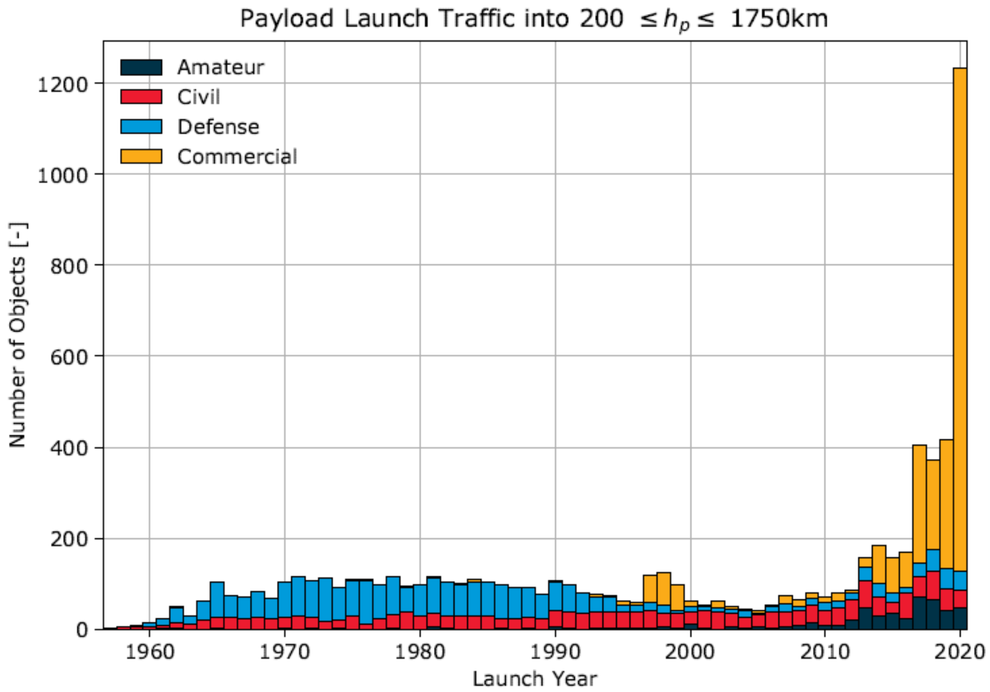
DIVE & Design for Demise Models	Designing Demisable Spacecraft
21/09 @ 16:00-18:00 & 22/09 @ 09:30-11:10	22/09 @ 11:30-13:10

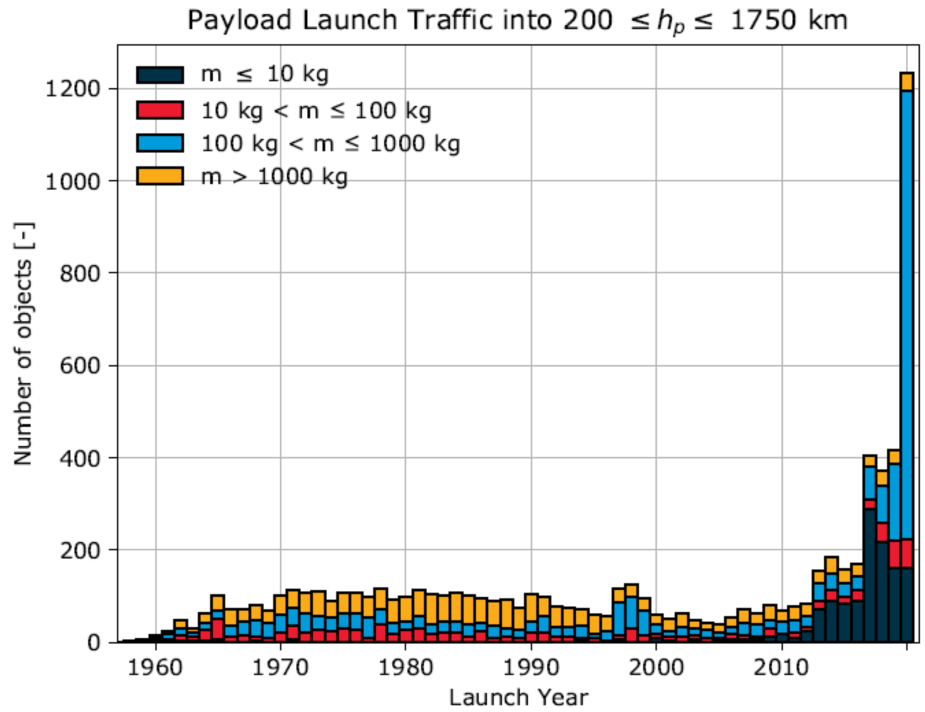
Current Challenges: State of the (tracked) environment



ESA Environment Report
https://sdup.esoc.esa.int/discosweb/statistics/

Current Challenges: New Space Revolution

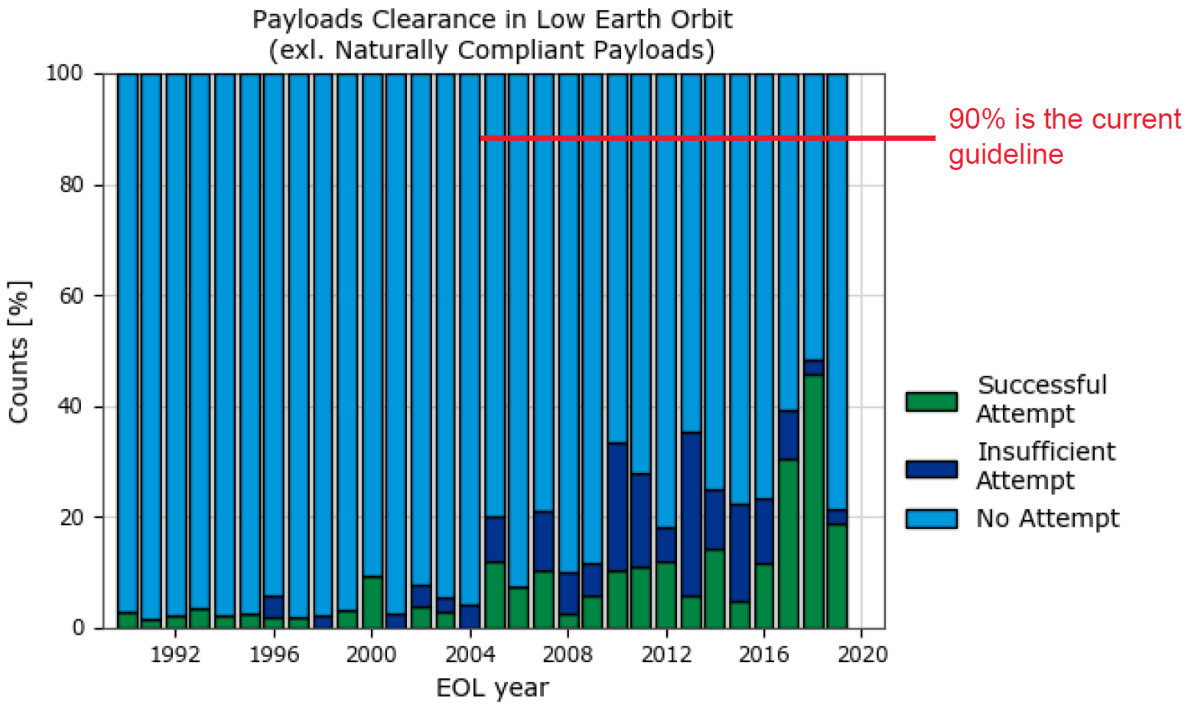


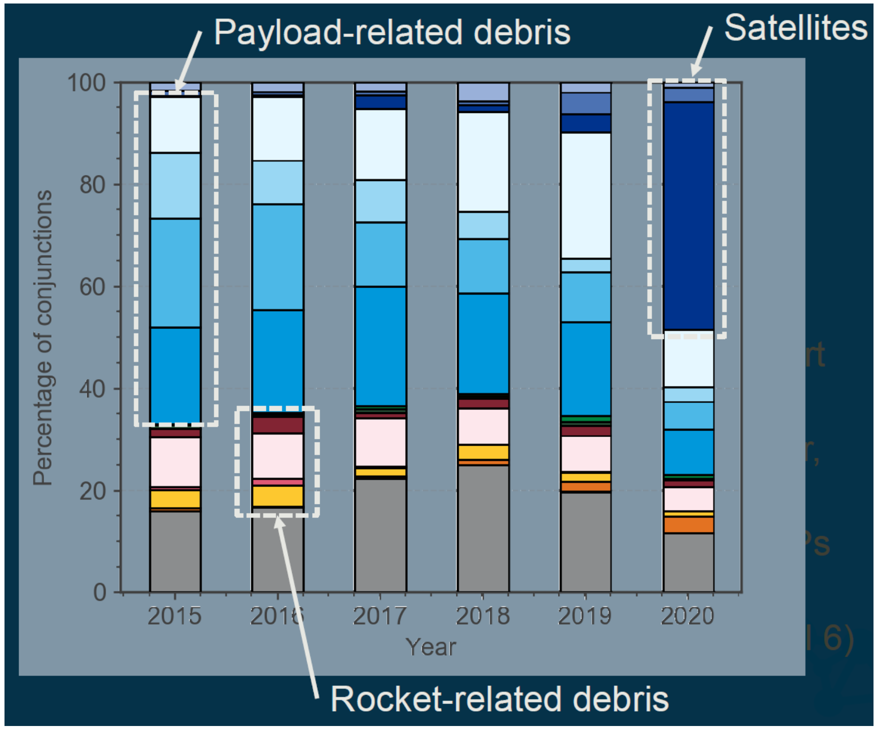


In view of the increase in traffic, in particular large constellations, IADC[1] already advises probability of successful disposal is significantly above 90% (with a goal of 99%) and remaining orbital lifetimes after disposal well below 25 years.

[1] IADC Statement on Large Constellations of Satellites in Low Earth Orbit, IADC-15-03 July 2021

Current Challenges: Compliance and collision avoidance statistics



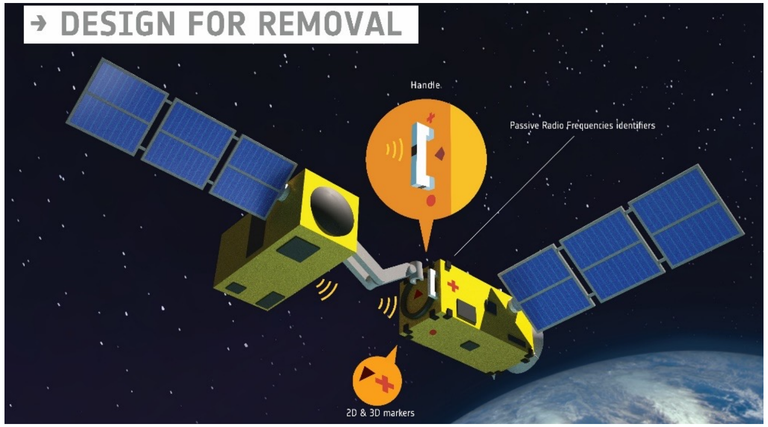


Future Solutions: resilient to in-orbit failures

ESA is already going beyond the current SDM requirements

Copernicus Expansion missions include:

- Electric passivation even for S/C performing controlled re-entry
- Design for Removal to ease remove S/C from orbit in case of failure



Developments

- Mechanical Interface for Capture at EoL
- Markers to support navigation and tracking
- Passive magnetic detumbling

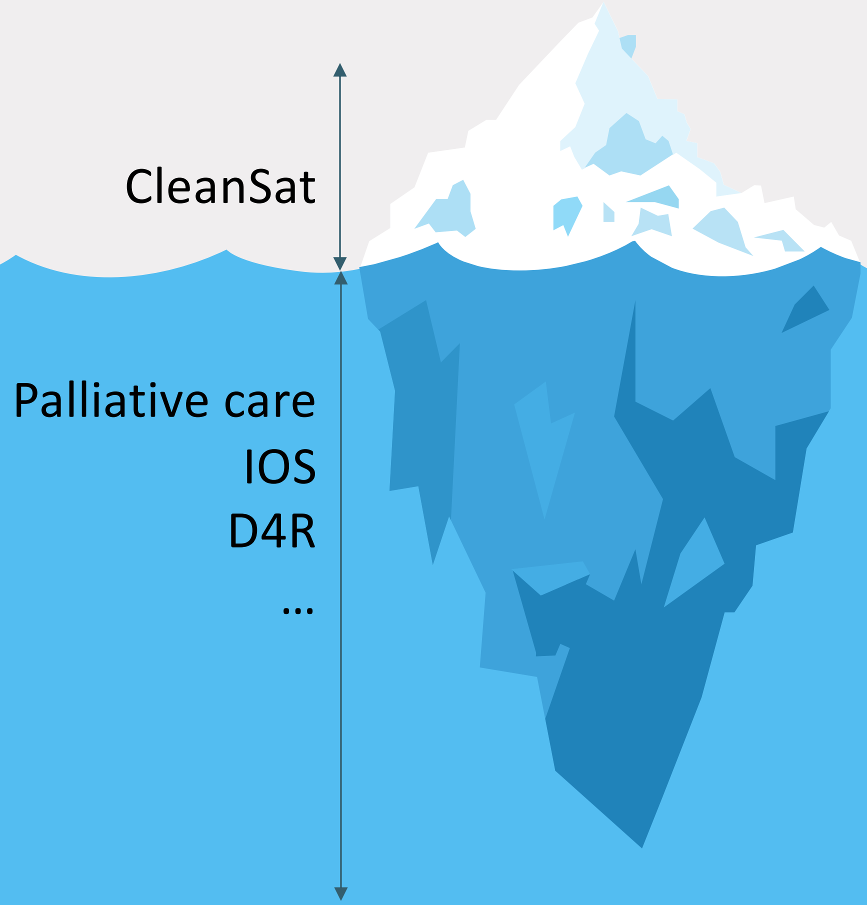
How will EoL servicing develop in the future?

Clean Space Industry Days
Design for Removal
24/09 @ 09:30-11:30

Future solutions

Lessons learned

- The platforms needs to be prepared to include key elements of End of Life **BEFORE** being used in a project.



Our goals for the upcoming years

➔ **Enhance European platforms with the new EoL technologies.**

➔ **Anticipate evolution of debris environment and requirements.**

➔ **Promote novel system solutions to improve European platforms competitiveness.**