Webinar

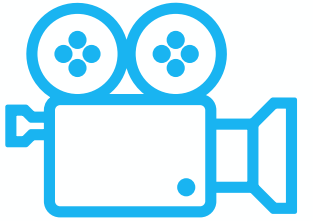
Standardised De-orbit Interface Definition for Satcom-class Spacecraft - Phase 1

Clean Space

04/06/2024

Instructions

This webinar will be recorded



If you have any questions, post them in the chat

Speakers

ESTEFANIA PADILLA GUTIERREZ

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Index

- Background and context:
  - Zero Debris Approach
  - ESA Space Debris Mitigation Requirements
- Activity overview: Standardised De-orbit Interface Definition for Satcom-class Spacecraft
- Existing Technologies and Removal Interfaces
- Conclusions
- Q&A session

Background and context

Zero Debris approach and ESA Space Debris Mitigation Requirements

"In ESA we are implementing a policy that by 2030, we have 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. We need to **lead by example** here."

ESA Director General, Josef Aschbacher

Zero Debris Scope

Developing ESA Zero Debris approach

Engaging partners, building a community

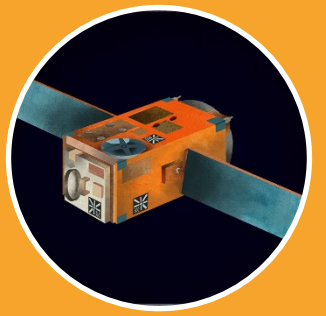
ESA SDM Policy & Standard

Technical requirements for ESA missions and contributions

ESA Technical Developments

ESA support to industry's transition and compliance to SDM standards

Zero Debris Technology Booklet



Crowd-sourced technical solutions to reach Zero Debris targets by 2030

Zero Debris Charter

Jointly defined principles and targets for long term space sustainability

Independent Safety Office (TEC-QI)

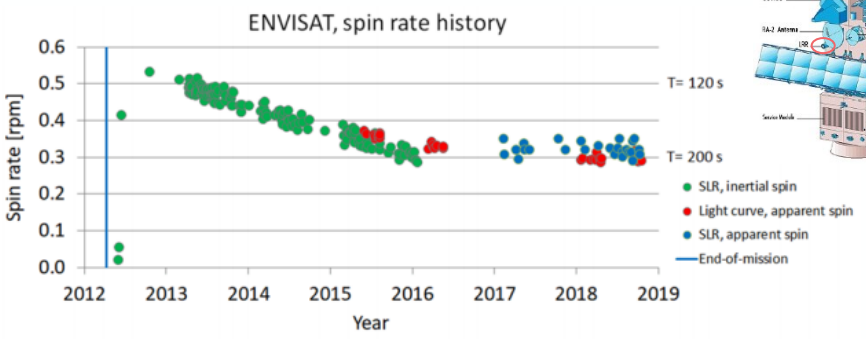
Space Safety Programme Office (OPS-S)

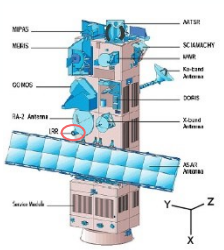
PROTECT (OPS-T)

What is D4R and why is needed?

Active Debris Removal (ADR) is challenging

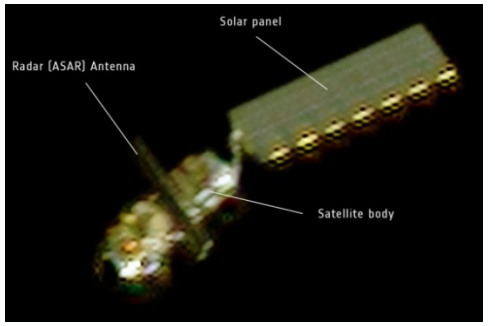
Debris objects spin



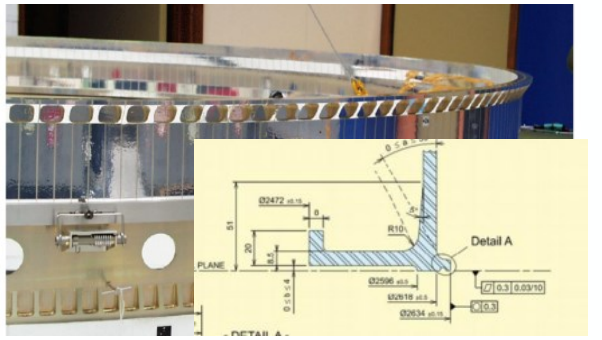


ENVISAT Retroreflector

Debris is not designed for capture



Missing Capture interfaces



The set of specific design features, which allow spacecraft readiness for being removed by a servicer spacecraft is referred as **Design for Removal** (D4R)

D4R implies dedicated modifications to cover certain functions, in order to ease removal by external servicer and **decrease associated risks and costs**

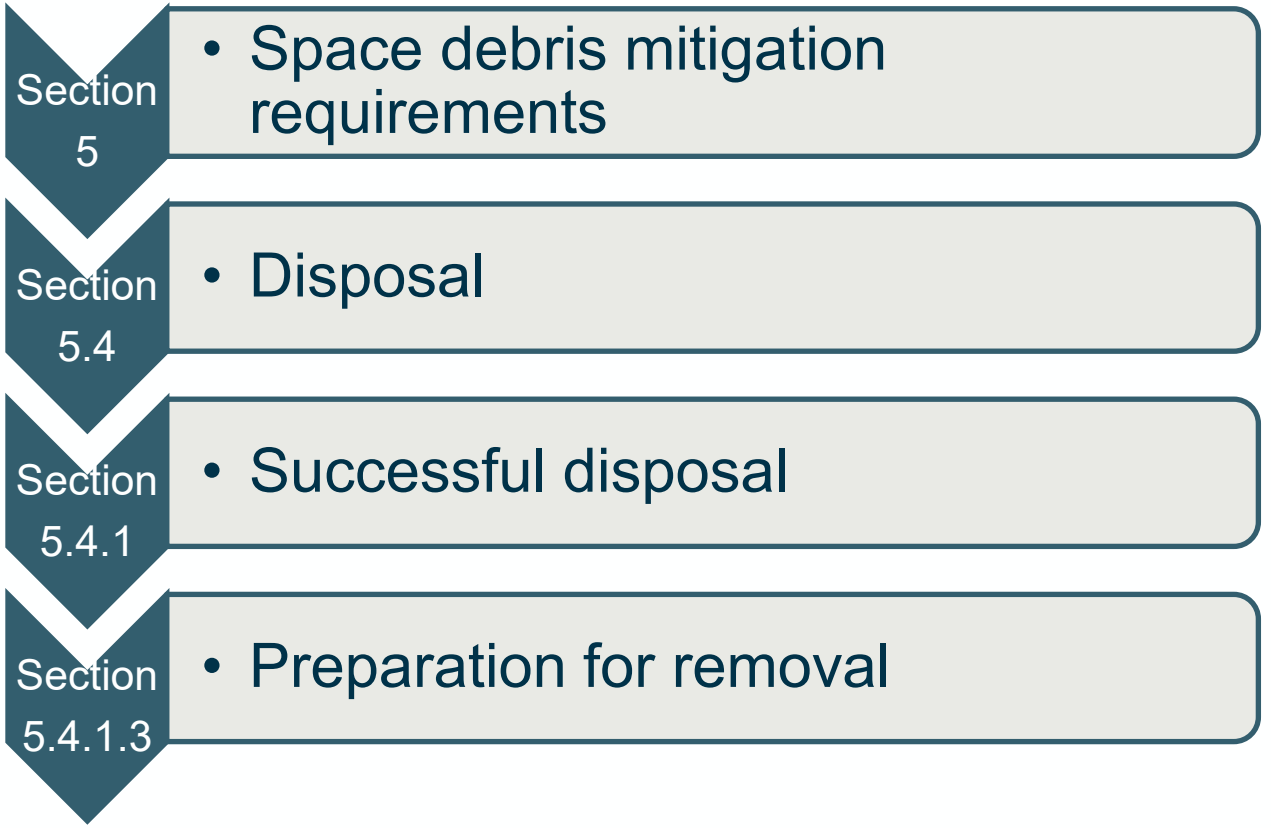
Definition of a Standard D4R Interface in terms of needed functions and technical requirements is considered as optimal approach for ADR challenges

ESSB-ST-U-007: ESA Space Debris Mitigation Requirements

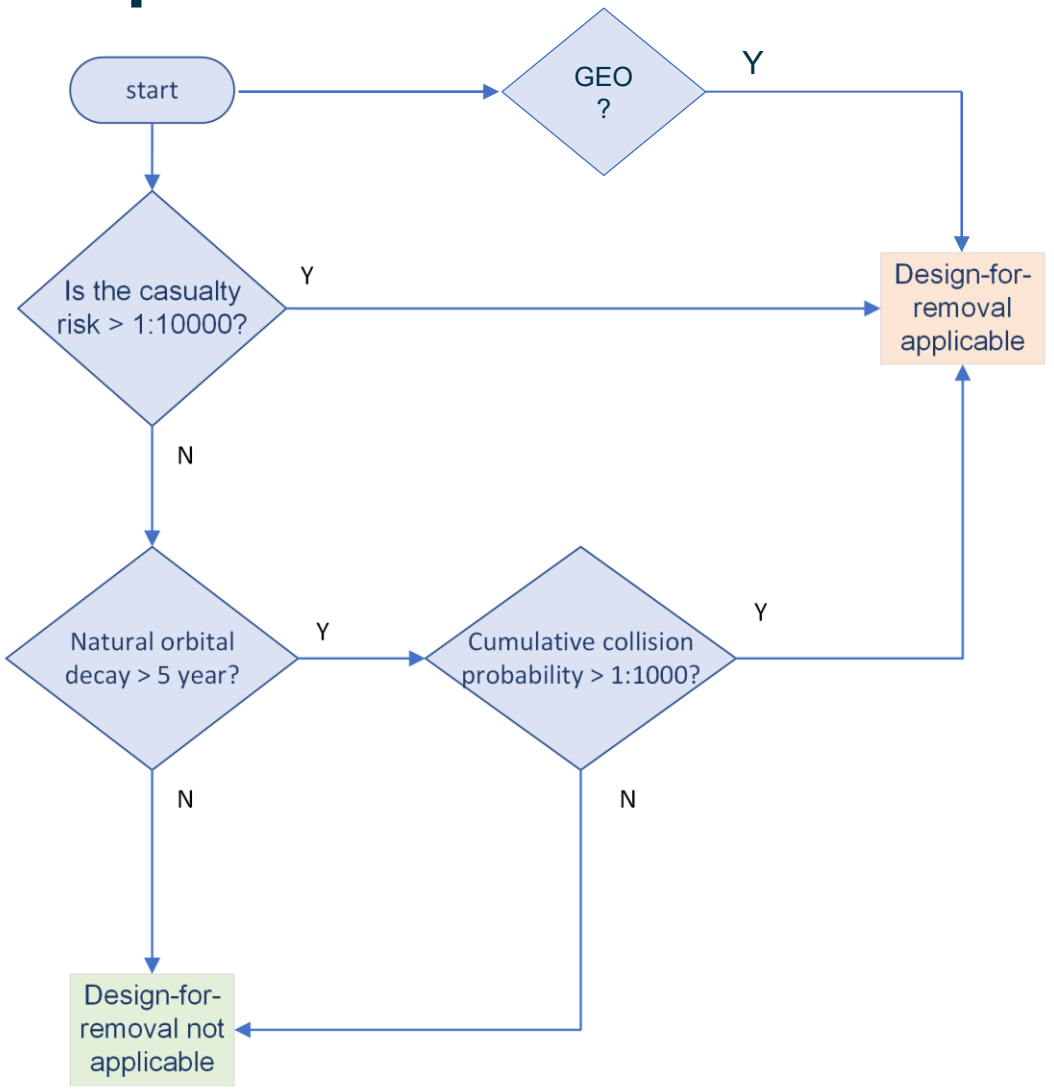
ESSB-ST-U-007 October 2023 specifies the requirements for the **preparation of removal** of a spacecraft by an external servicer spacecraft in order to enhance compliance of disposal of the spacecraft with the space debris mitigation and re-entry safety requirements.

The set of specific design features, which allow spacecraft readiness for being removed by a servicer spacecraft is referred as “Design for Removal”.

“Design for Removal” can facilitate the operation of removal of a spacecraft, as potential issues associated to removal operations (including close proximity and rendezvous operations) are preventively tackled. “Design for removal” can enhance reduction of complexity and increase of efficiency for a removal operation. For a client spacecraft in LEO, removal operations normally imply capture, detumbling, de-orbit, and safe re-entry of the client spacecraft with the assistance of a servicer spacecraft.



ESA Space Debris Mitigation Requirements Section 5.4.1.3 Preparation for Removal



The requirements cover several aspects

- Mechanical **interfaces**
- Support to **relative navigation**
- Assessment of long-term **attitude**
- **Attitude reconstruction** from ground
- Limiting and damping **angular rates**
- **Cooperative/Uncooperative** scenarios

Applicability

Orbit

LEO GEO

ESA Space Debris Mitigation Requirements Section 5.4.1.3 Preparation for Removal

ID	Requirement text
5.4.1.3.c.	A spacecraft, when prepared for removal, both in un-cooperative and cooperative scenario, shall have the following features or characteristics: 1) Passively ensure access to a mechanical interface compliant with capture, detumbling and removal mechanical loads 2) Passively support the relative navigation of the space object performing the close proximity operations NOTE 1 It is good practice that the mechanical capture interface allows for capture before contact. NOTE 2 It is good practice that the design of the support to the servicer relative navigation considers compatibility with different rendezvous sensors. NOTE 3 The compliance with the requirement can be met if compatibility with at least one possible removal service interfaces is demonstrated. ESA-OPS-SC-RD-2023-001 provides a valid reference removal service Interface Requirements Document.
5.4.1.3.d.	The developer of a spacecraft, when prepared for removal, shall perform an assessment of the long-term evolution of the spacecraft attitude if in free drift in its operational orbit.

The requirements cover several aspects

- Mechanical **interfaces**
- Support to **relative navigation**
- Assessment of long-term **attitude**
- **Attitude reconstruction** from ground
- Limiting and damping **angular rates**
- **Cooperative/Uncooperative** scenarios

ESA Space Debris Mitigation Requirements Section 5.4.1.3 Preparation for Removal

ID	Requirement text
5.4.1.3 .e.	A spacecraft operating in LEO protected region, when prepared for removal, in an uncooperative scenario, shall have the following features or characteristics: 1) Passively enable attitude reconstruction on ground 2) Limiting and damping the spacecraft angular rates NOTE 1 The target accuracy for the attitude reconstruction from ground of the spacecraft angular rate vector magnitude is better than ±1 deg/s, and of the spacecraft direction vector magnitude is better than ±10 deg. NOTE 2 The target for the evolution of the module of the spacecraft angular rates vector is convergence to values lower than 1 deg/s. NOTE 3 Measures to limit and damp the angular rates include: • use of angular rates damping system or device. • orientation of appendages when in Safe Mode to minimise the torques resulting from solar radiation pressure. • passivation of propulsion system not increasing spacecraft angular rates (e.g. through zero-torque venting pipe outlet).

The requirements cover several aspects

- Mechanical **interfaces**
- Support to **relative navigation**
- Assessment of long-term **attitude**
- **Attitude reconstruction** from ground
- Limiting and damping **angular rates**
- **Cooperative/Uncooperative** scenarios

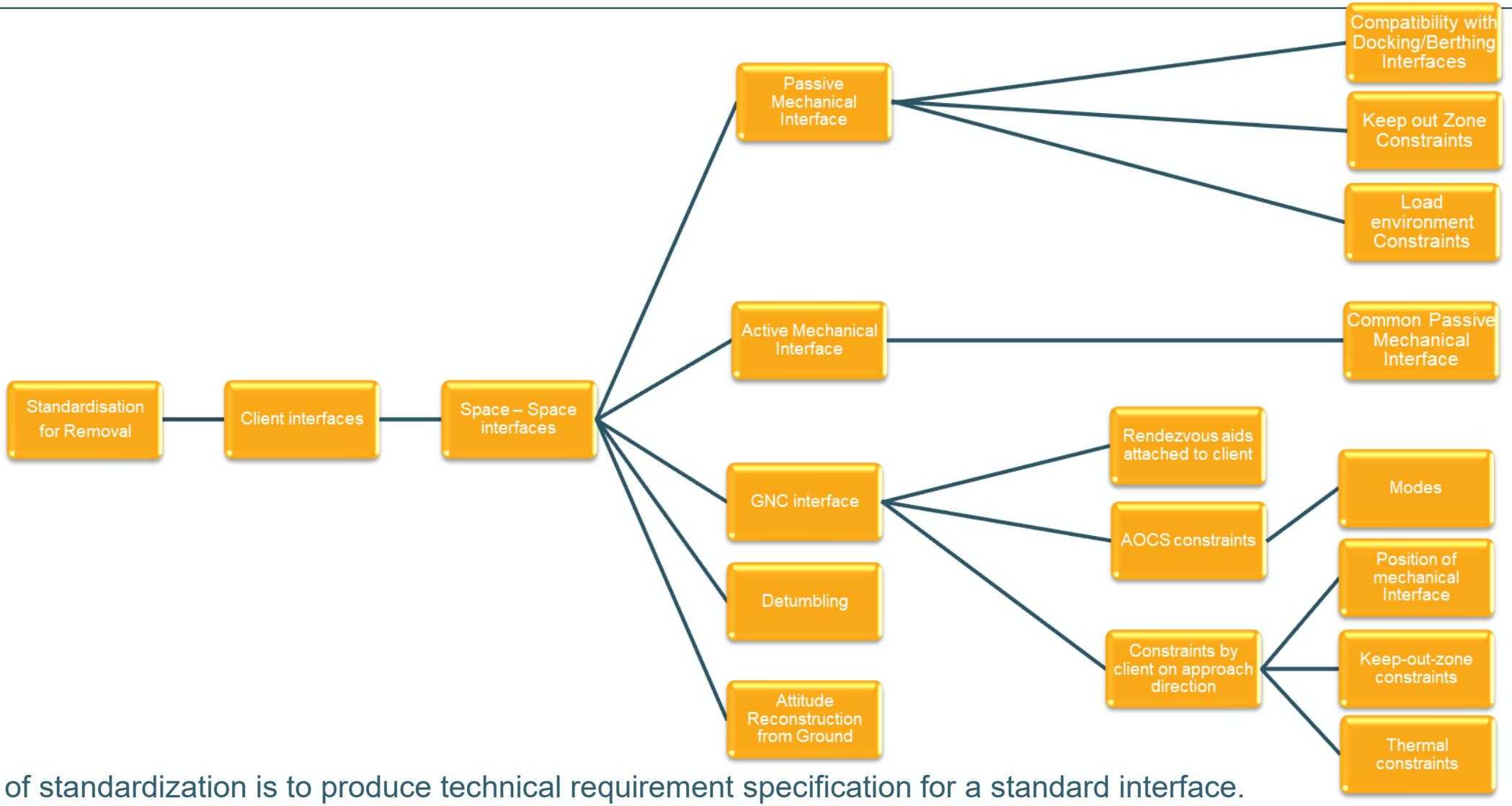
ESA Space Debris Mitigation Requirements Section 5.4.1.3 Preparation for Removal

ID	Requirement text
5.4.1.3.f.	A spacecraft, when prepared for removal, in a cooperative scenario, shall implement the following functions: 1) System modes and operational procedures supporting the cooperative capture and removal 2) Delivery of orbit and attitude data with the accuracy required by the removal service NOTE 1 Considerations when defining system modes and operational procedures supporting cooperative capture and removal from a servicer include: • orientation of appendages allowing the servicer approach and mechanical interface capture. • stable angular rates allowing the servicer approach and mechanical interface capture. • use of AOCS actuators that do not impact or impinge on the servicer relative navigation sensors and attitude control during the close proximity operations. • prevention of AOCS from reacting against capture and manoeuvring by the servicer. NOTE 2 The system Safe Mode attitude and configuration allow for a cooperative removal. NOTE 3 The compliance with the requirement can be met if compatibility with at least one possible removal service interfaces is demonstrated. ESA-OPS-SC-RD-2023-001 provides a valid reference.

The requirements cover several aspects

- Mechanical **interfaces**
- Support to **relative navigation**
- Assessment of long-term **attitude**
- **Attitude reconstruction** from ground
- Limiting and damping **angular rates**
- **Cooperative/Uncooperative** scenarios

Standardisation Aspects for Removal



Objective of standardization is to produce technical requirement specification for a standard interface.
This needs to be done in accordance with the selection of the features to be implemented

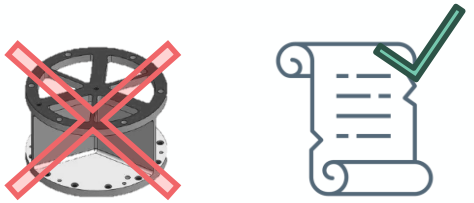
Activity overview

Standardised De-orbit Interface Definition for Satcom-class Spacecraft

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Introduction I

The objective of the whole activity is:

To generate a **standard** (NOT hardware) for an interface that would allow for **in-orbit satellite-to-satellite latching for de-orbiting**



- ✓ Different interfaces could be designed and manufactured in line with this standard
- ✓ The interface should facilitate the non-cooperative rendezvous and capture of telecom-class platforms at end-of-life to support debris mitigation activities within the sector. Other platform classes might be benefited by this standard too.
- ✓ **The intention is to have industry and interested parties engaged throughout the process.**

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Introduction II

Example of functions to be covered by the standard:

Capture

- Enable capture before contact
- Sustain the transversal loads during capture and de-orbiting
- …

Relative navigation for rendezvous

- Include navigation aids for rendezvous and CPO
- …

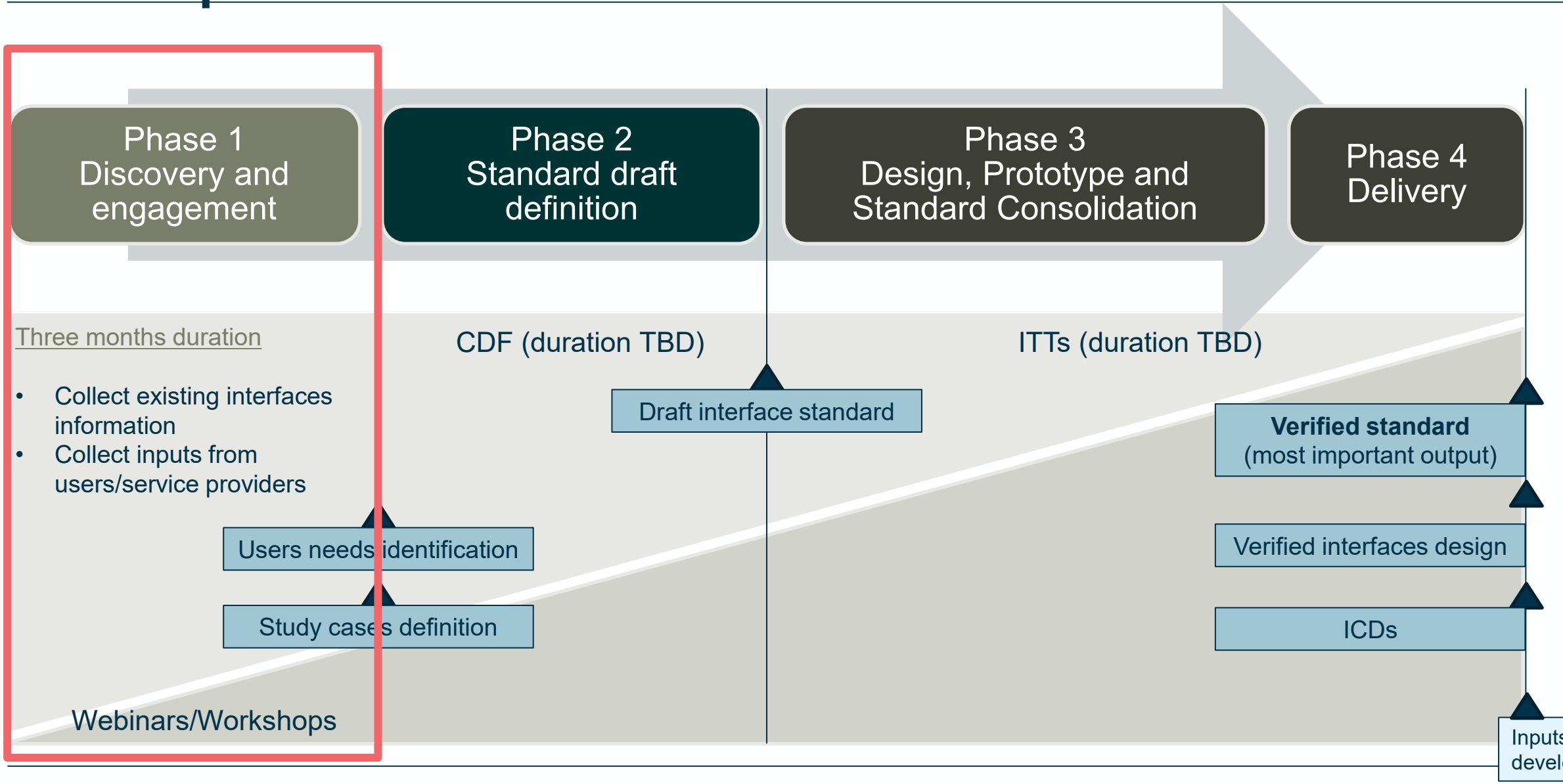
Attitude reconstruction from ground

- Include features for attitude determination from ground
- …

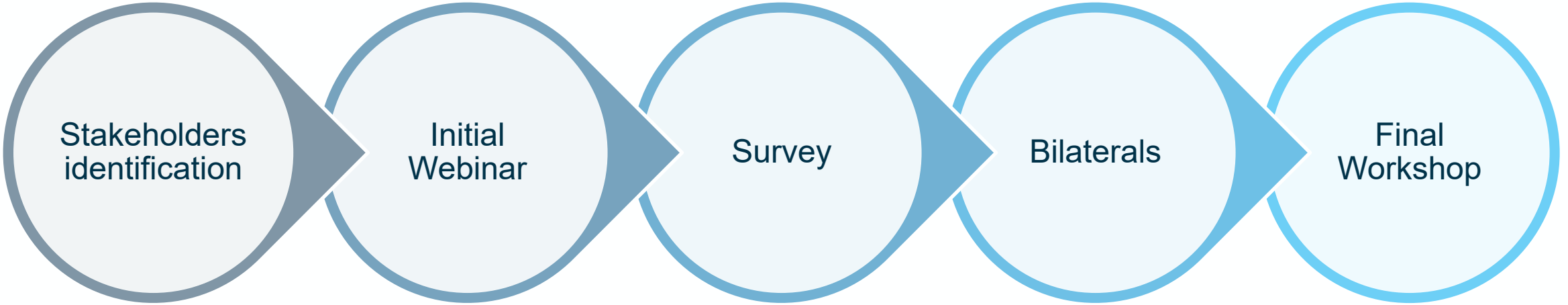
Detumbling

- Enable detumbling of the target
- …

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – General overview



Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1



Note: An ESA internal group of experts is defined for this phase, covering different fields: GNC, mechanisms, robotics, systems and RAMS

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey

The objective of the Survey is to collect inputs from User and Service Providers in order to:

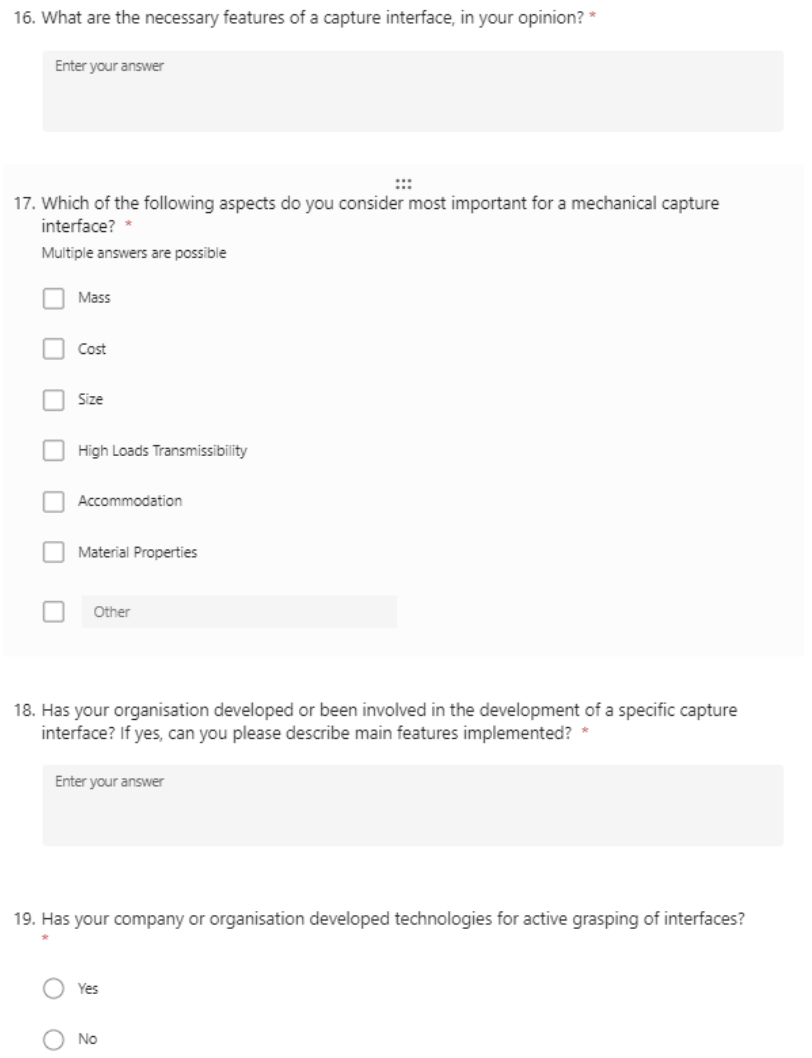
- **Identify User Needs**
- **Define Study Cases**

It is divided into four sections covering the functions of Removal Interface :

- Capture
- Relative navigation for rendezvous
- Attitude Reconstruction from Ground
- Detumbling

With a fifth section requesting inputs on the approach to standardisation

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey II


16. What are the necessary features of a capture interface, in your opinion? *

Enter your answer

17. Which of the following aspects do you consider most important for a mechanical capture interface? *

Multiple answers are possible

- [ ] Mass
- [ ] Cost
- [ ] Size
- [ ] High Loads Transmissibility
- [ ] Accommodation
- [ ] Material Properties
- [ ] Other

18. Has your organisation developed or been involved in the development of a specific capture interface? If yes, can you please describe main features implemented? *

Enter your answer

19. Has your company or organisation developed technologies for active grasping of interfaces? *

- ( ) Yes
- ( ) No

Survey is divided in five parts

- Capture
- Relative navigation for rendezvous
- Attitude Reconstruction from Ground
- Detumbling
- Standardization approach

Objective of Capture Section:

- Collection of User needs
- Identification of key drivers for Passive Mechanical Interface
- Interoperability Aspects for Active mechanical Interfaces
- Identification of topics for requirements definition

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey III

28. Please provide a brief description of your organisation's mission(s) or studies involving rendezvous and Close Proximity Operations. *

Enter your answer

29. Has your organisation developed specific technologies for rendezvous and CPO Navigation aids? *

- Yes
- No

30. Please provide a brief description of thes specific technologies for rendezvous and CPO Navigation aids your organisation has developed. *

Enter your answer

31. When defining these rendezvous and CPO Navigation aids, which sensors were assumed to be embarked on the chaser spacecraft? *

Enter your answer

32. What do you consider to be the necessary features of rendezvous and CPO Navigation aids? *

Enter your answer

Survey is divided in five parts

- Capture
- Relative navigation for rendezvous
- Attitude Reconstruction from Ground
- Detumbling
- Standardization approach

Objective of Relative navigation for rendezvous Section:

- Collection of User needs
- Identification of key drivers for Navigation aids
- Identification of topics for requirements definition
- Identification of drivers for AOCS modes for Removal

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey IV

36. Does your organisation have experience with attitude reconstruction from ground? *

- ◯ Yes
- ◯ No

37. Please provide a brief description of the technologies used for attitude reconstruction from ground *

Detail the ground-based sensor as well as any embarked devices like retroreflectors on the space object whose attitude was reconstructed

Enter your answer

38. Which features do you consider necessary for embarked hardware to enable attitude reconstruction from ground? *

Enter your answer

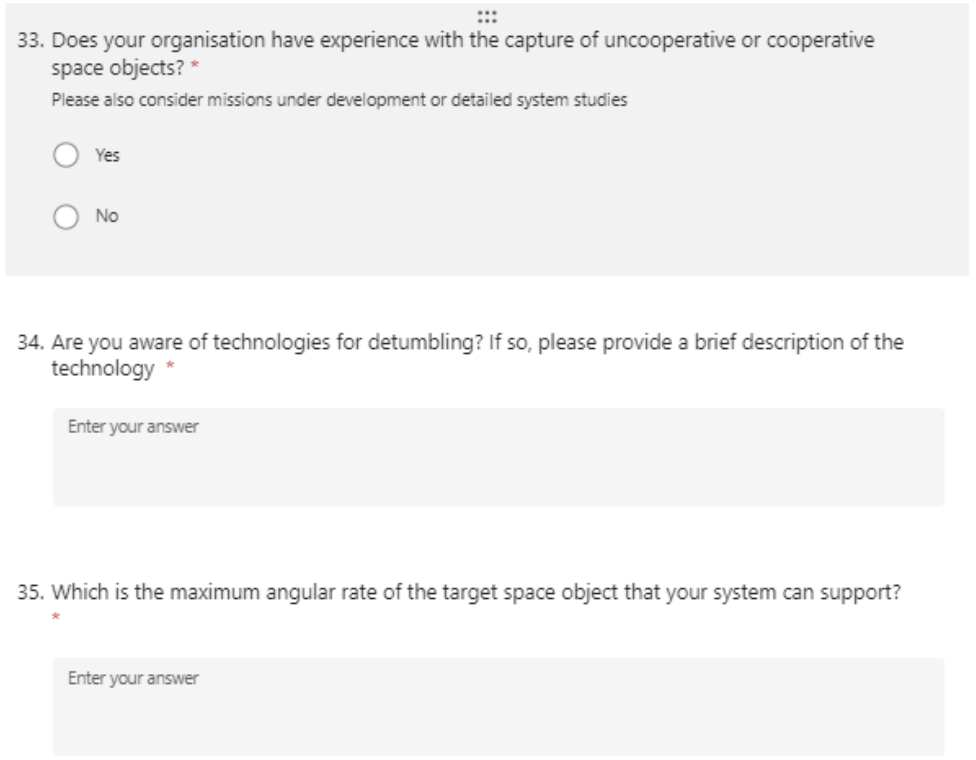
Survey is divided in five parts

- Capture
- Relative navigation for rendezvous
- **Attitude Reconstruction from Ground**
- Detumbling
- Standardization approach

Objective of Attitude Reconstruction from Ground Section:

- Collection of User needs
- Identification of key drivers for Attitude reconstruction from Ground

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey V



33. Does your organisation have experience with the capture of uncooperative or cooperative space objects? *

Please also consider missions under development or detailed system studies

- ◯ Yes
- ◯ No

34. Are you aware of technologies for detumbling? If so, please provide a brief description of the technology *

Enter your answer

35. Which is the maximum angular rate of the target space object that your system can support? *

Enter your answer

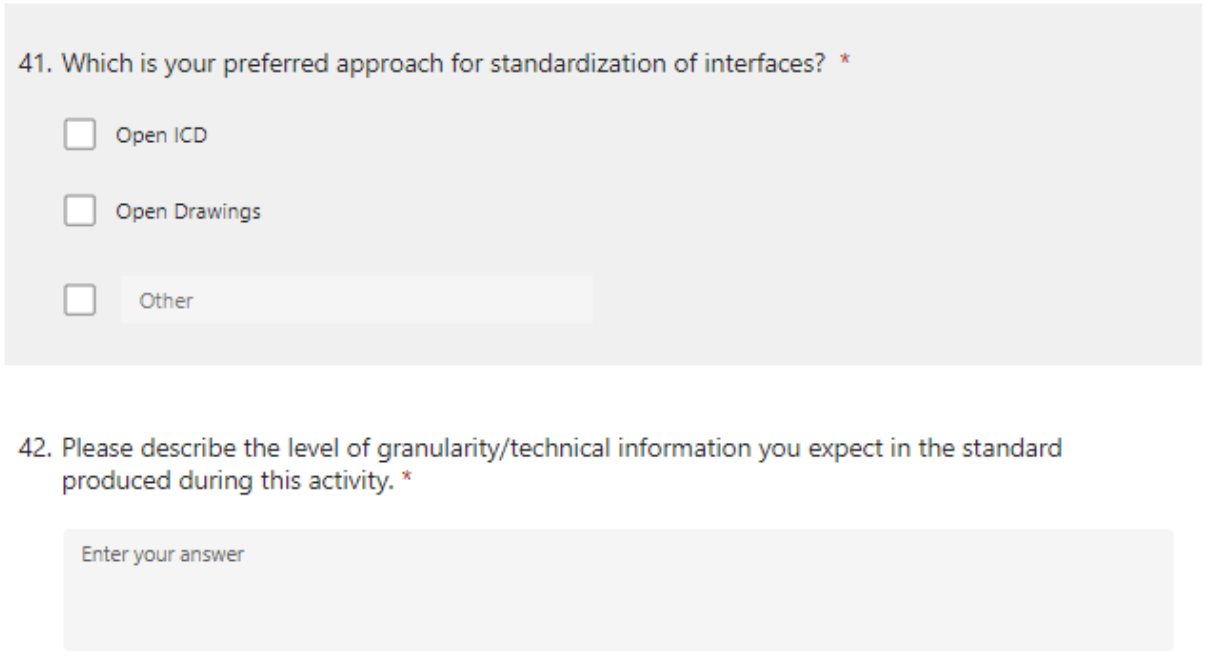
Survey is divided in five parts

- Capture
- Relative navigation for rendezvous
- Attitude Reconstruction from Ground
- Detumbling
- Standardization approach

Objective of Detumbling Section:

- Collection of User needs
- Identification of topics for requirements definition

Standardised De-orbit Interface Definition for Satcom-class Spacecraft – Phase 1 Survey VI



Survey is divided in five parts

- Capture
- Relative navigation for rendezvous
- Attitude Reconstruction from Ground
- Detumbling
- Standardization approach

Objective of Standardization approach Section:

- Collect User needs
- Level of granularity expected
- Identification of key drivers

Survey mechanics

We will share the link with all attendees of this webinar.

Please fill in the survey with your own opinions. We encourage you to share with colleagues or other stakeholders

Opens: Friday 7th at 09:00 CEST

Closes: Sunday 23rd at 23:45 CEST

Should take about 15-20 minutes depending on your inputs. The survey questions asked are tailored to each respondent and are at a high level, we are not asking for granular technical detail

Contact us at cleanspace@esa.int to organise a bilateral meeting to discuss your inputs further

Existing Technologies and Removal Interfaces

Common Elements of Space Interfaces

Common Technical Features

- Symmetry (trilateral/quadrilateral)
- Fiducial markers & retroreflectors for relative navigation
- Self-alignment (through alignment pins/petals)
- Self-compatibility (also referred to as androgyny)

Challenges

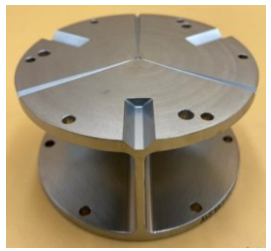
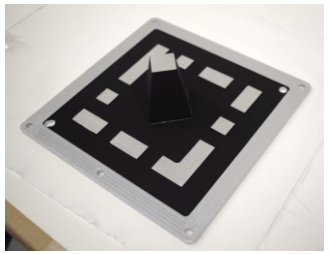
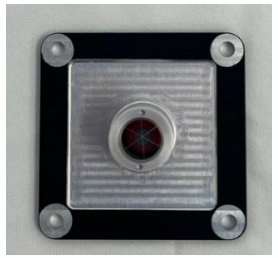
- Many options, but few open standards
- Features required for in-orbit servicing interfaces are different from de-orbiting interfaces
- Many interfaces do not support detumbling or attitude reconstruction from ground

Examples of Existing Deorbit Interfaces

Note that this is not an exhaustive list

ESA Design for Removal (D4R)

1st generation standard interface optimised for controlled re-entry has been developed and implemented in the 4/6 Copernicus Expansion missions.


Credits: GMV, Admatis, Zarm

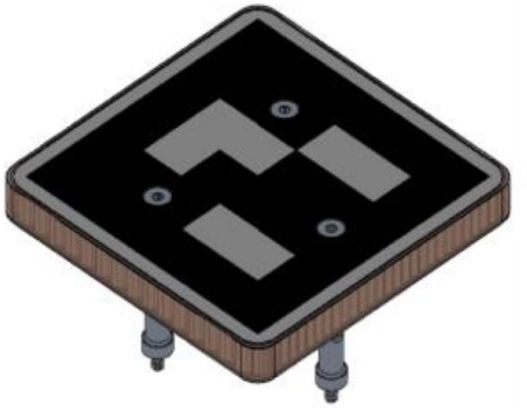
AstroScale Docking Plate

Lightweight magnetic docking plate with fiducial markers and retroreflectors designed to ease satellite removal.

Credits: Astroscale

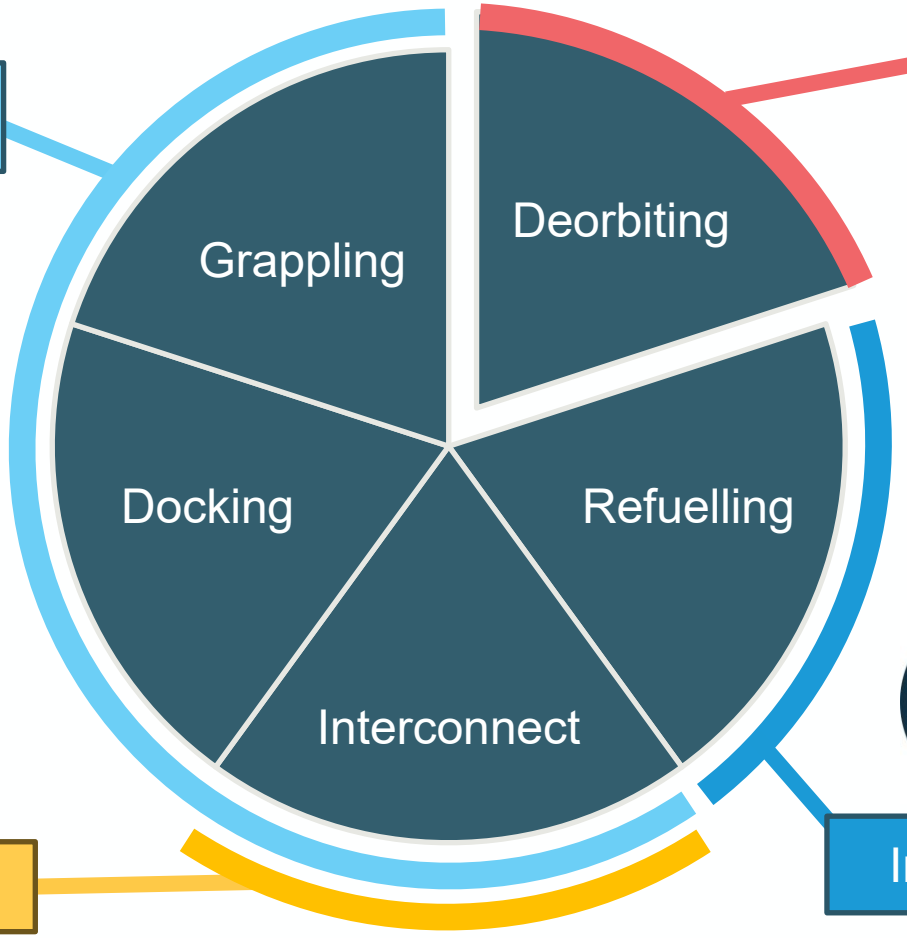
DogTag

Lightweight interfaces that enable a satellite to be grappled via a range of methods including magnetic, electrostatic or gecko adhesive, or mechanical pinch grasping



Credits: Voyager Space

Complementary Activities



InSPoC-1

Focusses on in-orbit Grappling, Docking, and Interconnect

SpaceUSB

System interconnect

InSPoC-2

Refuelling

This Activity

Focusses on passive de-orbiting interfaces for SatCom satellites

This activity complements parallel activities within ESA (In-Space Proof-of-Concept 1 and 2) and in Europe (SpaceUSB) and will seek input from a wide community of stakeholders.

We will aim to build as large a group of stakeholders as possible and focus on **Passive De-orbiting Interfaces**

The outcome of this activity is expected to shape ESA's inputs to ongoing standardisation activities in the wider space industry (e.g. CONFERS)

Conclusions

Take-home messages

- We need your inputs!
- Please answer the survey before **Sunday 23rd at 23:45 CEST**
- We will present the final outputs in the Workshop on 25th July PM (TBC)

Q & A

Let’s stay in touch!

today

Recordings of previous Clean Space webinars

Standardised De-orbit Interface Definition for Satcom-class Spacecraft

Zero Debris Week
25-28 June 2024
ESOC
https://indico.esa.int/e/zerodebrisweek

Clean Space Days
8-10 October 2024
ESTEC
https://indico.esa.int/e/CSD2024

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Thank you for your attention