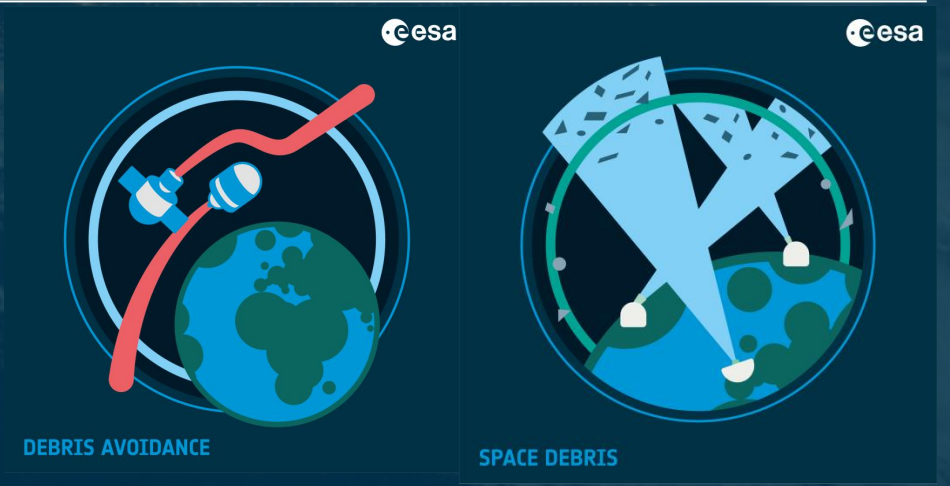
Zero Debris

Collision avoidance and SST

Klaus Merz, Tim Flohrer, Quentin Verspieren, Tiago Soares

2024/05/15 – SSA Operators' Workshop, Boulder, CO



Zero Debris approach

Council at Ministerial Level 2022

ESA encouraged by Member States to implement “a Zero Debris approach for its missions; and to encourage partners and other actors to pursue similar paths, thereby collectively putting Europe at the forefront of sustainability on Earth and in space, while preserving the competitiveness of its industry”

ESA/C-M/CCCXIII/Res.1.36

ESA Zero Debris approach

Engaging partners, building a community

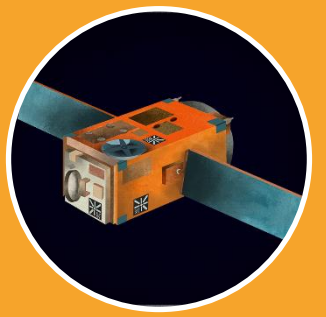
ESA SDM Policy & Standard

Technical requirements for ESA missions and contributions

ESA Technical Developments

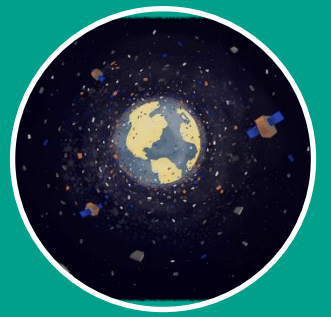
ESA support to industry's transition and compliance to SDM standards

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

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ESA's Space Debris Mitigation Requirements

Classical requirements
with specified thresholds/**targets**

Seed requirements
i.e. request of quantification/assessment

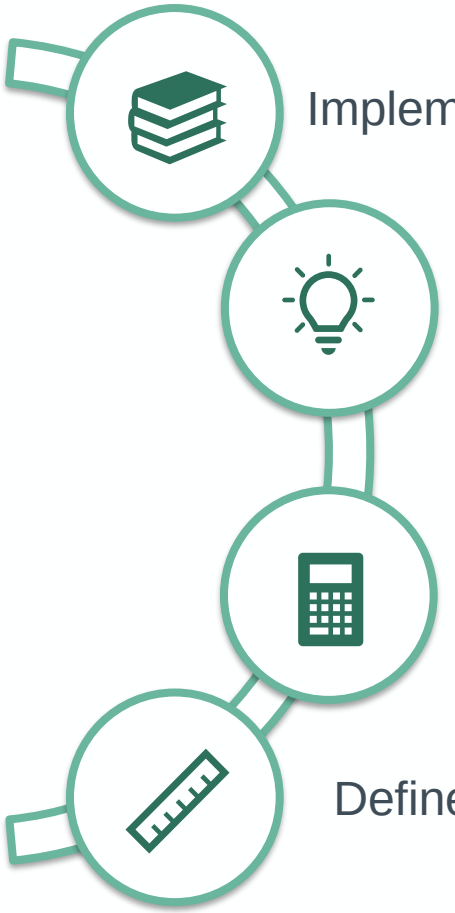
During the design, the developer of a spacecraft operating in near Earth orbit with a recurrent manoeuvre capability shall quantify the operational impact during normal operations due to conjunctions.

The developer of a spacecraft or launch vehicle orbital element injected in near Earth orbit shall quantify:

- the expected number of conjunctions at 10^{-4} and 10^{-6} collision probability threshold,
- the estimated number of collision avoidance manoeuvres triggered thereby on other spacecraft

during normal operations and after end of life until re-entry or up to 100 years.

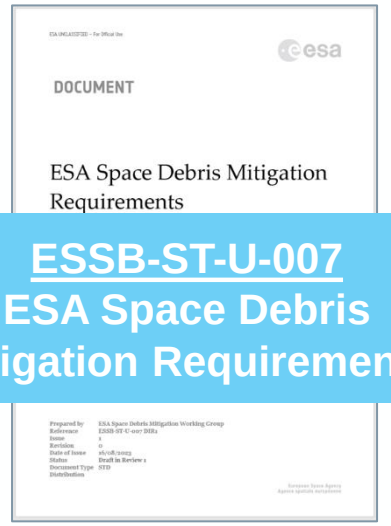
Seed requirements motivations



ESA's Space Debris Mitigation Requirements

What's new

What?



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

Clearance criteria

+ **5 years in LEO**
+ Collision probability threshold
+ Apogee below 375 km for constellations
+ If graveyard, no crossing with known constellations

Probability of successful disposal

+ ≥ 90% considering both **internal** (reliability) and **external** (impacts) factors
+ ≥ 95% for large constellations
+ Monitoring and reassessment

COLA & STC

+ Encoding of current best practices (e.g. data sharing)
+ Recurrent manoeuvre capability in GEO, in LEO for high and very high-risk objects, and for constellations
+ Collision probability threshold for action ≤ 1:10000

Design for removal

+ Preparation for removal for high-risk objects in the protected regions

https://technology.esa.int/upload/media/ESA-Space-Debris-Mitigation-Requirements-ESSB-ST-U-007-Issue1.pdf

COLA: Collision Avoidance | STC: Space Traffic Coordination

Collision avoidance operations

Recurrent manoeuvre capability in GEO, in LEO for high and very high-risk objects, and for constellations

Request for quantification of the **impact** of CAMs on **operations** + expected number of conjunctions, highlighting ones with other operators

Ability to **generate ephemerides** within 1 day after injection

Ability to **perform CAMs** within 2 days after injection

Ability to **plan** a **CAM** if alert received at least 12 hours before TCA

Acceptable collision probability threshold below **10^{-4}** per conjunction and **90% reduction** of annual collision probability in dense orbital regime

If a CAM is executed, the probability should be reduced of at least **two order of magnitude**

CAM: Collision Avoidance Manoeuvre | TCA: Time of Close Approach

Space Surveillance and Tracking

Ensure that the spacecraft can be **tracked** + **unambiguous identification** within **1 day** from injection

Include a **space surveillance segment**, able to provide **daily** updated **ephemerides** + **on-request screening**

Request for **quantification** of the **position** and **velocity accuracy** + target values for **position accuracy** during normal **operations** in the protected regions

Ground segment able to perform **orbit determination**, produce forecasted **ephemerides**, generate/process **CCSDS formats**

Virtual Workshop:
Space Surveillance and Tracking for Spacecraft Operations - connecting the dots between modelling, design and practice

Topics

- Default / estimated parameters for SST services
- Better characterisation of SST assets
- Verification with limited disclosure of sensor parameters

22 May 2024
https://indico.esa.int/event/519/

CAM: Collision Avoidance Manoeuvre | CDM: Conjunction Data Message | ODM: Orbit Data Message | TCA: Time of Close Approach

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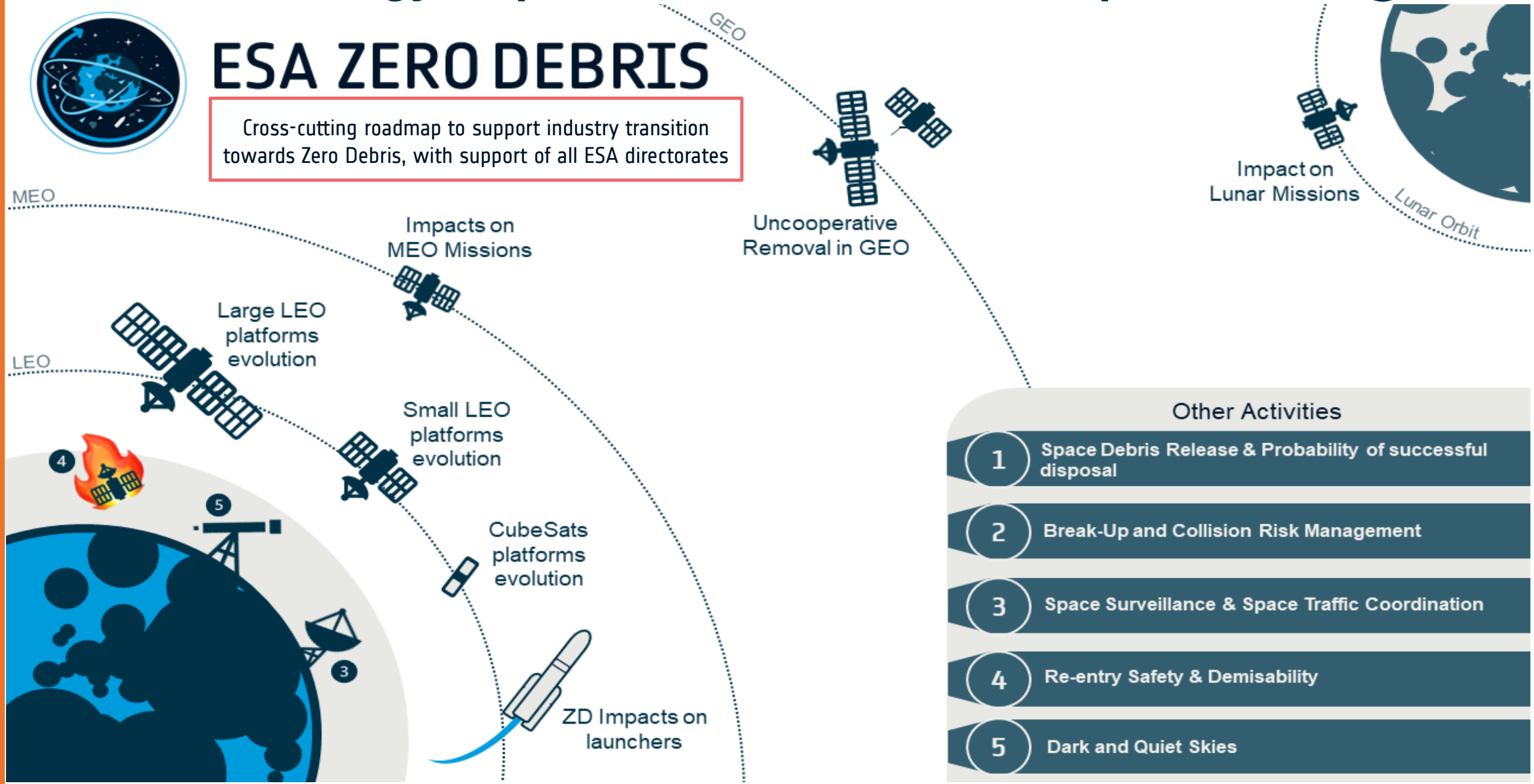
From Technology Gaps to Zero Debris roadmap 23-25

ESA ZERO DEBRIS

Cross-cutting roadmap to support industry transition towards Zero Debris, with support of all ESA directorates



Other Activities

1. Space Debris Release & Probability of successful disposal
2. Break-Up and Collision Risk Management
3. Space Surveillance & Space Traffic Coordination
4. Re-entry Safety & Demisability
5. Dark and Quiet Skies

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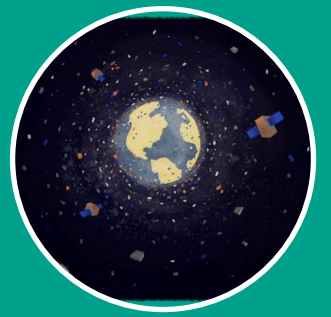


Jointly defined principles and targets for long term space sustainability

Zero Debris Charter: drafting and release

- **CM22:** ESA encouraged to implement a Zero Debris approach for its missions, and to **“encourage partners and other actors to pursue similar paths”**

  - **Charter’s objective: build a community** of proactive actors in Europe and beyond, committed to space safety and sustainability

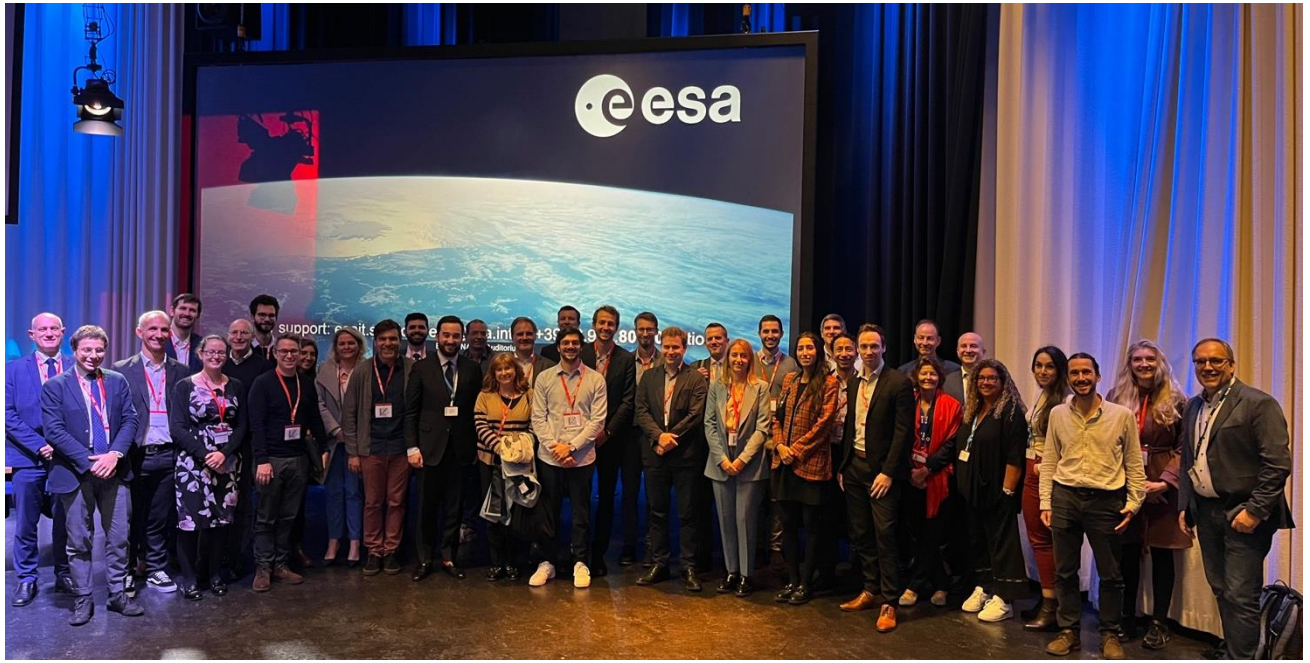
- July-October 2023: **open and collaborative drafting of the Zero Debris Charter** with 40+ proactive entities in Europe and beyond

- **Seville Space Summit (6 November 2023):** release of the Charter and acknowledgement by Member States that ESA has “followed up on the call of Council (…) for encouraging partners and other actors to pursue similar paths, inter alia through the **Protect Accelerator** and **the introduction of the Zero Debris Charter”**

Zero Debris Charter Co-development Workshops

4 September 2023: **Zero Debris Charter Co-development Workshop #1**

16 October 2023: **Zero Debris Charter Co-development Workshop #4**



Zero Debris Charter: a unique approach

1. **Bridging high-level orientations and concrete technical developments**
   (principles and targets)
2. **Involving public and private actors alike**
   (government, inter-governmental, industry of all sizes, academia)
3. **Only the first step: active follow-up to achieve the targets**
   (regular exchanges, technical booklet, collaborative roadmap)

Zero Debris Charter: Principles and Targets

PRINCIPLES

Release of space debris

No intentional release of space debris and minimise unintentional generation

1

Aduerse consequences of Space Debris

Adverse impacts of space debris on the population, infrastructure, earth environment, and dark and quiet skies should be minimised.

2

Common knowledge and understanding of Space Debris

Constant and collaborative efforts to improve our understanding of the space debris population and its impacts

3

TARGETS

Probability of Debris generation by break-ups or collisions

The probability of space debris generation through collisions and break-ups should remain below 1 in 1000 per object during the entire orbital lifetime.

1

Timely and successful clearance

Timely clearance of low Earth orbit and geostationary Earth orbit regions should be achieved with a probability of success of at least 99% after end of mission, including through external means when necessary.

2

Casualty risk on ground

The casualty risk from re-entering objects should remain significantly lower than 1 in 10 000, striving towards zero casualty. A suitable aggregate risk threshold for constellations of satellites in the low Earth orbit region should be identified.

3

Space Traffic Coordination

Routine and transparent information sharing should be facilitated and active participation in strengthening global space traffic coordination mechanisms should be encouraged.

4

Space Surveillance and Tracking

Access to timely and accurate data on space objects down to a size of 5 cm or smaller in low Earth orbit and 20 cm or smaller in geostationary Earth orbit should be improved to enhance decision making capabilities for collision avoidance.

5

Link to the Charter

Zero Debris Charter: community response

Zero Debris Charter

Supporting the Zero Debris Charter

Committing to the Zero Debris Charter

Satellites in orbit underpin our modern lives. But swirling fragments of past space endeavours are trapped in orbit around Earth, threatening our future in space in sharply increasing numbers.

The Zero Debris Charter represents a collaborative effort within the global space community, serving as foundational document and initiative. This community-driven charter covers overarching guiding principles and jointly defined targets to get to Zero Debris by 2030.

Facilitated by ESA's 'Protection of Space Assets' Accelerator and co-developed by 40+ space actors, the Zero Debris Charter was published on 7 November 2023.

It is open for signatures by all entities dreaming of and committing to a Zero Debris future by 2030. Many have already registered their commitment and support, as demonstrated by the list of supporters below.

ESA is committed to a profound internal transformation of its space debris mitigation and remediation practices through the ESA Zero Debris approach. The Agency aims to stimulate similar endeavours in Europe and beyond, including supporting the Zero Debris Charter and its community.

Join the Zero Debris community

The Zero Debris Charter's community is made up of a wide and varied array of space entities from Europe and beyond, committed to further advancing space safety and sustainability. It includes industrial players of all sizes, government agencies, universities and research centres, international organisations and more.

Together, we develop a precise and common vision of space sustainability for 2030 – combining far-reaching guiding principles and highly ambitious yet realistic technical targets on which to build an ambitious Zero Debris roadmap.

Register your organisation's commitment to sign the Zero Debris Charter and be part of driving global space debris mitigation and remediation efforts, shaping a sustainable future in space.

REGISTER NOW

Supporters of the Zero Debris Charter

3S Northumbria Ltd
AICO EDV-Beratung GmbH
AIKO
Airbus Defence and Space
Aldoria
Alpine Space Ventures
Asociacion española de derecho aeronáutico y espacial
Association of Space Explorers
Astareon
Astroscale Ltd
Astros Solutions
Austrian Research Promotion Agency
Avanti Communications
BHO Legal
Bufete Mas y Calvet

DEIMOS Group
Digantara
DLR - German Aerospace Center
DSI Aerospace GmbH
EchoStar Corporation
Ecosmic
Enpulsion
EAS - European Astronomical Society
ESO - European Southern Observatory
ESPI - European Space Policy Institute
Exolaunch
Gama
GATE Space

The sustainable and safe use of space is a high priority for Germany, as expressed in the national space strategy. Space as a global common must be preserved and protected for future generations. We welcome and support the Zero Debris Charter initiative as an important contribution to establish a community that pursues the same principles and goals for space activities. We firmly believe that only an ambitious and internationally coordinated approach will lead to a solution to the space debris challenge.

[Supporting the Zero Debris Charter | OPS Portal (esa.int)]

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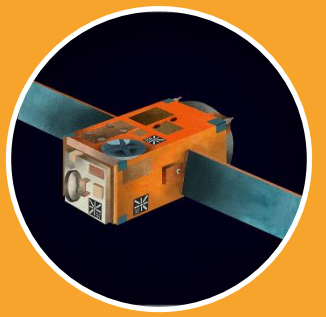

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How to Reach Zero Debris by 2030?

The Zero Debris Technical Booklet

Where we want to be by 2030
Zero Debris Charter

How to get there?
Zero Debris Technical Booklet

Zero Debris Technical Booklet: List of needs, technical solutions and contributions gathered through the Zero Debris community to achieve the jointly defined sustainability targets by 2030

Capacity building and collaboration from ZD partners

Inputs: ZD Charter, space laws, guidelines, best practices

Booklet is for the **benefit of everyone, participation is voluntary,** and outcome is for **information**

ESA is a **facilitator and** one of the contributors.

Inputs include **Zero Debris Charter** but also **national and international regulatory frameworks.**

Registration co-development

Zero Debris Week in June 2024

Zero Debris Week

25–28 Jun 2024
ESOC
Europe/Amsterdam timezone

Enter your search term

- Overview
- Registration
- THEMIS – Final presentation and demonstration
- Zero Debris Technical Booklet
- Close-Proximity Operations Workshop

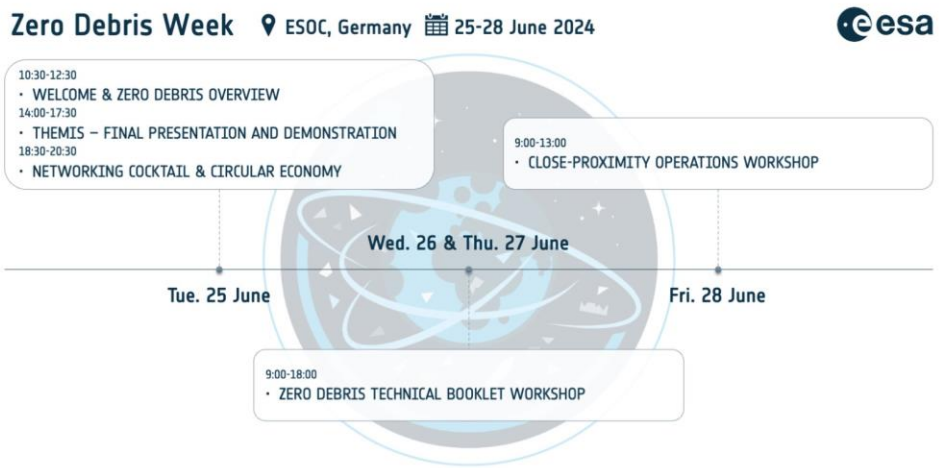
Contact
cleanspace@esa.int

The Zero Debris Technical Booklet grows into a Zero Debris Week!

The workshop that aims to co-create the zero debris technical booklet will be expanded to include several activities related to the application of the zero debris approach.

Join the Zero Debris Week, a week packed with events that focus on the application of the zero debris approach. The event will run from Tuesday, 25th of June at 10:30 AM (CET) to Friday, 28th at 1:00 PM.

Event overview



https://indico.esa.int/event/511/