

# Introducing the Zero Debris Charter

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→ THE EUROPEAN SPACE AGENCY

### 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

### **Zero Debris implementation**





#### **ESA Zero Debris approach**

New state-of-the-art technical requirements, applicable to ESA missions, in a step-by-step approach to implement a Zero Debris by 2030.



#### Zero Debris Charter



Engaging like-minded actors of the space sector in a collective effort towards space safety and sustainability



#### Zero Debris Technical Bookle



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



# eesa

# The Protect Accelerator

The Protect Accelerator was established to connect space and non-space actors beyond ESA to protect European assets from space hazards, including debris and space weather interferences, in synergy with relevant national, EU or other European initiatives.

Implemented by the ESA Directorate of Operations, it aims to leverage the capabilities and solutions developed by the Space Safety Programme (S2P) to foster collaborative capacity building activities with all relevant actors of the European and global space sectors for the achievement of a Zero Debris future by 2030 and to ensure the availability of space weather services in Europe.

#### Zero Debris Charter: building a pro-active community



#### **Objectives**

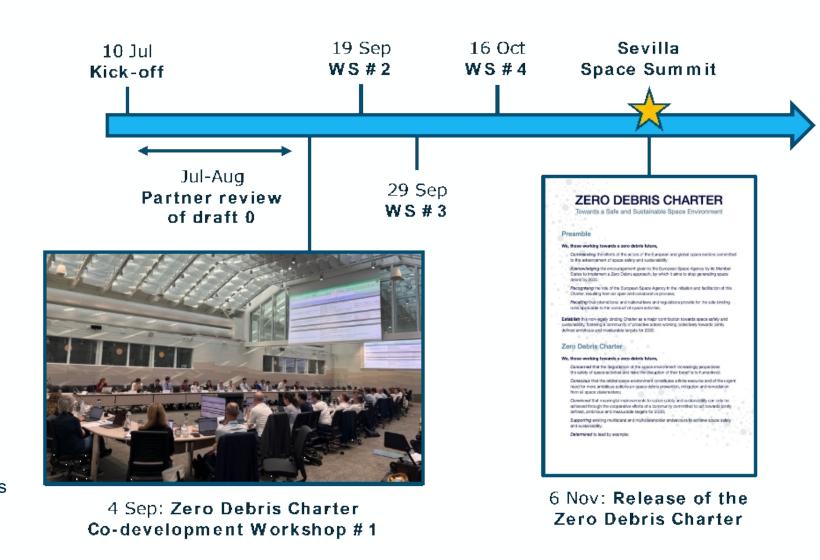
- Community building around Zero Debris
- Collaborative capacity building

#### **Co-development process**

- Collaborative and open to all.
- 40+ active participants (legacy and New Space, institutional, academic, etc.)
- 100+ closely following.

#### **Charter's contents**

- 3 guiding principles.
- 5 measurable targets for 2030.
- Commitment to work collaboratively towards the achievement of the targets.
- Not legally binding



#### ZERO DEBRIS CHARTER

PRINCIPLES AND TARGES



#### TARGETS

#### Probability of Debris generation by break-ups or collisions. PRING PLES The probability of space debris generation through collisions and break-ups should remain below 1 in 1000 per object during the entire orbital lifetime. Release of space debris (1) Timely and successful dearance No intentional release of space debris and minimise Timely dearance of low Earth orbit and geostationary Earth orbit regions should be achieved with a probability unintentional generation of success of at least 99% after end of mission, including (2)through external means when necessary. Adverse consequences of

Link to the Charter

## Space Debris

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

#### Common knowledge and understanding of Space Debris

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

3

#### 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.

#### Space Traffic Coordination

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

#### Space Surveillance and Tracking

(3)

(5)

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.

### Zero Debris Charter: a unique approach



- Bridging high-level orientations and concrete technical developments (principles and targets)
- 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)

#### Goal of the ZD Technical Booklet





Define collaboratively how to reach Zero Debris by 2030:



1. Involve all stakeholders in identifying the **technical needs** and **possible solutions** 



2. This booklet is for the **benefit of everyone** involved in the Zero Debris effort and could be the support different stakeholders' contributions in the future



3. ESA acts as a **facilitator for the booklet**, is one of the contributors and will be one of the beneficiaries.



4. Participation is voluntary and the outcome is for information

Join us in Co-Developing the Zero Debris Technical Booklet

Zero Debris Technical Booklet Webinar #1 (18 January 2024): https://indico.esa.int/event/496/



#### Thank you for your attention!

**Questions? Comments?** 

For any further question, contact Quentin Verspieren, Protect Accelerator Coordinator, at <a href="mailto:quentin.verspieren@esa.int">quentin.verspieren@esa.int</a>

### **Overview of Charter Targets**



- 1. The probability of space debris generation through collisions and break-ups should remain below 1 in 1000 per object during the entire orbital lifetime. A suitable aggregate probability threshold for constellations of satellites in the low Earth orbit region should be identified.
- 2. 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.
- 3. 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.
- 4. Routine and transparent information sharing should be facilitated and active participation in strengthening global space traffic coordination mechanisms should be encouraged.
- 5. 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.

# 1. The probability of space debris generation through collisions and break-ups should remain below 1 in 1000 per object during the entire orbital lifetime. A suitable aggregate probability threshold for constellations of satellites in the low Earth orbit region should be identified.



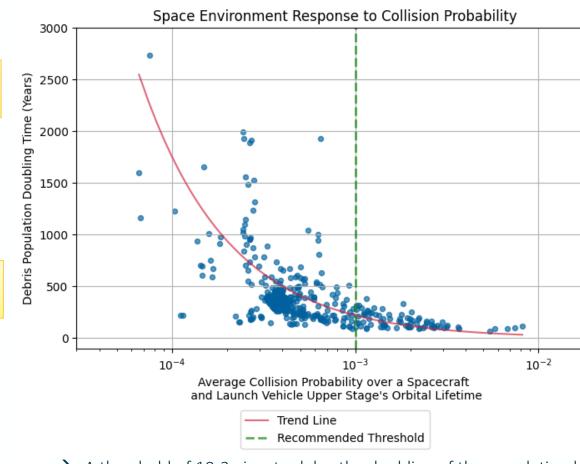
• We need a risk-driven parameter for in-orbit break-up, because this guarantees that the requirement follows the environment evolution

ISO 24113 : 6.2.2.1 The probability of accidental break-up of a spacecraft or launch vehicle orbital stage in Earth orbit shall be less than 10–3 until its end of life.

- Extend it to external sources and to the whole orbital lifetime:
  - include risks of internal break-ups after end of life
  - limit collisions (driver of future debris generation)
- Other current guidelines already targeting the same problem:

NASA: (...) for a spacecraft or upper stage, a program will estimate and limit the probability of collision with objects 10 cm and larger during orbital lifetime to less than 0.001

- Impacts with smaller debris expected to cause significant number of debris in the future.
- → Will foster developments in the fields of:
  - High probability of successful passivation (>99%)
  - Timely orbit clearance from populated orbits (in low-risk orbits)
  - Shielding and fragmentation prevention
  - Improve COLA capability based on SST timely and accurate data



→ A threshold of 10-3 aims to delay the doubling of the population by about 1 order of magnitude. e.g. 10-2 the average doubling time is 27.8 years and at 10-3 the average doubling time is 220.3 years.

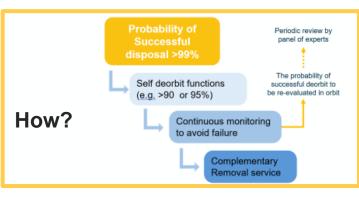
Note: Using data from IADC-04-06, needs to be updated and extended

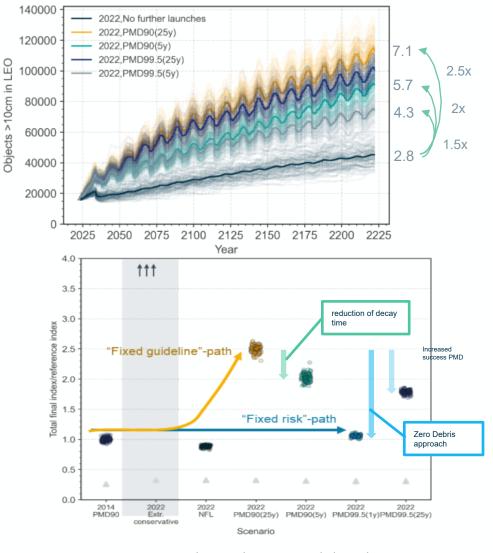


# 2. Timely clearance of low Earth orbit and geostationary Earth orbit regions should be achieved with a probability of success of at least 99% after end of mission, including through external means when necessary.



- Even if no further launch the number of debris will continue to increase.
- Sustainable use of protected regions:
  - to reduce as much as possible the growth of debris
  - limit the level of risk for operational missions
- Requires combination of:
  - reduced decay time
  - increased success PMD →
- Successful PMD is key to:
  - Avoid accumulation of debris in valuable orbits
- → Will foster developments in the fields of:
  - Improvement of platform design and reliable disposal functions
  - Failure prognostic, health monitoring and watchdog technologies
  - Design for Removal and Standard Interfaces
  - Maturation of ADR services (stimulate IOS market)





**Note**: assumptions and population model under review

# 3. 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.

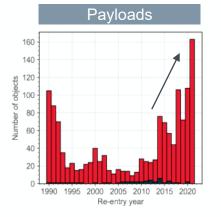


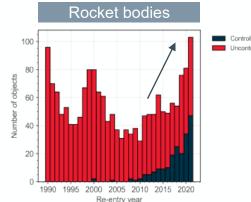
- The risk on-ground is increasing together with the growing number of payloads and upper stages re-entering uncontrolled.
- The future aggregated casualty risk will become very significative if large constellations are not designed fully demisable of for controlled re-entry.

Table 9. Casualty Expectation ( $E_{CSAT}$ ) for world population and probability of an Aircraft Downing Accident ( $P_{ADG}$ ) in 2035 resulting from possible reentries of <u>satellites</u> from proposed large constellations.

| Year 2035         | Risk   | USA Administration<br>Authority | Likely Launched on<br>USA Launch Vehicle |
|-------------------|--------|---------------------------------|--|
| Ecsat             | 0.61   | 91%                             | 95%                                      |
| P <sub>ADIS</sub> | 0.0007 |                                 |  |

- Current simulation capabilities have known limitations and are not harmonised and collaborative work is necessary
  - Charter aims to improve this exchange and promote knowledge development
- The overall risk strongly driven by elements that are used recurrently:
  - Demisable technologies under development can improve significantly the situation
- Europe has currently the edge on demise knowledge and technology
- → Will foster developments in the fields of:
  - Development of demisable technology aiming ate fully demisable product lines (platforms)
  - Enhancement of knowledge on reentry to prevent unknown risks
  - Improvement simulation capabilities







A 3-meter-long debris, originating from the SpaceX Dragon capsule, which was supposed to be demisable, reached the ground in Australia in July 2022

Source: BBC

Spain closes airspace and delays 300 flights as Chinese rocket debris plummets to earth



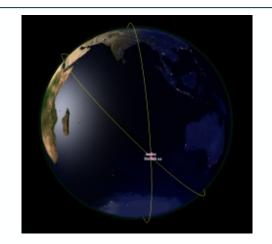


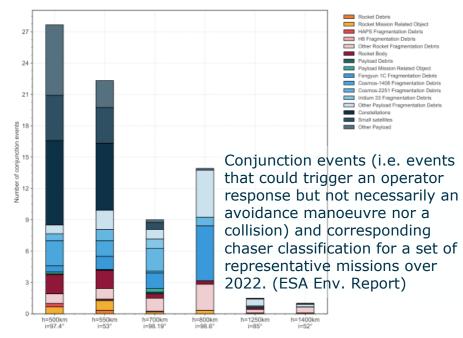
# 4. Systematic and transparent information sharing and active participation in strengthening global space traffic coordination mechanisms.



- September 2019: **ESA-Aeolus/Starlink-44 close approach** for the first time highlighted increased needs for efficient coordination
- Much of coordination today is still largely manual and requiring ad-hoc pragmatism of operators
- Effort for active vs. active collision avoidance is today a **main cost driver** in spacecraft operations
- An IOAG working group of sustainable operations in space recommended on technology for operator coordination, integrity of data protection for traffic coordination/collision avoidance and better data <a href="https://www.ioag.org/Public%20Documents/SOSWG%20report%20B.pdf">https://www.ioag.org/Public%20Documents/SOSWG%20report%20B.pdf</a>
- urgent needs:
  - Traffic coordination and communication protocols
  - Effective and trusted sharing of orbital data (includes plans!)
  - Improve Space surveillance and tracking
  - Increase tracking ability in satellite design

ESA is running technology development and demonstration through automated risk estimation and mitigation initiative as part of its **space safety activities (CREAM)** 





# 5. Access to timely and accurate orbital data on space objects down to a size of at least 5 cm or smaller in LEO and 20 cm or smaller in GEO should be improved to enhance decision making capabilities for collision avoidance.



Coverage of the space object population through catalogues is needed for 1) and 2)

- 1) Consequences for the environment  $\rightarrow$  address the catastrophic collision risk
- Risk for **catastrophic collision**: Energy-to-mass-ration (EMR)>40J/g is approximately assumed in absence of better data [1], and, widely, this is then related to a size threshold of 10 cm in LEO for larger satellites/upper stages
- Smaller objects can still cause catastrophic collisions, especially to smaller satellites [2,3]
  - → Ref [2] estimated for LEO 5cm target in LEO for <u>covering largest part</u> of the catastrophic collision flux of satellites >100kg
  - → to cover also (future) smaller missions, a lower future target of <3cm should be aimed at
  - → NB: avoiding lethal collisions (EMR>0.015J/g) and the respective generation of smaller numbers of space debris, also calls for a target threshold << 2 cm (ESA-contracted analyses considering impactor size, velocity, and vulnerability of several types)
  - (NB: a LEO mission like Sentinel-1 has a 6% chance of being hit by a 1-10 cm debris during mission lifetime)

#### 2) Coverage of intact objects for collision avoidance and monitoring

- reflecting that all missions need operational collision avoidance, i.e., satellites are easily and regularly tracked
- considering the need to improve debris tracking capabilities for lowering the number of false alerts (e.g., laser ranging, tracking radar networks)
- target is widely compatible with the various (commercial, governmental, multi-national, ...) ongoing efforts for 2030 addressing the increase of space surveillance capabilities (size threshold, data frequency, accuracy)
- supporting the needed knowledge in operational support, and for LEOP & EoL monitoring of the expected smallest satellites in the regime
- [1] Tedeschi, W.J., et al., "Determining the effects of space debris impacts on spacecraft structures", Acta Astronautica, vol. 26, no. 7, p. 501-512, 07/1992.
- [2] Krag, H., et al., "The European space surveillance system--required performance and design concepts", Proceedings SpaceOps Conference, 2010.
- [3] Lindsay, M. et al, "The Efficacy of Limiting Catastrophic fragmentations in Low Earth Orbit by Regulating Probability of Collision with Large Objects", Proceedings of AMOS conference 2021.

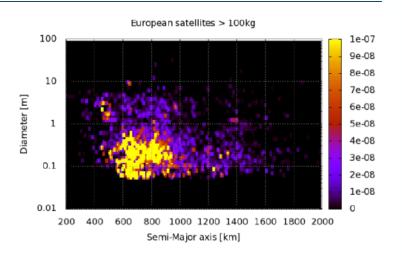


Figure 3: Distribution of the catastrophic collision flux for European satellites > 100kg

