Recent developments of spatial activities

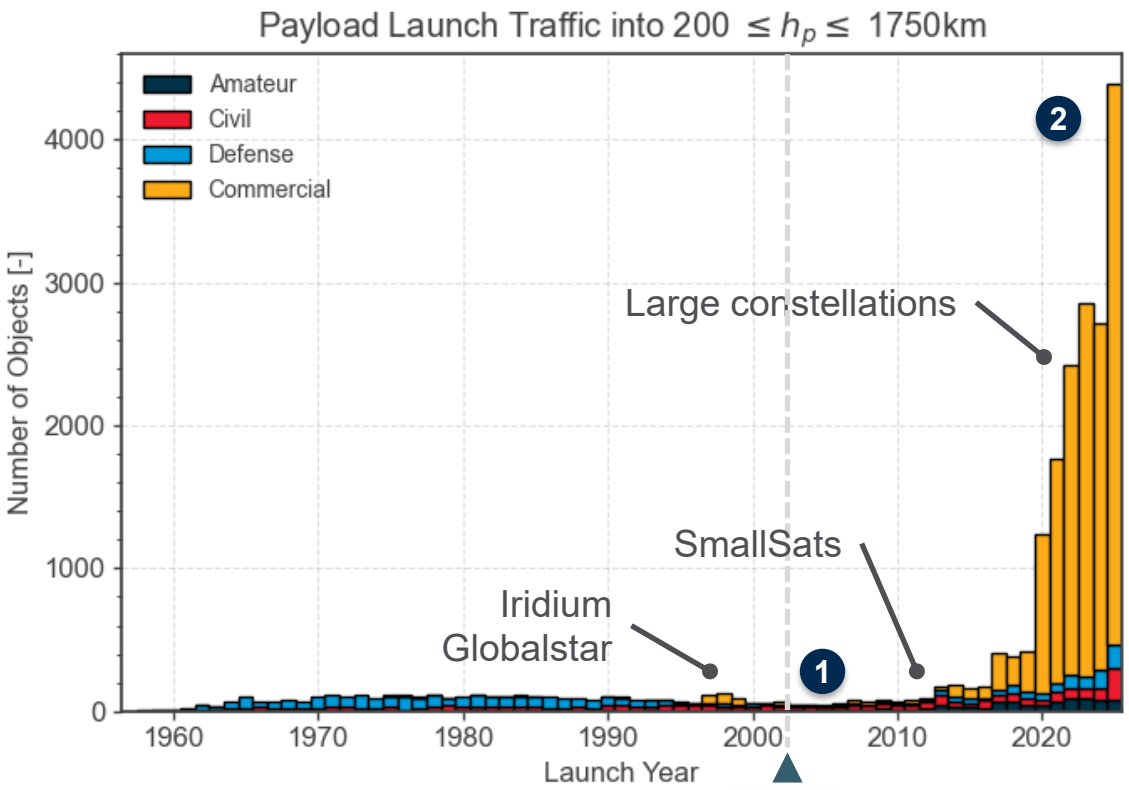
09/11/2026 – FRDO/CFDD Environmental impacts of space activities

Francesca Letizia, Space Debris Mitigation & Re-entry Safety Engineer

EUROPEAN SPACE AGENCY

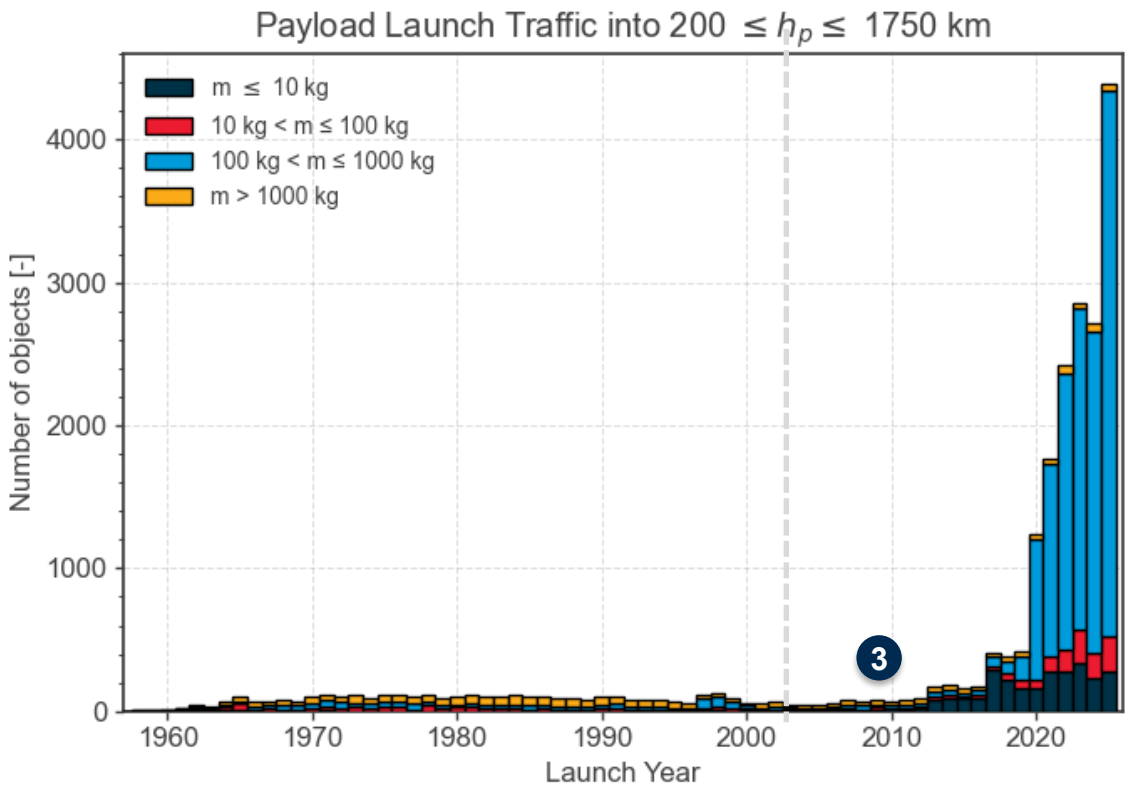

>1cm

LAUNCH TRAFFIC IN LOW EARTH ORBIT





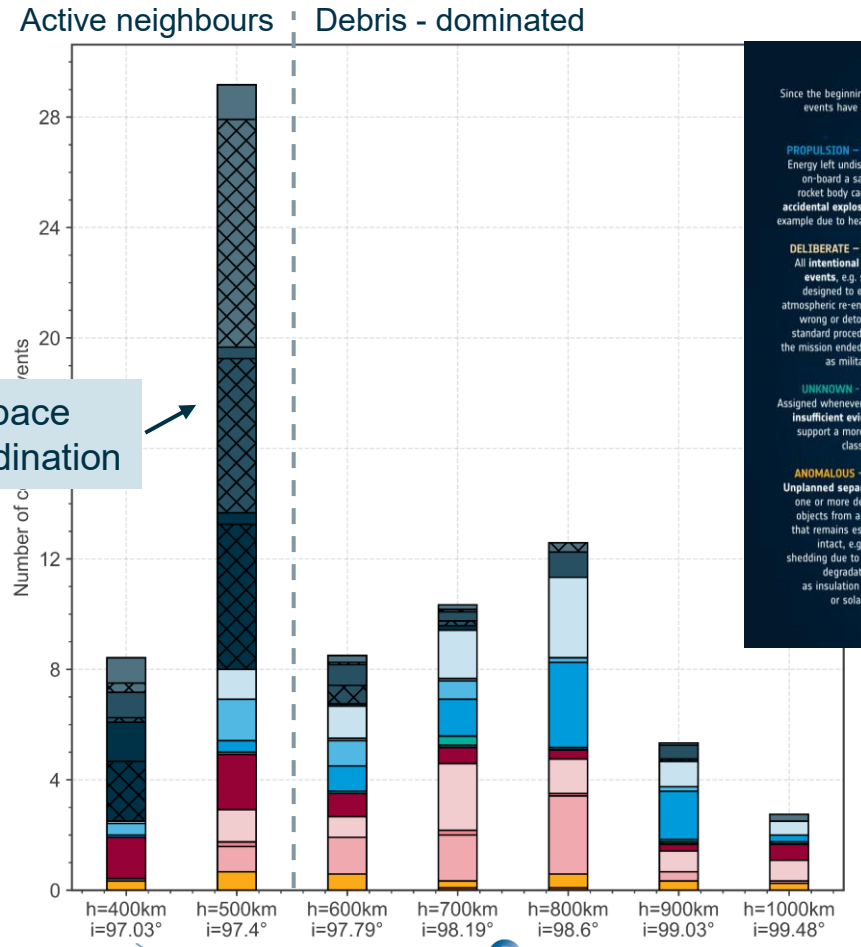
IADC 2002



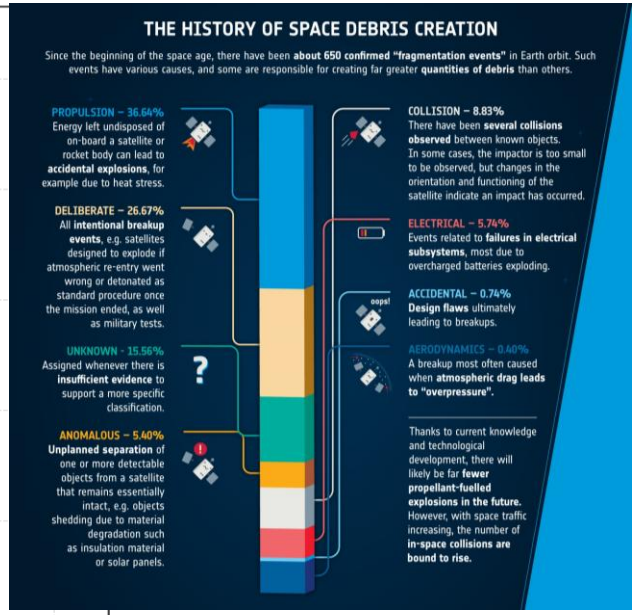
1. Operators
2. Volume
3. Size

OPERATING IN A NEW ENVIRONMENT

- Rocket Debris
- Rocket Mission Related Object
- L-15 (YF-115) (Long March (CZ) 6A) Fragmentation Debris
- HAPS Fragmentation Debris
- Other Rocket Fragmentation Debris
- Rocket Body
- Payload Debris
- Payload Mission Related Object
- Fengyun 1C Fragmentation Debris
- Cosmos-2251 Fragmentation Debris
- Iridium 33 Fragmentation Debris
- Other Payload Fragmentation Debris
- Constellations: Active
- Constellations: Inactive
- Small satellites: Active
- Small satellites: Inactive
- Other Payload: Active
- Other Payload: Inactive



Need for space traffic coordination

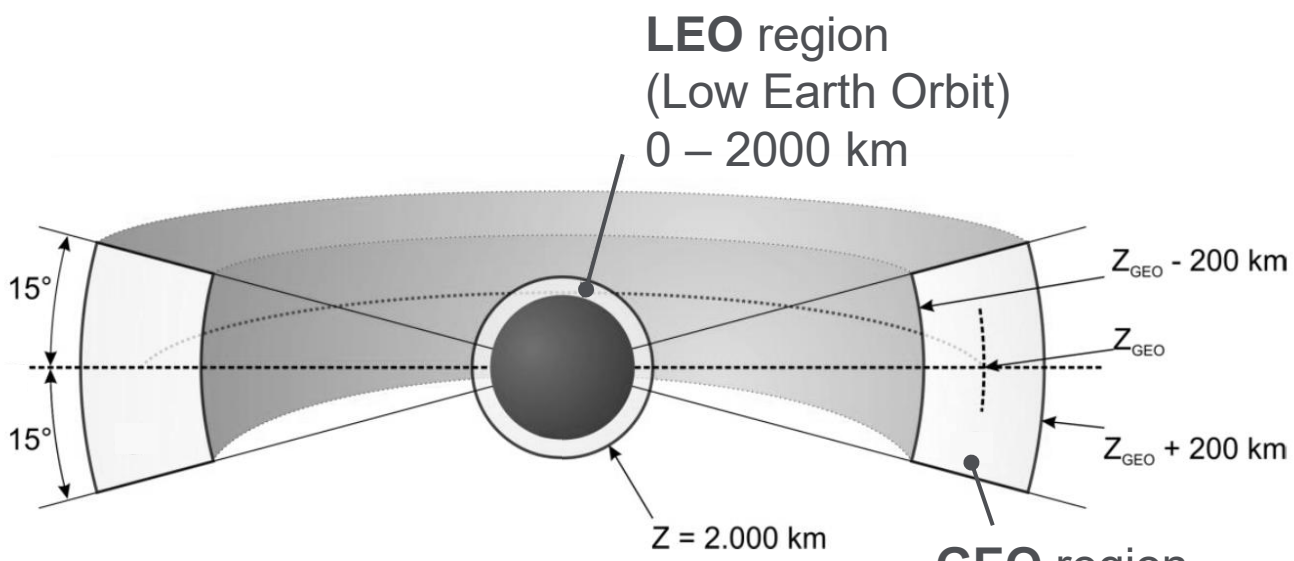


Representative missions in Sun-synchronous orbits
Conjunctions events with collision probability above 10^{-6}
3 days before the event

Location of ESA-operated Earth Observation satellites



CLEARING THE PROTECTED REGIONS

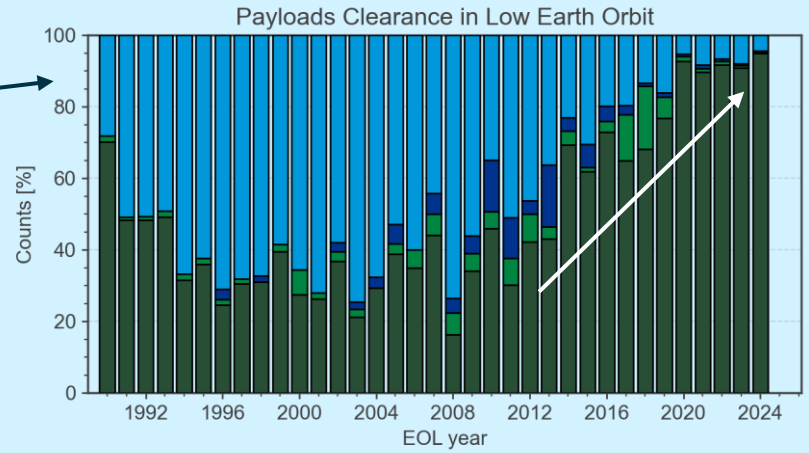


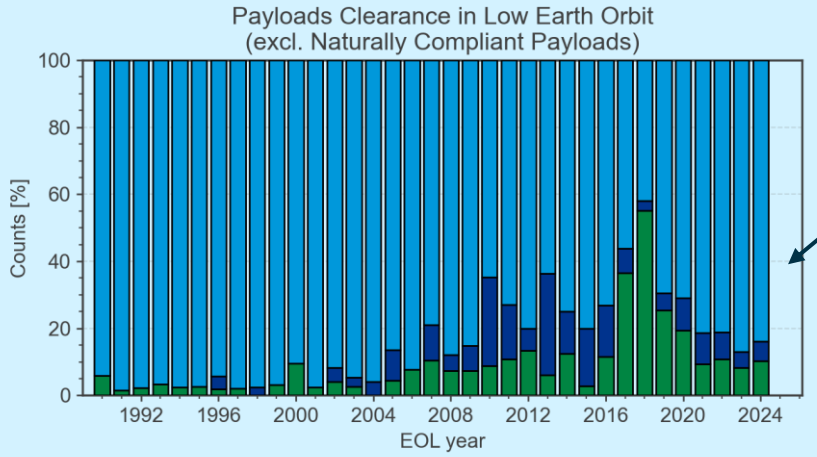


Visualisation of the protected regions
Image credits: re-adapted from ISO24113

CLEARING THE PROTECTED REGIONS

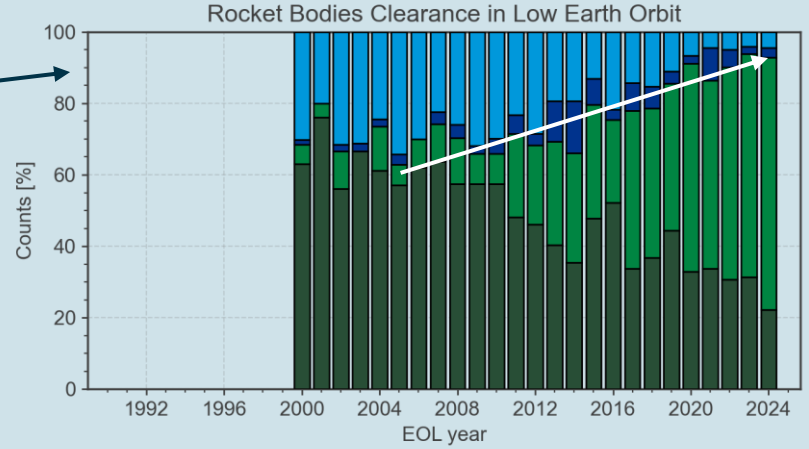
Missions in LEO moving towards lower altitudes

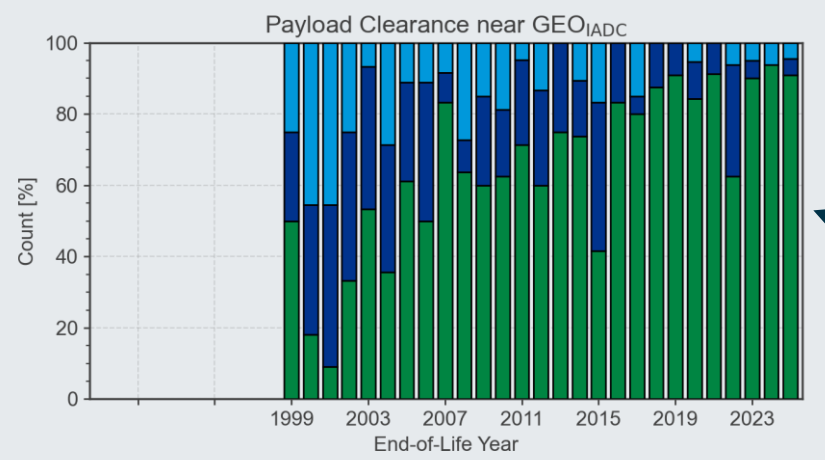




Insufficient level of active disposal for high-risk objects in LEO

Improving trends for rocket bodies in LEO



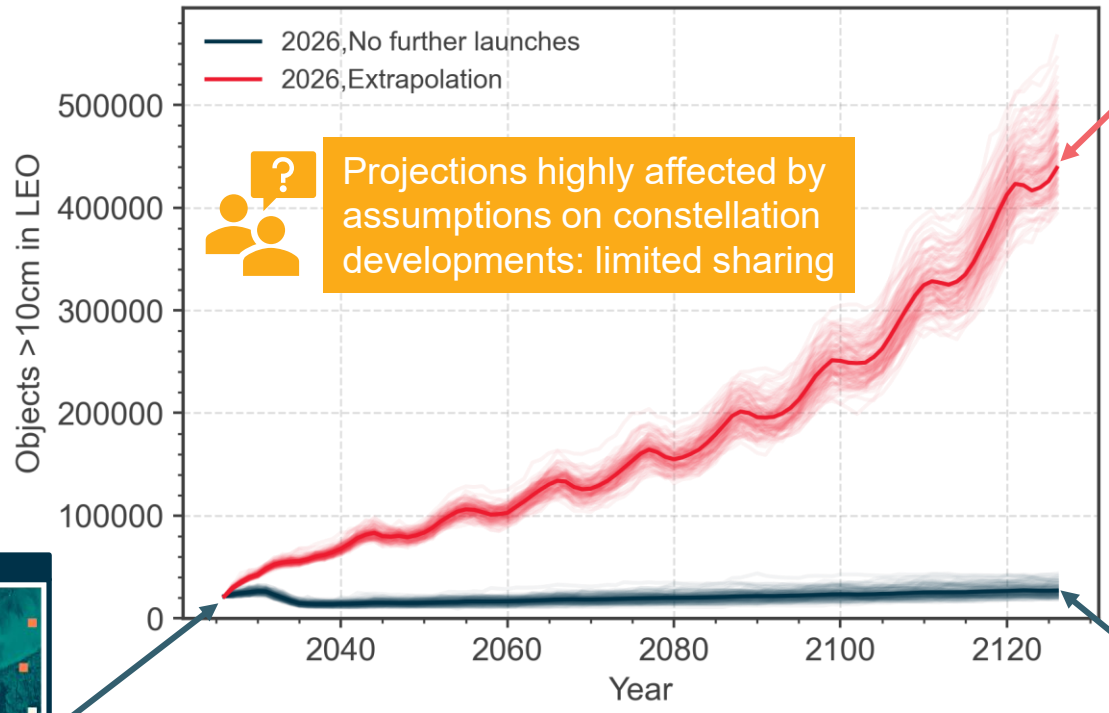




Consistent good disposal performance in GEO

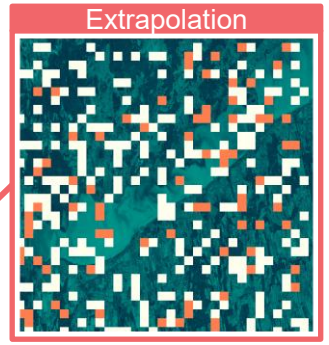
LOOKING AT THE FUTURE





Projections highly affected by assumptions on constellation developments: limited sharing

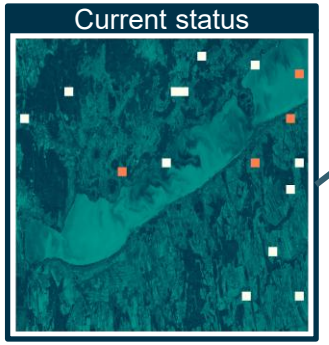
Extrapolation



~20x

Technology development can help to increase the resilience of space platforms to the debris population growth

Current status



No further launches



~1.25x

=1 year

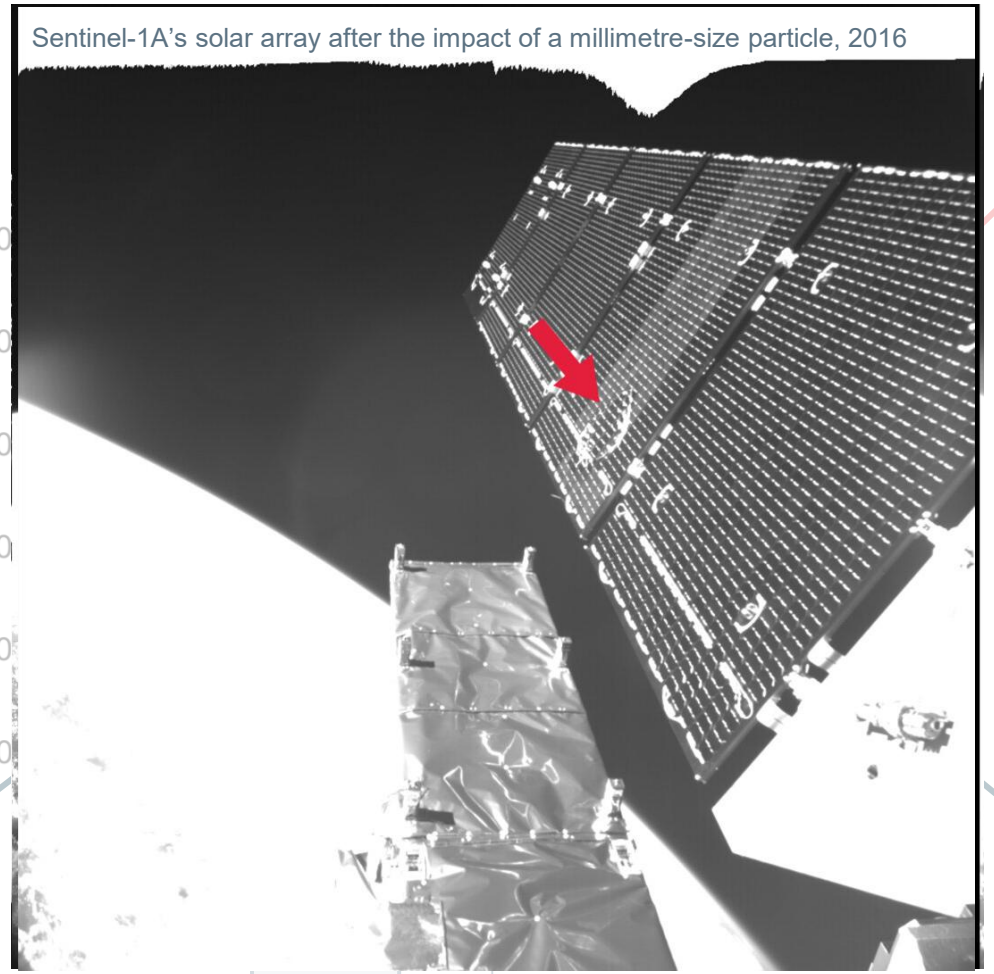
CAM
visualised as an 8-hour outage of operations

Escalated event
i.e. monitored conjunction notified to the mission team that did not result in a CAM

LOOKING AT THE FUTURE



Sentinel-1A's solar array after the impact of a millimetre-size particle, 2016



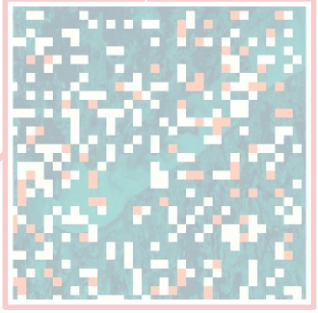
Objects >10cm in LEO

500000
400000
300000
200000
100000
0

Current status



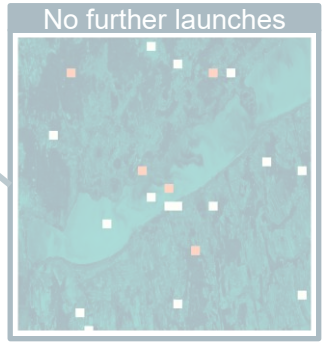
Extrapolation



~20x

Technology development can help to increase the resilience of space platforms to the debris population growth

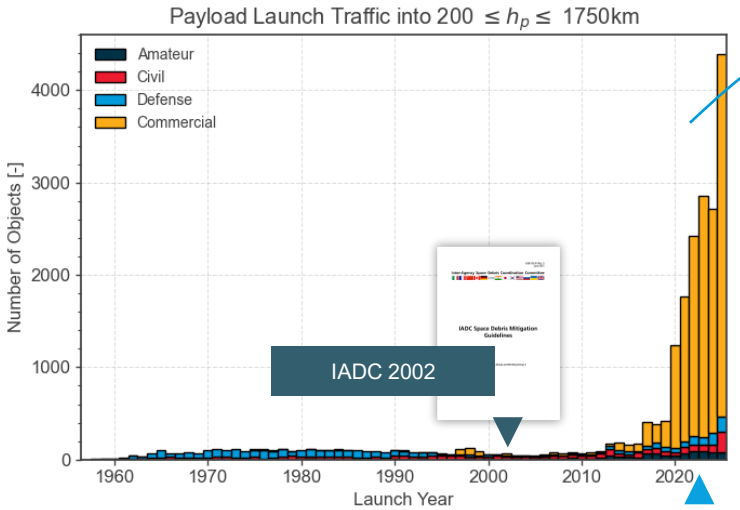
No further launches



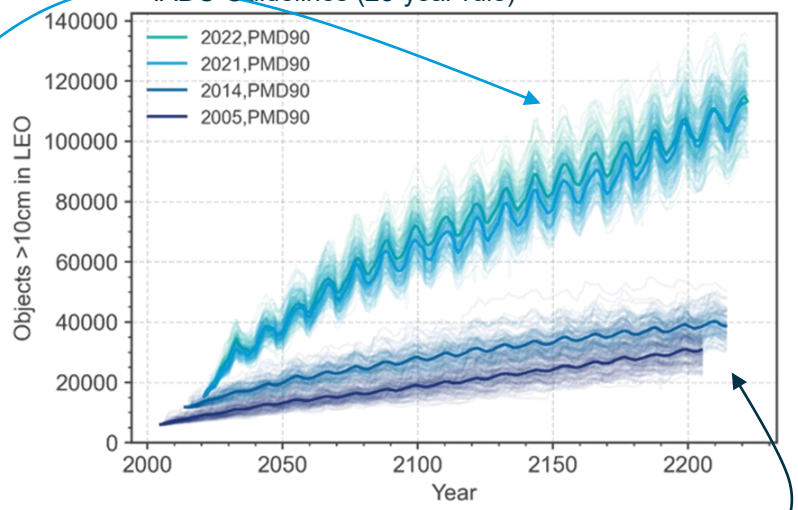
~1.25x

Escalated event
i.e. monitored conjunction notified to the mission team that did not result in a CAM

TOWARDS SUSTAINABLE OPERATIONS

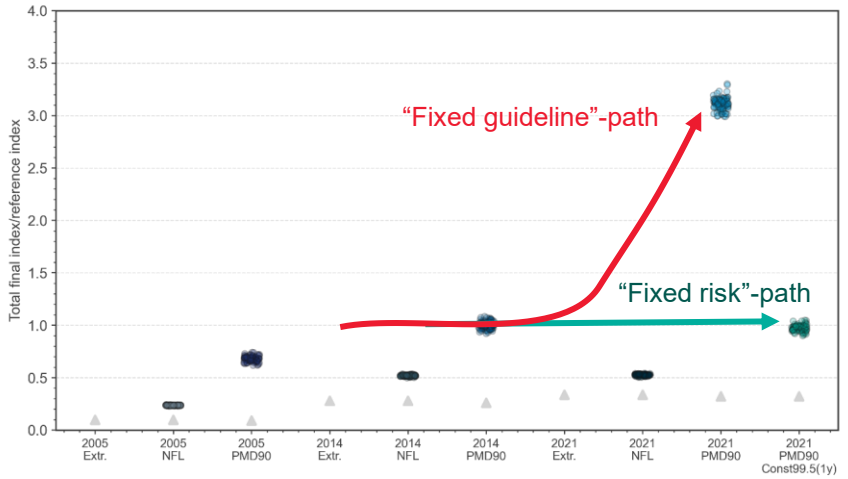


Space debris population evolution assuming high-level of compliance (90%) to the IADC Guidelines (25-year rule)



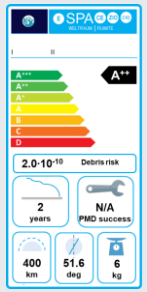
What the IADC Guidelines mean now

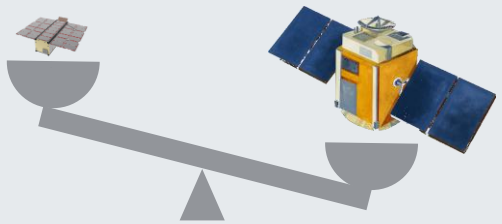
What the IADC Guidelines meant at publication

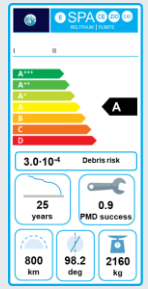


ESA ZERO DEBRIS APPROACH

Development of a **risk-based** approach to capture the potential contribution of a mission to the space debris environment
e.g. burden on neighbours, contribution to Kessler's syndrome







The **aggregation** of this **risk metric** over the whole **population** of in-orbit objects can be used as an indicator of the **health** of the space debris environment

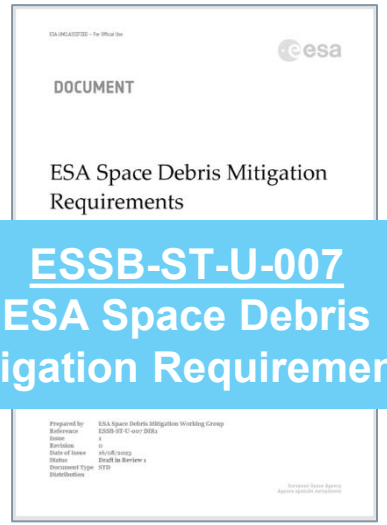
ESA'S ZERO DEBRIS APPROACH

> *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.*

Josef Aschbacher, ESA Director General, 2022

Developing ESA Zero Debris approach		Engaging partners, building a community	
ESA SDM Policy & Standard	**ESA Technical Developments**	**Zero Debris Technology Booklet**	**Zero Debris Charter**
			
Technical requirements for ESA missions and contributions	ESA support to industry's transition and compliance to SDM standards	Crowd-sourced technical solutions to reach Zero Debris targets by 2030	Jointly defined principles and targets for long term space sustainability

ESA'S SPACE DEBRIS MITIGATION REQUIREMENTS



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

Clearance criteria

+ Disposal in **5 years** (or less) in **LEO**
+ 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 & STM

+ Encoding of current **best practices**
+ Recurrent manoeuvre capability in GEO, in LEO for high and very high-risk objects, and for constellations
+ Collision probability threshold for action ≤ 1:10000

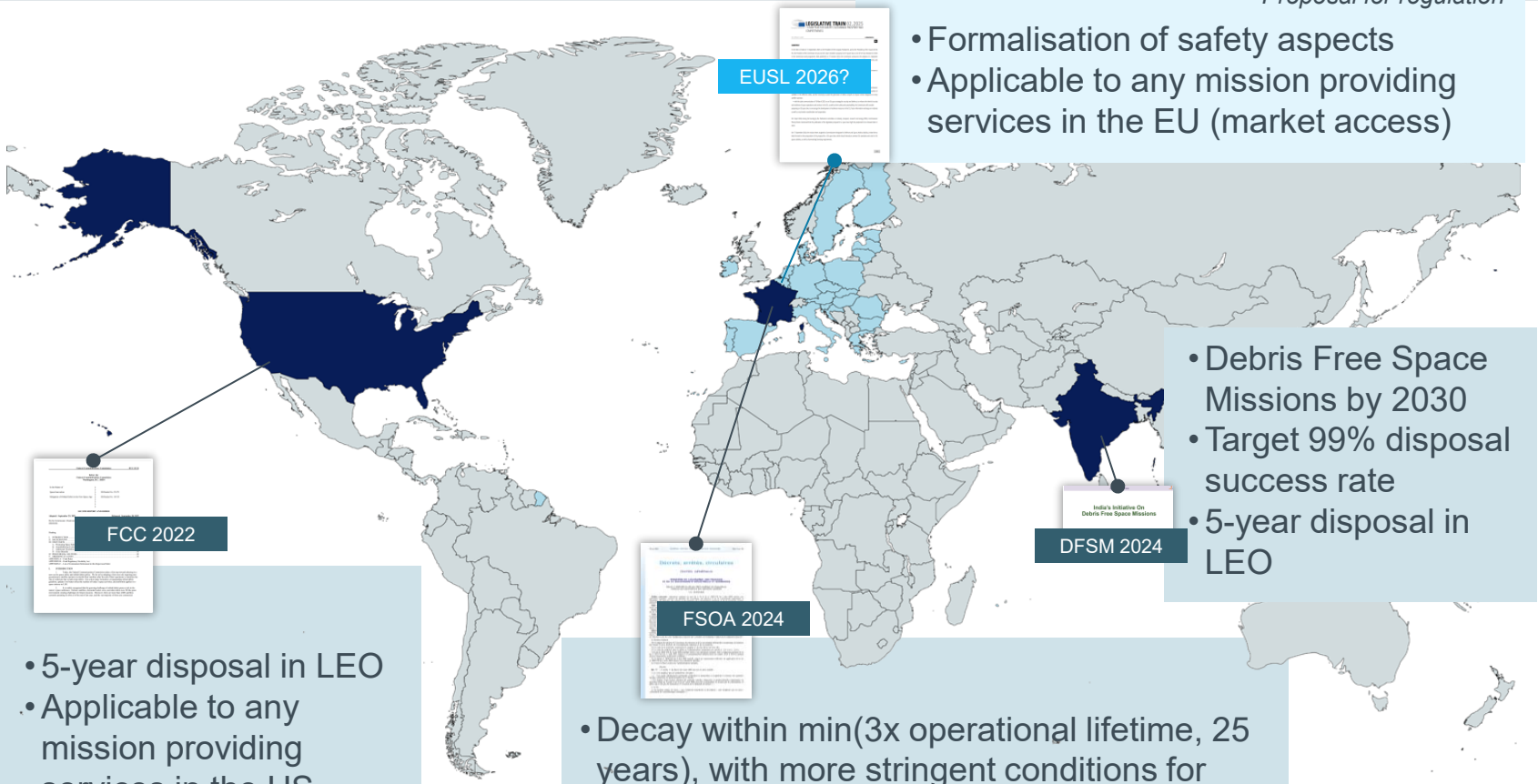
Design for removal

+ 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 | STM: Space Traffic Management

EVOLUTION OF SPACE DEBRIS MITIGATION INSTRUMENTS



Proposal for regulation

- Formalisation of safety aspects
- Applicable to any mission providing services in the EU (market access)

- Debris Free Space Missions by 2030
- Target 99% disposal success rate
- 5-year disposal in LEO

- 5-year disposal in LEO
- Applicable to any mission providing services in the US (market access)
- First fine for missed disposal issued in 2023

- Decay within min(3x operational lifetime, 25 years), with more stringent conditions for large constellations, including on reliability
- Manoeuvrability above 600 km
- Aggregated casualty risk threshold for large constellations

- Coverage of **collision avoidance** operations
- Evolution of **numerical values** (i.e. decay duration reduction)
- **Tailoring** based on **risk** profile
- Introduction of new **metrics** for evaluation
- Provisions **beyond protected regions**
- Foundations for **active debris removal/servicing** missions
- Extensions to other topics (e.g. **Dark&Quiet skies,** cybersecurity)

All applicable to

CONCLUSIONS



Level and **type** of current **space activity** very different from the one when international guidelines for space debris mitigation were drafted



Emerging need to **refine** and **strengthen mitigation measures** to ensure sustainable operations, while increasing the **resilience** of space infrastructures



Several **international initiatives** worldwide with **common traits** (e.g. collision avoidance activities, risk tailoring)



ESA Zero Debris approach: goal to reduce debris growth in the future through the adoption of more **stringent technical requirements** and the support to the development of enabling **technology solutions**

EUROPEAN SPACE AGENCY

THANK YOU!

francesca.letizia@esa.int