An Update on Space Safety Activities in ESA and on ESA's Zero Debris Approach

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20/10/2023

Outline

1. Space safety overview

   → see “Space Debris - How can laser technology contribute to a sustainable solution for the further exploitation of space as a resource?” presentation at ILRS Workshop 2022 in Guadalajara

2. ESA’s Laser Ranging Test-bed

   Update IZN-01 and upcoming (funded) activities addressing Laser Ranging in ESA’s Space Safety Programme

3. Zero Debris Approach in ESA

   Charter, ESA new Standard, ESA Space Debris Requirements, and Technology needs

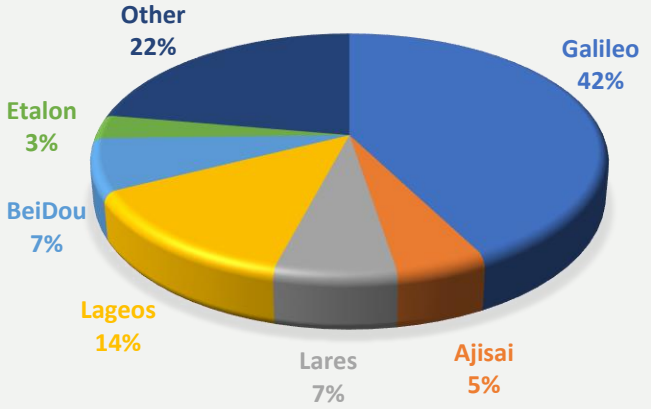
IZN-1 status update

IZN-1 status update 2023

- Pointing improvements and station optimization
- Establishing reliable operations
- Operations disrupted after severe wildfires in August

https://tenerifeweekly.com/

IZN-1 SLR passes (2023)



Satellite	# Normal Points
Galileo	2130
Lageos	1146
Lares	644

https://edc.dgfi.tum.de

1. SLR

- Station routinely operated for ILRS targets
- Lageos RMS: **5.9 mm** (https://ilrs.gsfc.nasa.gov/)

IZN-1 status update 2023

NorSat-TD

Image credit: Space Flight Laboratory

2. Optical communications

- Optical comms tests: uplink of 1590 nm beacon for satellite acquisition
- Development of interface for Optical Nucleus Network
- Upcoming installations:
  - Generic adaptive optics module for QKD/optical communications
  - Additional C/L band beacon and scanning optical head for SDA/CCSDS optical communications

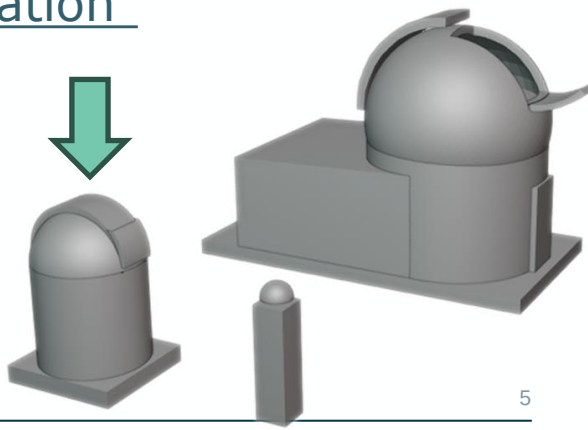
3. Space debris Laser Ranging

- SDRL upgrades as part of ongoing activity under Space Safety (prime GMV):

"Laser Ranging - Evolution towards Active Sensor Networking for Debris Observation"

  - Additional pulsed laser (1064 nm, >40W average power) on tracking mount
  - Separate dome
  - Stare and Chase capability

IZN-1



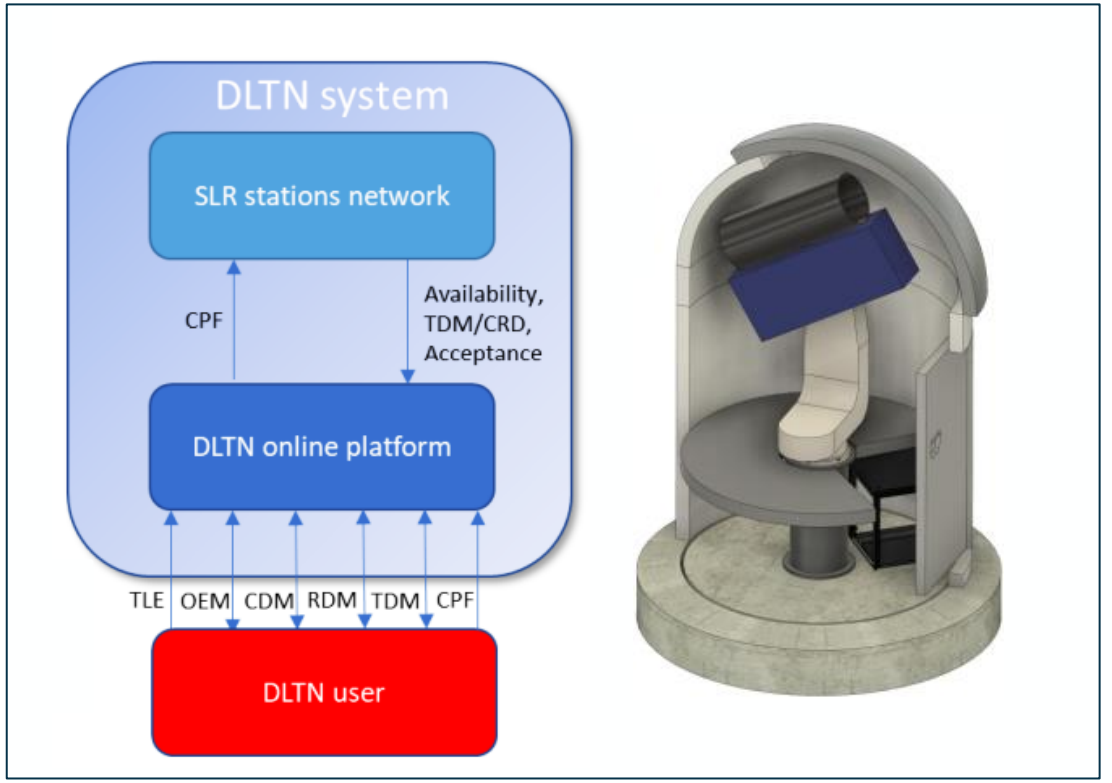
IZN-1 Space Debris Laser Ranging (con't)

- Significant increase of the debris tracking capacity
- Establishment of a "proof-of-concept" Tracking Network of space debris (DLTN)

Project Timeline

- DLTN Software implementation review by end 2023
- IZN-1 as DLTN Node – upgrades completed by mid 2024
- SDLR validation campaigns in 2024 for:
  - On-demand orbit improvement
  - High-accuracy cataloguing
  - Daytime/night-time tracking

DLTN = Debris Tracking Laser Network



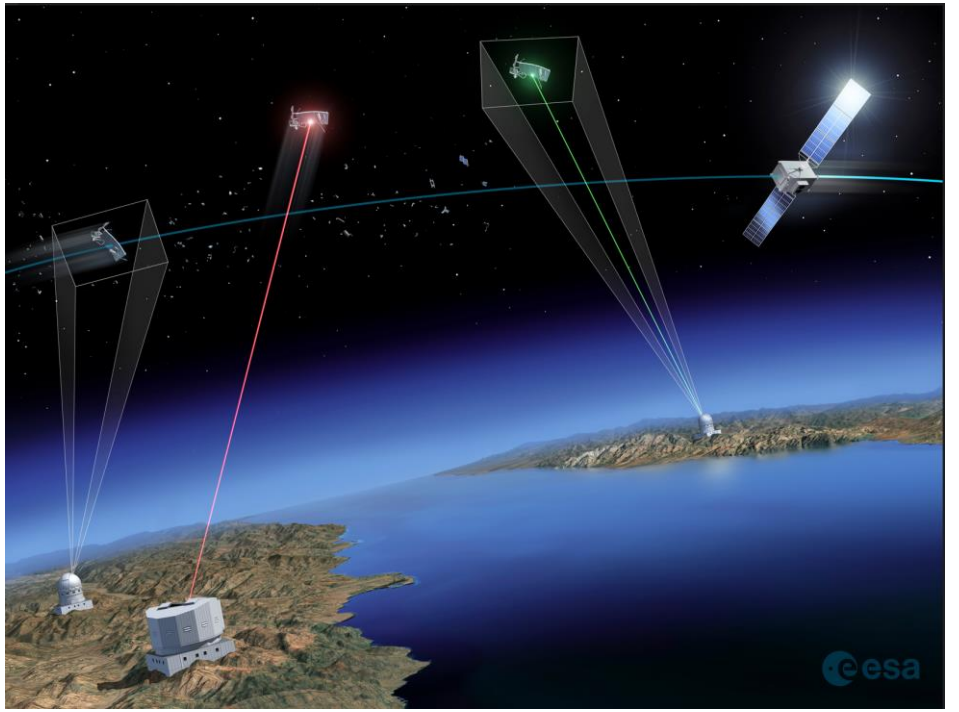
Laura Aivar, 22nd International Workshop on Laser Ranging, 2022

Next activities

Space Safety laser ranging technology developments

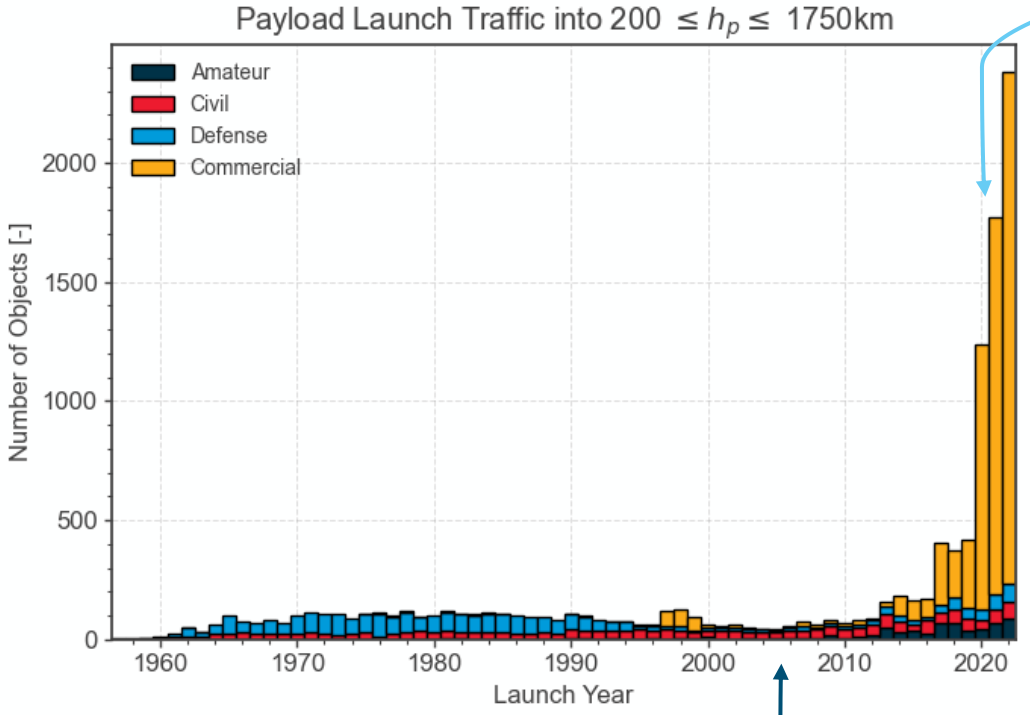
- S2-LT-01 Eye-safe Space Debris Laser Ranging
- S2-LT-02 Phase A/B1 OMLET (Laser Momentum Transfer Orbit Maintenance via Laser momEntumTransfer)
- S2-LT-03 Experiment support for IZN-1 testbed

(all approved, tendering to start soon for activities to run 2024-2025/26)

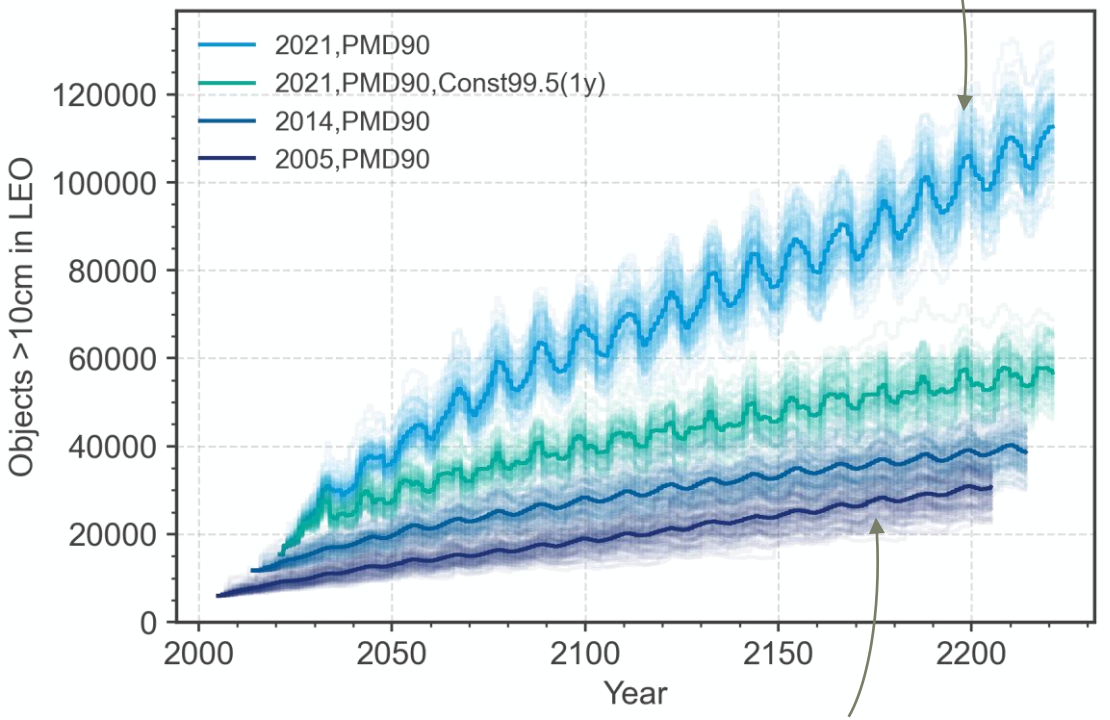


- Support to S2-LT-02: ITT is open for a Pre-Phase A of Laser Momentum Transfer (LMT) In-Orbit Verification
  ➔ **consolidated mission design concept** for demonstration using CubeSats
    - ➔ analyse the feasibility and technology readiness
    - ➔ identify possible gaps and mitigation actions & estimate the costs and risks

Why do we need Zero Debris



What PMD90(25y) means now:
is this acceptable?



What PMD90(25y) meant when
IADC drafted their recommendation

Urgent actions are needed to ensure the safety of future missions and prevent debris proliferation for future generations

Zero Debris implementation

ESA Space Debris Mitigation Standard & Policy

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

Facilitate Zero Debris Charter

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

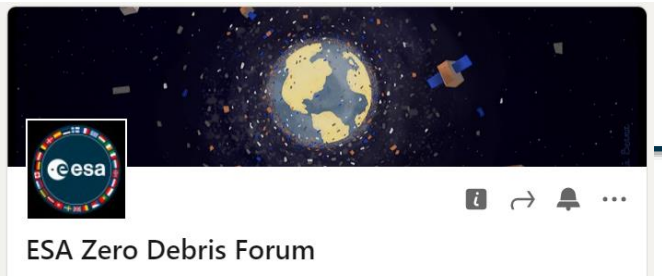
Facilitate Zero Debris Technical Booklet

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

Change needs to be built together…

Zero Debris Operations WS

Zero Debris CDF Study



Workshops

Studies

Forums

Webinars

Industry Days

National Agencies

Operators

Integrators

SST providers

Investors

Innovators

Insurers

Researchers

Delegations

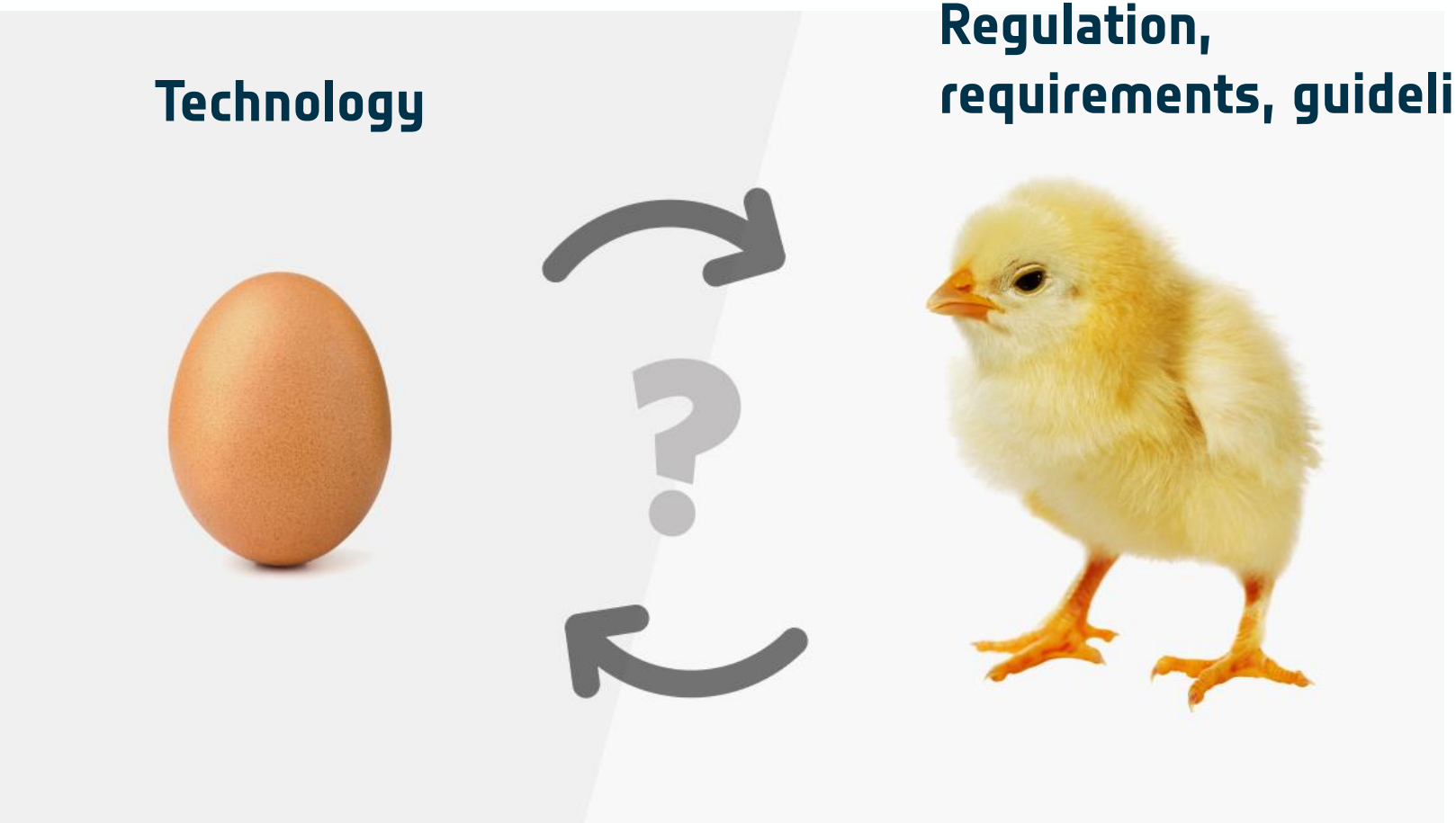
Academia

Common Goal

And many more…

Charter co-development Workshops

Technology drives Regulation drives Technology…



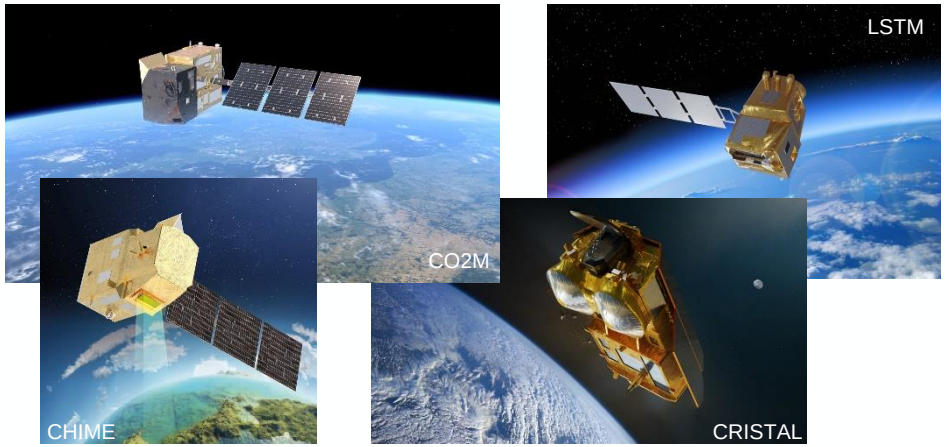
Breaking the loop → turn it into a virtuous spiral

Making Zero Debris a reality at ESA…

ESA Space Debris Mitigation standard

New **ESA SDM standard (ESSB-ST-U-007)** to be published in November 2023 → **1st step** towards Zero Debris expected to become applicable to **all ESA missions** that did not complete SRR yet.

Missions already in phase C that proactively applied dedicated requirements aligned with the Zero Debris e.g. Design for Removal interfaces and extra passivation features



Missions entering design phase, already with specific additional requirements aligned to new requirement

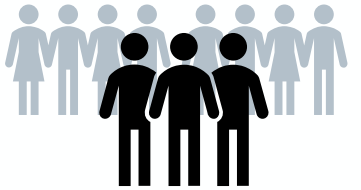
Why an ESA's own standard?

"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."

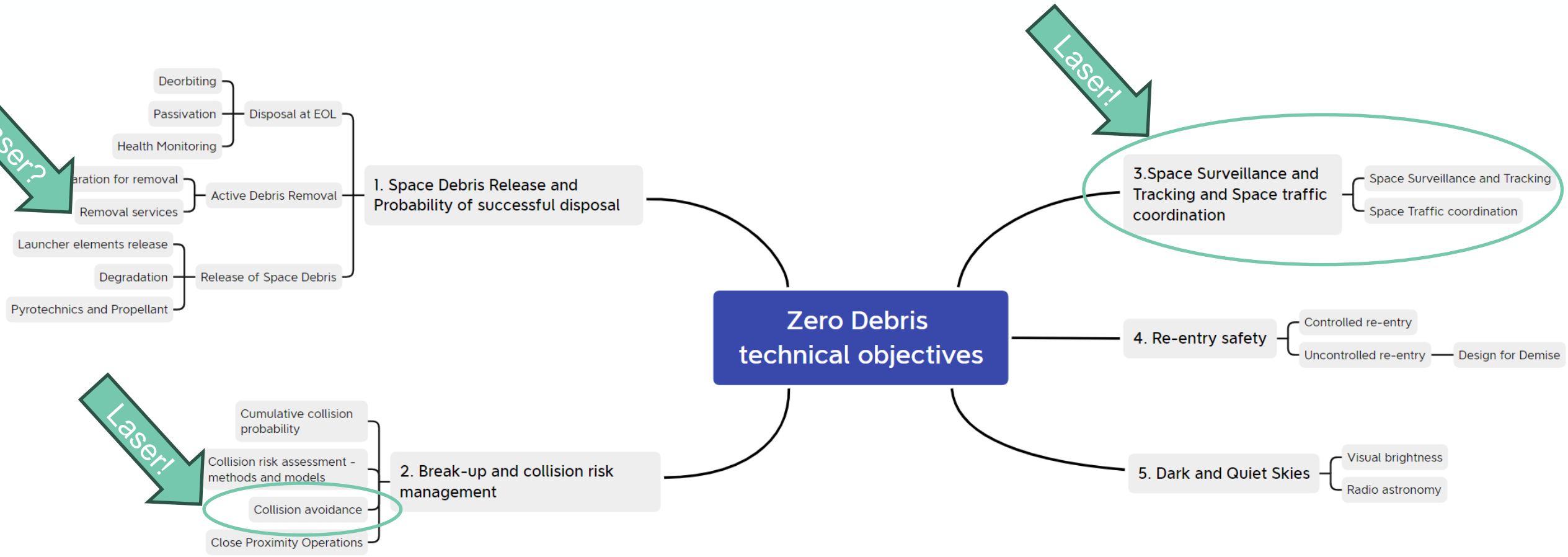
Josef Aschbacher
ESA Director General
"Agenda 2025"

Lead = own standard where we can **steer** the **process** (content & pace)
Lead ≠ proceed in **isolation**

Intention to flow-back requirements into the ECSS standard in the upcoming years



Co-developing a Zero Debris Technology Booklet with the community



Risk-driving conditions in Zero Debris considerations

LIFETIME

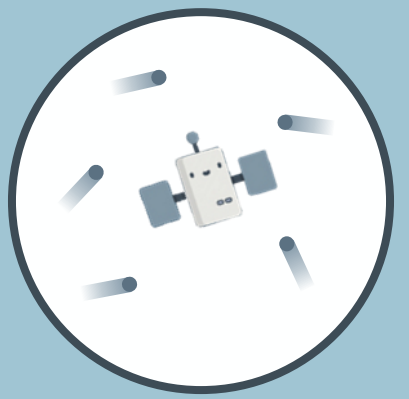
High risk
natural orbital decay duration
between 5 and 25 years

Medium risk
natural orbital decay up to 5 years
and crossing altitudes above 375 km

Very high risk
natural orbital decay duration
longer than 25 years

COLLISION PROBABILITY

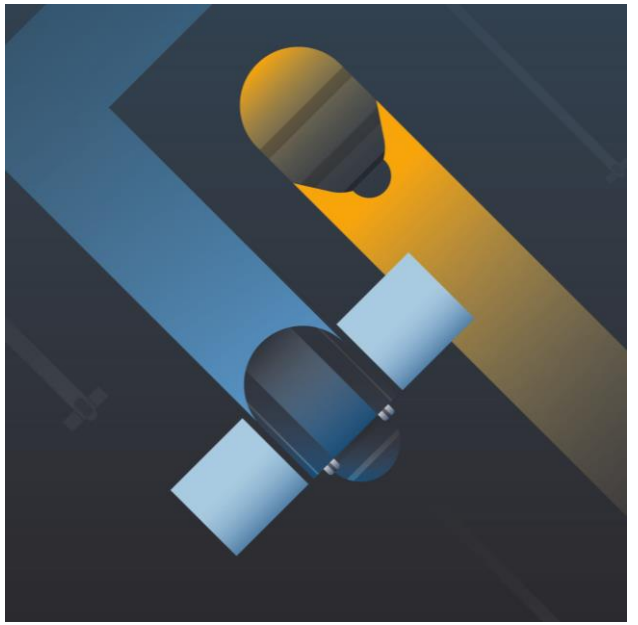
Collision probability with **space debris** objects larger than **1 cm**



A space object in Earth orbit without capability of performing collision avoidance manoeuvres and with a cumulative collision probability with space objects larger than 1 cm above **1 in 1000** is considered **environmentally** as a risk.

What is new in the requirements for COLA & STM?

- Ability to be **unambiguously identified** within **1 day after injection**
- Need for support to provide **daily updated ephemerides** and **on-demand screening**
- Adoption of data exchange standards (e.g., ODM, CDM) according to **CCSDS formats**
- Operational procedures for the generation and **distribution** of **ephemerides**



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

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

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

Summary

1. ESA’s Laser Ranging Test-bed IZN-01
   - is performing excellently (and survived the nearby fires)
   - is getting ready for new Space Safety activities!
2. Space Safety is starting
   further relevant technology developments
   - towards ground-based LMT engineering station
   - concept study for a space-based element to validate LMT
3. Zero Debris Approach in ESA (Charter, Policy, Standard)
   - will open many new opportunities for laser tracking of space debris and supporting spacecraft operations
   - drafting of detailed technology needs is at full swing with deep involvement of the community