MASTER in support of environmental impact assessments

From Measurements to Understanding: MASTER Modelling Workshop
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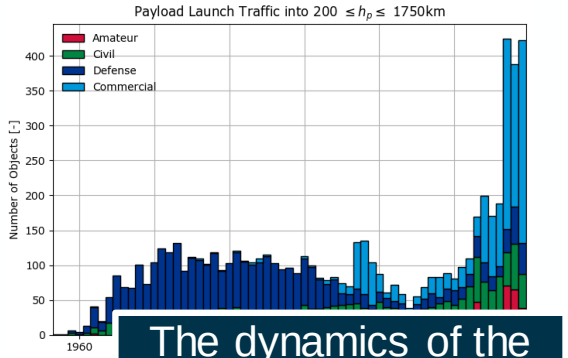
Towards environmental impact assessments

Current **debris mitigation guidelines** do not fully capture

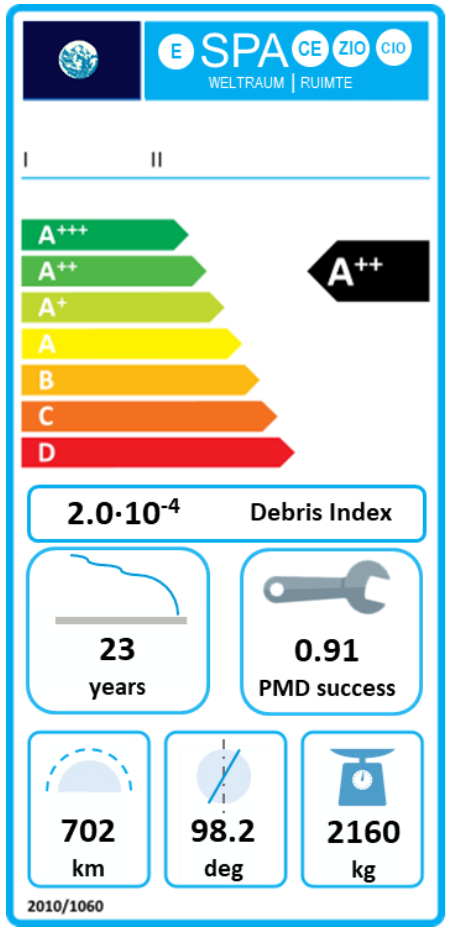
The objective of sustainable spaceflight



The dynamics of the space environment

The different ways of being compliant

Alternative approach is to perform **impact assessments**



Space debris index

▸Letizia et al., 7th ESDC, 2017

$$I = p_c \cdot e_c + e_e \cdot p_e$$

Collision probability

Explosion probability

Collision effect

Explosion effect

Debris population

Object type

Spacecraft size

Orbit

Distribution of operational satellites

+ **Reliability**
(PMD success rate)

▸Letizia et al., 69th IAC, 2018

$$I_\alpha = \alpha \left(\int_{t_0}^{\Delta t_{oper}} I(a,i)dt + \int_{\Delta t_{oper}}^{t_e} I(a,i)dt \right) + (1-\alpha) \left(\int_{t_0}^{\Delta t_{oper}} I(a,i)dt + \int_{\Delta t_{oper}}^{t_l} I(a,i)dt \right)$$

Risk in operational phase

Risk during disposal

Risk if abandoned

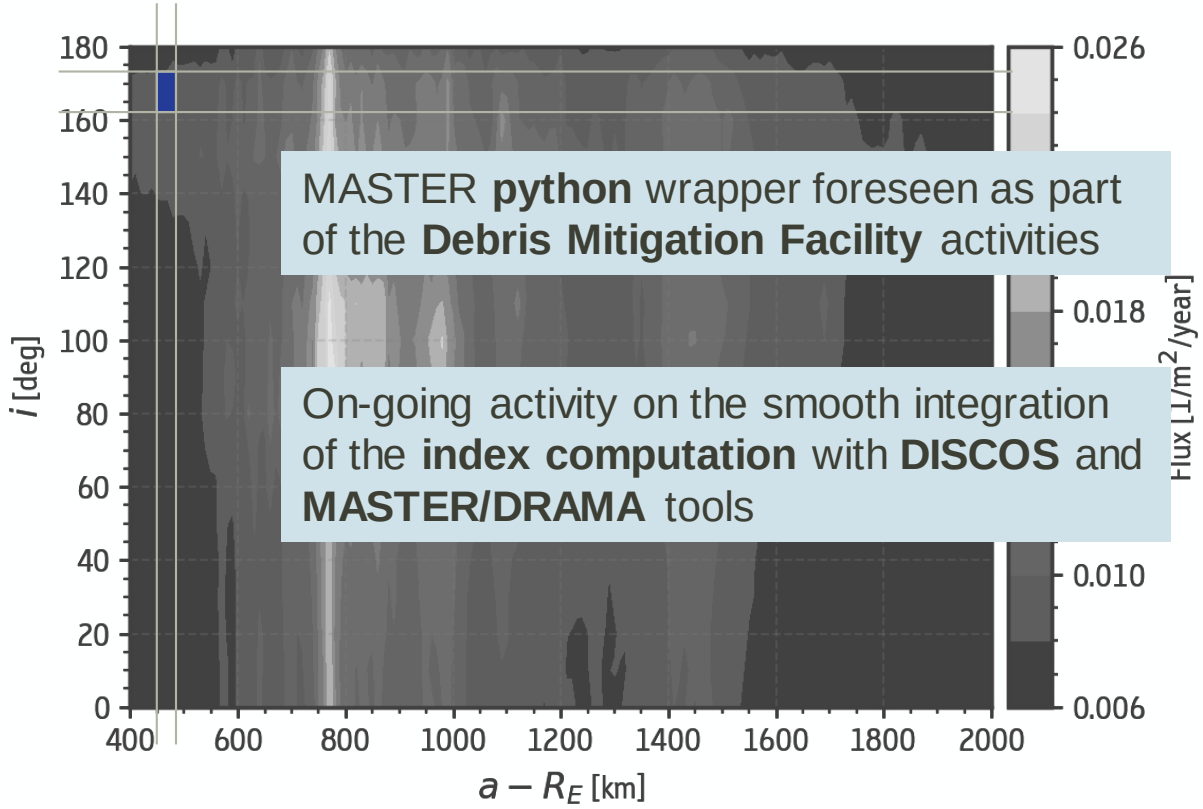
Collision avoidance

EOL design

Orbit (lifetime)

Inclusion of data from MASTER

Python wrapper for MASTER to collect debris flux values for cells of **10 km** x **10 deg** for objects larger than **1 cm**

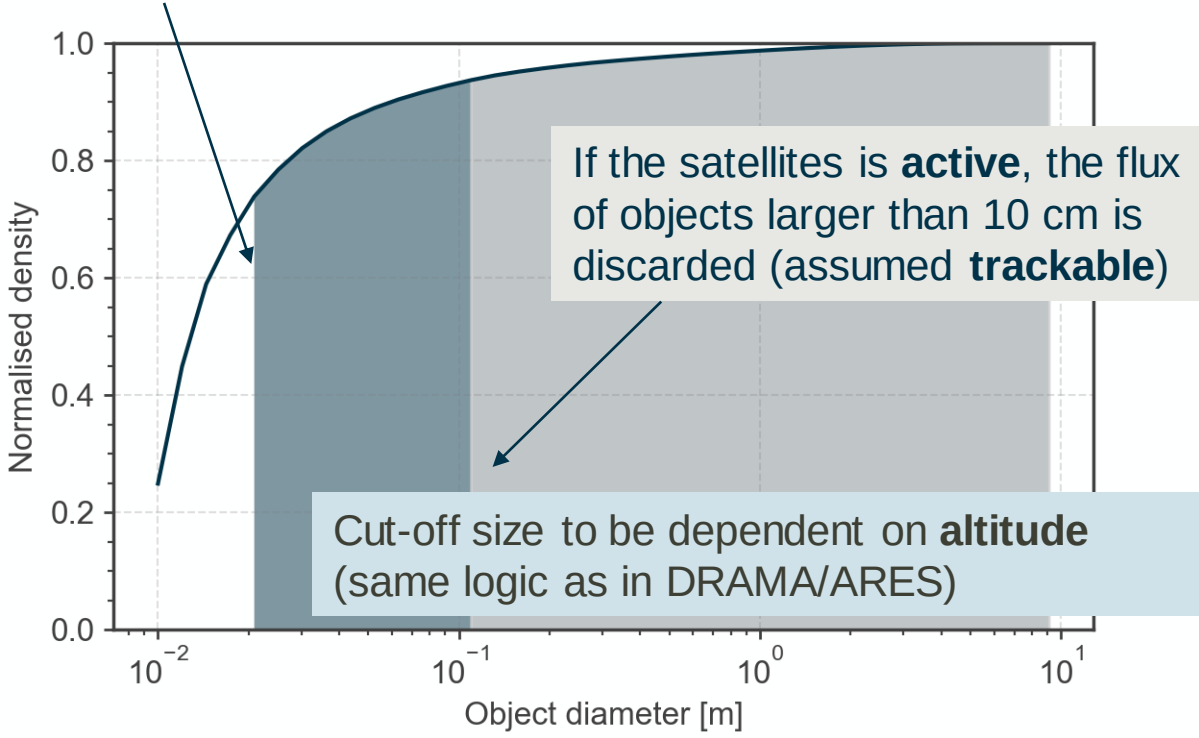


MASTER **python** wrapper foreseen as part of the **Debris Mitigation Facility** activities

On-going activity on the smooth integration of the **index computation** with **DISCOS** and **MASTER/DRAMA** tools

Global function to describe the dependence of flux levels on **size**

Minimum diameter for **catastrophic** collisions (from the 40J/g criterion)



If the satellites is **active**, the flux of objects larger than 10 cm is discarded (assumed **trackable**)

Cut-off size to be dependent on **altitude** (same logic as in DRAMA/ARES)

Example of application: impact of ESA fleet

Paper to be presented at the **8th European Conference on Space Debris**

Disclaimer

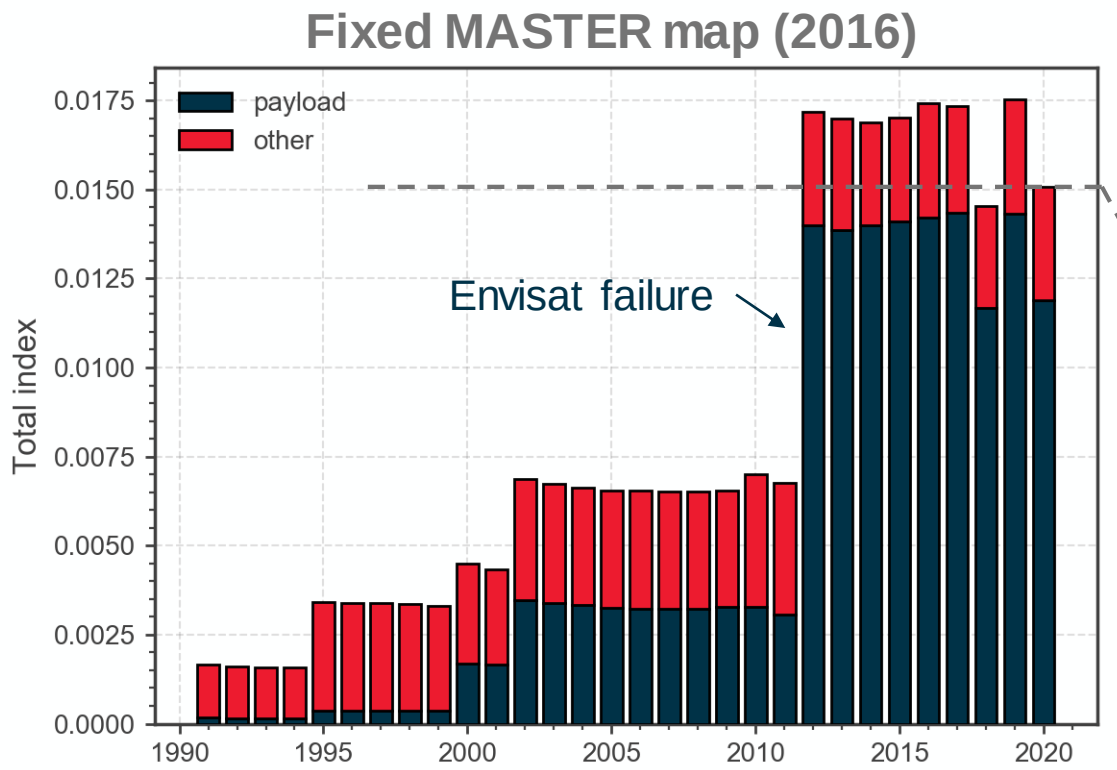
only intermediate results here: same post-mission disposal success rate for all missions

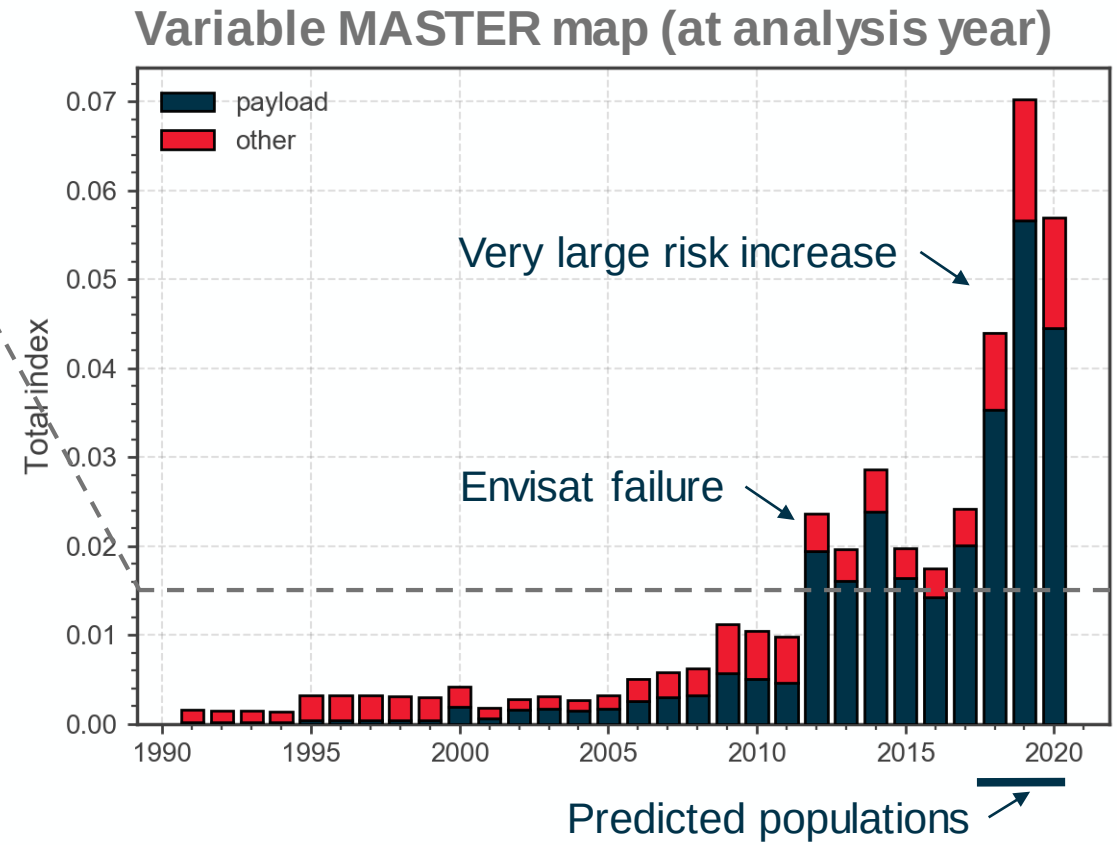
Example of application: impact of ESA fleet

Intermediate results

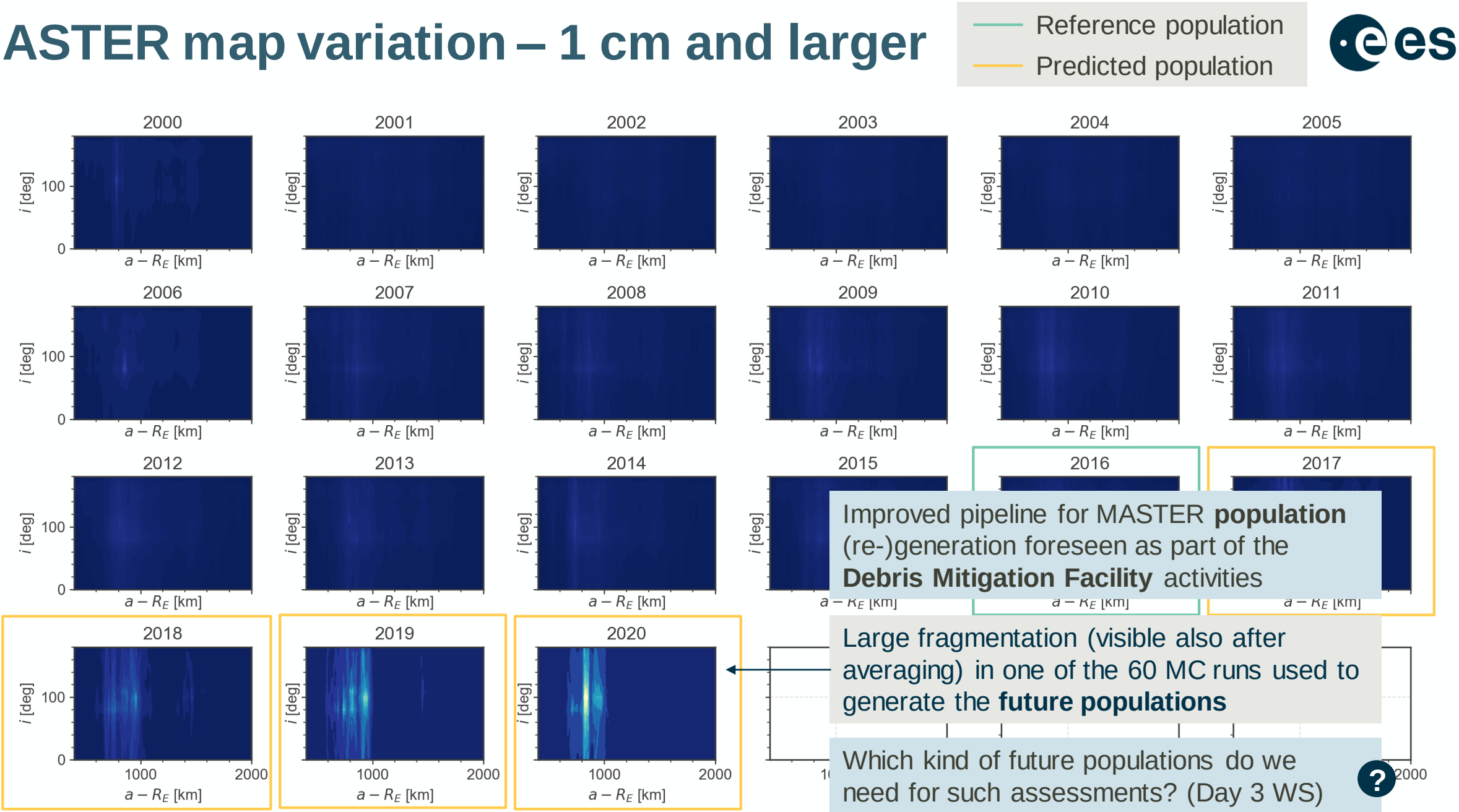
for each year of analysis:

- check which ESA satellites are in-orbit
- check their activity status
- compute debris index, considering also the contribution from associated objects





MASTER map variation – 1 cm and larger



Improved pipeline for MASTER **population** (re-)generation foreseen as part of the **Debris Mitigation Facility** activities

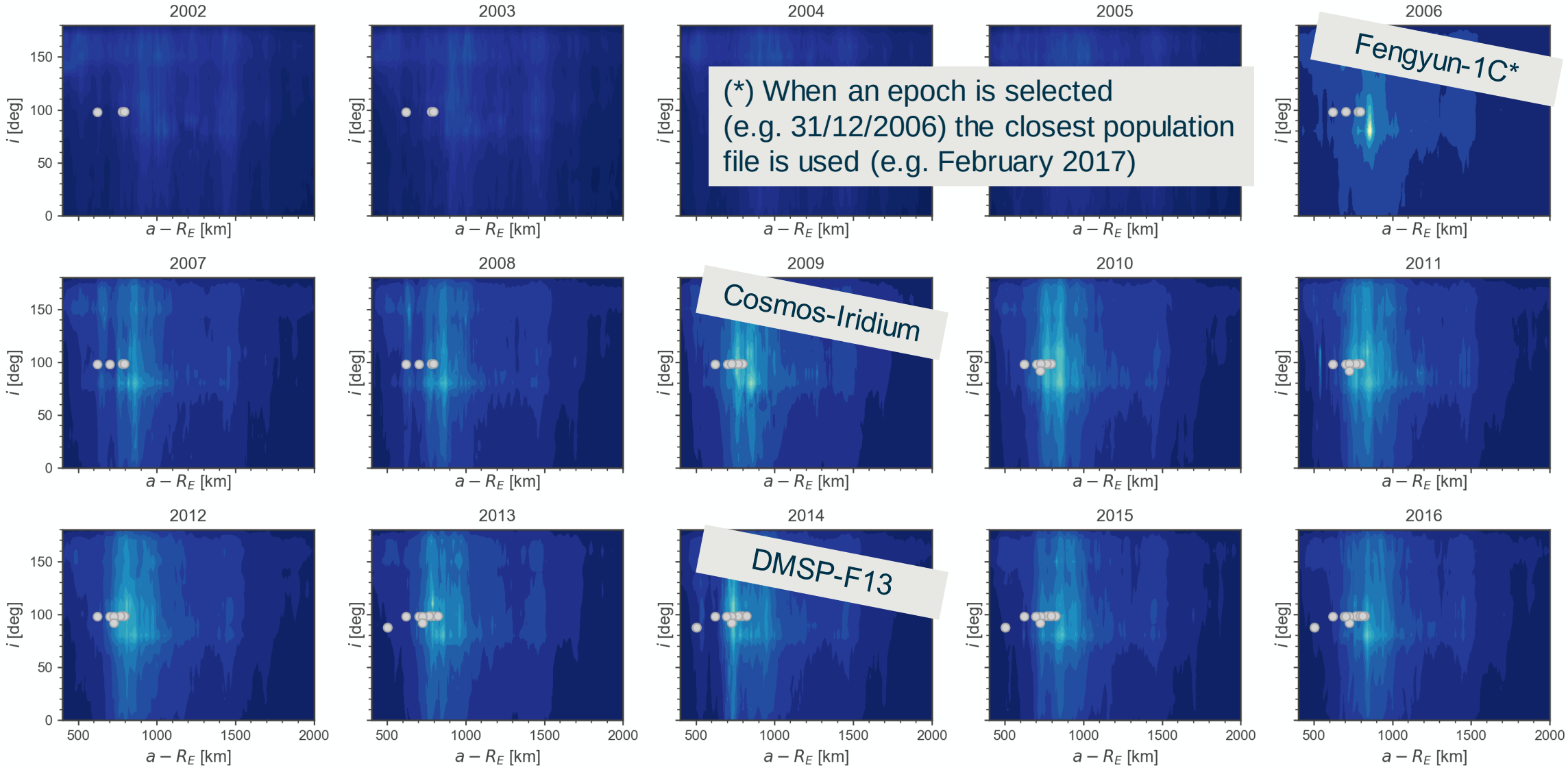
Large fragmentation (visible also after averaging) in one of the 60 MC runs used to generate the **future populations**

Which kind of future populations do we need for such assessments? (Day 3 WS)

?

MASTER map variation up to 2016

Location of ESA satellites



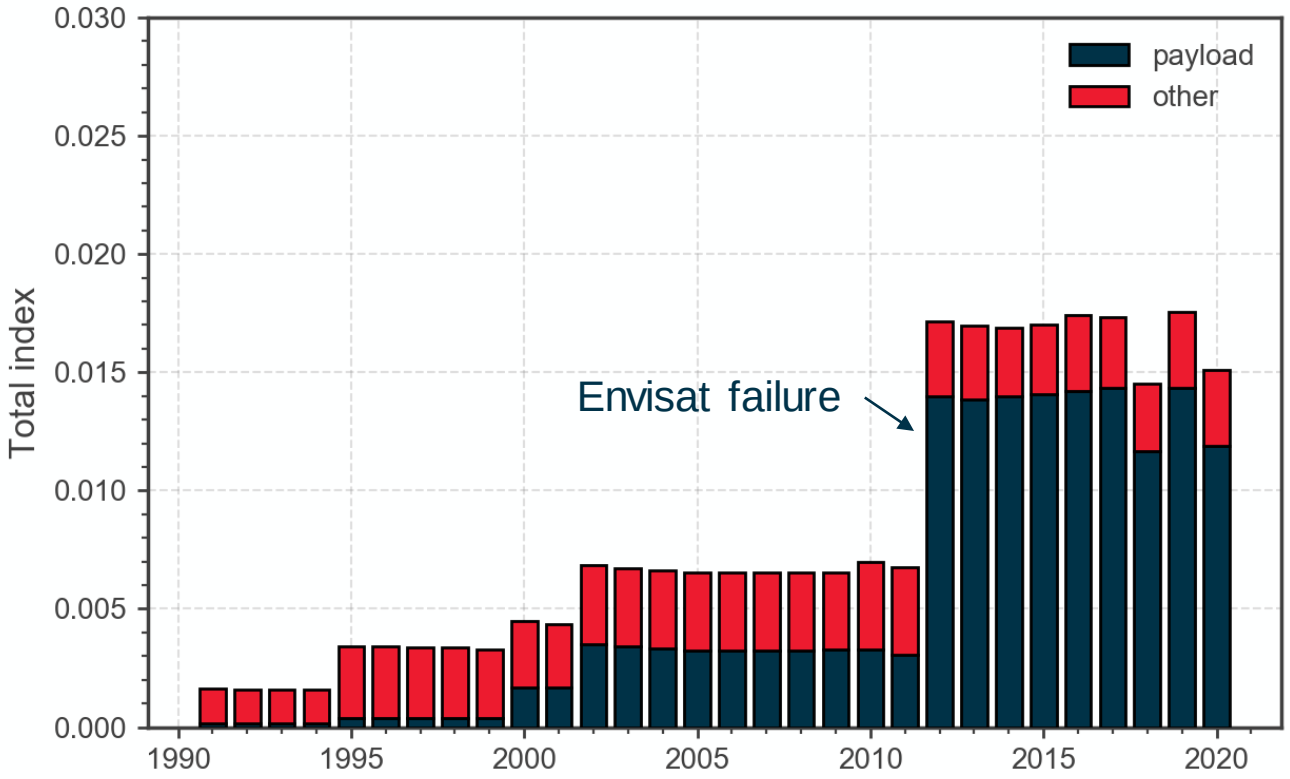
(*) When an epoch is selected (e.g. 31/12/2006) the closest population file is used (e.g. February 2017)

Example of application: impact of ESA fleet

Intermediate results

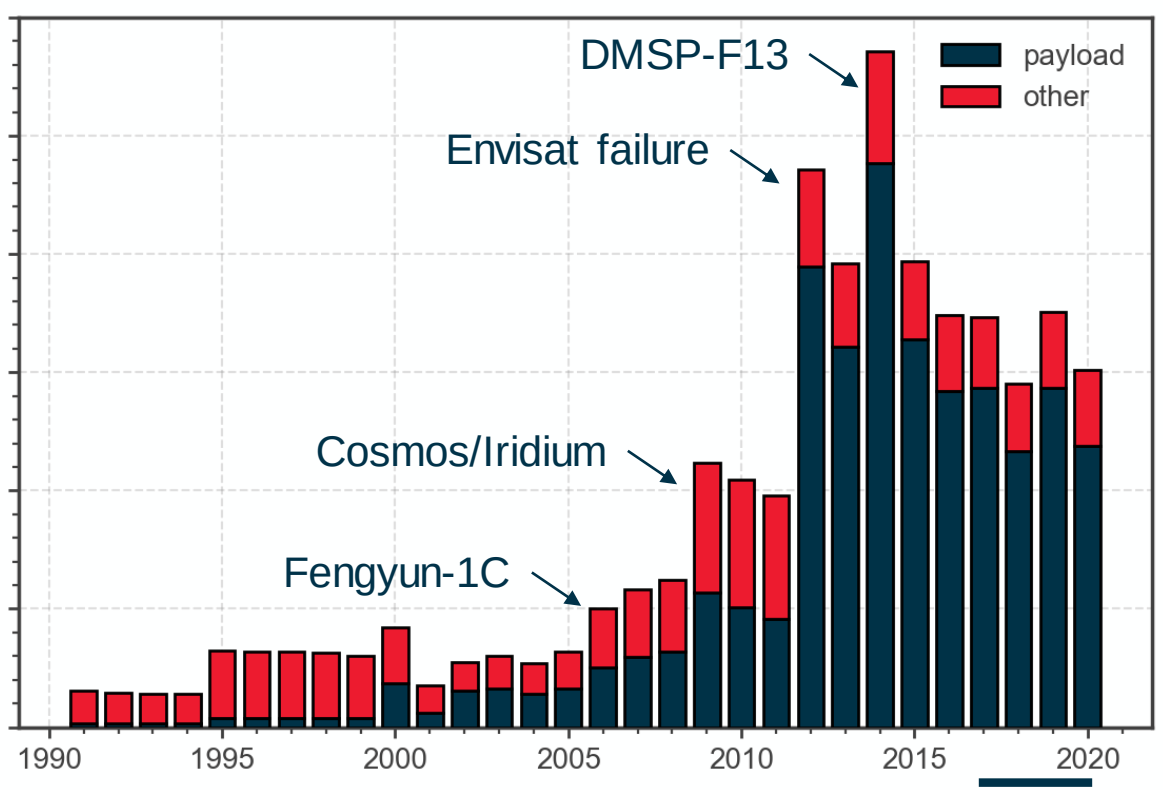
esa

Fixed MASTER map (2016)



The *static* formulation capture the change in **risk** due to the change in the spacecraft **activity** status

Variable MASTER map (at analysis year)



Updating the **debris population** allows capturing the change in **risk** due to **fragmentation** events

Conclusions

Emerging approach to space debris mitigation based on **environmental impact assessments**

Models of the **debris population** (such as MASTER) are essential for such assessment. In particular, in our formulation we exploit the granularity in information in

- **orbital regions** (i.e. semi-major axis, inclination),
- **size regime**,
- **epoch**.

Updating the underlying population allows tracking the **evolution** of the environment and the change in risk due to **fragmentation events**.

Environment assessment analysis would benefit from

- a more user-friendly **command line interface** to MASTER,
- a more **automated pipeline** for the re-generation of MASTER **population**,
- a discussion on how to model **future scenarios**.

DMF-01 S1-SC-01

DMF-02

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