Level of Adherence to SDM Guidelines

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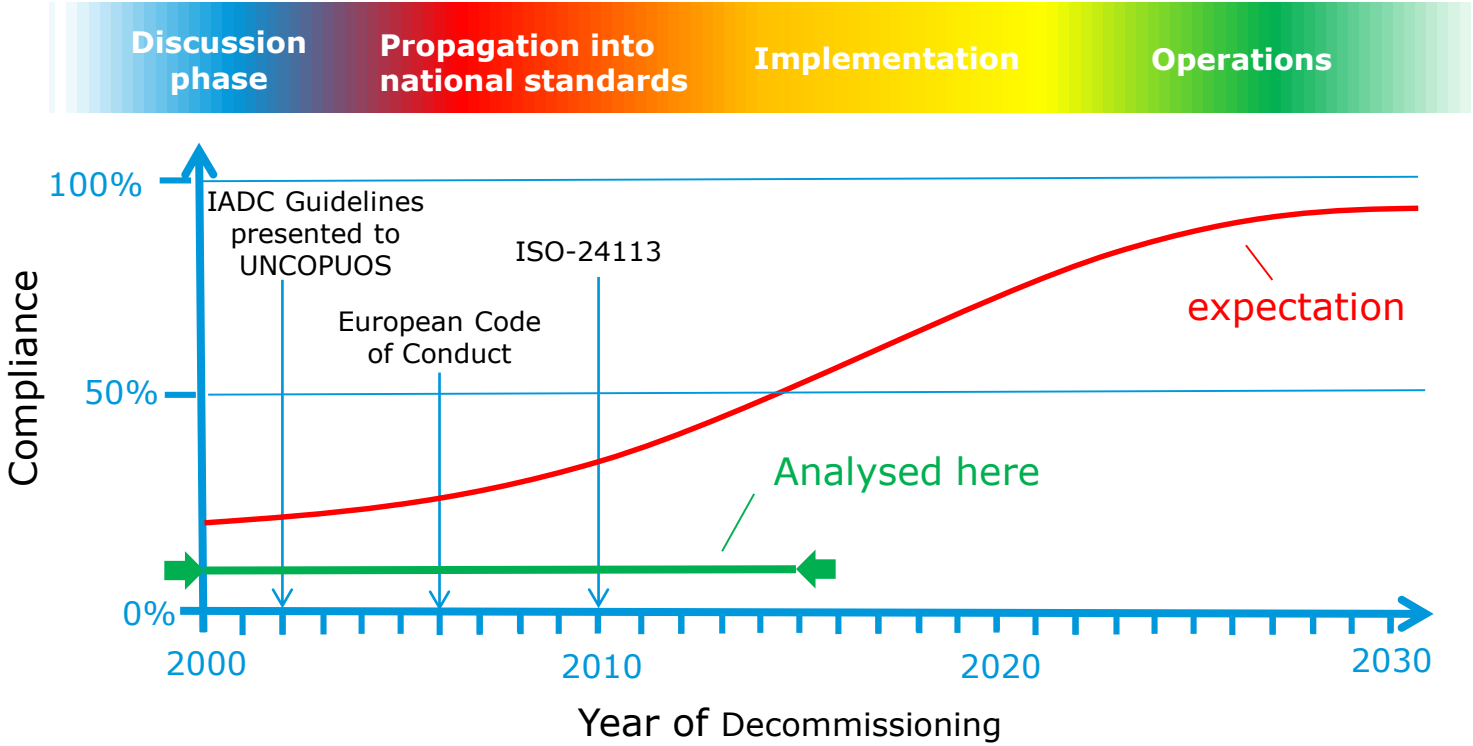
Introduction

Assess the compliance of operators w.r.t. the IADC guidelines stipulating:

- refraining from releasing mission related objects (MROs),
- the clearance of the LEO and GEO protected regions after end of mission/life,
    - LEO: de-orbit to reduce lifetime (25 years rule)
    - GEO: re-orbit above protected region
- the passivation of spacecraft to limit fragmentations.

Post mission disposal (PMD) recommendations have been adopted by various international and national standards and legislation.

Adoption Expectation (LEO)



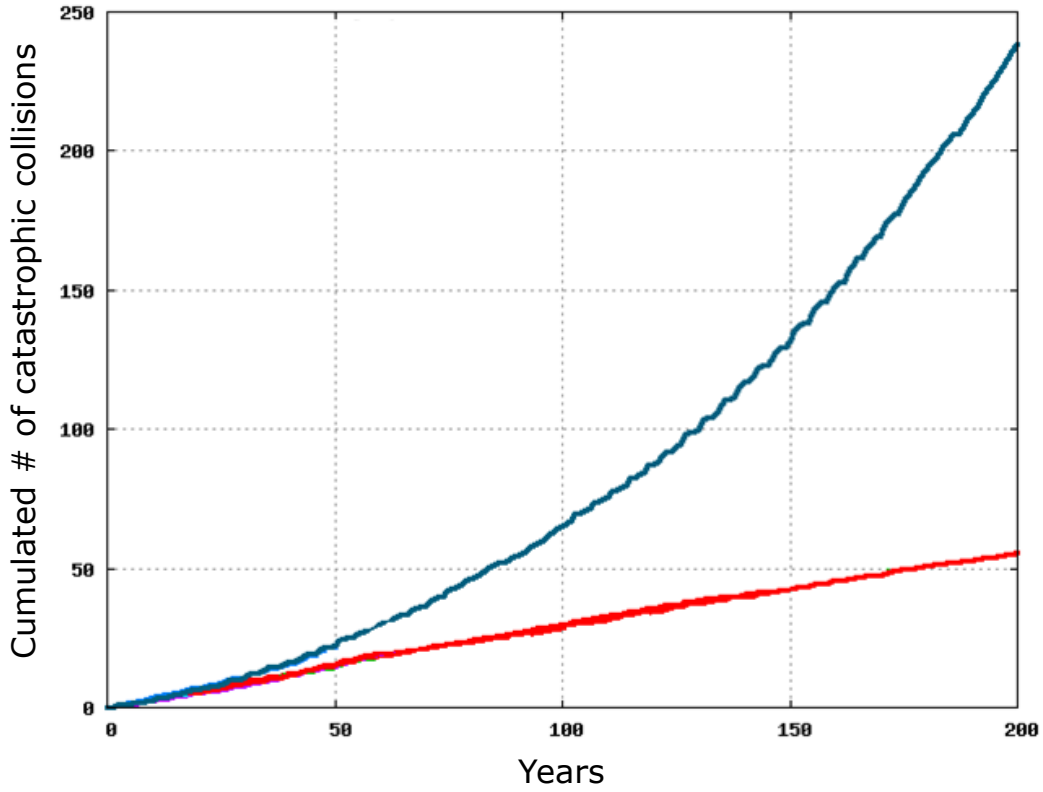
Adoption Expectation

To quantify adherence and where we are now on the curve, we use the following datasets:

- Release of MRO's from payloads and rocket bodies (orbit information and researching/inquiries)
- Payloads and rocket bodies violating the GEO protected region (orbit information)
- Payloads violating the LEO protected region (orbit information)
- Rocket Bodies violating the LEO protected region (orbit information and researching/inquiries).
- Fragmentation of objects in space (orbit information and researching/inquiries)

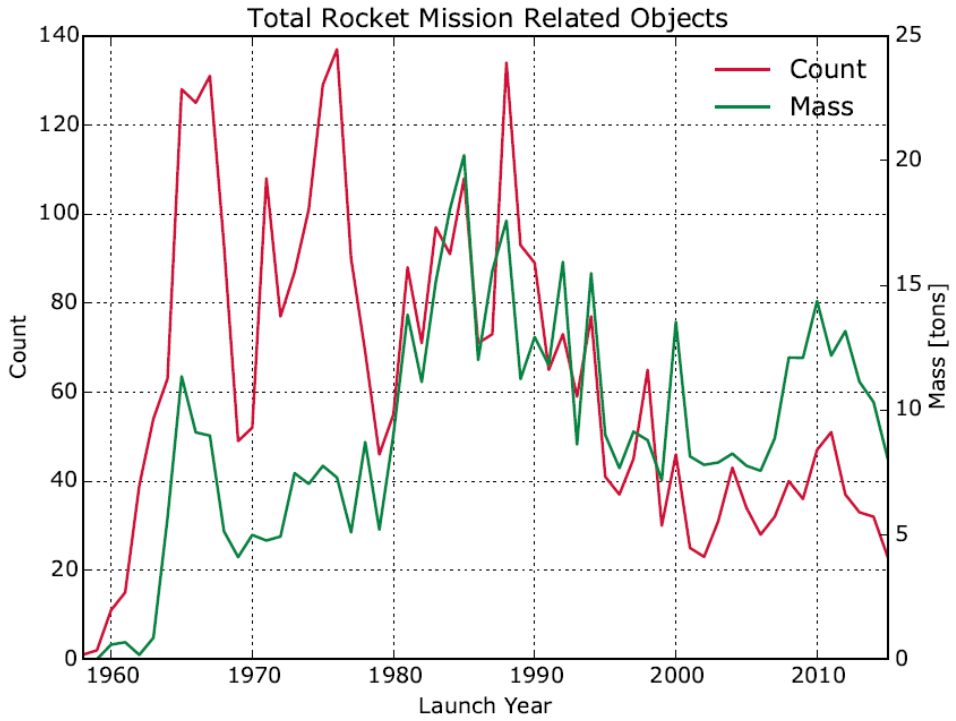
Effects of the Mitigation Guidelines

	PMD	Frag.	MROs
———	0%	Yes	Yes
———	90%	No	No

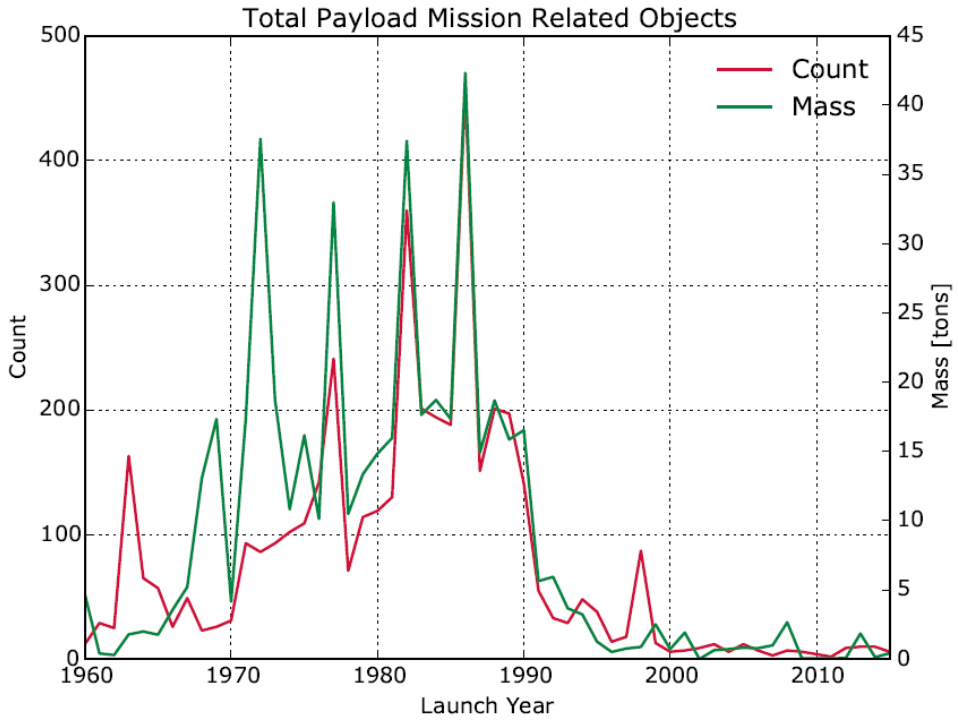


Mission Related Objects (MROs)

Release of MROs



Release of MROs



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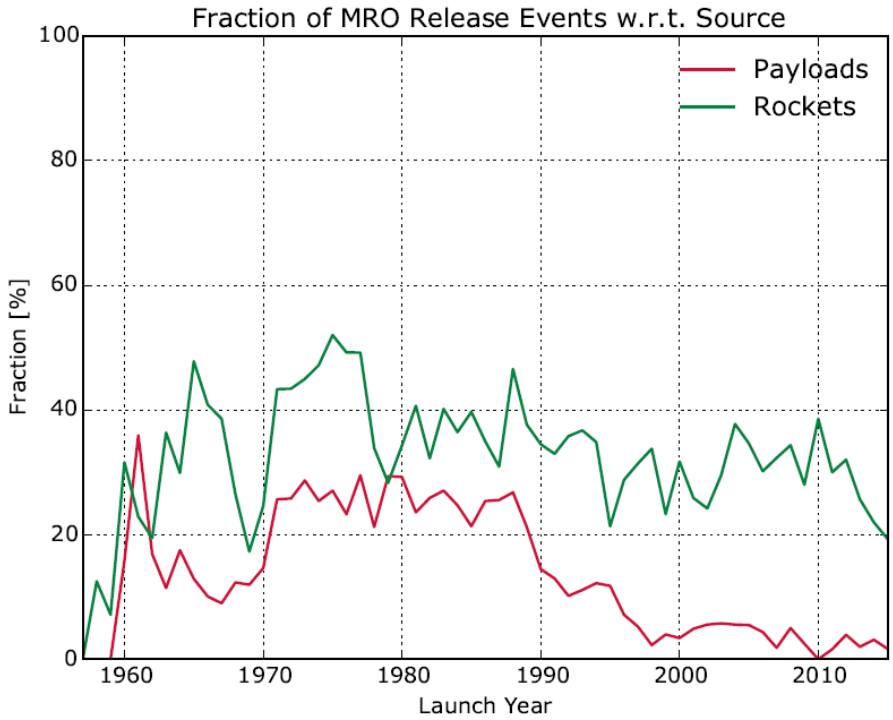

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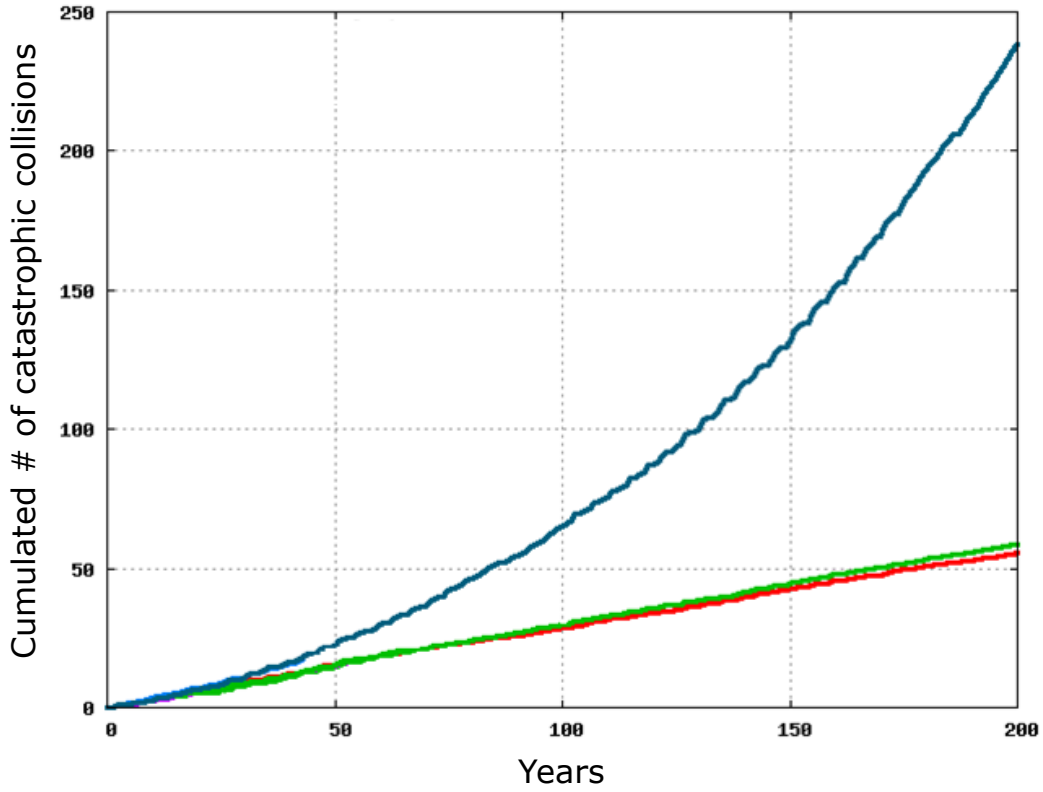
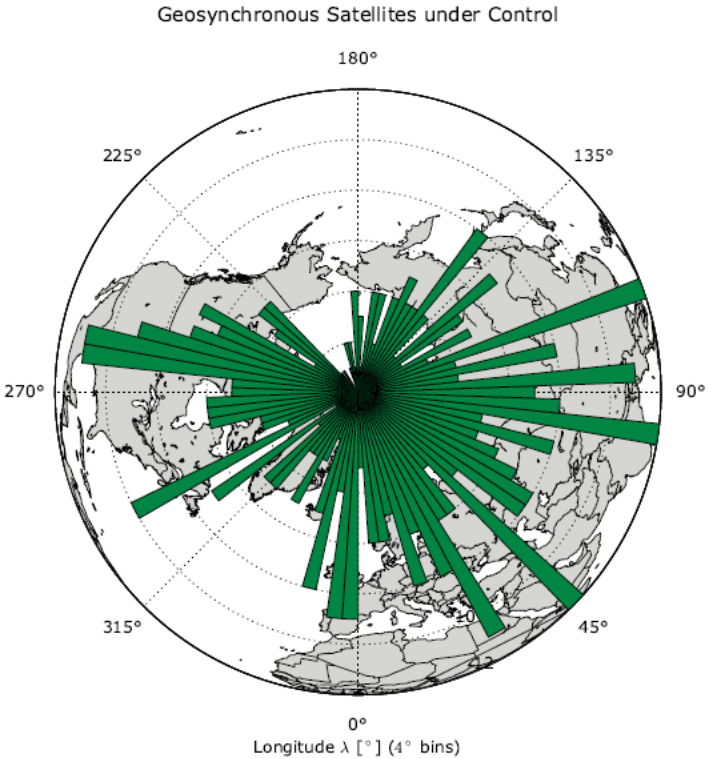


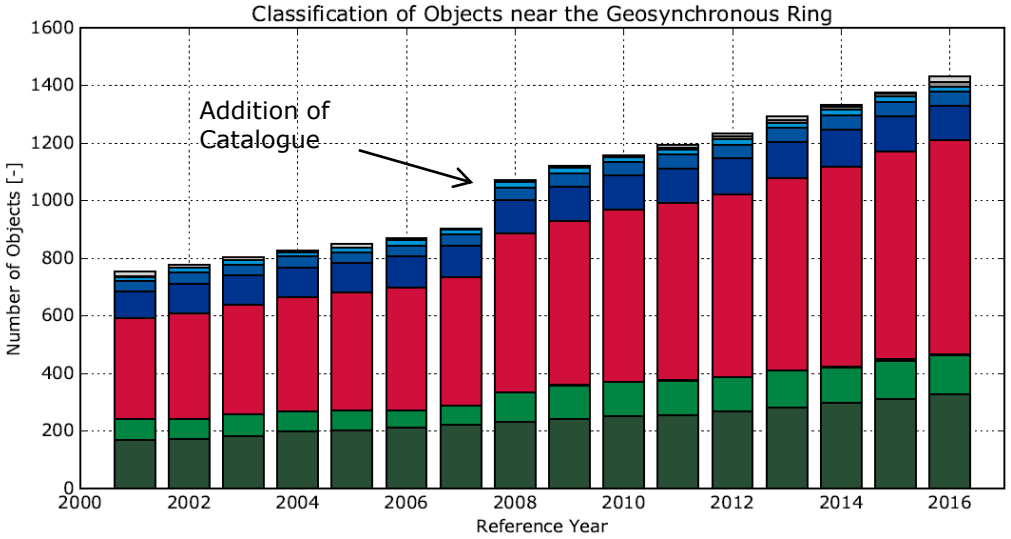
Clearance / Post Mission Disposal (PMD)

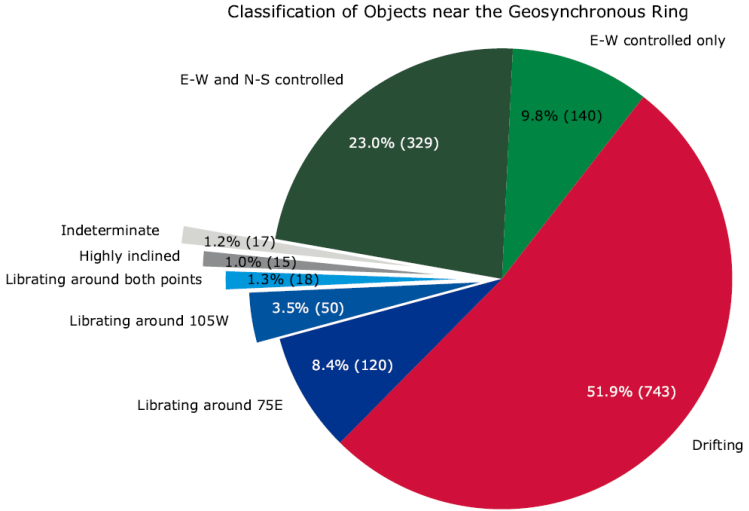
GEO Clearance

- Classification of GEO objects based on history of orbital elements from multiple catalogues:
  - semi-major axis $a \in a_{geo} \pm 0.1 a_{geo}$
  - inclination $i < 25°$
  - eccentricity $e < 0.25$
- Assessment of orbit changes (in particular EOL manoeuvers) to the last yearly report
- Input from operators



GEO Clearance

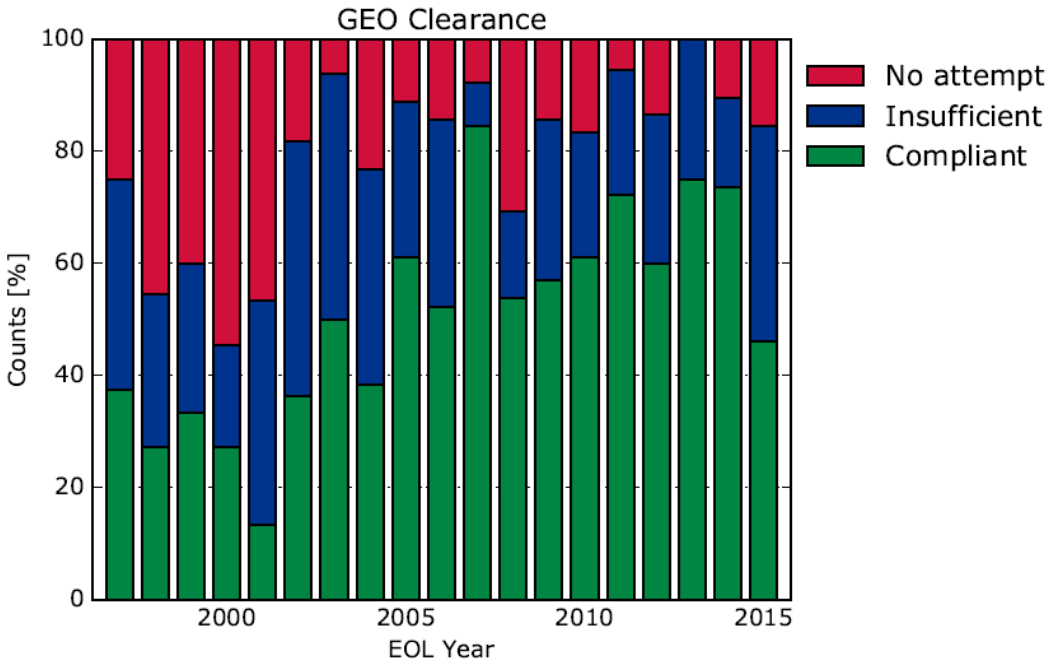




GEO Clearance

In 2015, at least 13 spacecraft reached end-of-life, of which

- 6 were re-orbited in compliance with the IADC guidelines
- 5 were re-orbited too low
- 2 seem to be abandoned and have started librating



Clearance of the LEO Protected Region

Clearance verified using orbital elements in ESA's DISCOS database, i.e. no TLE no analysis:

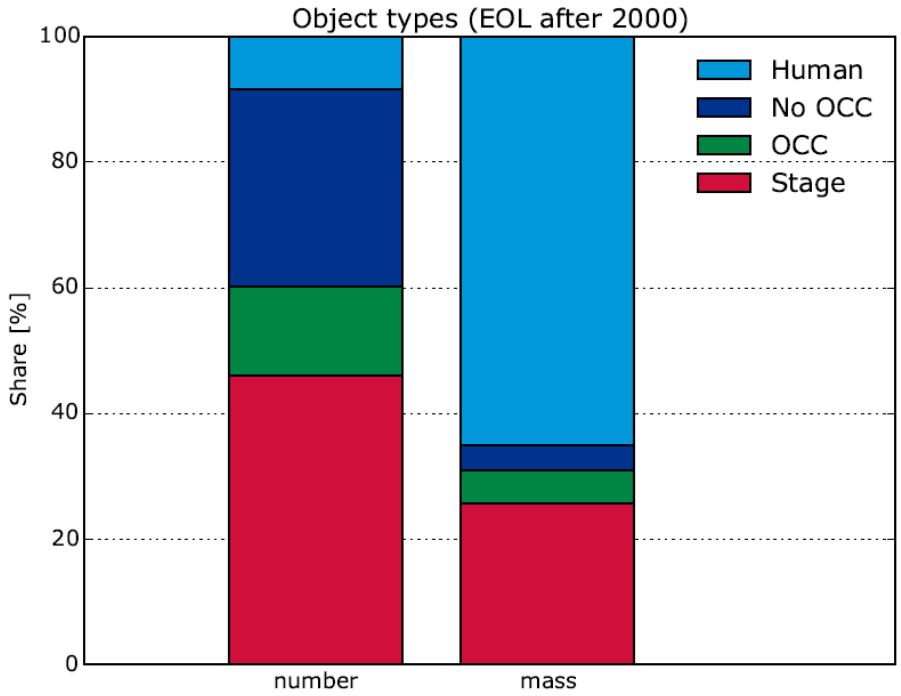
- All upper-stages are analysed
- Payloads are analysed if they have perigee altitudes <2000km.

End of mission is defined when a payload:

- is found to be manoeuvering in the year of analysis, but not one year later; i.e. showing orbit control capabilities (OCC),
- is not found to be manoeuvering ever and elapsed a mission specific lifetime,
- was launched and decayed in the year of analysis.

Space vehicles related to human spaceflight and return capsules are separated.

Clearance of the LEO Protected Region



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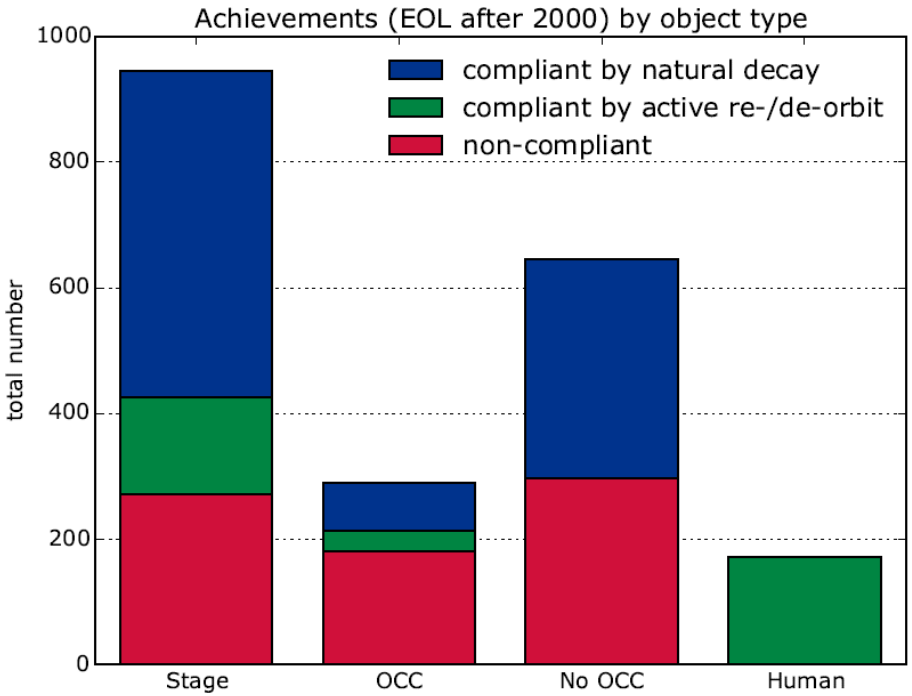
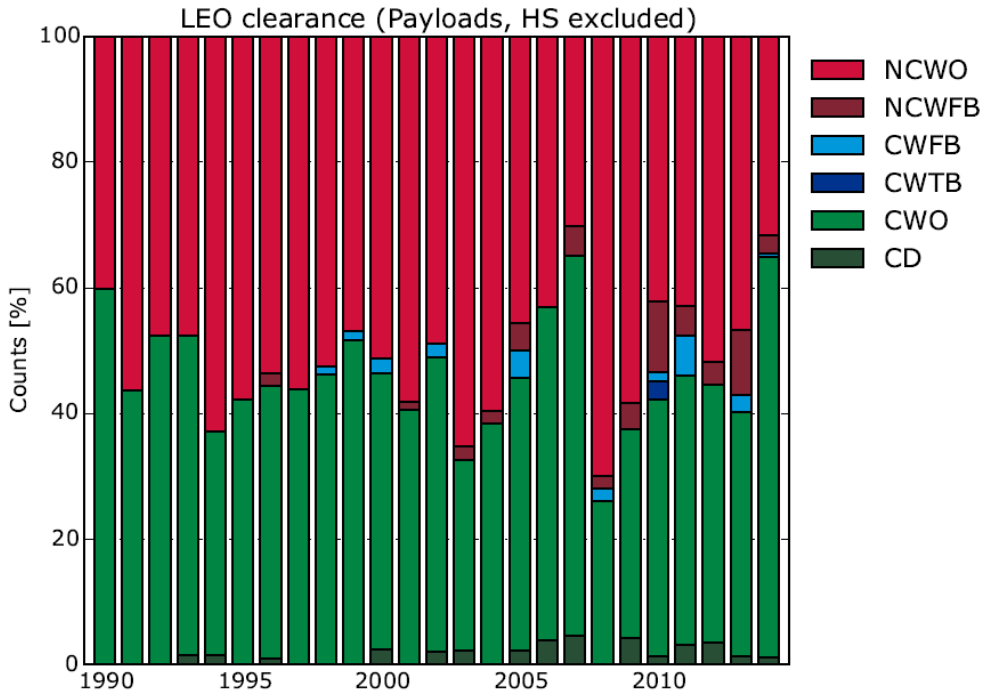


Clearance of the LEO Protected Region

CD	Compliant with direct re-entry.
CWO	Compliant without an attempt.
CWFB	Compliant with attempt where the destination orbit would not have been compliant.
CWTB	Compliant with attempt where the destination orbit would have been compliant.
NCWFB	Not compliant with attempt where the destination orbit would not have been compliant.
NCWTB	Not compliant with attempt where the destination orbit would have been compliant (not happened yet).
NCWO	Not compliant without an attempt.

Clearance of the LEO Protected Region



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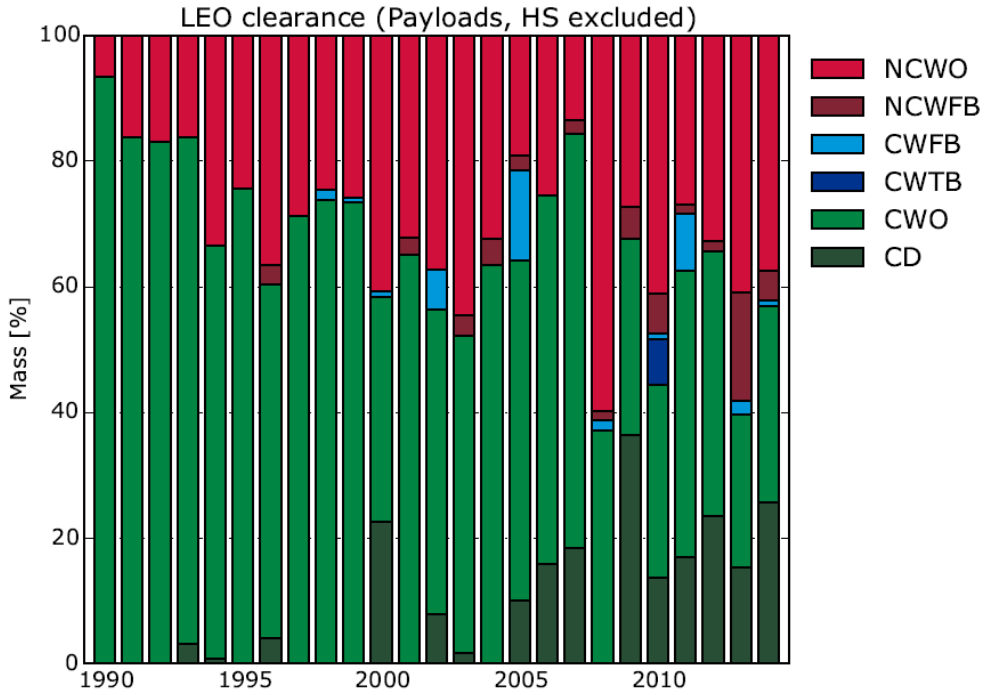

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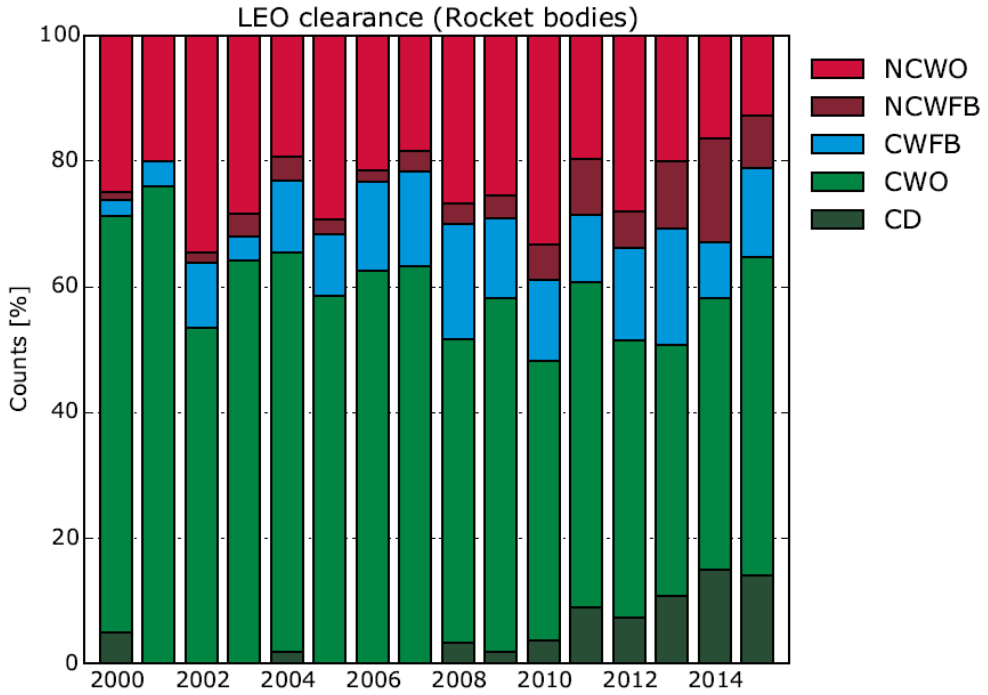

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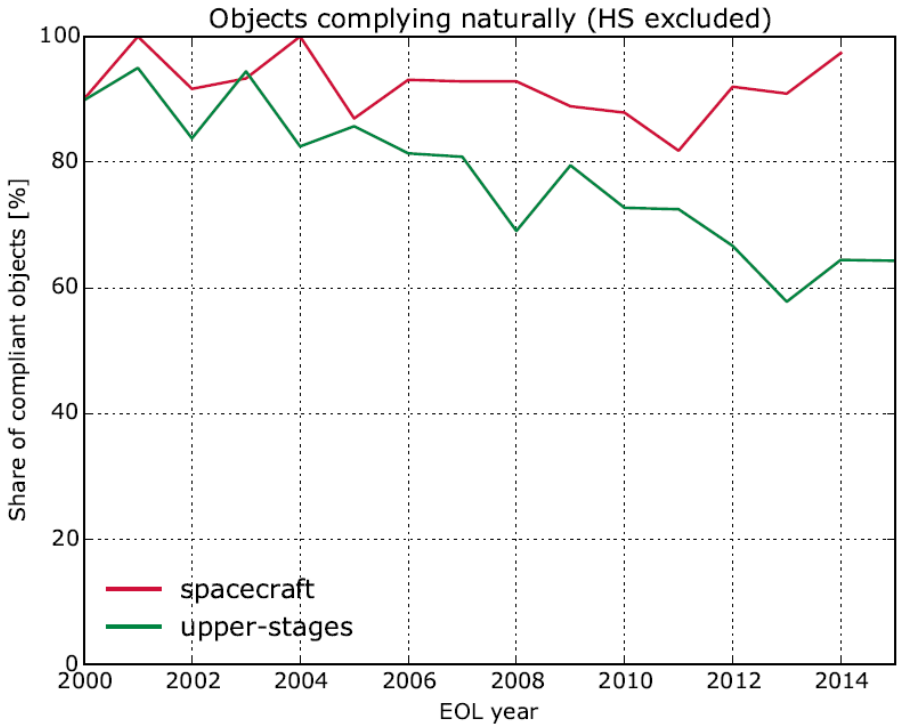

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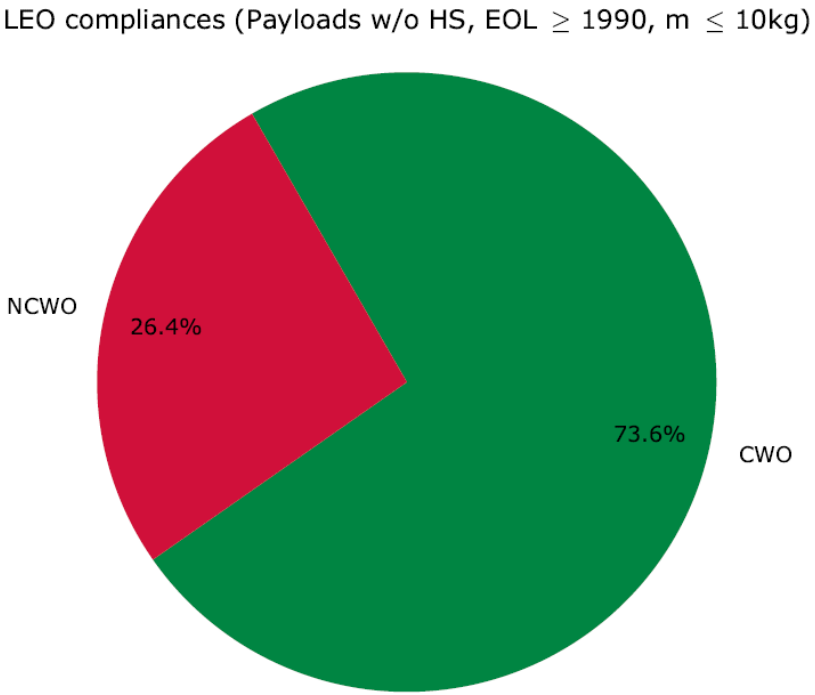

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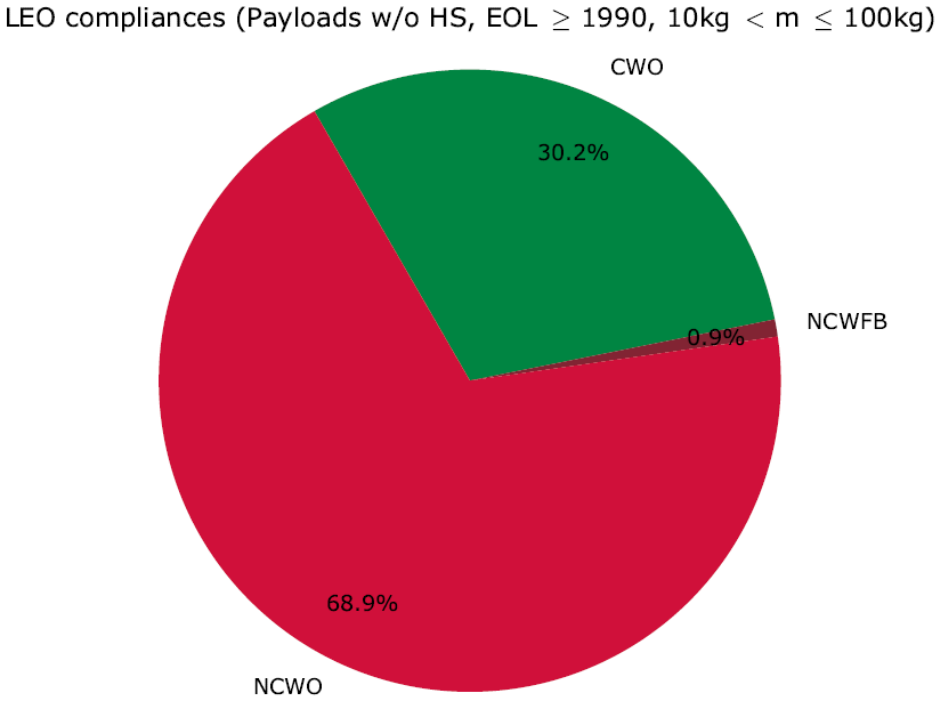

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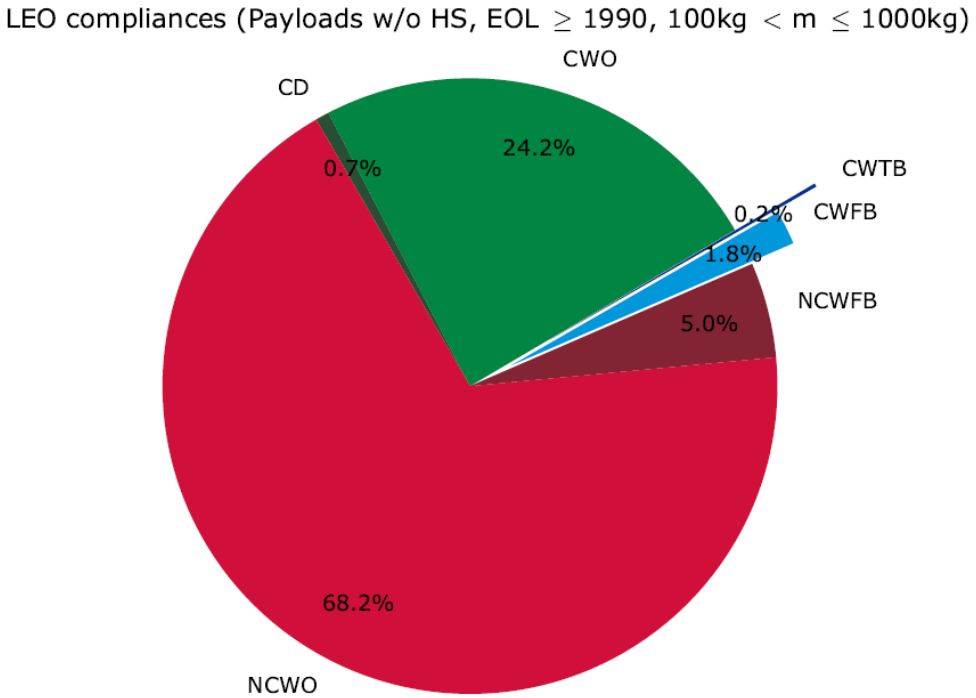

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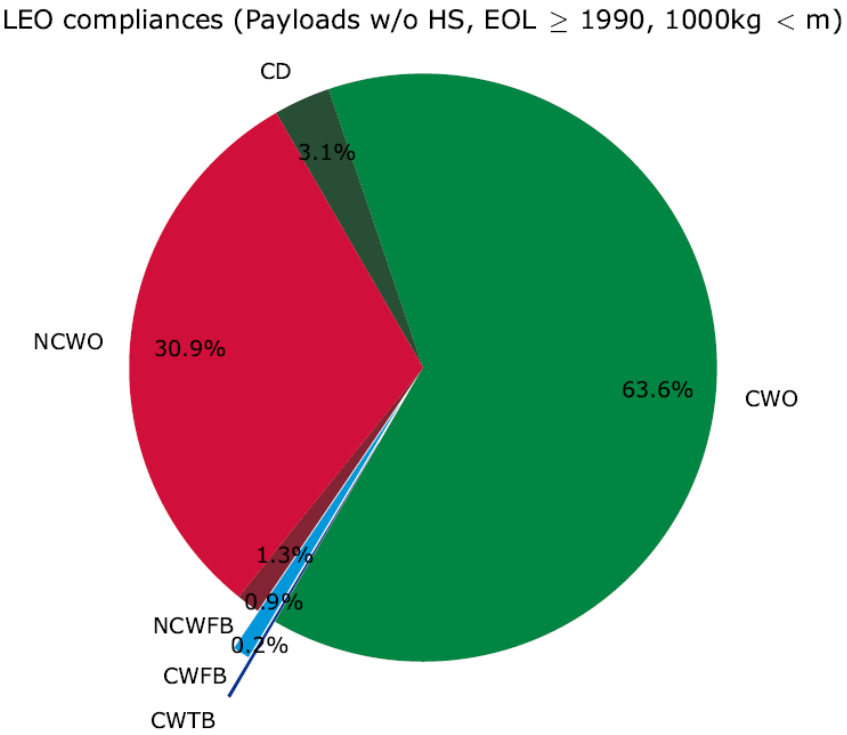

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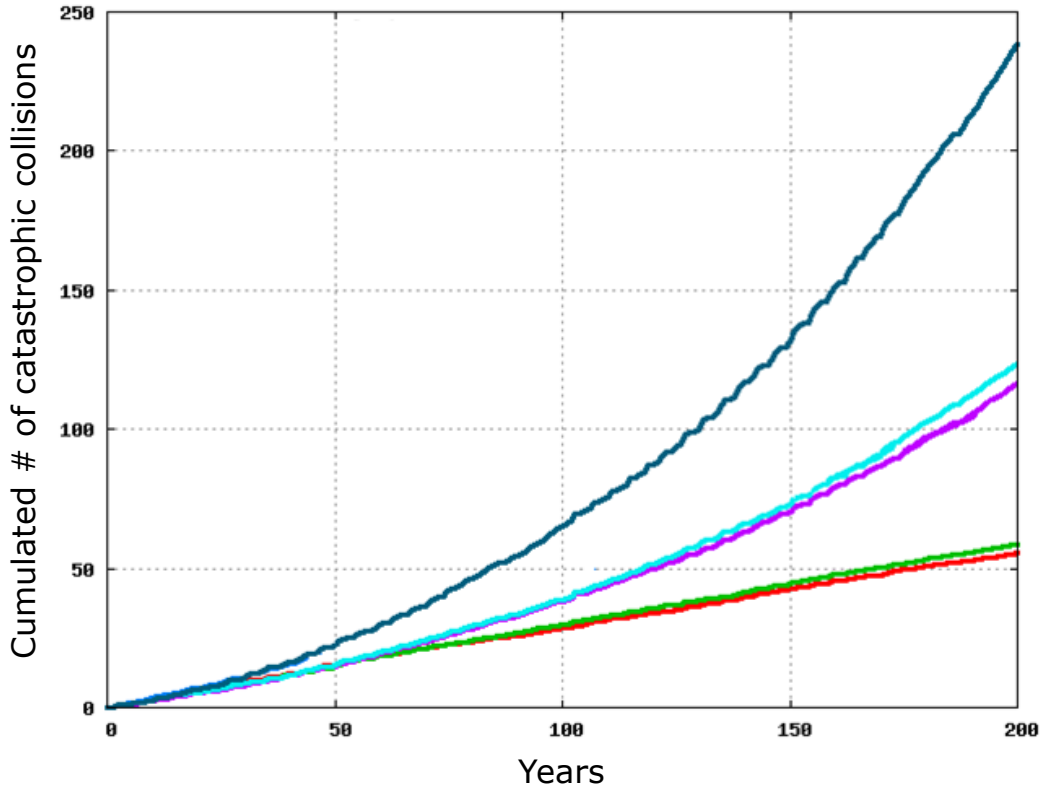
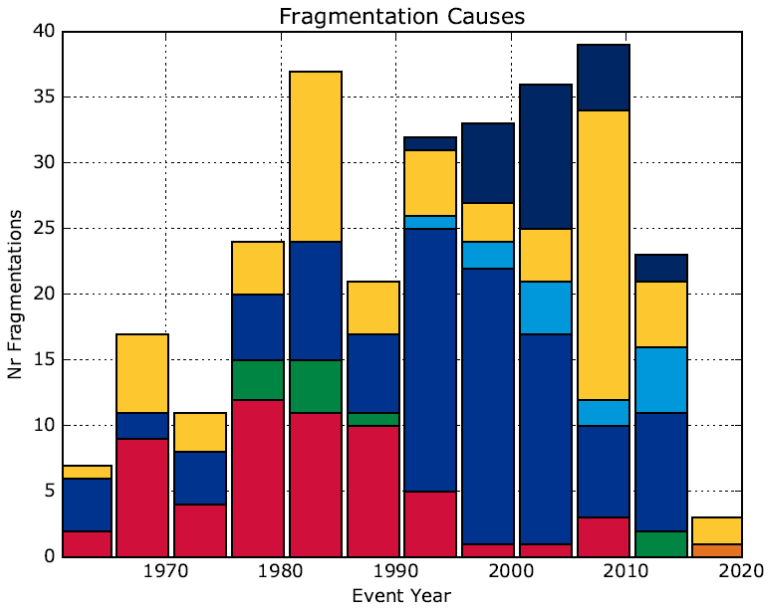
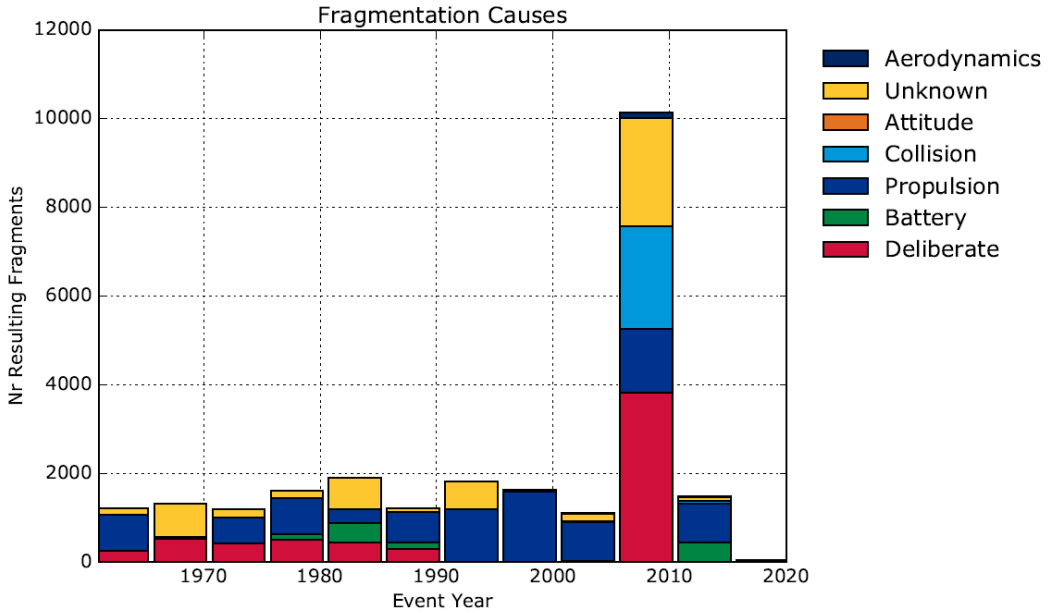


Fragmentations

Fragmentation Events





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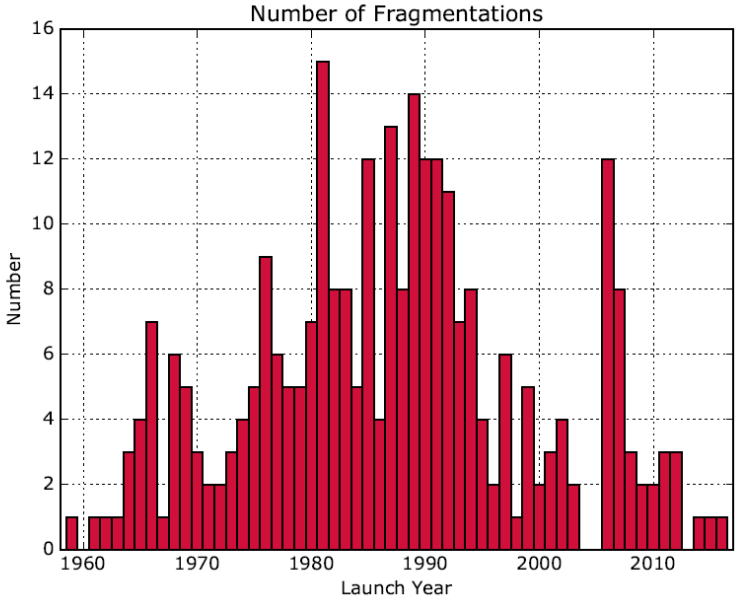

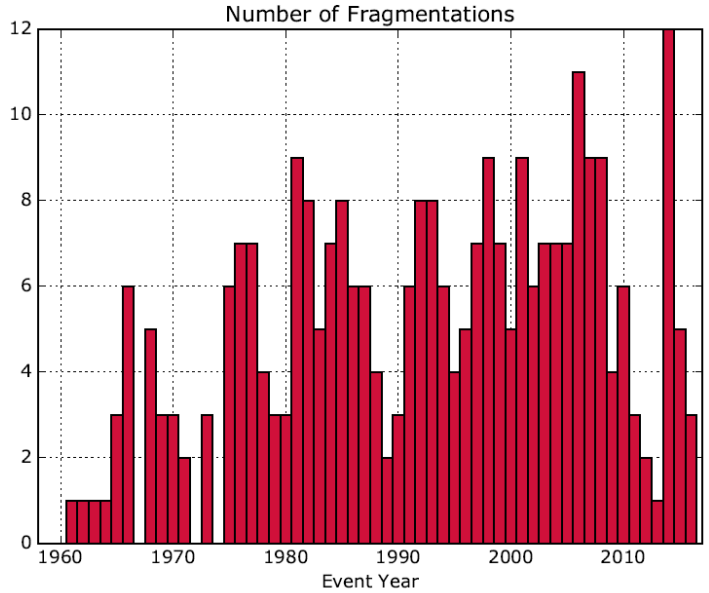

On average 2.3 non-deliberate fragmentations per year, on average/median 8.2/3.6 years after launch

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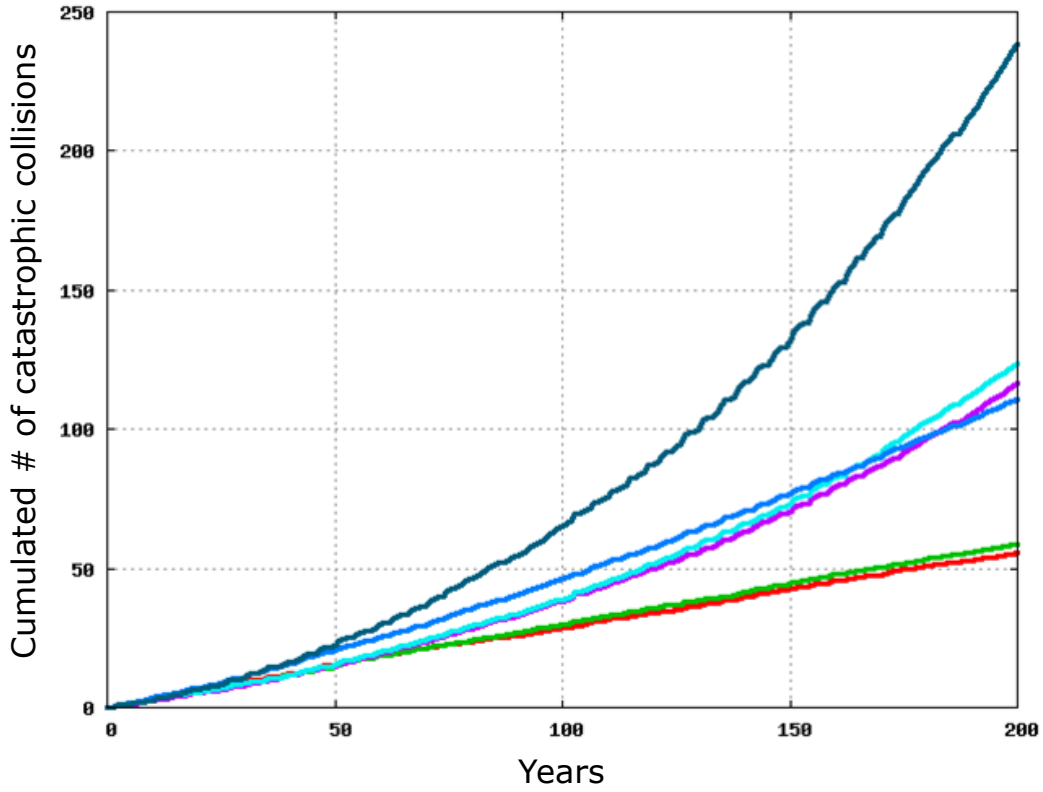


Conclusions

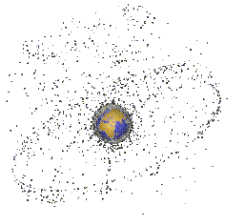
Our level of adherence to the guidelines is strongly driven by the impact on the design of the spacecraft as well as the economical impact of non-adherence:

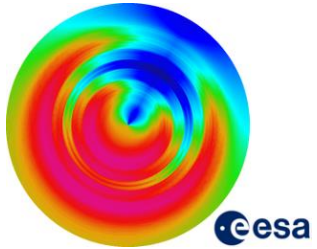
1. ~30% of all RBs (entire space age), and ~5% of all PLs (post 90s) release MROs in orbit.
2. Evolution towards better compliance in GEO, asymptotic 'cap' of ~10% non-clearance attempts. Was 2015 'noise' on the data?
3. LEO PL compliance is for +90% achieved through natural decay, with the lowest compliance rates for objects between 10 and 1000 kg (~30%).
4. The amount of active de/re-orbiting attempts is on the rise (mainly for RBs).
5. ~10% of PLs requiring a manoeuvre do so, with various degree of success.
6. On average 2.3 non-deliberate fragmentations per year, on average/median 8.2/3.6 years after launch. Was 2014 'noise' on the data?

Space Debris User Portal

The following tools are available at https://sdup.esoc.esa.int/

- MASTER
- DRAMA
- DISCOSWEB
- ORIUNDO





The material for the DRAMA workshop on Thursday afternoon can be downloaded at https://sdup.esoc.esa.int/ → DRAMA → Downloads in section Training Material

Support related to Space Debris: space.debris.support@esa.int