

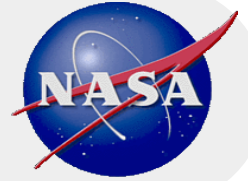
Space Debris Mitigation Guidelines

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Symposium on Small Satellite Programmes for Sustainable Development
“Implementing Small Satellite Programmes: Technical, Managerial,
Regulatory and Legal Issues

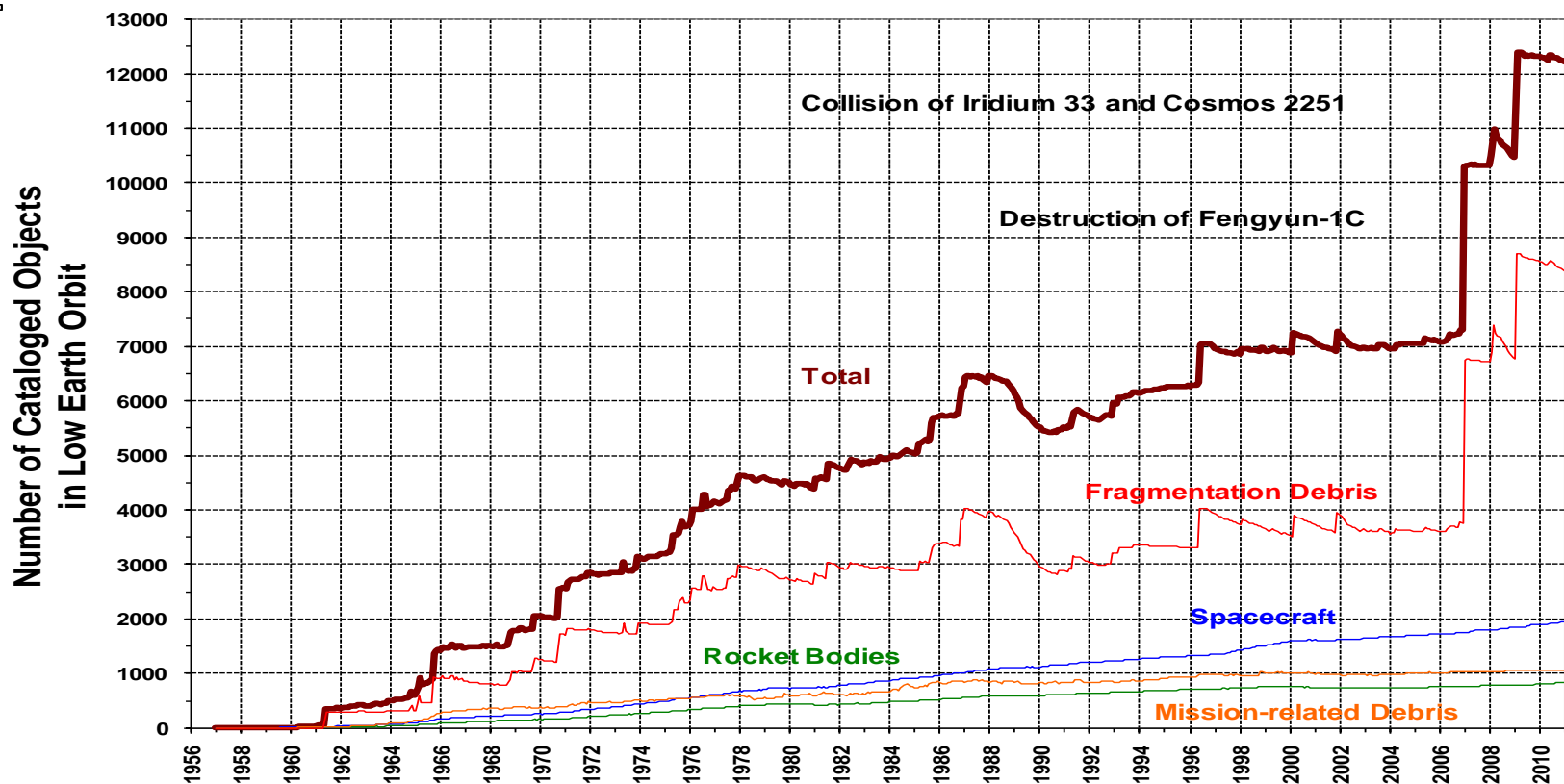
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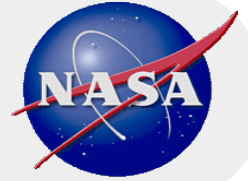
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Purpose of Space Debris Mitigation Guidelines

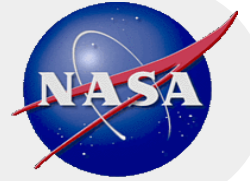
- The purpose of national and international space debris mitigation guides is to promote the preservation of near-Earth space for applications and exploration missions far into the future.
 - To accomplish this objective, the accumulation of objects, particularly in long-lived orbits, must be eliminated or curtailed.





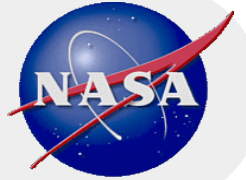
National and International Space Debris Mitigation Guidelines

- **The major space-faring nations have adopted national space debris mitigation guidelines, e.g., USA (1995), Japan (1996), France (1999), Russian Federation (2000), and China (2005).**
- **Europe's five leading space agencies established a Code of Conduct for Space Debris Mitigation in 2006.**
 - ESA and the national space agencies from France, Germany, Italy, and the UK
- **The first international set of space debris mitigation guidelines was created by the then 11 members of the Inter-Agency Space Debris Coordination Committee in 2002.**
 - Find at http://www.iadc-online.org/index.cgi?item=docs_pub
- **The United Nations, through the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee, approved a set of space debris mitigation guidelines in 2007.**
 - Find at http://orbitaldebris.jsc.nasa.gov/library/Space%20Debris%20Mitigation%20Guidelines_COPUOS.pdf



Extent of Space Debris Mitigation Guidelines

- **The scope of the United Nations Space Debris Mitigation Guidelines is representative of other national and international space debris mitigation guidelines.**
 - Guideline 1: Limit debris released during normal operations
 - Guideline 2: Minimize the potential for break-ups during operational phases
 - Guideline 3: Limit the probability of accidental collision in orbit
 - Guideline 4: Avoid intentional destruction and other harmful activities
 - Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy
 - Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission
 - Includes the mitigation of reentry risks to people and property on Earth
 - Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with geosynchronous Earth orbit (GEO) region after the end of their mission

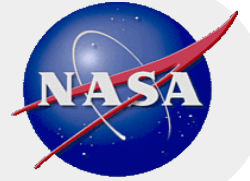


Application of Space Debris Mitigation Guidelines

- **National and international space debris mitigation guidelines are applicable to all spacecraft and launch vehicle orbital stages, regardless of mission, size, or power source.**

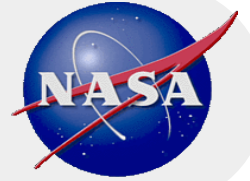
Space debris mitigation guidelines apply to all small satellites.

- **Typically, satellites with a mass of less than 100 kg easily meet guidelines covering the intentional release of debris, accidental breakups, post-mission passivation, and reentry risks.**



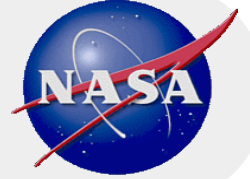
Small Satellites and the LEO and GEO Protected Regions

- **To date, the most frequent violation of space debris mitigation guidelines by small satellites is persistence in the low Earth orbit region following mission termination, *i.e.*, residual lifetimes in excess of 25 years.**
 - Potential solutions include
 - post-mission orbit changes (via propulsion or drag augmentation) or
 - limiting operational orbits to below ~700 km, depending upon ballistic coefficient.
 - The relatively short operational lifetimes and increasing number of small satellite make compliance with this guideline especially important.
- **The deployment of small satellites in the geosynchronous region should be avoided. If high altitude orbits are necessary, orbital regimes above or below the GEO protected region (GEO +/- 200 km) are recommended.**
 - If small satellites are deployed within the GEO region, they are subject to standard GEO spacecraft disposal guidelines, *i.e.*, removal from the GEO protected region after end of mission.



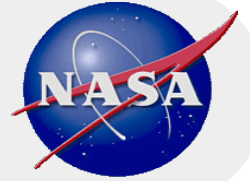
Trackability of Small Satellites

- **To limit the probability of accidental collisions (UN Space Debris Mitigation Guideline 3), small satellites should be trackable by established space surveillance systems.**
- **Small satellites with at least one dimension of 10 cm or larger are normally trackable in LEO by ground-based radar networks.**
- **Small satellites with at least one dimension of 80 cm or larger are normally trackable in GEO by ground-based radar or optical networks.**
- **In many cases trackability can be enhanced with simple passive devices which can boost optical or radar signatures.**
 - Corner reflectors
 - Dipoles



Small Satellite Constellations

- **Space debris mitigation guidelines do not explicitly limit the number of operational satellites in a constellation.**
- **However, concepts to deploy very large numbers (100's or 1000's) of small satellites should be carefully examined for negative environmental consequences.**
- **Large numbers of non-maneuverable small satellites in narrow orbital regimes would increase collision probabilities not only among themselves, but also with other resident space objects, both functional and non-functional.**
- **The addition of large numbers of new satellites would also further stress existing conjunction assessment processes.**



Summary

- **During the past two decades, great strides have been made in the international community regarding orbital debris mitigation for the purpose of preserving near-Earth space for future generations.**
- **The majority of space-faring nations have reached a consensus on an initial set of orbital debris mitigation measures.**
- **Implementation of and compliance with the IADC and UN space debris mitigation guidelines should be a high priority for all spacecraft and launch vehicle designers and operators.**
- **These space debris mitigation guidelines apply to spacecraft of all sizes.**