

Requirements on Space Debris Mitigation for ESA projects

**Presentation to the 48th session of the Legal Subcommittee
of the UN Committee on the Peaceful Uses of Outer Space**

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Introduction

Number of non-functional man-made objects in Earth orbit, “Space Debris”, growing rapidly.

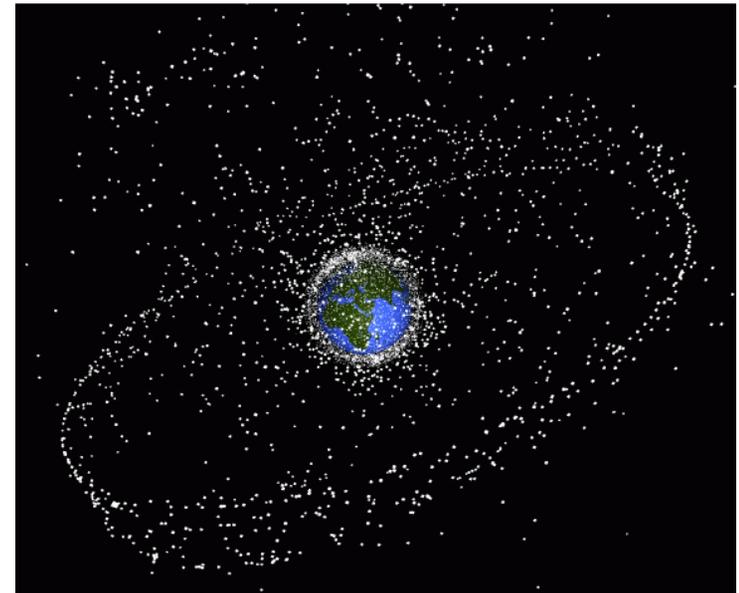
→ Significantly increased collision hazard for man-made satellites.

Based on the *IADC Guidelines* for Space Debris Mitigation and the Space Debris Mitigation Guidelines of the *Scientific and Technical Subcommittee* of the UN COPUOS, ESA developed its own *Administrative Instruction on Space Debris Mitigation for Agency Projects*:

- Translates these Guidelines into applicable ESA Requirements
- ESA applicable standard for all procurements of space systems, such as new launchers, satellites and inhabited objects, and of launch services for ESA programmes.

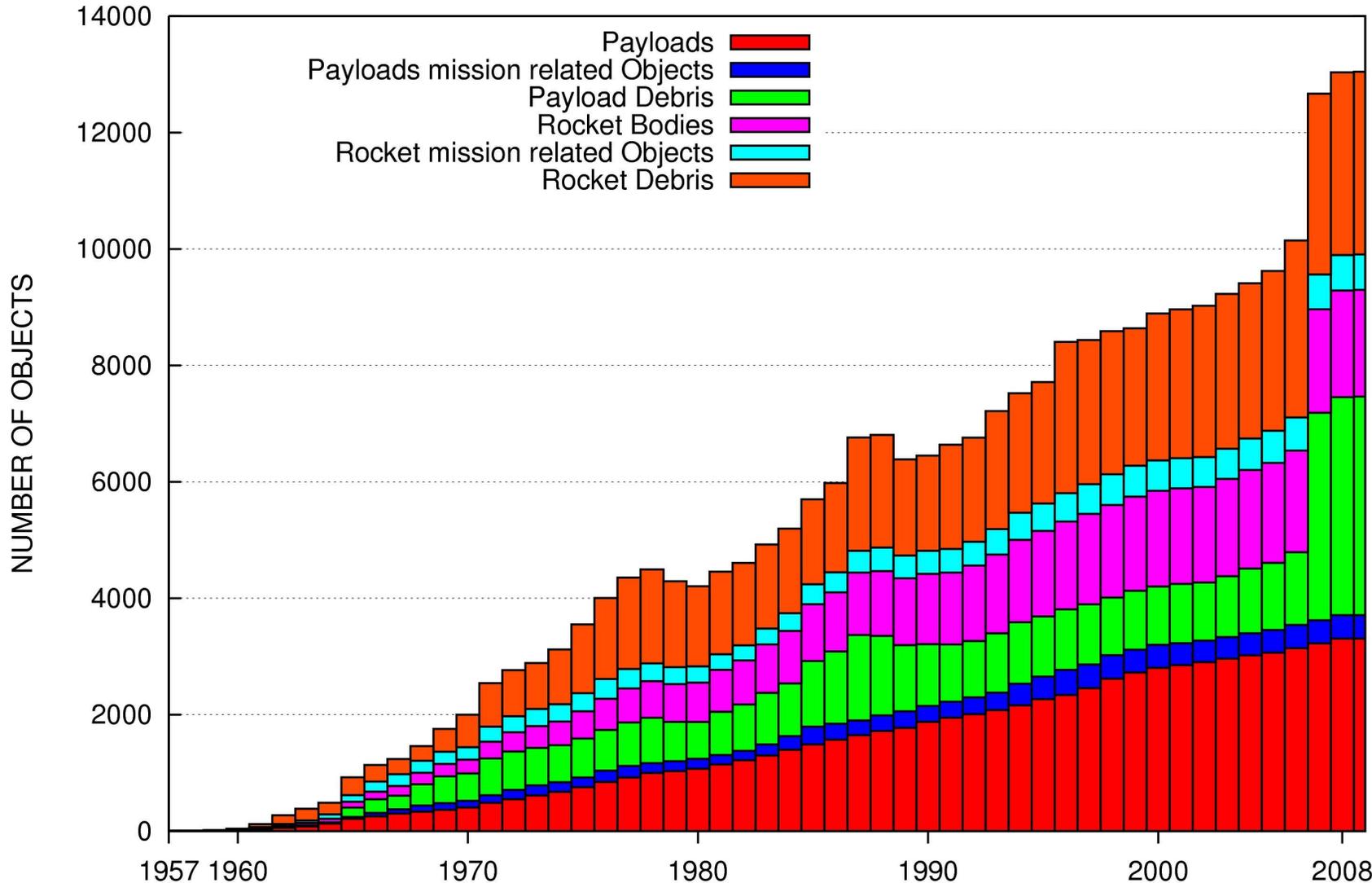
Technical Background: Space Debris Environment in 2008

- 4,616 launches and 245 on-orbit break-ups led to 12,500 catalog objects of the United States' Space Surveillance Network by Dec. 2008
- orbital distribution of SSN catalog:
 - low Earth orbits \Rightarrow 73%;
 - near-geostationary orbits \Rightarrow 8%;
 - highly eccentric orbits \Rightarrow 10%;
 - other orbits (incl. GNSS) \Rightarrow 9%
- catalog composition:
 - 25 % satellites (only 7% operational)
 - 14% rocket bodies
 - 8% mission-related objects, and
 - 53% fragments





Technical Background: Catalogued Space Objects in Orbit



Scope of the ESA Policy

The Requirements on Space Debris Mitigation for ESA Projects define a minimum set of requirements for the *limitation of space debris*, in particular, in the LEO and GEO protected areas, and a minimum set of risk reduction measures in the *case of re-entries* of space-systems or their components into the Earth's atmosphere.

Three pertinent issues:

- management requirements
- design requirements;
- operational requirements:

Scope of the ESA Policy: Management requirements

- Specific responsibilities of the prime contractor:
 - define derived system and sub-system design requirements
 - verify compliance with the design requirements
 - define and verify related operation procedures prior to launch
 - document all of the above activities and procedures
 - report on verification & compliance up to flight acceptance review
 - maintain a “space debris mitigation document” (part of DJF)
- Scope of “space debris mitigation document”:
 - prepare for the System Requirement Review (SRR); update for the Preliminary & Critical Design Review (PDR & CDR)
 - provide a compliance table, a description of design & operational measures to achieve compliance, a feared-events list, and a list with characteristics of objects released during a nominal mission

Scope of the ESA Policy: Design Requirements

- Launcher design requirements:
 - no more than 1 extra launch vehicle element shall be released into orbit for a single payload; no more than 2 extra elements shall be released into orbit for multiple payloads of a single launch
- Spacecraft design requirements:
 - releasing mission-related objects into orbit shall be avoided
 - if mission-related objects cannot be avoided, they shall remain outside the GEO protected zone, and they shall not remain in the LEO protected zone for more than 25 years after their release;
 - space systems shall not be intentionally destroyed in orbit
 - solid rocket motors and pyrotechnic devices shall not release products larger than 1 mm into orbit
- End-of-life disposal of space systems:
 - the design shall allow end-of-life clearance of the LEO & GEO zone, with adequate allocation of propellant to perform the disposal
 - the space system shall be permanently passivated after disposal



Scope of the *ESA Policy: Operational Requirements*

- disposal requirements:
 - space systems in LEO shall be disposed of by re-entry into the Earth atmosphere within 25 years after their operational phase
 - space system in GEO shall be disposed of by permanently removing them from the GEO protected region (GEO \pm 200 km)
 - space systems in other orbits shall be disposed of with the aim to avoid long-term interference with operational orbit regions
 - launcher stages shall perform a direct re-entry as part of their mission sequence
- end-of-life passivation:
 - passivation of a space system shall be completed within 2 months after its operational phase
- end-of-life disposal by means of re-entry:
 - the prime contractor shall perform an analysis to determine entry fragments surviving to ground impact, and their risk potential
 - if the casualty risk exceeds 1 in 10,000, uncontrolled re-entry is not allowed; instead, a de-orbit must be performed over ocean areas



Assessment of the ESA Requirements against IADC and STSC Guidelines

Compliance of “ESA Requirements” with IADC & UN Guidelines:

- limit debris release during nominal operations ⇒ IADC, UN, ESA
- minimize break-up potential during operations ⇒ IADC, UN, ESA
- limit accidental in-orbit collision probability ⇒ IADC, UN, ESA*
- avoid intentional destruction & harmful activities ⇒ IADC, UN, ESA
- limit the probability of post-mission break-up ⇒ IADC, UN, ESA
- limit the long-term presence of spacecraft and launcher orbital stages in the LEO protected region ⇒ IADC, UN, ESA;
re-entry objects resulting from this recommendation must not pose an undue risk to the ground population ⇒ IADC, UN, ESA
- limit the long-term interference of spacecraft and launcher orbital stages with the GEO protected region ⇒ IADC, UN, ESA

**adopted by ESA as a guideline, but not as a binding requirement, due to the dependence on external (US) Catalogue data for conjunction analyses but ESA performs operational collision avoidance for ERS-2 and Envisat*

Conclusions

- **Scope of ESA/ADMIN/IPOL(2008)2:**
 - **definition of applicable requirements for space debris mitigation and control**
 - **applicable to ESA procurements**
 - **full compatibility with IADC and UN STSC Guidelines**
- **Implementation of ESA/ADMIN/IPOL(2008)2:**
 - **“applicable document” for all new ESA space projects**
 - **has effect on statements of work, management requirements, system design requirements, and operational requirements**
 - **will be part of the “contractual baseline” in the invitation to tender and request for quotation of a space project.**