Small Satellite Debris Mitigation Guidelines - A Community Effort

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IAA Permanent Committee on Small Satellite Missions
Conducted by key experts and interest groups members of the space debris and small satellite community for members of the community (YOU!)

• Orbital debris mitigation is becoming increasingly important
• Technology improvements and cost reduction of access to space: easier to deploy missions
• Small satellite systems can provide significant benefit
• Earth orbital environment is a limited resource - requires coordination and careful understanding in small satellite implementation in order to ensure long term sustainability

IAA has formulated a study group to bring together a range of advice and practical steps that can be taken to help new and more experienced developers of micro, nano & pico satellites

• Understand obligations, international guidelines, standards, and national laws related to ensuing they sustainably develop their small satellite missions: openly available manual
“Compliant, Complete, Coherent, Compelling”

D. McKnight
Co-Chair
IAA SG 4.23
## An International Effort

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- Livio Gratton (Argentina), Klaus Schilling (Germany), Roberto Opromolla (Italy), Christophe Bonnal (France), Vera Pinto Gomes (Portugal), Rene Laufer (Germany), and many others
Debris Mitigation Guidelines

• In general, all the space debris mitigation rules (such as ISO 24113) apply to any spacecraft, whatever its size.

• Debris mitigation guidelines for this handbook basically present four major requirements:

  1. Passivate energetic sources (e.g., batteries and capacitors) and vent excess propellant.

  2. Eliminate creation of all debris greater than 1 mm; especially avoid explosions and collisions.

  3. Ensure that all objects left on-orbit are reentered or moved to an acceptable graveyard orbit within 25 years after their operational life with a probability of 90%.

  4. Reentry casualty risk to humans must be less than $10^{-4}$.

• This handbook primarily focuses on the last two requirements.
Calculating Orbital Lifetimes: An Art and Science

Empirical – Simple, Intuitive

Analytical – Complete, Accurate

- STELA
  - Semi-analytic Tool for End of Life Analysis
  - Designed by CNES to support the French Space Operations Act
  - STELA is available for download [https://logiciels.cnes.fr/en/content/stela](https://logiciels.cnes.fr/en/content/stela)

- Provides more flexibility in dealing with varying spacecraft orientations, solar activity levels, and altitudes/orbits

- Meet 25 year threshold in LEO: circular below ~625 km or perigee below ~400 km

- Effect of increased area increasing drag is evident...
Reduce Lifetime by Propulsion

✓ Strategy varies across LEO: require 10s to 100s m/s of delta velocity
Reduce Lifetime by Non-Drag Forces

- **Solar Radiation Pressure**
  - Solar – simple, slow; deal with stability, durability, & collision cross-section issues

- **Electrodynamic Tether (EDT)**
  - EDT - flexible, fast; deal with stability, durability, & collision cross-section issues
Reentry Survival

• Four primary characteristics that drive reentry survival:
  ✓ Material: typically aluminum and circuit boards
  ✓ Mass: under 100 kg (for micro satellites and smaller)
  ✓ Construction: no hardened or high density devices
  ✓ Reentry Trajectory: due to contraction from atmospheric drag

Micro satellites and smaller satellites will pose little air or ground impact risks
- Beware of densely-built components such as control moment gyros and batteries
Trade Study – What is Best for you?

• What can you control and what will provide greatest effects?

Spacecraft Design → Deployed Orbit → Operations → Post-Mission Disposal → Reentry

Payload

Propulsive System

Grapple Point

Material/Structure
Summary

• This manual complements other standards...
  ✓ ISO 24113, Space Systems – Debris Mitigation
  ✓ ISO/TS 20991, Space Systems – Requirements for Small Spacecraft

• Encourages and enables micro satellite (and smaller) operators to be responsible space users

• Choice for assuring adherence of a specific micro satellite or smaller to debris mitigation guidelines depends on...
  • Operational altitude, functional capabilities, and resources available

• Completion of the final draft planned for 15 January 2019

  Study group leadership and members are working very hard for you!