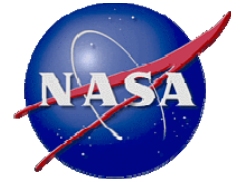


National Aeronautics and Space Administration

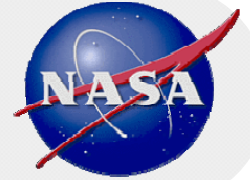


Current Issues in Orbital Debris

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Current State of Orbital Debris

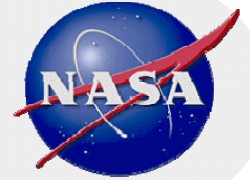
- **While the number of operational spacecraft in Earth orbit continues to increase (now ~ 1000), the rate of growth of the orbital debris population is even greater.**
 - Four known accidental collisions between cataloged space objects
 - 1810 cataloged debris (93%) from Cosmos 2251-Iridium 33 collision still in orbit; many more potentially hazardous debris from the event still in orbit
 - Growing evidence of potentially hazardous smaller debris impacts
 - Jason 1 spacecraft in 2002
- **On the positive side, the need for orbital debris mitigation measures has been recognized by virtually all space-faring nations and organizations.**
 - IADC Space Debris Mitigation Guidelines, 2002
 - United Nations Space Debris Mitigation Guidelines, 2007
 - Increasing number of national space debris mitigation policies, guidelines, requirements, regulations, etc.



Issue 1: Implementation of Mitigation Guidelines

- **The IADC and UN space debris mitigation guidelines were created to assist governments and international organizations to establish orbital debris mitigation policies and measures.**
 - “In its resolution 62/217 of 22 December 2007, the General Assembly endorsed the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space and agreed that the voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number of national and international organizations, and **invited Member States to implement those guidelines through relevant national mechanisms.**”

Preface, Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space
- **Within the U.S., implementation is effected via NASA standards, Department of Defense directives, and regulations of the FAA, FCC, and NOAA.**
- **Some space-faring nations and organizations have not yet adopted orbital debris mitigation measures consistent with the IADC and UN guidelines.**
 - To the greatest extent possible, a level international playing field is needed.



Issue 2: Compliance with Mitigation Guidelines

- **Although the IADC and UN space debris mitigation guidelines are not legally enforceable, the objective of the international aerospace community has been that all spacecraft and launch vehicle designers and operators adhere to these guidelines to the greatest extent possible.**
- **Compliance with every guideline on every space mission is not essential for the preservation of near-Earth space. However, an overall high level of compliance is necessary.**
- **Mechanisms should be established to monitor the compliance of national orbital debris mitigation measures.**
 - At NASA, each space project must prepare an Orbital Debris Assessment Report at PDR and prior to CDR which explicitly identifies any non-compliance issue.
 - Efforts are made through design and / or operations to resolve non-compliance issues.



Issue 3: Scope of Orbital Debris Mitigation Guidelines

- **The IADC and UN space debris mitigation guidelines were developed to serve as a set of foundation guidelines and were envisioned to be evolutionary in light of improved understanding of the orbital debris environment and technological advances.**
- **Some nations and organizations have already implemented more comprehensive or detailed mitigation policies. For example,**
 - Specific postmission orbital lifetime limits in LEO (i.e., the 25-year rule)
 - Specific limitations on human casualty risks following reentries
 - Specific measures of effectiveness, e.g.,
 - Smallest size of debris to be managed
 - Limitation of probabilities of collisions with small and large debris
 - Reliability of disposal operations
- **Consistent with new international consensus views, the IADC and UN space debris mitigation guidelines should be expanded.**



Issue 4: Space Vehicle Passivation

- **Both the IADC and UN space debris mitigation guidelines, as well as other national and organizational guidelines, call for the postmission passivation of space vehicles.**
 - The IADC and UN recommend that energy sources be depleted or made safe when no longer required for the mission.
- **Some current space vehicle designs do not permit the depletion of residual propellants and pressurants or the disconnection of batteries from their charging circuits.**
 - Modifications of the design of these vehicles are highly desirable.
- **The level at which some energy sources are “safed” (IADC) or “made safe” (UN) is ambiguous and has led to failures to reach consensus on the issue of compliance or non-compliance with these guidelines.**



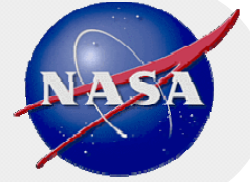
Issue 5: Reducing Reentry Risks

- **Although the IADC and UN space debris mitigation guidelines do not yet set a maximum risk threshold for human casualties related to space vehicle reentries (Issue 3), the *de facto* international standard is 1 in 10,000 per reentry event.**
- **For space vehicles with a mass in excess of 500 kg, achieving a human casualty risk of 0.0001 or less normally requires either design changes or adoption of controlled reentries.**
- **NASA has made significant advances in the design of spacecraft to reduce reentry risks, *i.e.*, “design for demise”. Examples include propellant tanks and reaction wheel assemblies, as well as simple structural members and ballast items.**
 - Many of these solutions can be applied to future space vehicle designs.
- **The U.S. has increased the use of controlled reentries for both robotic spacecraft and launch vehicle orbital stages.**



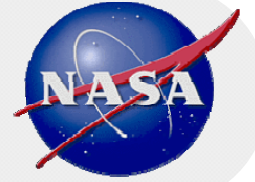
Issue 6: Small Satellites

- **IADC and UN space debris mitigation guidelines, as well as other national and organizational guidelines, are applicable to spacecraft regardless of size, mass, or mission.**
- **To date, the operation of many small satellites (including minisats, microsats, nanosats, and picosats) are not in compliance with international orbital debris mitigation norms.**
- **Small satellites should not be deployed in orbits which would result in excessive postmission orbital lifetimes in LEO (Issue 3), particularly since small satellites typically have relatively short or very short operational lifetimes.**
 - Potential solutions include postmission orbit changes (via propulsion or drag augmentation) or limiting operational orbits to below 700 km.
- **Concepts to deploy very large numbers (100's or 1000's) of small satellites should be carefully examined for negative environmental consequences.**
 - The trackability of very small satellites should also be given serious consideration.



Issue 7: Improved SSA

- **Space situational awareness is important to both the characterization of the Earth satellite population and the safe operation of piloted and robotic spacecraft.**
- **Greater sharing of SSA information is in the interests of the entire aerospace community.**
 - The U.S. has greatly increased the scope of its already broad international SSA sharing efforts since 2009.
- **Expanded and more sensitive SSA capabilities are needed for both the LEO and GEO regions.**



Issue 8: Space Environment Remediation

- **Numerous studies by multiple national space agencies have concluded that the current Earth satellite population is already unstable in some regions, *i.e.*, the generation of debris from future accidental collisions will exceed the loss of space objects from natural orbital decay in those regions.**
- **The intelligent removal of large, derelict resident space objects could significantly curtail the long-term growth of the orbital debris population.**
- **To date, the technical and economic challenges of orbital debris removal remain great, but studies continue.**
- **Orbital debris removal operations will likely be accomplished as part of an international endeavor and will require attention to additional policy issues.**



Summary

- **During the past two decades, great strides have been made in the international community regarding orbital debris mitigation.**
- **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 remain a high priority.**
- **Improvements of the IADC and UN space debris mitigation guidelines should continue as technical consensus permits.**
- **The remediation of the near-Earth space environment will require a significant and long-term undertaking.**