

The 2019 U.S. Government Orbital Debris Mitigation Standard Practices

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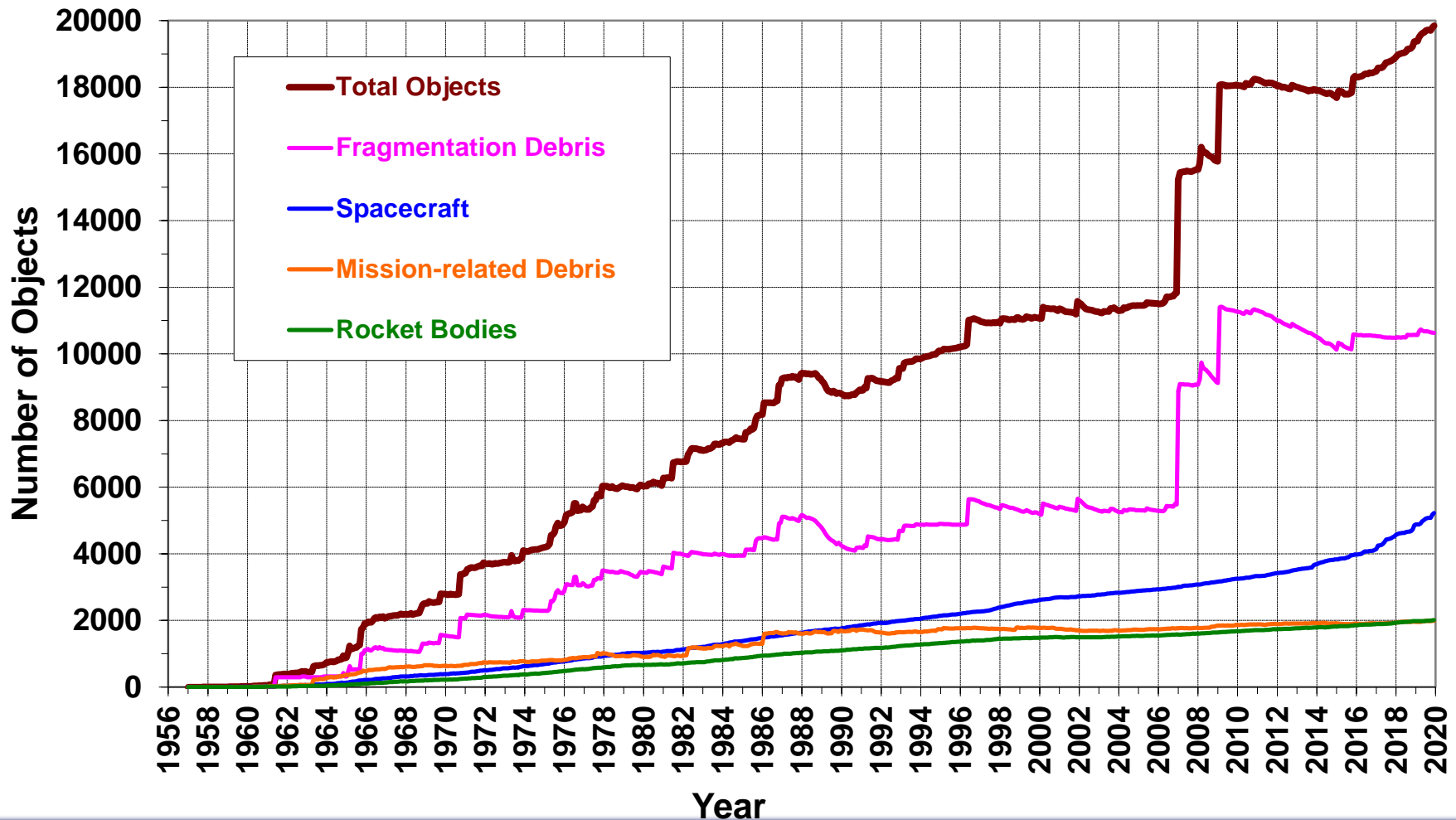
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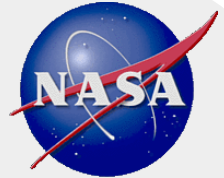
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Evolution of the Cataloged Satellite Population

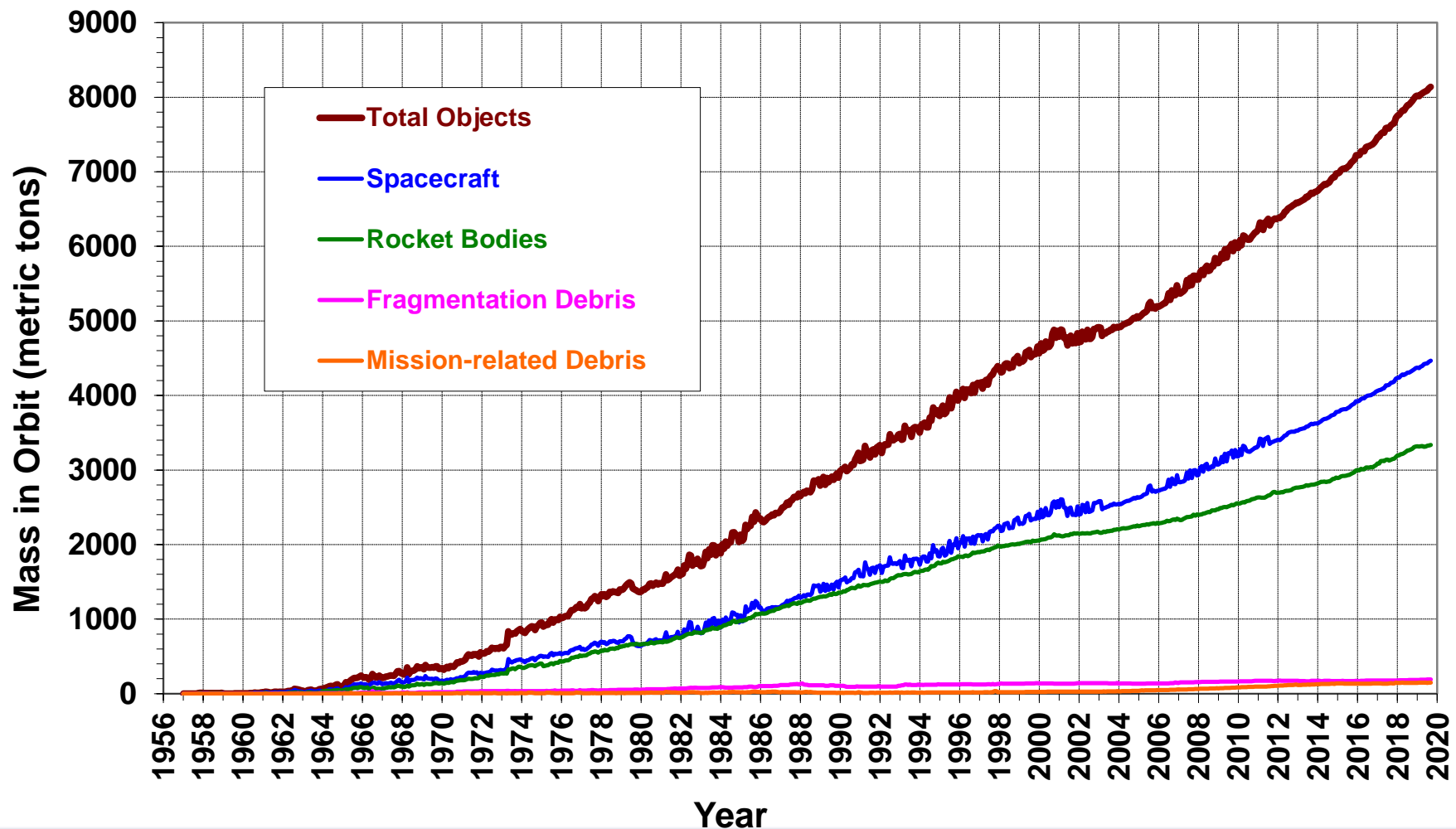
- According to the U.S. Satellite Catalog, the number of 10 cm and larger objects in Earth orbit continued to increase in 2019





Evolution of the Cataloged Satellite Population

- The total mass of material exceeded 8100 metric tons in 2019





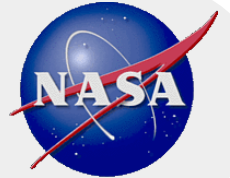
U.S. Space Policy Directive-3

- **To better address the growing threat from orbital debris, the 2018 Space Policy Directive-3 (SPD-3), the National Space Traffic Management Policy, initiated an effort to update the 2001 U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP)**
 - The SPD-3 tasked NASA to lead a U.S. government (USG) interagency working group (IWG) for the update
 - After more than a year's work by the IWG, which consisted of over 80 representatives from 7 departments and agencies, the update was completed in December 2019
 - The 2019 ODMSP is available at:
<https://orbitaldebris.jsc.nasa.gov/reference-documents/>



Key New Elements in 2019 ODMSP (1/9)

- **Limit the generation of mission-related debris**
 - A “less than 100 object-years” limit for debris released during normal operations per upper stage or spacecraft in low Earth orbit (LEO)
 - **This new limit aims to reduce the long-term presence of mission-related debris in LEO**
- **Limit the generation of accidental explosion fragments**
 - An accidental explosion probability limit of “less than 0.001 (1 in 1,000)” during deployment and mission operations
 - **As of 1 January 2020, 60% of the cataloged on-orbit fragments were the outcome of accidental explosions. This 0.001 limit is achievable and effective in reducing the generation of accidental explosion fragments.**



Key New Elements in 2019 ODMSP (2/9)

- **Limit collision with large objects**
 - A “less than 0.001 (1 in 1,000)” probability of collision with large objects during a satellite’s orbital lifetime
 - **This limit can be achieved by the selection of a safe flight profile, including mission altitude, background debris environment, and end of mission planning.**
- **Limit collision with small micrometeoroid and orbital debris (MMOD)**
 - A “less than 0.01 (1 in 100)” probability of collision with small MMOD to ensure successful postmission disposal operations
 - **Cost-effective protective shields for critical components (propulsion systems, etc.) can be designed and implemented to meet this threshold.**



Key New Elements in 2019 ODMSP (3/9)

- **Postmission disposal (PMD): from 25-year rule to immediate removal**
 - The effectiveness of the 25-year postmission orbital lifetime limit (the “25-year rule”) has been studied and confirmed by many organizations, including the Inter-Agency Space Debris Coordination Committee (IADC), over the past 20 years
 - **The 25-year rule is still a good balance between cost (fuel requirement) and benefit**
 - Regardless, the 2019 ODMSP encourages operators to go beyond the 25-year rule and, for the first time, **establishes “immediate removal from Earth orbit” as the preferred disposal option and an aspirational goal for the global community**
 - **The USG has followed this preferred option for some missions in the past and plans to implement it for more missions in the future (to lead by example)**



Key New Elements in 2019 ODMSP (4/9)

- **PMD: storage between LEO and GEO**
 - A practical, low-risk, eccentric (such as GEO transfer orbit) PMD storage option
 - The conditions for this option are to limit the $\text{GPS} \pm 300$ km zone crossing dwell time to less than 25 years over 200 years and avoid crossing LEO and GEO for 100 years, which can easily be met with a careful selection of the initial storage orbit.
- **PMD: storage above GEO**
 - A storage option to “move-away-and-stay-away” from $\text{GEO} + 200$ km for 100 years
 - This option better meets the intent of a storage orbit to avoid interference with spacecraft operating inside the GEO zone. Simple trajectory analyses can be performed to select a storage orbit that will meet this objective.



Key New Elements in 2019 ODMSP (5/9)

- **PMD: long-term reentry**
 - A option utilizes orbital resonances to increase the eccentricity of a disposed structure so that the structure's perigee will eventually be low enough to allow the atmospheric drag to cause it to reenter
 - **The conditions for this option are a 200-year orbital lifetime limit; less than 25-year dwell time each in LEO, GEO, and GPS \pm 300 km; a less than 0.001 (1 in 1,000) probability of collision with objects 10 cm and larger during orbital lifetime; and less than 7 m² total reentry debris casualty area (DCA) or 0.0001 (1 in 10,000) human casualty risk for surviving components.**



Key New Elements in 2019 ODMSP (6/9)

- **PMD: direct retrieval**
 - The 2001 ODMSP direct retrieval option is maintained in the 2019 update, but with a new condition – the retrieval must take place within 5 years of the structure’s completion of mission
- **PMD: reliability**
 - A “no less than 90%” reliability limit
 - **A high level of compliance is key to the success of using the 25-year rule to limit future debris population growth in LEO. The 90% threshold is necessary and achievable. It is also very cost-effective in long-term orbital debris environment management when compared with active debris removal (ADR).**



Key New Elements in 2019 ODMSP (7/9)

- **Large constellations**

- Three additional standard practices: (1) the PMD reliability should be at a level greater than 0.9 with a goal of 0.99 or better, (2) the PMD reliability threshold should be established based on mass, collision probability, orbital location, and other relevant parameters, (3) **immediate removal is the preferred PMD option**
 - Depending on (2), **a 0.99 PMD reliability may be necessary for some large constellations**

- **Small satellites, including CubeSats**

- **They should follow the ODMSP**
- A “less than 100 object-years” per mission limit for LEO spacecraft smaller than 10 cm × 10 cm × 10 cm when fully deployed
 - **This limit ensures adequate risk mitigation for missions launching many (tens, hundreds, or more) very small “spacecraft”**



Key New Elements in 2019 ODMSP (8/9)

- **Rendezvous and proximity operations, satellite servicing**
 - Limit the probability of accidental collision with the target
 - **During the planning and execution of proximity operations**
 - Limit the probability of accidental explosion resulting from the operations
 - **Mitigate the risk of operating on hardware components (refueling, mechanical manipulation, etc.), including pressurized systems, which were not designed for servicing and with unknown degradation conditions after years in space**
 - Any planned debris generated as a result of the operations should follow the standard practices for mission-related debris
 - **Proper disposal of any generated debris, such as removed bolts and replaced solar arrays**



Key New Elements in 2019 ODMSP (9/9)

- **Safety of ADR operations**
 - Limit the probability of accidental collision with the target
 - Limit the probability of accidental explosion resulting from the operations
 - Any planned debris generated as a result of the operations should follow the standard practices for mission-related debris
 - Avoid fragmentation of the debris target
 - Any removed debris target should follow the applicable PMD practices, including the reentry human casualty risk limit



Summary

- **This 2019 ODMSP update includes improvements to the original objectives as well as clarification and additional standard practices for certain classes of space operations**
 - The updated standard practices are **significant, meaningful, and achievable**
- **The 2019 ODMSP, by establishing guidelines for USG activities, provides a reference to promote efficient and effective space safety practices for domestic and international operators to support the long-term sustainability of outer space activities**