National Aeronautics and Space Administration

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

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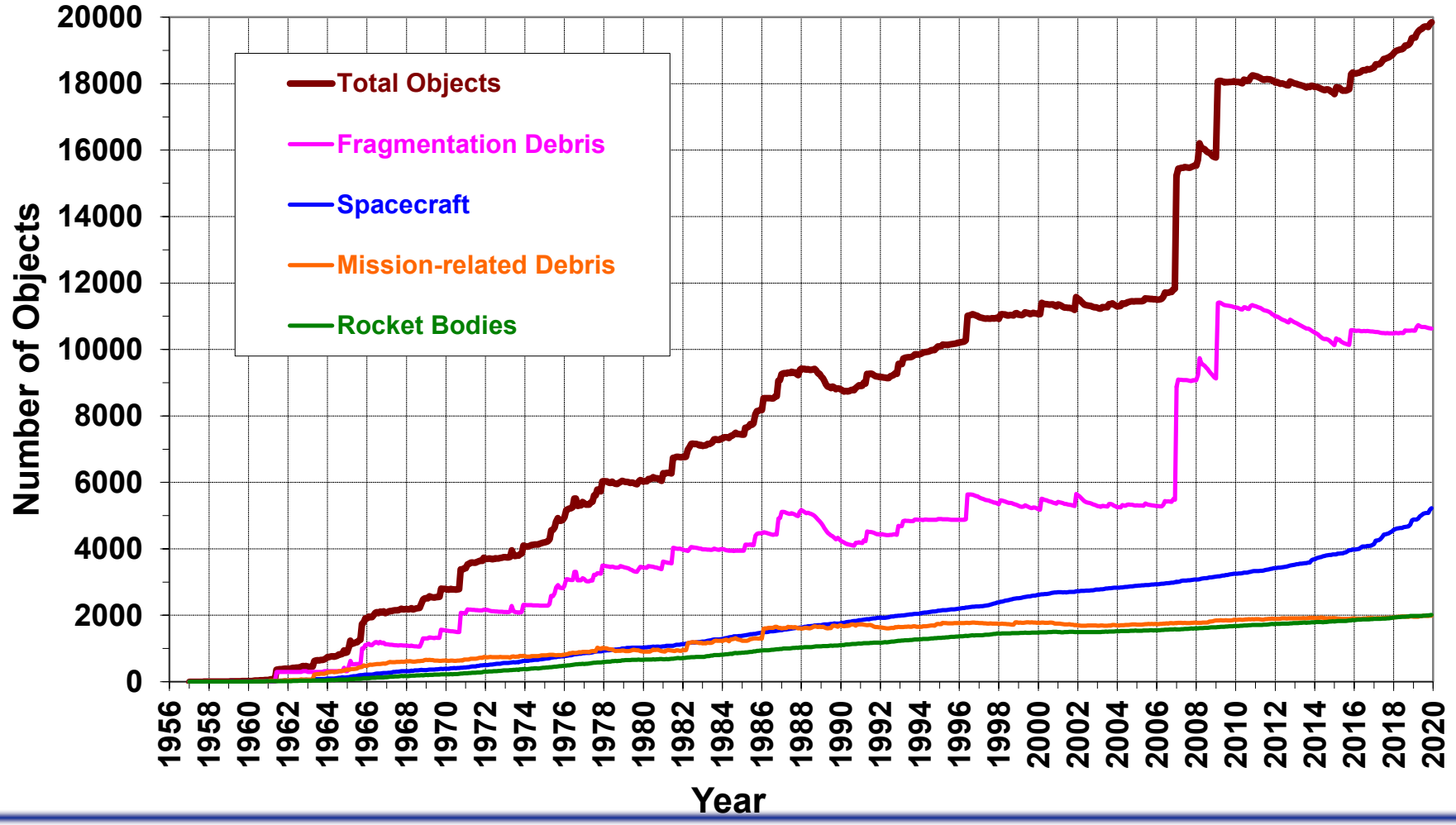
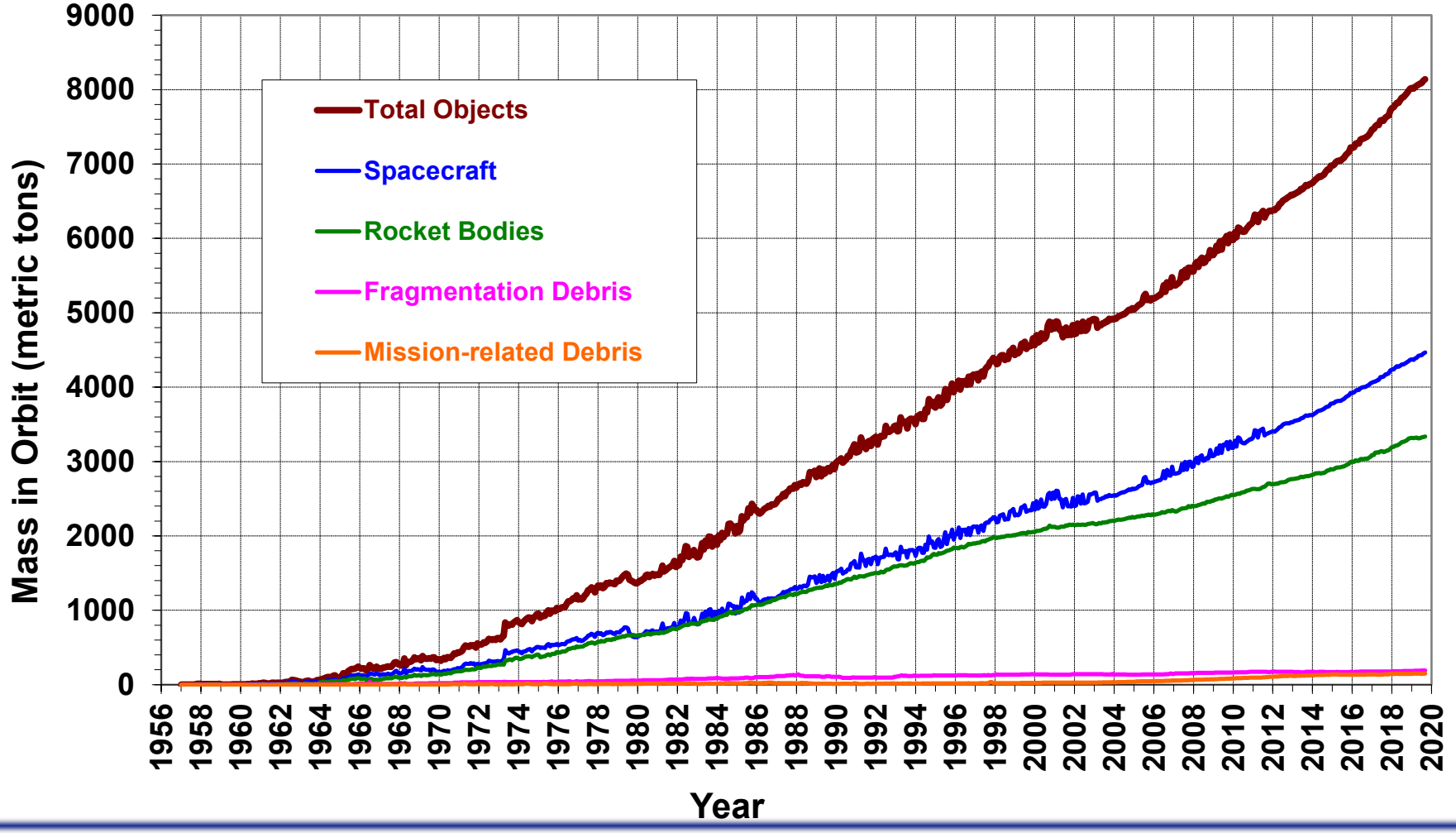
Evolution of the Cataloged Satellite Population

- **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 GPS ± 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 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**
  - An 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 ± 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 m^2 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**
  - 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 in support of the long-term sustainability of outer space activities**