National Aeronautics and Space Administration

Risk from Orbital Debris

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Brookings Institution, Washington DC, 13 May 2020

How Much Orbital Debris is Up There?

Softball size or larger (≥10 cm): ~23,000
(tracked by U.S. Combined Space Operations Center, CSpOC)

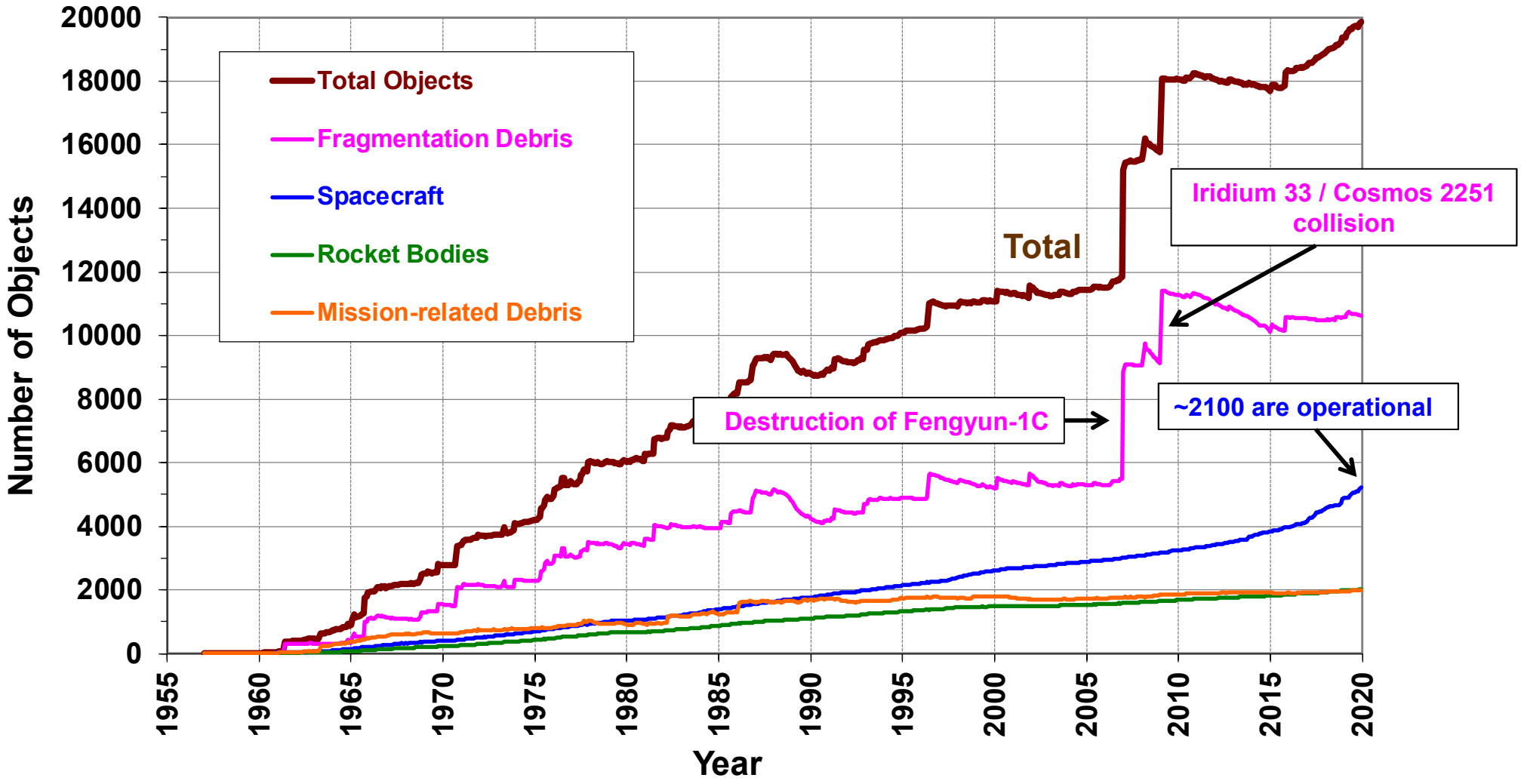
Marble size or larger (≥1 cm): ~500,000

Dot or larger (≥1 mm): >100,000,000
(a grain of salt)

- **Average impact speed in low Earth orbit (LEO) is ~22,000 miles per hour, more than 10 times the speed of a bullet**
  - ➢ Mission-ending threat is dominated by small, millimeter-sized debris impacts
- **Total mass: >8100 tons, LEO to GEO (geosynchronous Earth orbit)**

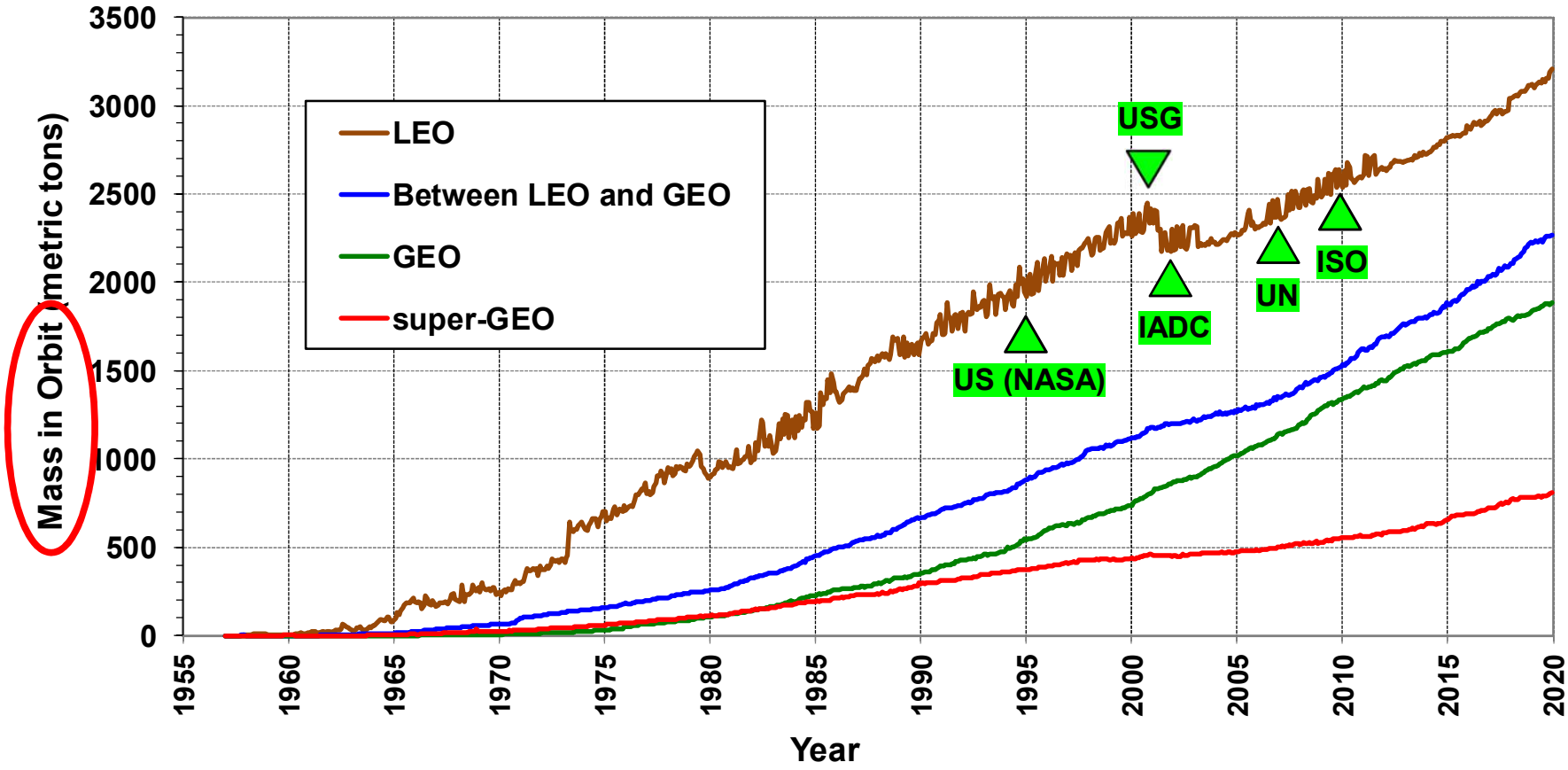
Growth of the Cataloged Populations

- **Fragmentation debris dominates the cataloged populations**



The Long-Term Orbital Debris Problem

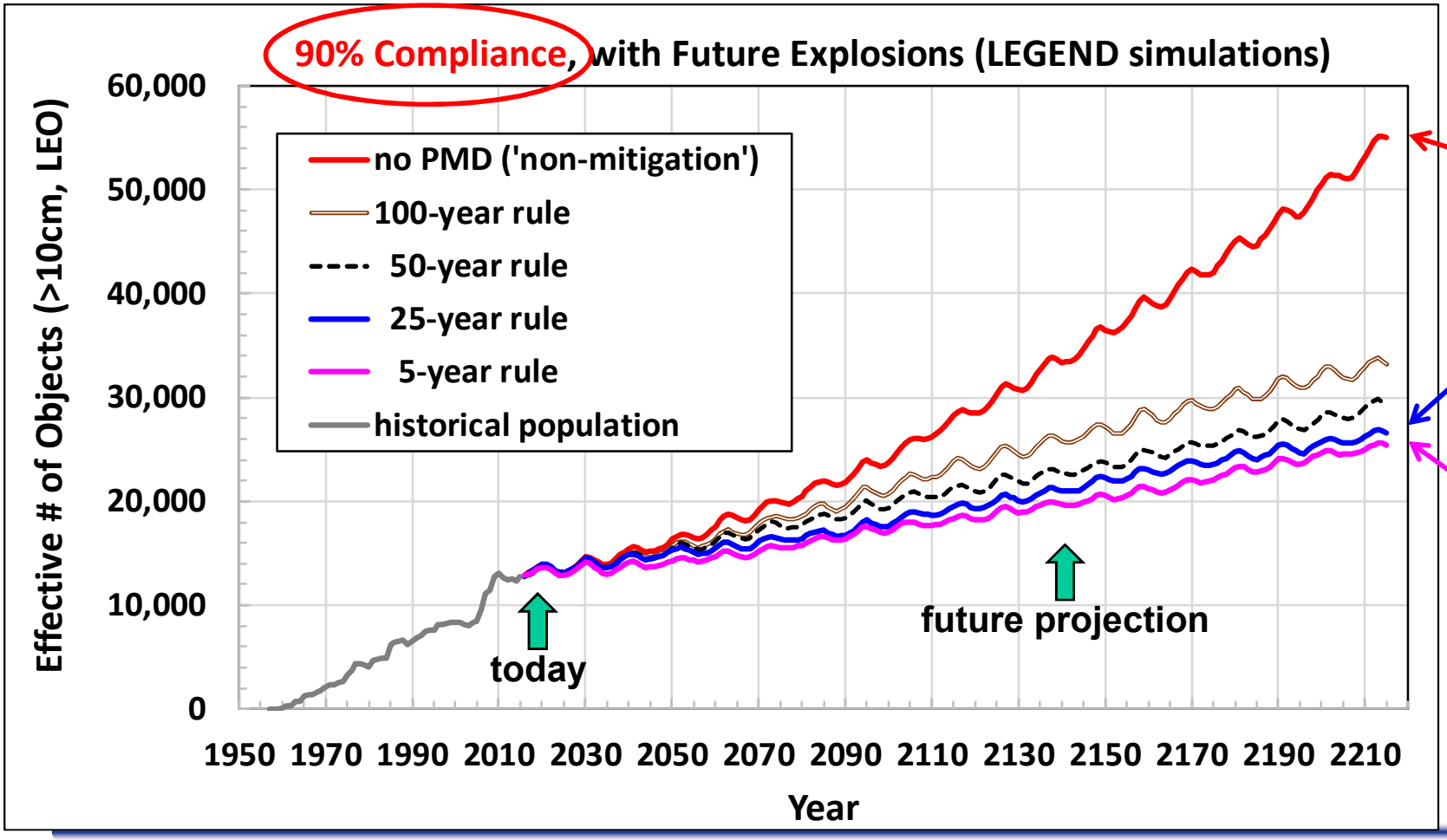
- **The OD population continues to increase over time despite decades of efforts to limit the generation of new debris**
  - Green triangles indicate when key OD mitigation guidelines and standard practices were first established



Effectiveness of the 25-Year Rule in LEO

- **The 25-year rule significantly limits future LEO debris growth**
  - The global 25-year rule compliance level is far less than 50%
  - Shortening the 25-year rule only leads to a second order benefit

Debris increase in 200 years



Mitigation and Remediation

- **Orbital Debris Mitigation = Prevention**
- **Orbital Debris Remediation = Cure**

2010 National Space Policy

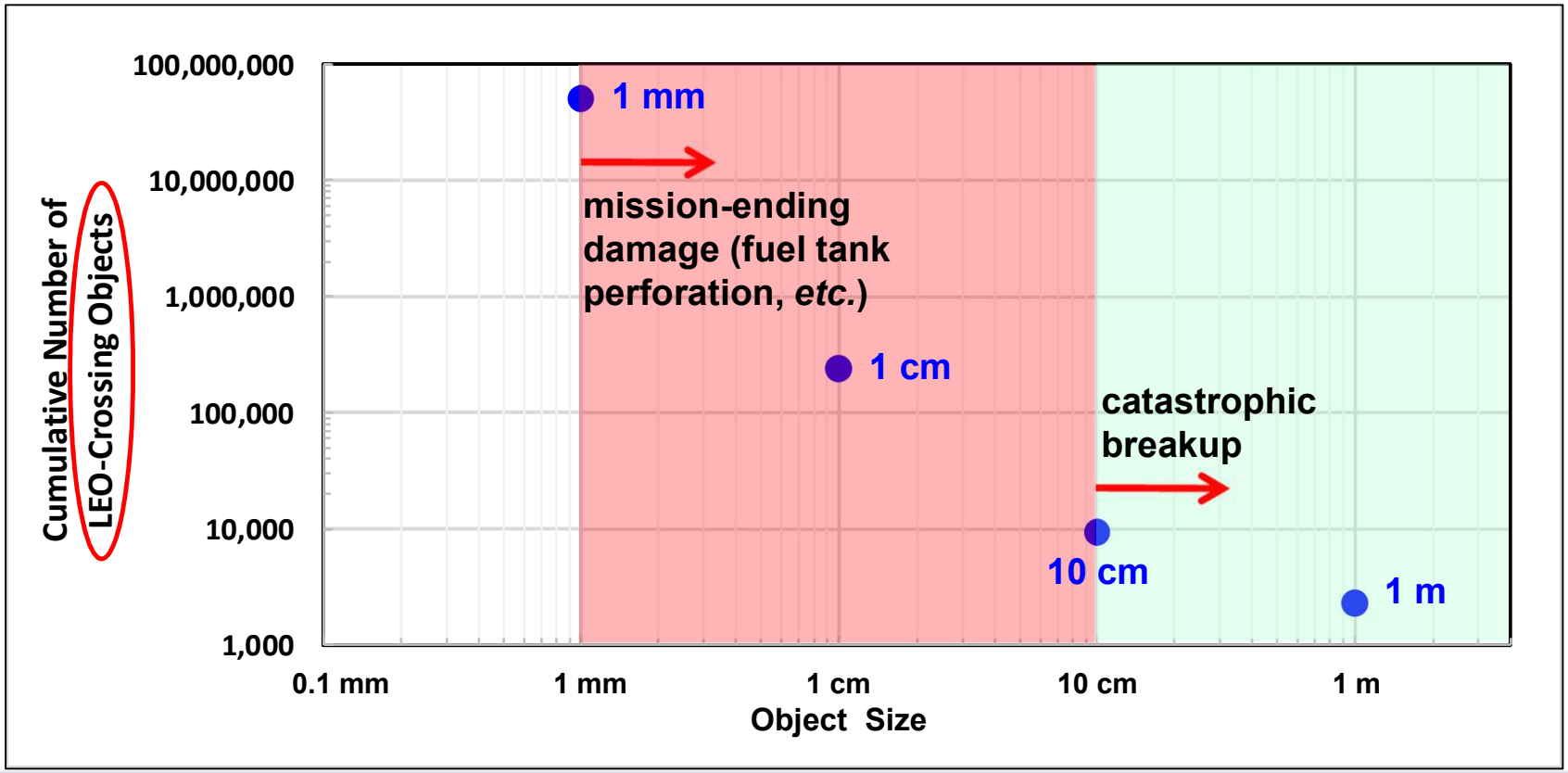
"Pursue research and development of technologies and techniques, through the Administrator of the National Aeronautics and Space Administration (NASA) and the Secretary of Defense, to mitigate and remove on-orbit debris, reduce hazards, and increase understanding of the current and future debris environment..."

2018 Space Policy Directive-3 (SPD-3)

"The United States should pursue active debris removal as a necessary long-term approach to ensure the safety of flight operations in key orbital regimes. This effort should not detract from continuing to advance international protocols for debris mitigation associated with current programs."

The Short-Term Orbital Debris Problem

- **There is far more small debris than large debris**
  - **Mission-ending risk for most operational spacecraft is driven by small, millimeter-sized OD**
  - **Conjunction assessments and collision avoidance against the large (≥10 cm) tracked objects only address <1% of the debris impact risk**



Top OD Risk to Space Missions in LEO

- **Millimeter-sized OD represents the highest penetration risk to most operational spacecraft in LEO**
  - As concluded by a recent NASA Engineering and Safety Center panel study (NASA/TM 2015-218780)
- **Currently, more than 400 missions operate between 600 km and 1000 km altitudes**
- **There is a lack of data on millimeter-sized OD above 600 km altitudes**
  - Direct measurement data on such small debris is needed to support the development and implementation of cost-effective, protective measures for the safe operations of future missions

Managing Risks from Orbital Debris

- "***Space Traffic Management*** ***shall mean the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment.***" **(SPD-3)**

- **Key orbital debris priorities to enhance the safety, stability, and sustainability of operations in the future space environment**
  - Improve space situational awareness on small debris, especially the millimeter-sized debris in LEO, to better protect future space missions
  - Promote better global compliance with existing OD mitigation best practices to slow down the debris population growth
  - Establish long-term goals, combining mitigation and remediation, to preserve the near-Earth space environment