National Aeronautics and Space Administration

U.S. Space Debris Environment and Activity Updates

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National Aeronautics and Space Administration

United States

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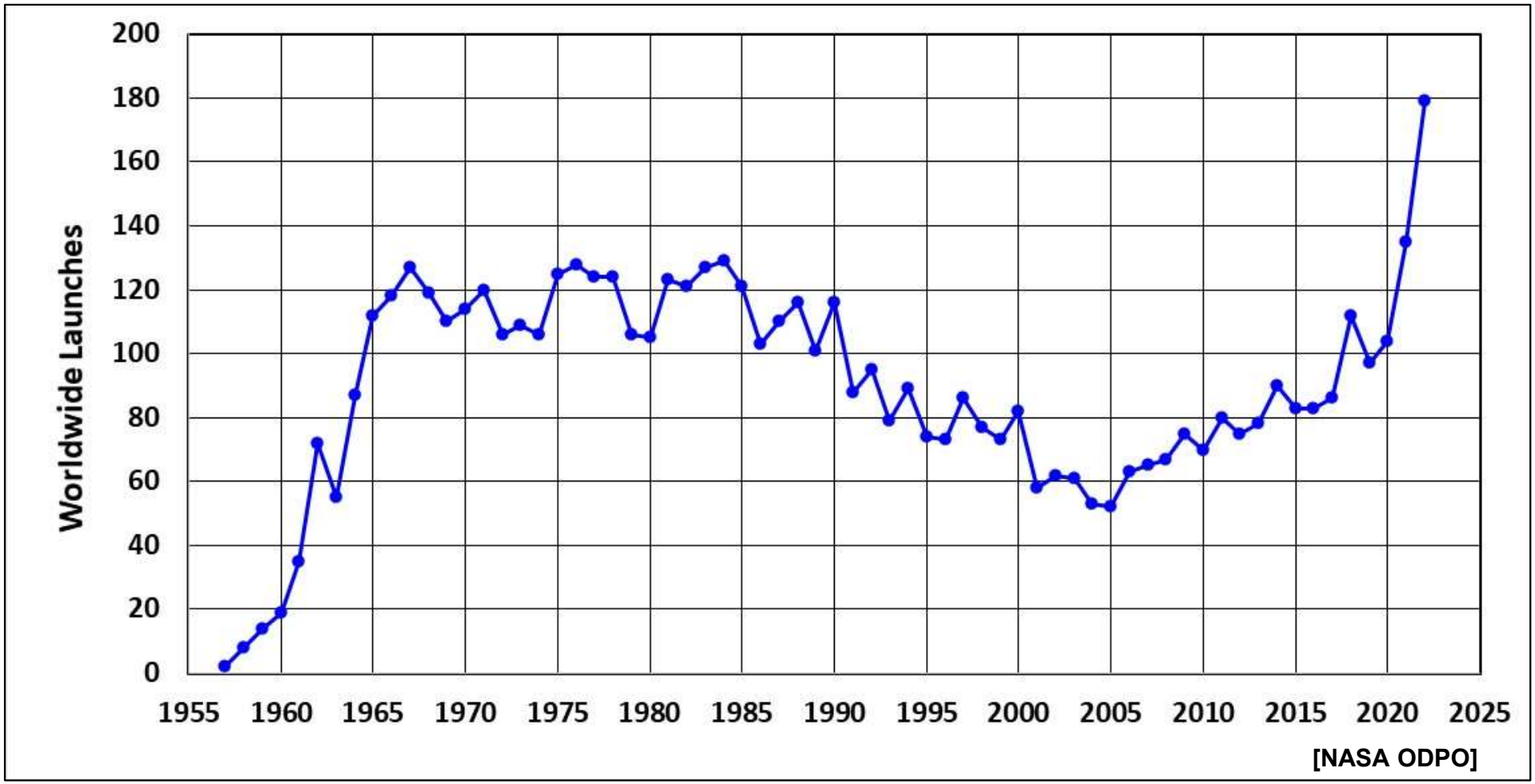
Presentation Outline

- **Worldwide Space Activity in 2022**
- **Earth Satellite Population (1957–2022)**
- **Satellite Fragmentations and Reentries in 2022**
- **Collision Avoidance Maneuvers**
- **Orbital Debris Model Update**

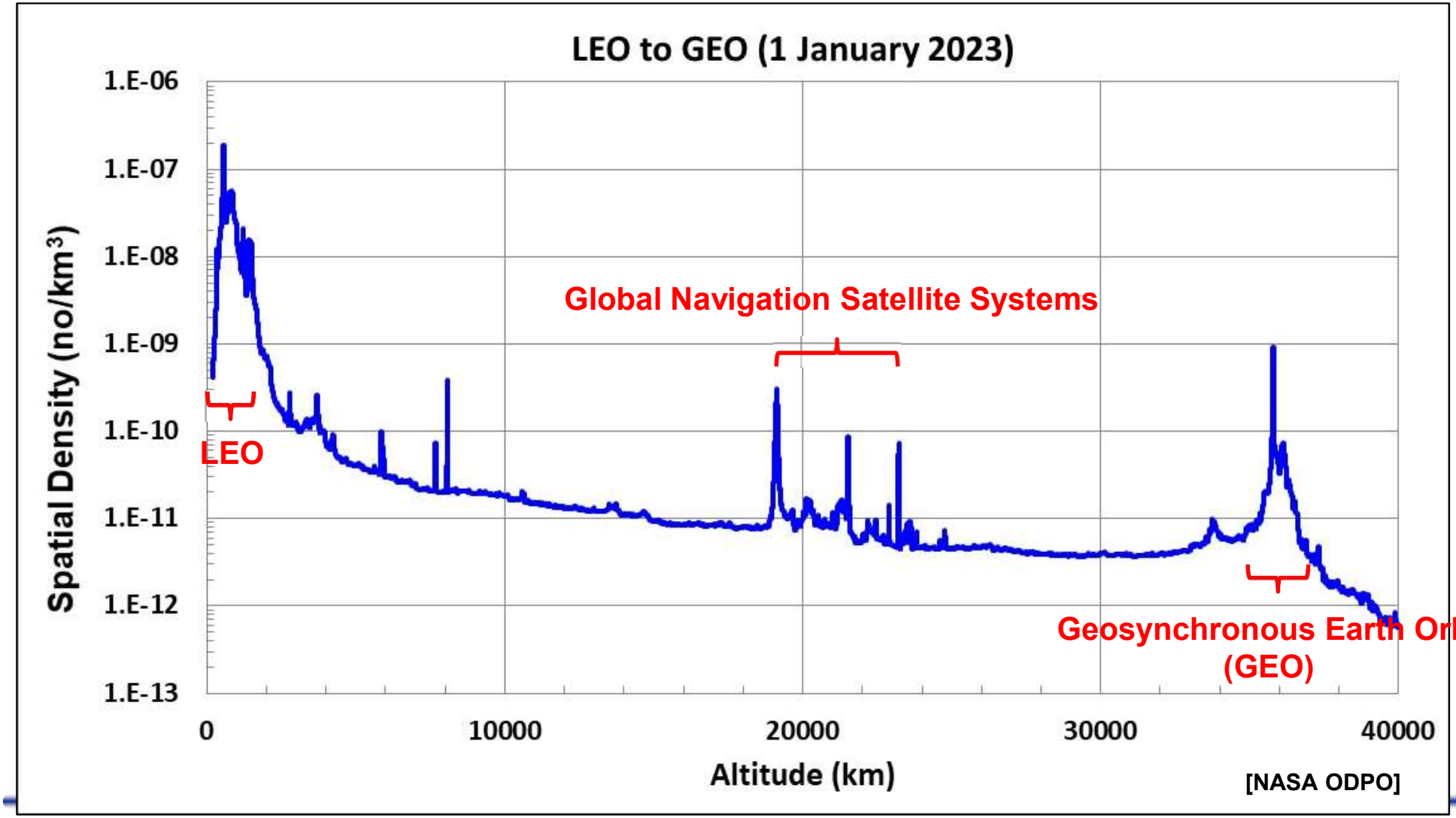
Worldwide Space Activity in 2022

- **Following the trend of increase in recent years, 179 new launches were conducted in 2022, setting another record and deploying more than 2300 spacecraft into Earth orbits**



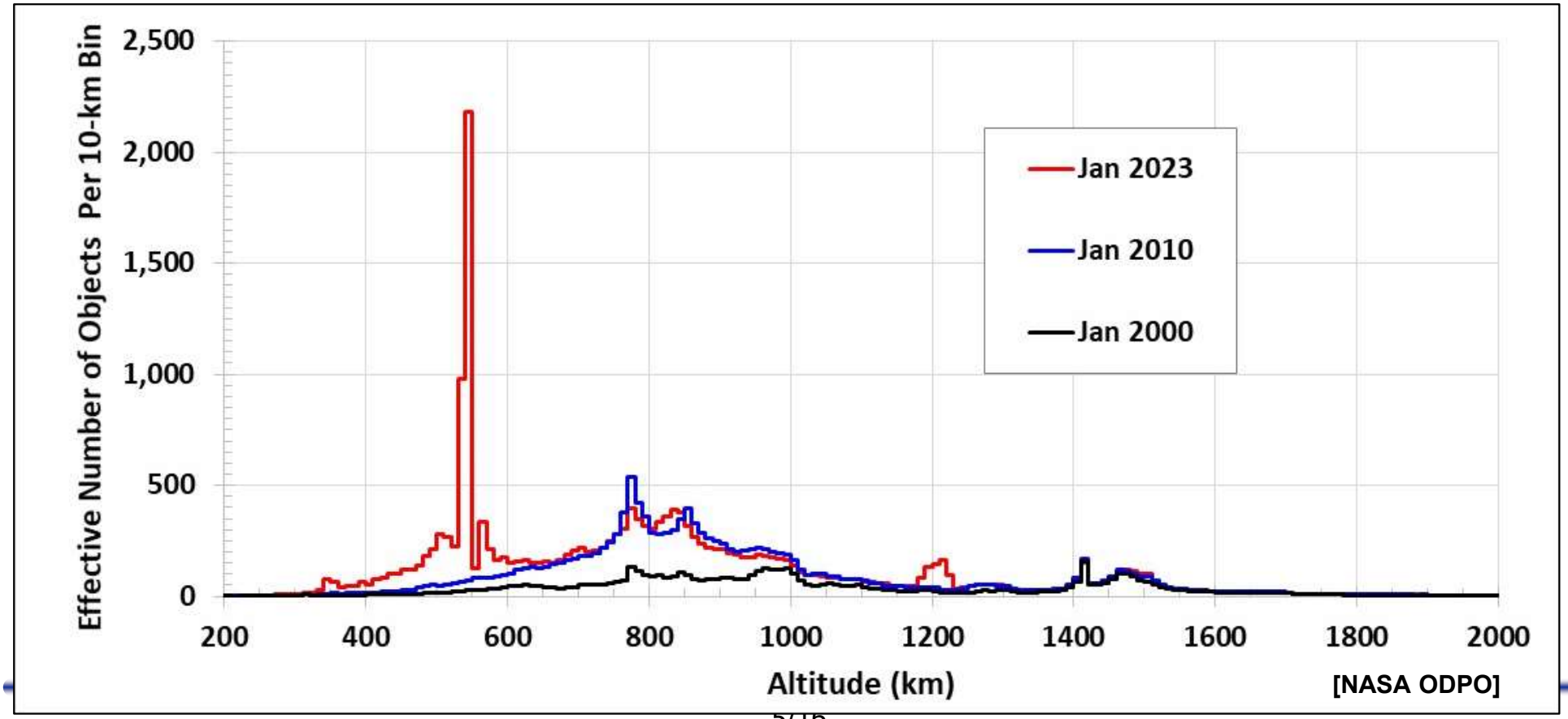
Distribution of the Cataloged Objects
– LEO to GEO

- **Low Earth orbit (LEO, the region below 2000 km altitude) has the highest concentration of operational spacecraft and orbital debris**



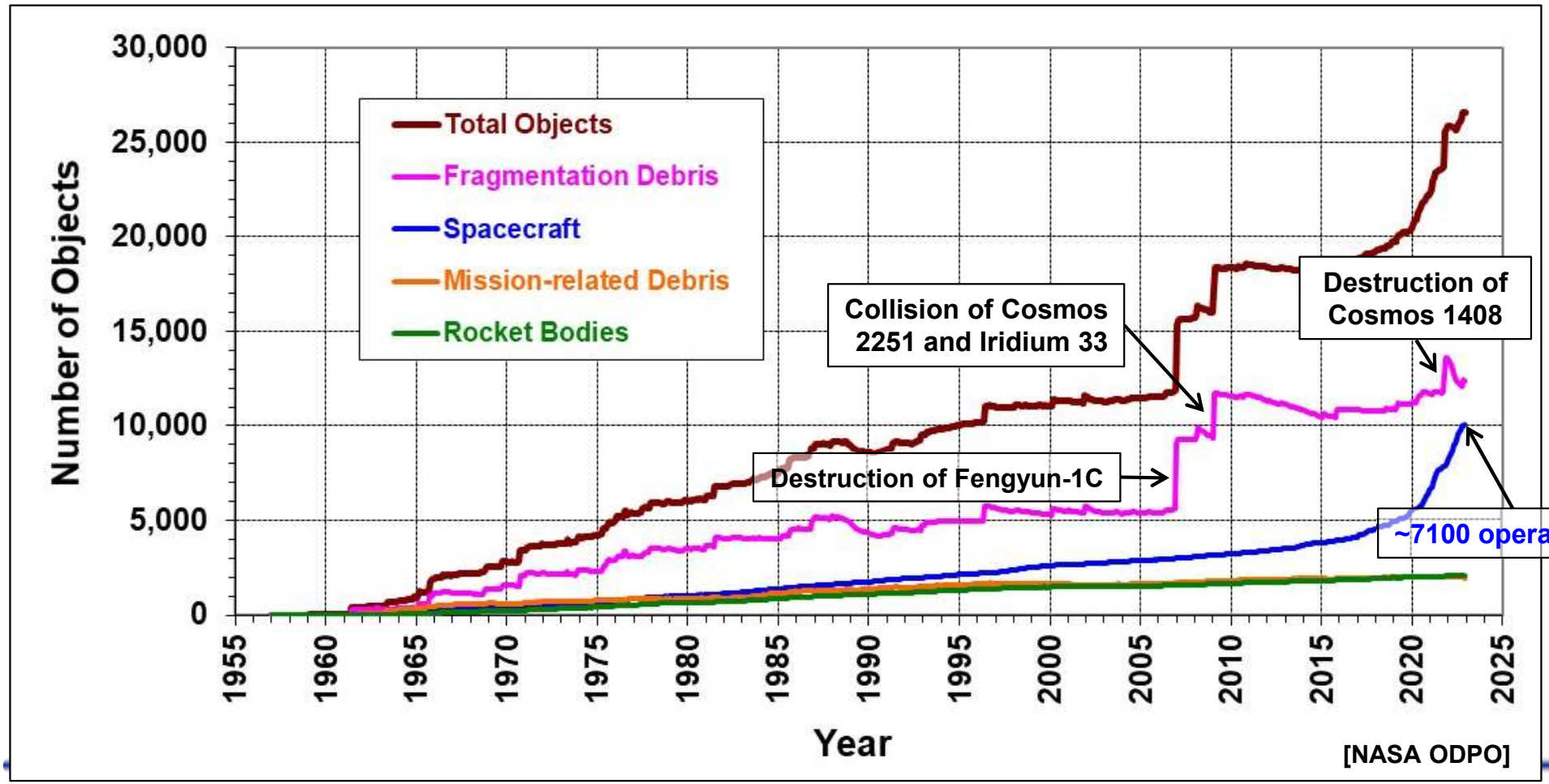
LEO Environment: 2000 to 2023

- **The LEO cataloged objects have significantly increased since 2000**
  - 2000 to 2010: The Fengyun-1C anti-satellite (ASAT) test and the collision between Iridium 33 and Cosmos 2251 drove most of the increase
  - 2010 to 2023: The proliferation of CubeSats and deployments of large constellations were primarily responsible for the increase below ~700 km



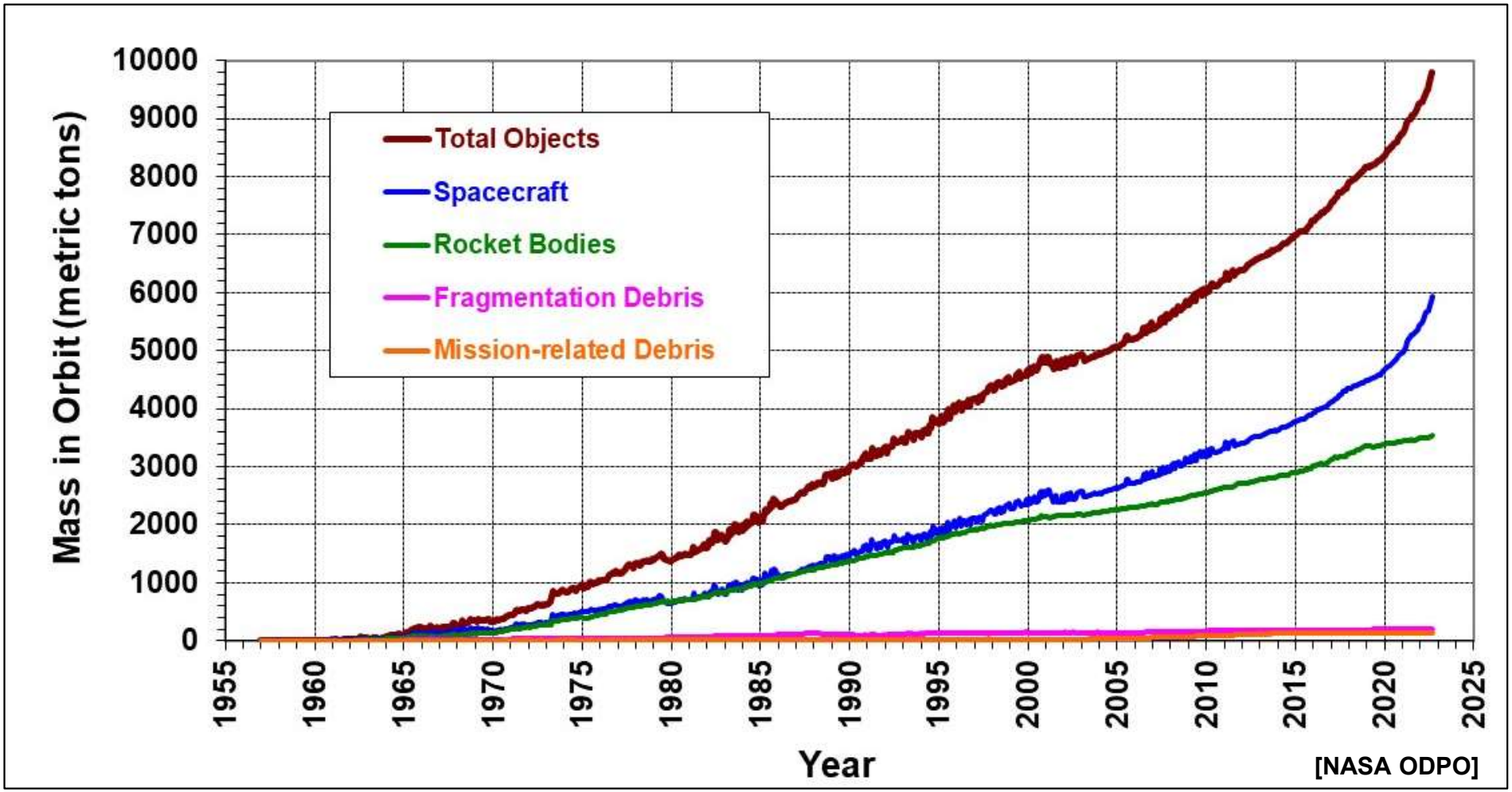
Growth of the Cataloged Populations

- **The USSF 18 SDS tracks/catalogs the largest objects in space**
  - Such objects only represent the tip of the iceberg for the orbital debris population
  - ~100,000,000 additional debris too small to be tracked but large enough to threaten human spaceflight and robotic missions exist in the environment



Mass in Orbit Continued to Increase

- **The total mass of material has exceeded 9500 metric tons**
  - About 4000 tons of material exists in LEO



On-orbit Fragmentations in 2022

- **The U.S. Space Surveillance Network (SSN) detected four on-orbit fragmentations during 2022**
  - These events generated hundreds of fragments large enough to be tracked by the SSN and many more additional fragments too small to be tracked but large enough to threaten human spaceflight and robotic missions

Common Name	International Designator	Perigee Altitude (km)	Apogee Altitude (km)	Debris Cataloged
SL-12 SOZ ullage motor	2007-065F	400	19,068	2
H-2A upper stage fairing cover	2018-084D	579	615	36
Long March 6A upper stage	2022-151B	813	847	533
H-2A upper stage fairing cover	2012-025F	609	633	30

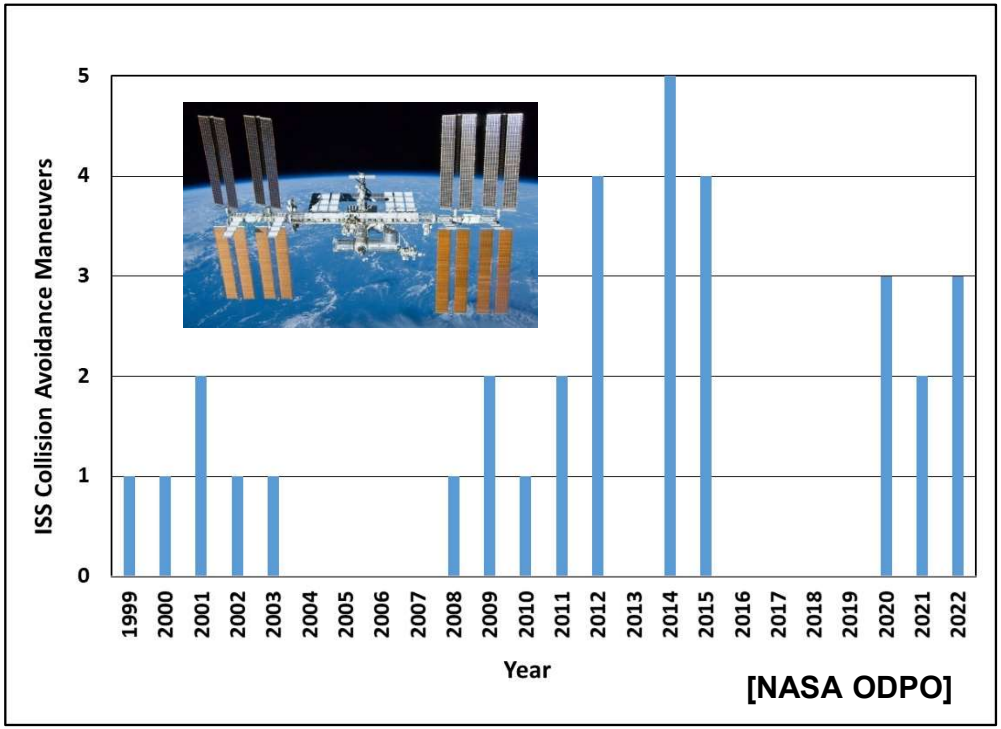
- **The breakup of the upper stage underlines the importance of minimizing the probability of accidental explosions via design improvements and/or end-of-mission passivation to limit the generation of new orbital debris**

Satellite Reentries in 2022

- **More than 2400 reentries of spacecraft, launch vehicle upper stages, and other cataloged debris were recorded by the U.S. Space Surveillance Network during 2022**
  - Spacecraft: 372 (including 107 SpaceX Starlinks)
  - Upper stages: 66
  - Other debris: 2005
- **The total mass of the 2022 reentries exceeded 280 metric tons**
- **Surviving components from some reentries were recovered, and no casualties were reported**

International Space Station and NASA Robotic Spacecraft Collision Avoidance Maneuvers

- **NASA has established conjunction assessment processes for its human spaceflight and robotic missions to avoid accidental collisions with large objects tracked by the SSN**
- **The International Space Station (ISS) has conducted 33 collision avoidance maneuvers since 1999**
  - Three times in 2022: Two of the avoided objects were fragments generated from the November 2021 Russian ASAT test, and the third avoided object was a fragment from the 2020 explosion of a Russian Fregat upper stage tank
- **NASA also executed or assisted in the execution of 18 collision avoidance maneuvers by robotic spacecraft during 2022**

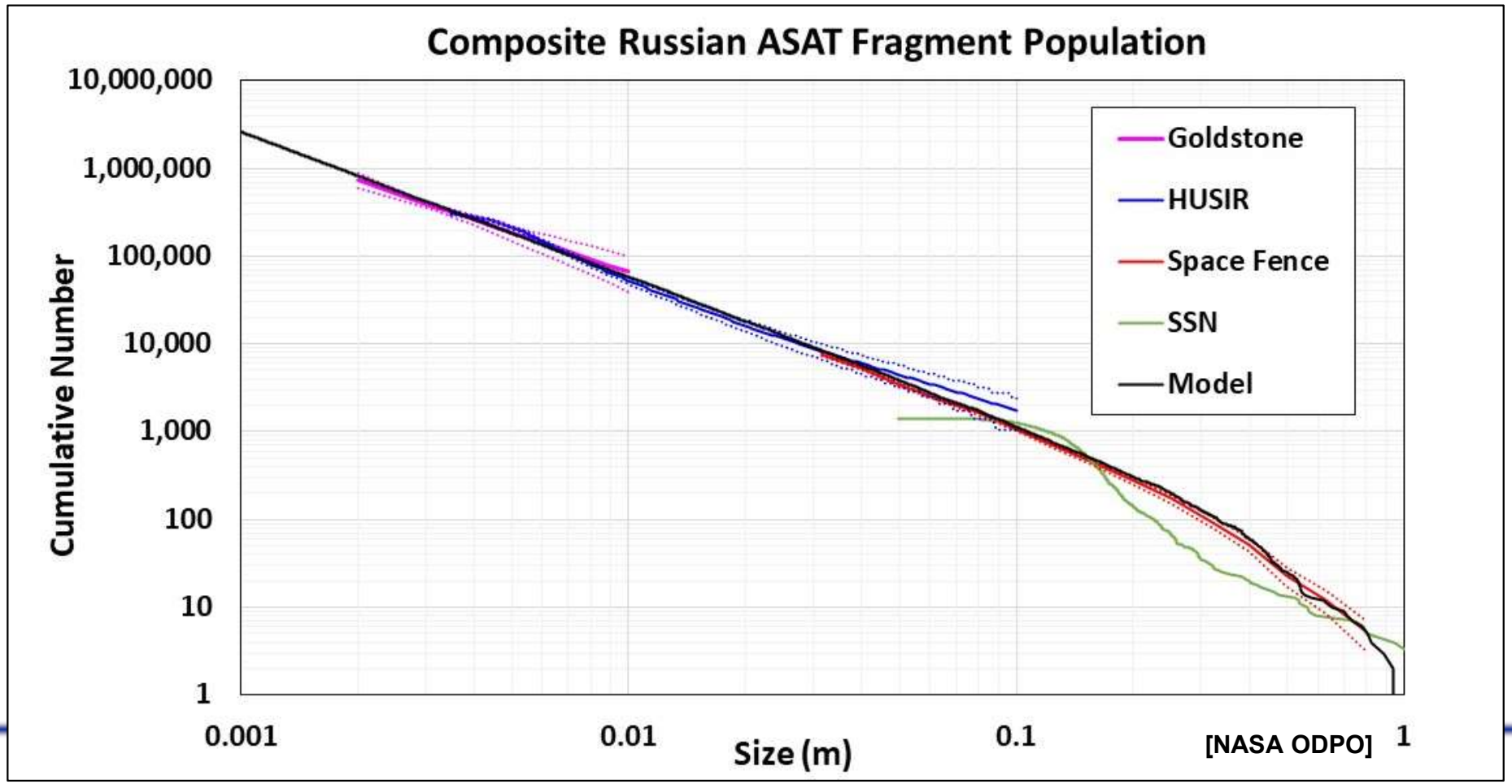


Cosmos 1408 Fragments
– Measurements and Risk Assessments

- **The Russian ASAT test on Cosmos 1408 (1750 kg, 490 x 465 km altitude) occurred on 15 November 2021**
- **The NASA Orbital Debris Program Office (ODPO) led efforts to assess risks from Cosmos 1408 fragments to the ISS and supported development of mitigation measures to protect the ISS crew**
- **The ODPO also made special arrangements for timely radar measurement data on Cosmos 1408 fragments immediately after the ASAT test occurred**
  - The Massachusetts Institute of Technology/Lincoln Laboratory's Haystack Ultrawideband Satellite Imaging Radar (HUSIR)
  - The NASA Jet Propulsion Laboratory's Goldstone radar
  - The Department of Defense's Space Fence
- **The ODPO used the measurement data to validate its risk assessments and to update NASA's Orbital Debris Engineering Model (ORDEM) with a new Cosmos 1408 fragment component**
  - ORDEM is used by hundreds of operators (NASA, U.S. government, commercial, international), academia, and research groups around the world

Cosmos 1408 Fragments
– Data and Mission Support Tool

- **The ODPO's prediction matches the radar measurement data well**
- **The updated ORDEM 3.2 with a new Cosmos 1408 fragment component was released to the user community in March 2022**
  - ORDEM 3.2 was also released as a cloud-based application



United States Policies Related to Space Sustainability (1/3)

2019 Orbital Debris Mitigation Standard Practices (ODMSP) Update

- Mitigates the creation of new debris that may be generated during normal operations and by accidental explosions or collisions

2020 National Space Policy

- *"Lead the enhancement of safety, stability, security, and long-term sustainability in space by promoting a framework for responsible behavior in outer space, including the pursuit and effective implementation of best practices, standards, and norms of behavior"*
- Encourages active debris removal in coordination with allies and partners

2021 National Orbital Debris R&D Plan

- Supports three essential elements of orbital debris risk management: limit debris generation by design, track and characterize debris, and remediate debris

Mitigate By Design

Track and Characterize

Remediate

United States Policies Related to Space Sustainability (2/3)

2021 U.S. Space Priorities Framework

- Prioritizes Mission Authorization and Supervision
  - *"…U.S. regulations must provide clarity and certainty for the authorization and continuing supervision of non-governmental space activities, including for novel activities such as on-orbit servicing, orbital debris removal, space-based manufacturing, commercial human spaceflight, and recovery and use of space resources…"*

Vice President Harris Releasing the U.S. Space Priorities Framework

- Prioritizes space sustainability and planetary protection.
  - *"The United States will increase efforts to mitigate, track, and remediate space debris. The United States will advance development and implementation of domestic and international best practices to mitigate the creation of space debris and will support efforts to evolve those practices to ensure continued safety of flight operations in the future…"*

United States Policies Related to Space Sustainability (3/3)

- **2022 National Orbital Debris Implementation Plan**
  - Identified 44 specific actions that implement the 2021 Orbital Debris R&D Plan
  - Some actions call for new policy development
- **2022 Federal Communications Commission (FCC) Regulatory Update**
  - Adopts a “five-year rule,” which would require commercial operators planning disposal through uncontrolled re-entry into Earth’s atmosphere to complete disposal as soon as practicable, and no more than five years following the end of mission.
- **2022 In-Space Servicing, Assembly, and Manufacturing National Strategy**
  - Prioritizes sustainability of the space environment
  - “Collaborate with commercial partners to support cost-effective space debris removal.”
  - “The USG will incentivize emerging ISAM logistics providers to remove space debris utilizing mission concepts such as fee-for-service, credits, bounties, or prizes.”
- **2022 National Cislunar Science and Technology Strategy**
  - Extends sustainability and debris policies into cislunar space
  - Support development of best practices related to debris mitigation and minimizing the hazard of Lunar landing ejecta in cislunar space and lunar orbit.
  - Extend space situational awareness capabilities into cislunar space to help satellite operators avoid collisions with other satellites or debris

NASA Activities That Support Space Sustainability

- **Evaluation of Concepts for Debris Mitigation and Remediation**
  - Created a NASA-wide internal working group to identify challenges and develop solutions. Solicited feedback from industry and other government agencies.
- **Cost-Benefit Analysis of Active Debris Remediation**
  - The Office of Technology, Policy, and Strategy (OTPS) is analyzing the risks posed to satellite operators by orbital debris and comparing with the potential costs of remediating those risks.
  - The study will identify the most cost-efficient approaches to remediate the risks posed by orbital debris and prioritize promising remediation technologies
- **Supporting Technical and Policy Research on Space Sustainability**
  - OTPS worked with the Organization for Economic Cooperation and Development (OECD) to develop research on the economics of space sustainability, such as the new publication, “Earth’s Orbits at Risk: The Economics of Space Sustainability.”
  - Funding research proposals from three university-based teams who will analyze the economic, social, and policy issues associated with space sustainability.
  - Made awards to two companies for the commercial development of active debris remediation (ADR) services