National Aeronautics and Space Administration

U.S. Space Debris Environment and Activity Updates

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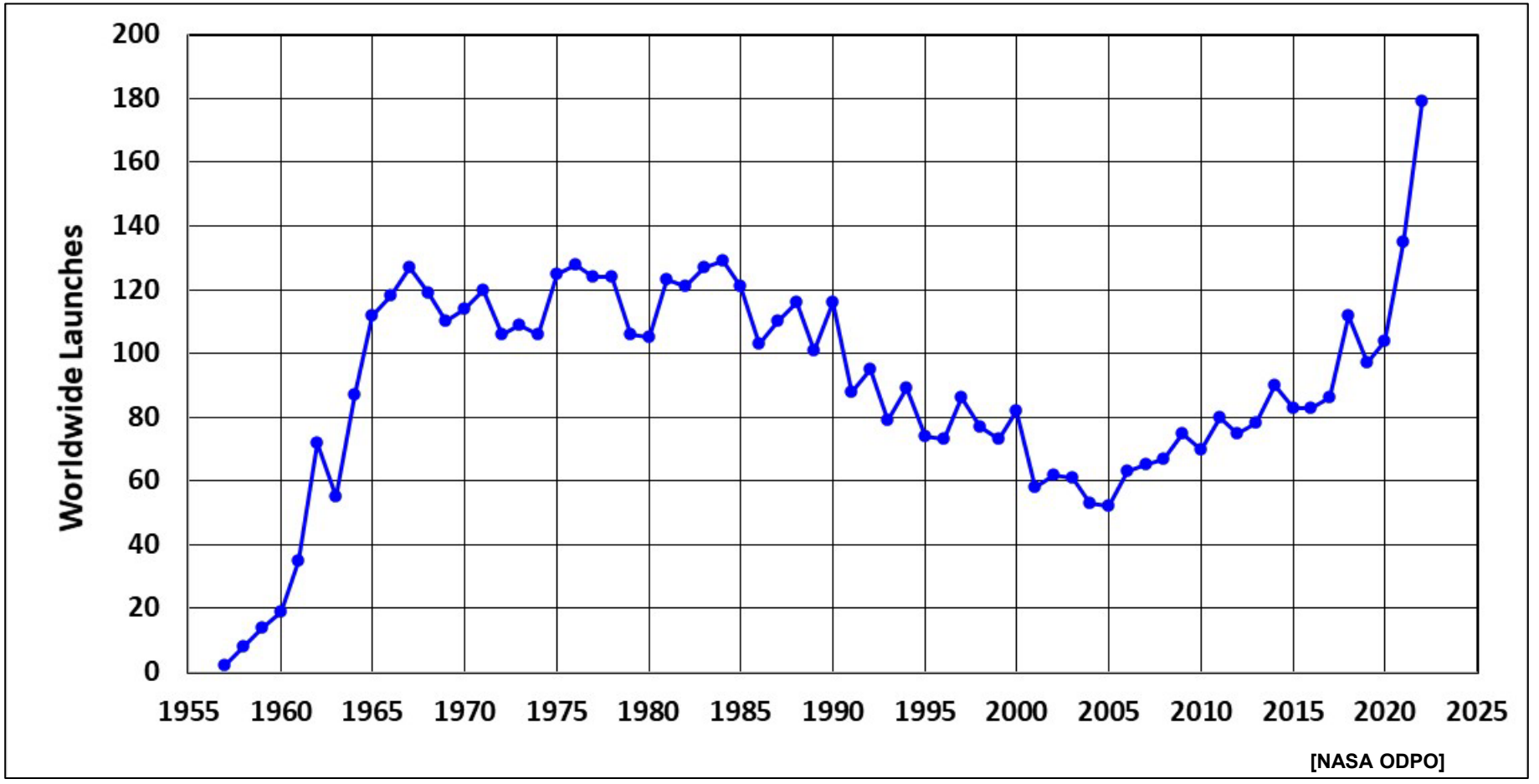
Presentation Outline

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

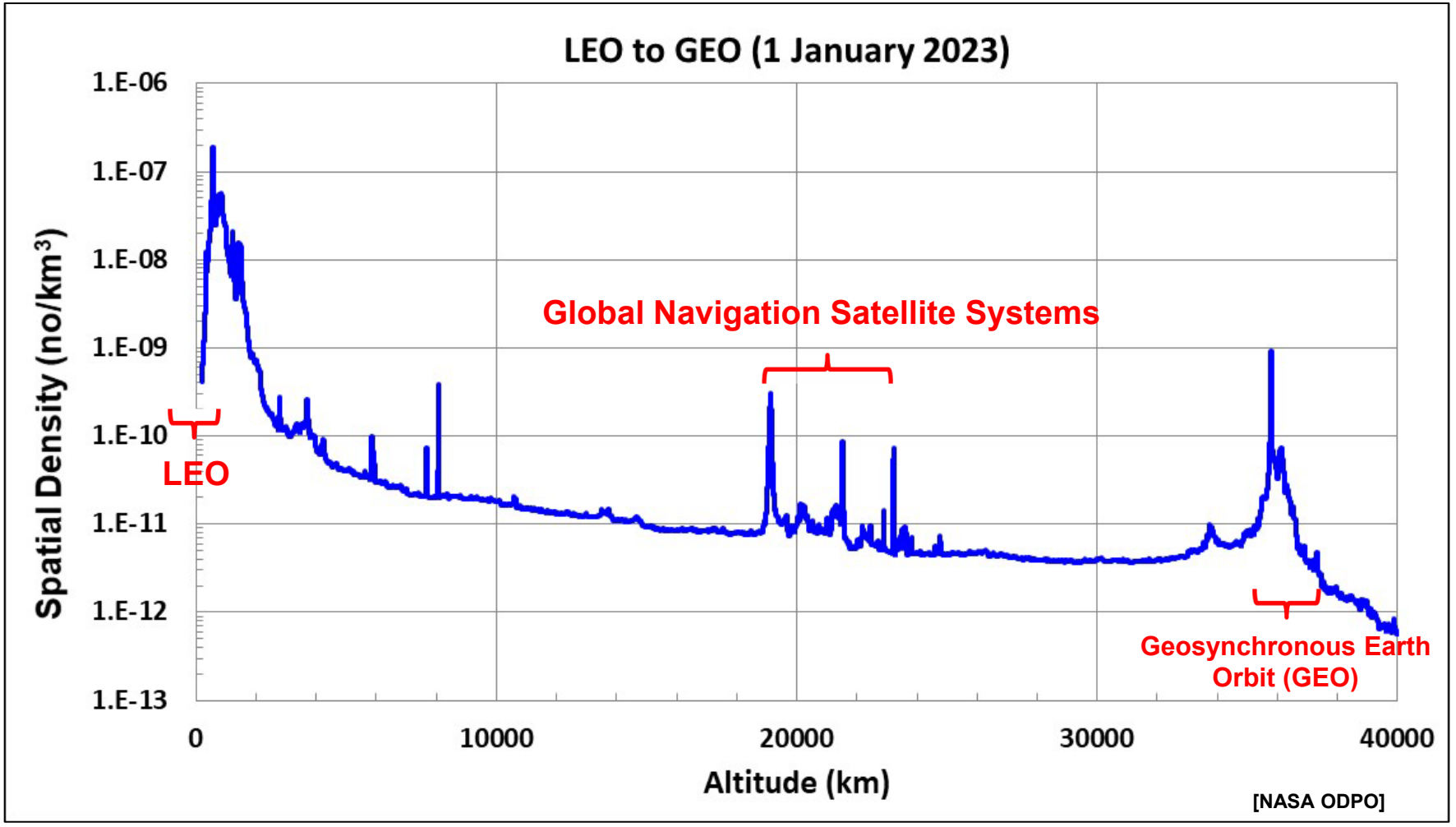
Worldwide Space Activity in 2022

- **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**



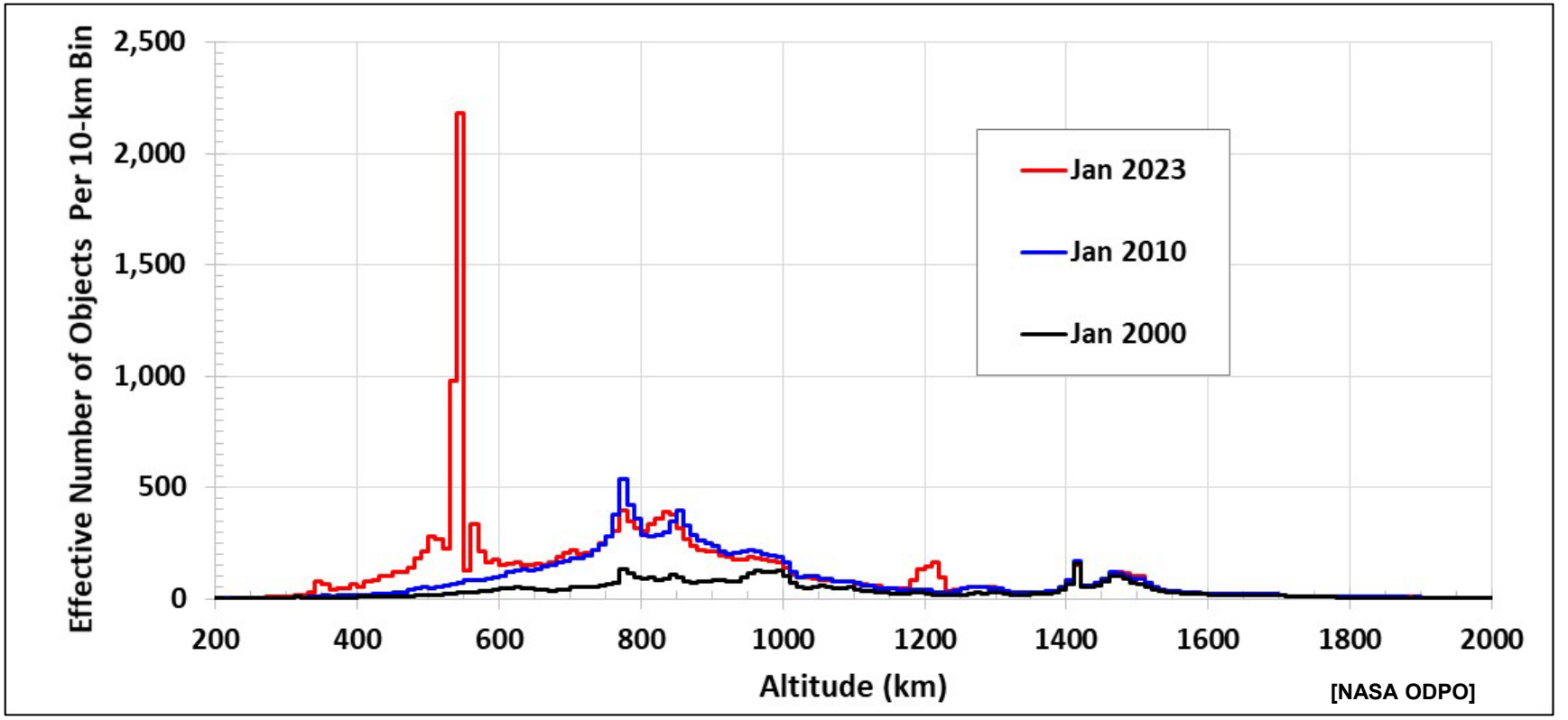
Distribution of the Cataloged Objects
– LEO to GEO

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



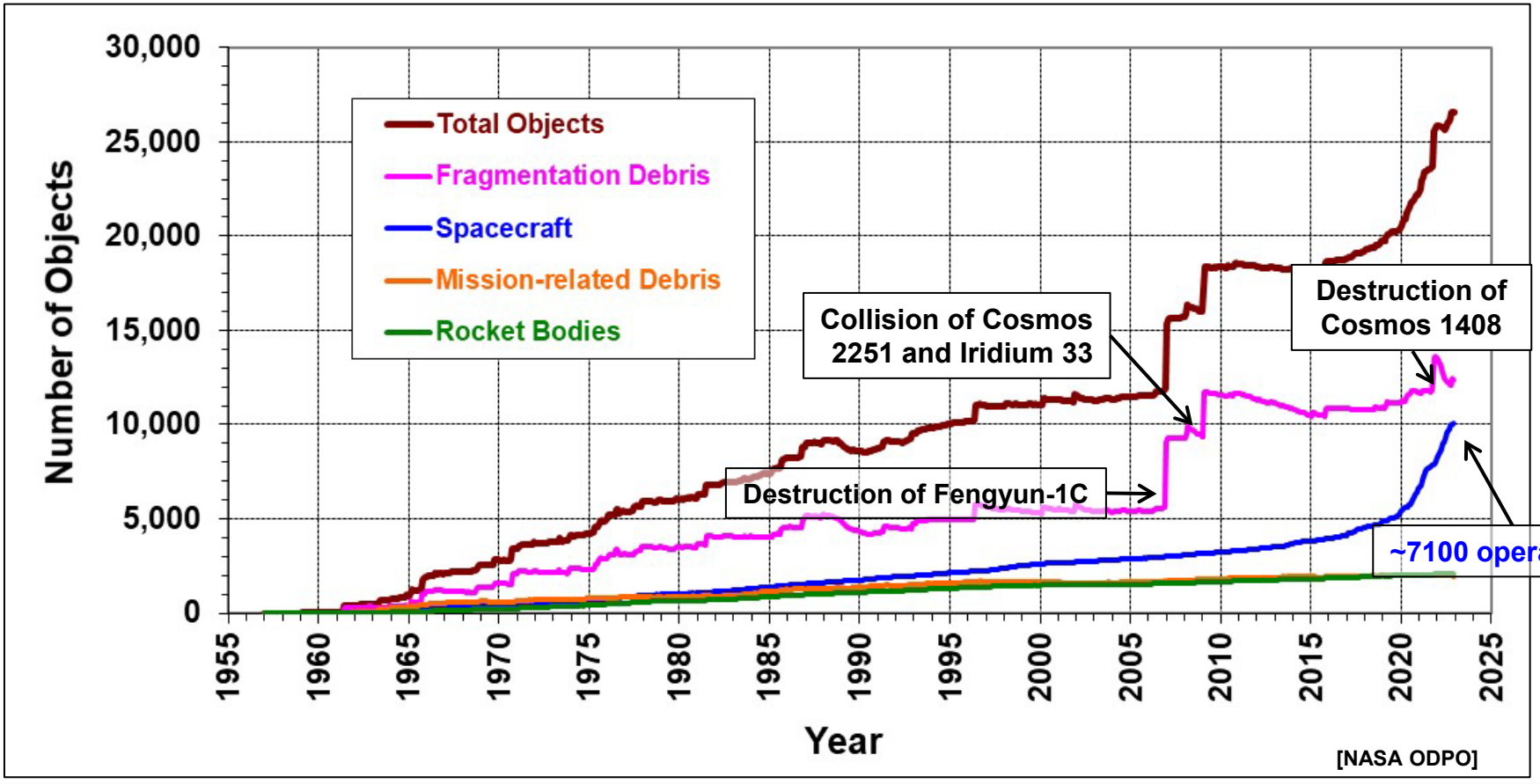
LEO Environment: 2000 to 2023

- **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



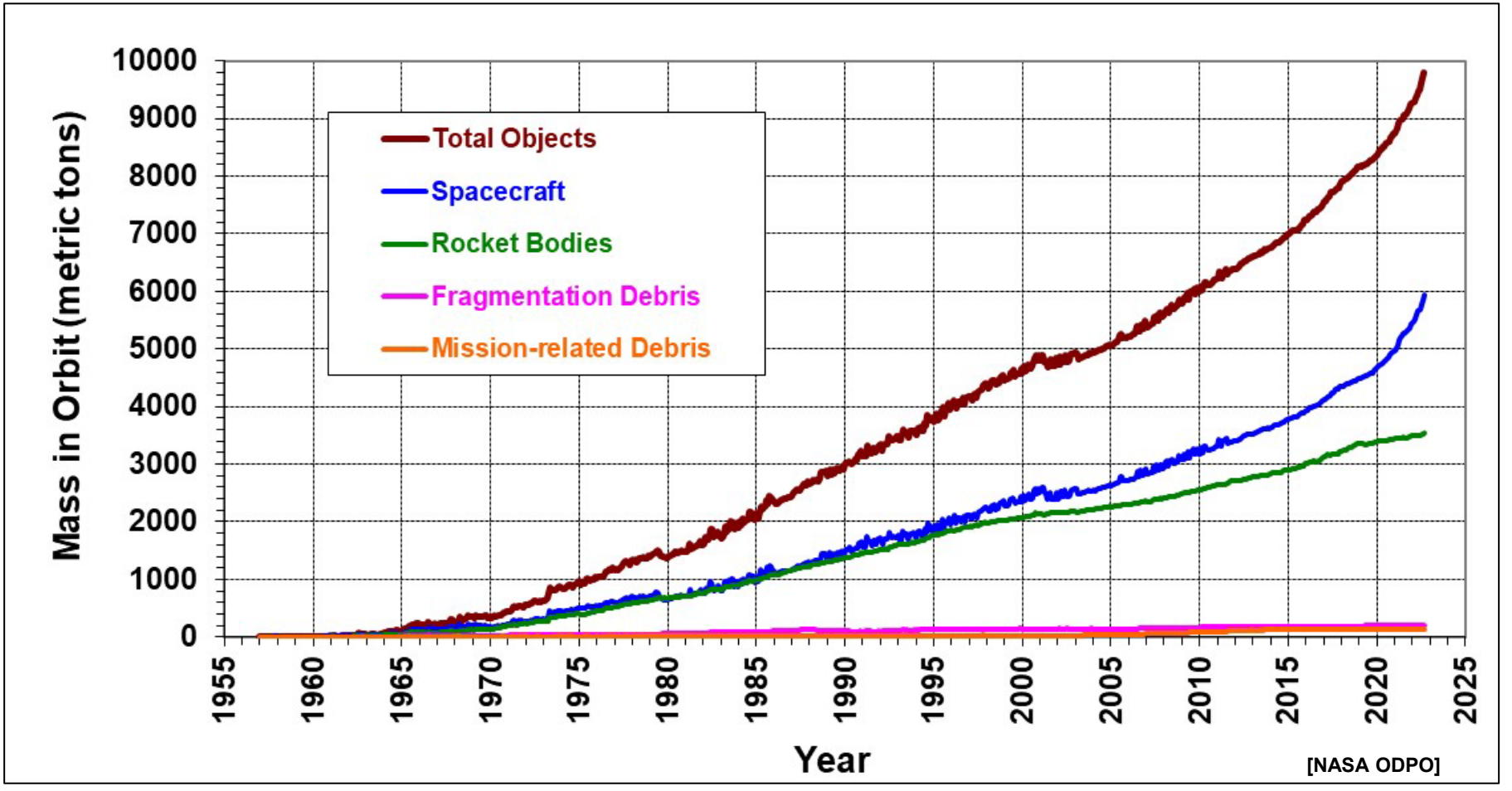
Growth of the Cataloged Populations

- **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	478
H-2A upper stage fairing cover	2012-025F	609	633	30

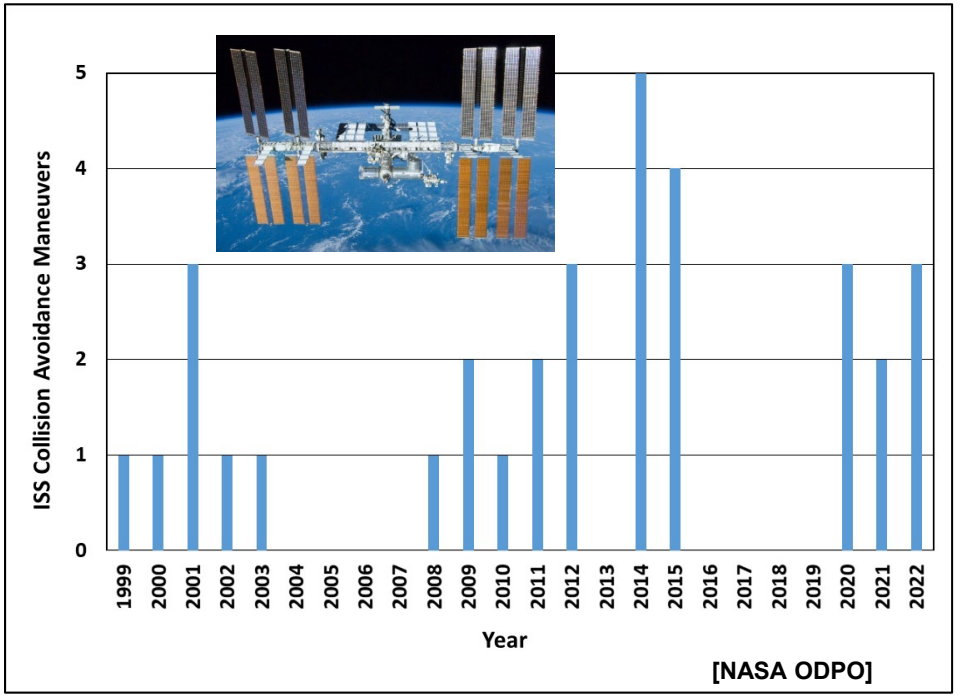
- **The breakup of the upper stage underlines the importance of minimizing the probability of accidental explosions via design improvements and/or end-of-mission passivation to limit the generation of new orbital debris**

Satellite Reentries in 2022

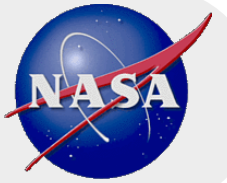
- **More than 2400 reentries of spacecraft, launch vehicle upper stages, and other cataloged debris were recorded by the U.S. Space Surveillance Network during 2022**
  - Spacecraft: 372 (including 107 SpaceX Starlinks)
  - Upper stages: 66
  - Other debris: 2005
- **The total mass of the 2022 reentries 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 to collect 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