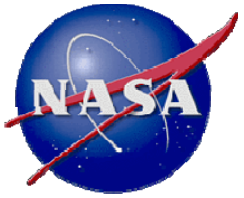
National Aeronautics and Space Administration




# Orbital Debris Challenges for Space Operations

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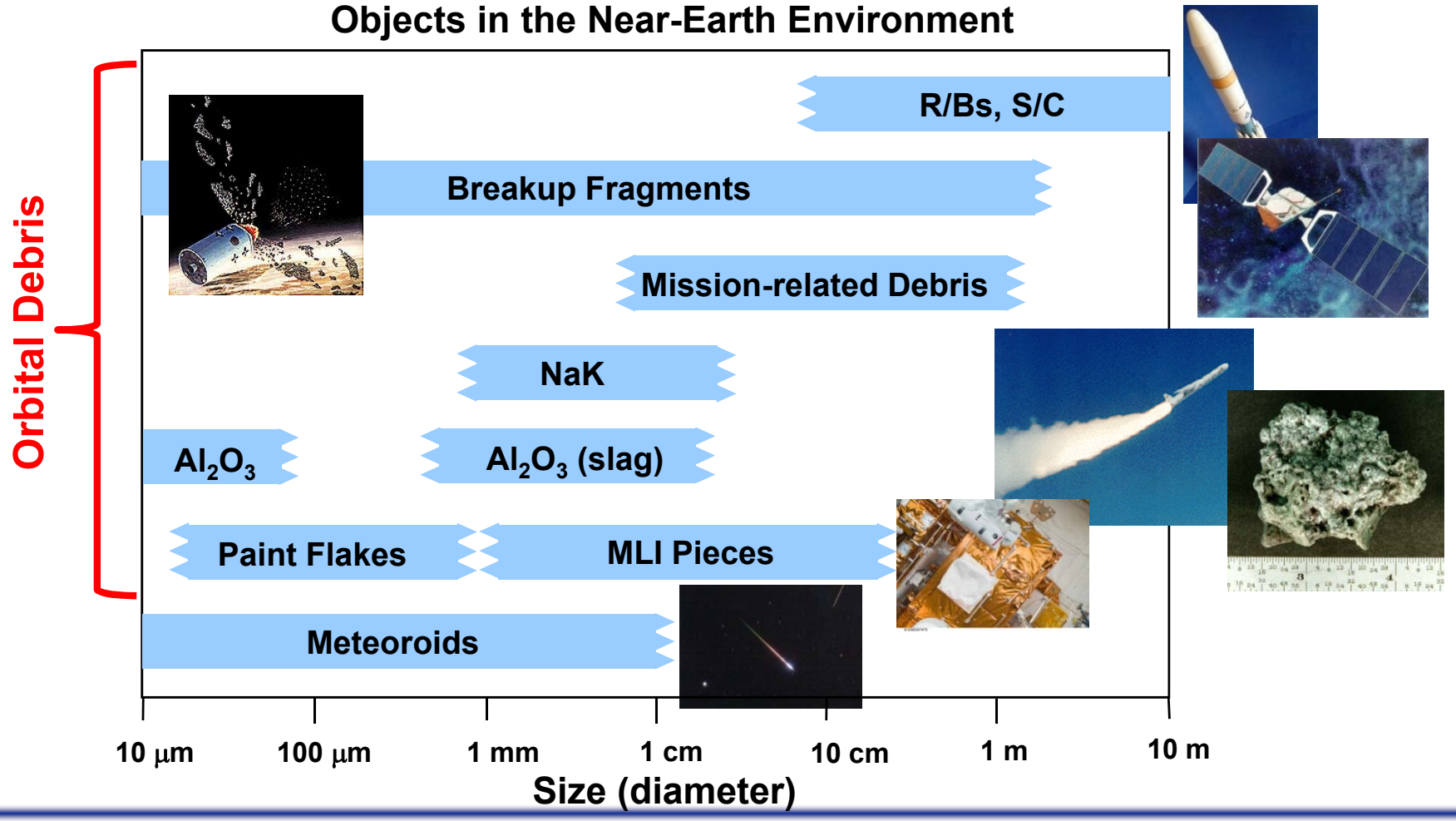
# Presentation Outline

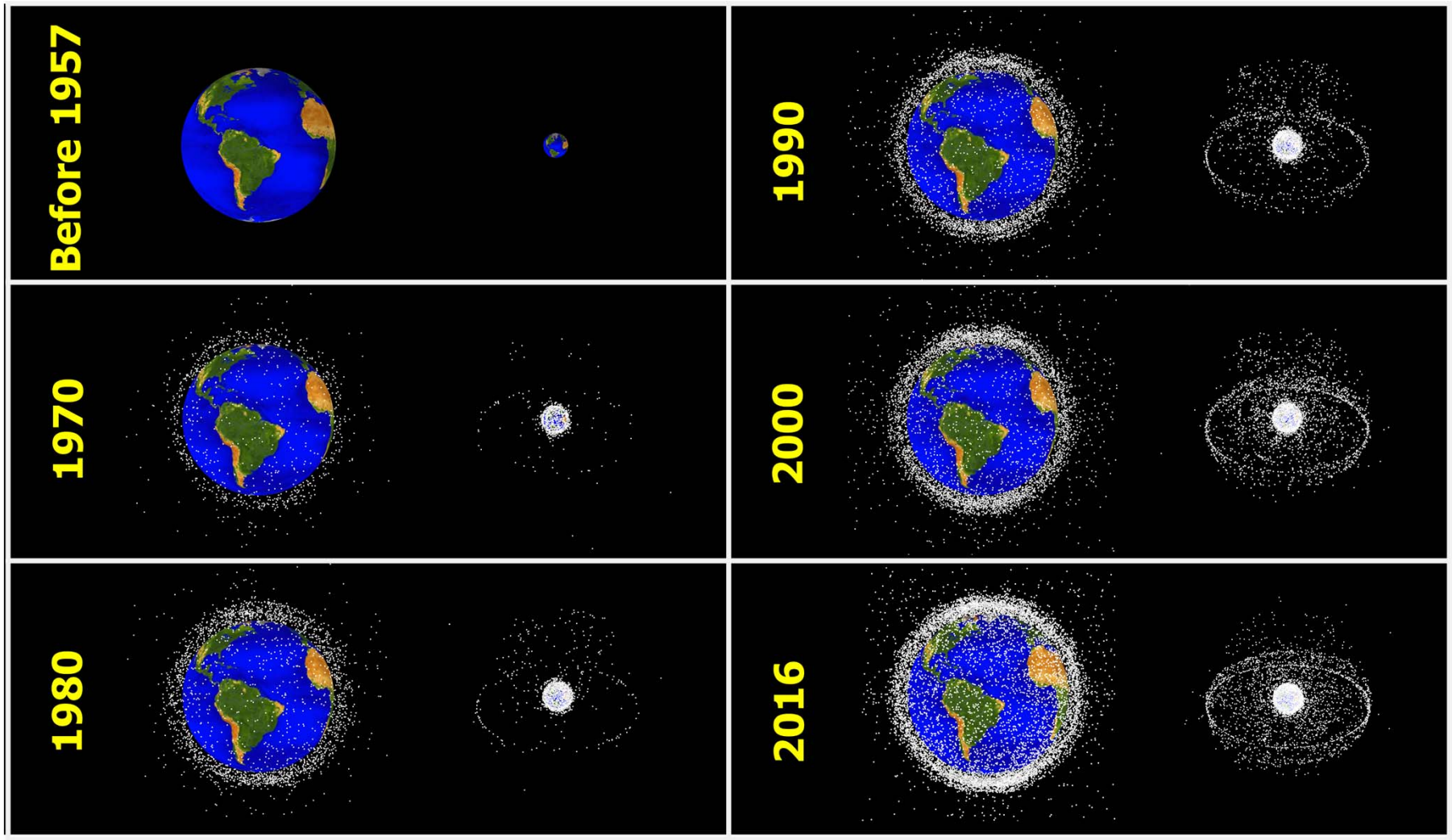
- **Historical and Current Orbital Debris Environment**
- **Danger of Orbital Debris**
- **Orbital Debris Mitigation Policy**

# What is Orbital Debris?

- **Orbital debris is any human-made object in orbit about the Earth that no longer serves any useful purpose**



# The Near-Earth Space Environment




- **Only objects in the U.S. satellite catalog (~10 cm and larger) are shown**
- **Sizes of the dots are not to scale**

# How Much Debris is Currently Up There?


**Softball size or larger (≥10 cm): ~23,000**
**(tracked by the U.S. Joint Space Operations Center, JSpOC)**

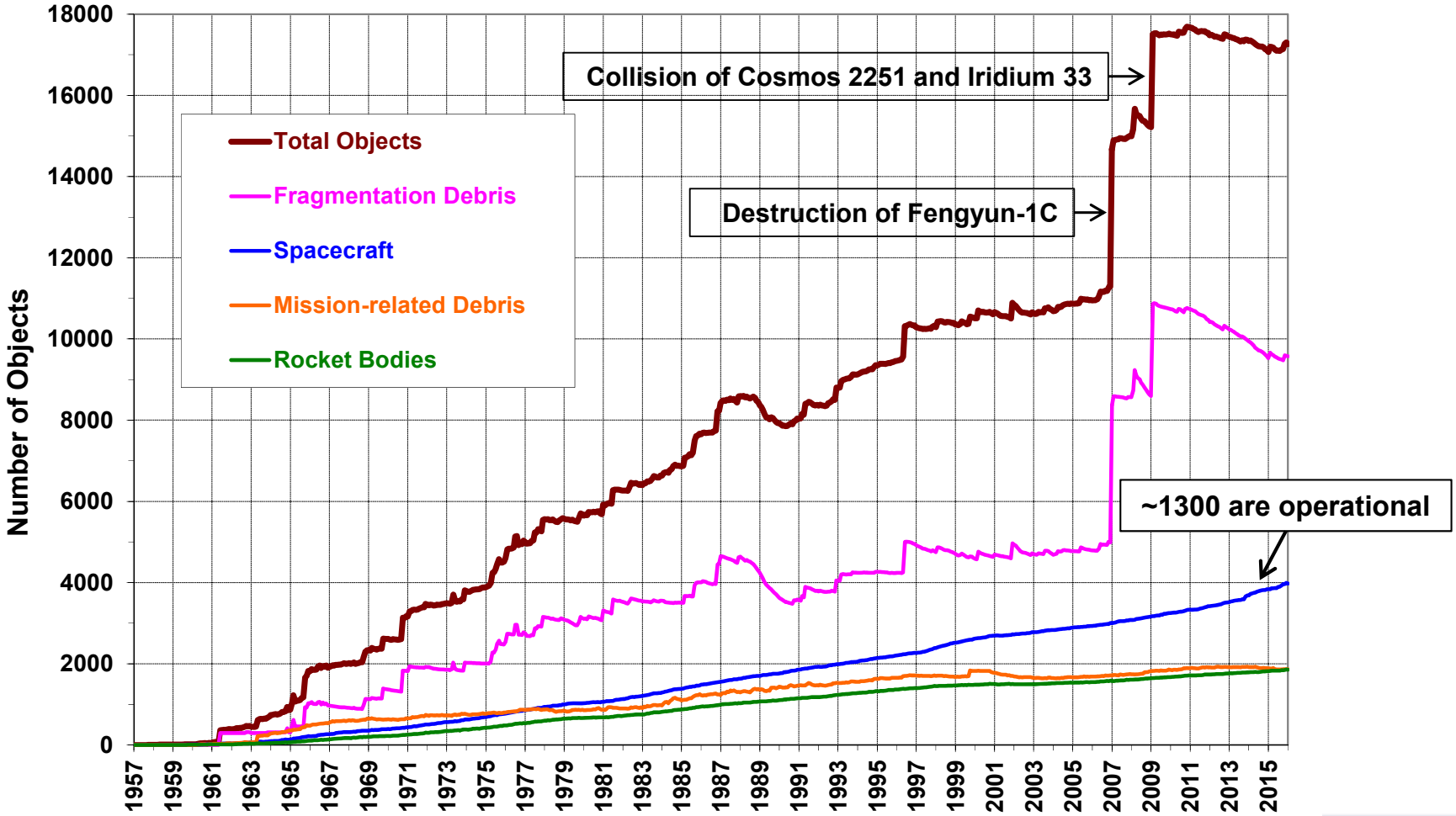
**Marble size or larger (≥1 cm): ~500,000**

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

- **Due to high impact speed in space (~10 km/sec in LEO), even sub-millimeter debris pose a realistic threat to human spaceflight and robotic missions**
  - **10 km/sec = 22,000 miles per hour (the speed of a bullet ~1,500 miles per hour)**
  - **5-mm aluminum sphere @ 7 km/sec could penetrate a 2.54-cm thick aluminum wall**
- **Total mass: >7000 tons LEO-to-GEO (~2700 tons in LEO)**

# Evolution of the Cataloged Population

- The U.S. Joint Space Operations Center (JSpOC) is tracking ~23,000 large objects and maintains most of their orbits in the U.S. Satellite Catalog
- JSpOC conducts conjunction assessments and provides warnings to all satellite owners/operators around the world



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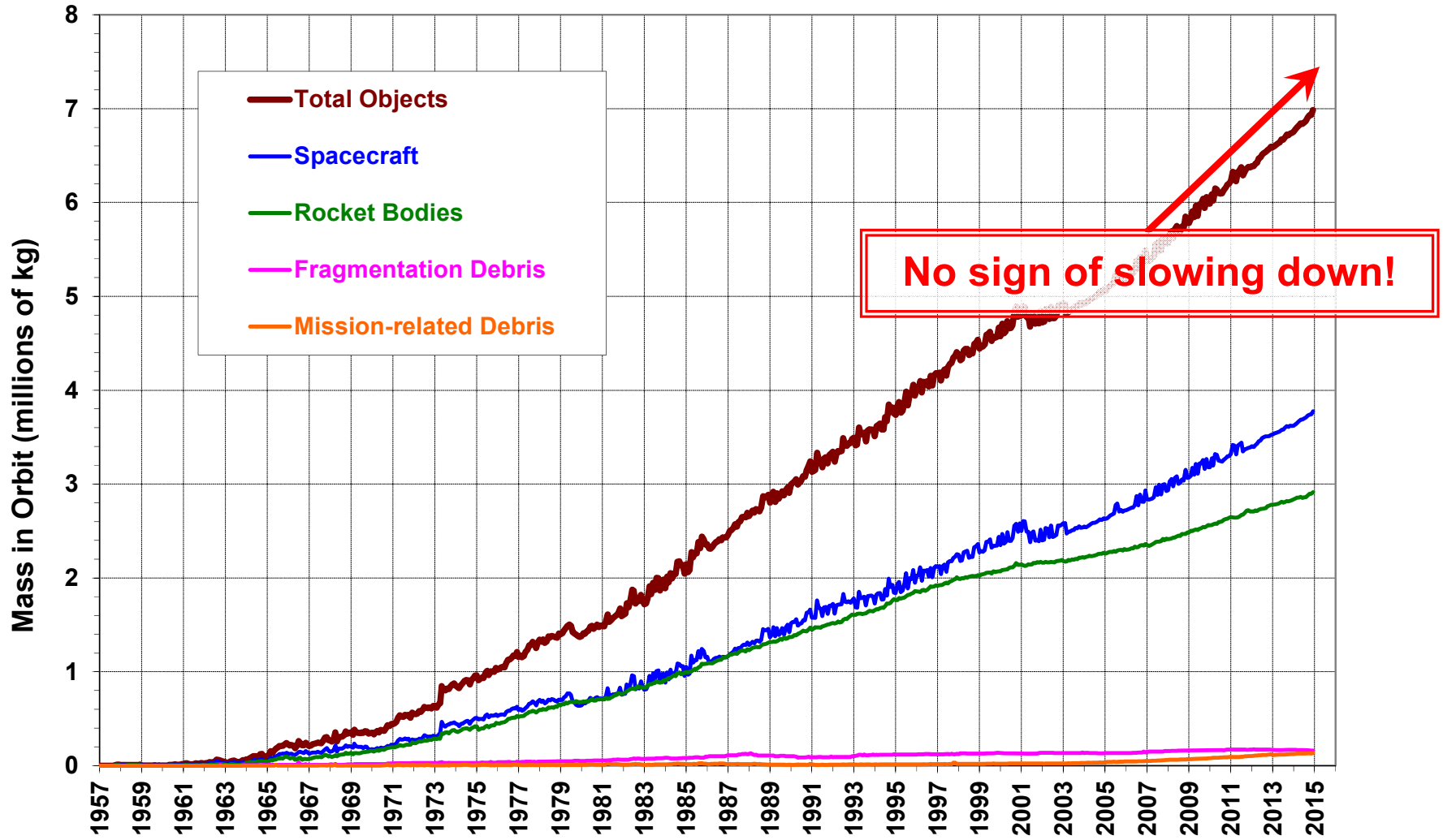
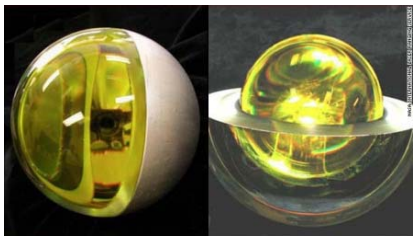
# Mass in Near-Earth Space Continues to Increase

- **The material mass in Earth orbit continues to increase and has exceeded 7000 metric tons**

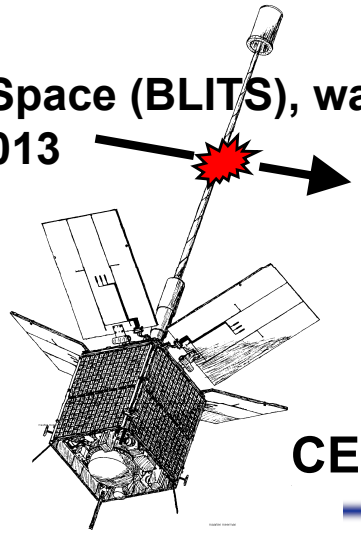


# Threat from Orbital Debris

- **The threat from orbital debris is real**
  - The gravity-gradient boom of an operational French satellite (CERISE) was cut in half by a tracked debris fragment in 1996
  - The fully operational Iridium 33 was destroyed by a retired Russian satellite (Cosmos 2251) in 2009
  - Near the end of the Space Shuttle Program, the Loss of Crew and Vehicle risks from MMOD impact damage were in the range of 1 in 250 to 1 in 300 per mission (OD to MM ~2:1 at ISS altitude)
  - Impacts by small, untracked debris could be responsible for many satellite anomalies
    - **A 17-cm Russian retro reflector, Ball Lens In The Space (BLITS), was damaged and shed a piece of trackable debris in January 2013**

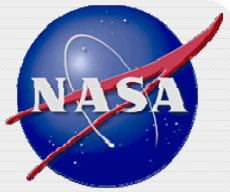


**BLITS**



**CERISE**

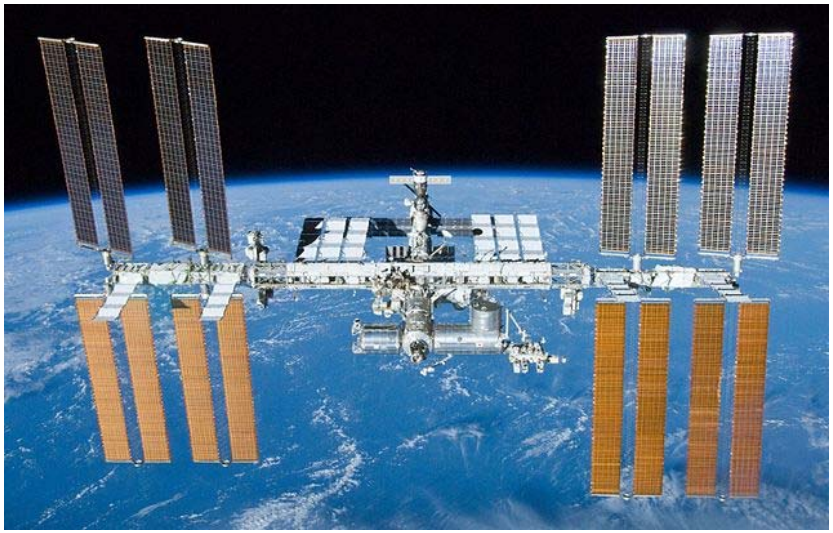
# Robotic Spacecraft Collision Avoidance Maneuvers

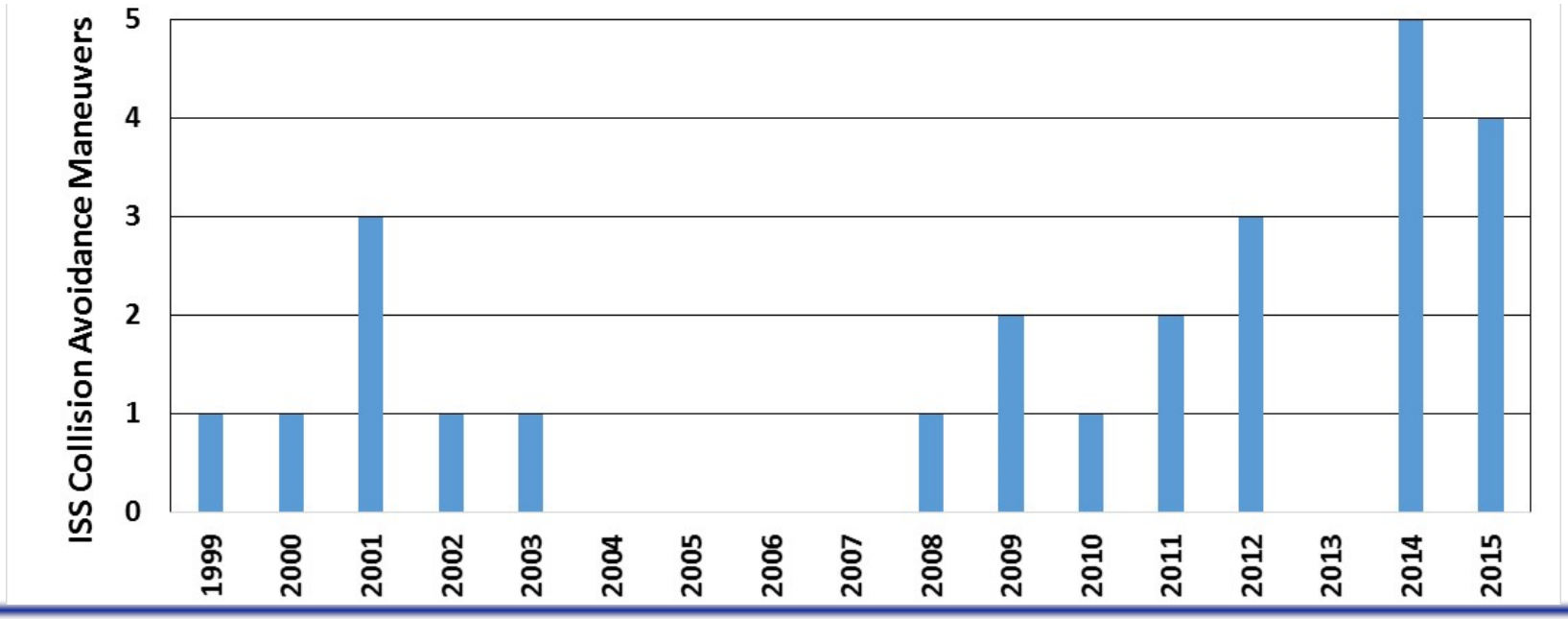



- **Since 2007 NASA has required frequent satellite conjunction assessments for all of its maneuverable spacecraft in LEO and GEO to avoid accidental collisions with objects tracked by JSpOC**
- **NASA also assists other U.S. government and foreign spacecraft owners with conjunction assessments and subsequent maneuvers**
- **During 2015 NASA executed or assisted in the execution of 26 collision avoidance maneuvers by robotic spacecraft**

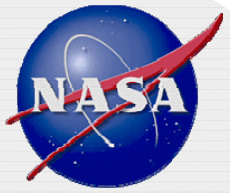
# ISS Collision Avoidance Maneuvers

- **The International Space Station (ISS) conducted 4 debris collision avoidance maneuvers in 2015**
- **In addition, due to a late notification of a high probability conjunction, the crew was directed to "shelter-in-Soyuz" on July 16th**
  - Fortunately the conjunction did not lead to a collision



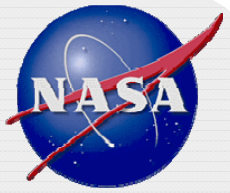


# U.S. Government Orbital Debris Mitigation Policy and Standard Practices




- **NASA was the first organization to develop orbital debris mitigation policy and guidelines in the 1990s**
- **NASA and the Department of Defense (DOD) led the effort to establish the U.S. Government Orbital Debris Mitigation Standard Practices (approved in 2001)**
- **The U.S. National Space Policy of 2006 and 2010 directs agencies and departments to implement the U.S. Government Orbital Debris Mitigation Standard Practices**
  - Control of debris released during normal operations
  - Minimizing debris generated by accidental explosions
  - Selection of safe flight profile and operational configuration
  - Postmission disposal of space structures

# International Orbital Debris Mitigation




- **Many major spacefaring nations have established orbital debris mitigation policies similar to the U.S. Government Orbital Debris Mitigation Standard Practices**
- **The Inter-Agency Space Debris Coordination Committee (IADC) established the first consensus on international orbital debris mitigation guidelines in 2002**
  - IADC members: ASI, CNES, CNSA, CSA, DLR, ESA, ISRO, JAXA, KARI, NASA, ROSCOSMOS, SSAU, and UKSA
- **The United Nations adopted a similar set of space debris mitigation guidelines in 2007**
- **The international space community needs to follow the existing mitigation guidelines to better preserve the near-Earth space environment for future space operations**