

The Orbital Debris Problem and the Challenges for Environment Remediation

J.-C. Liou, PhD

**NASA Orbital Debris Program Office
Johnson Space Center, Houston, Texas
jer-chyi.liou-1@nasa.gov**

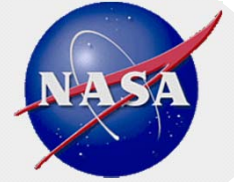
**Space Debris Symposium
Fukuoka, Japan, 25 January 2013**



Outline

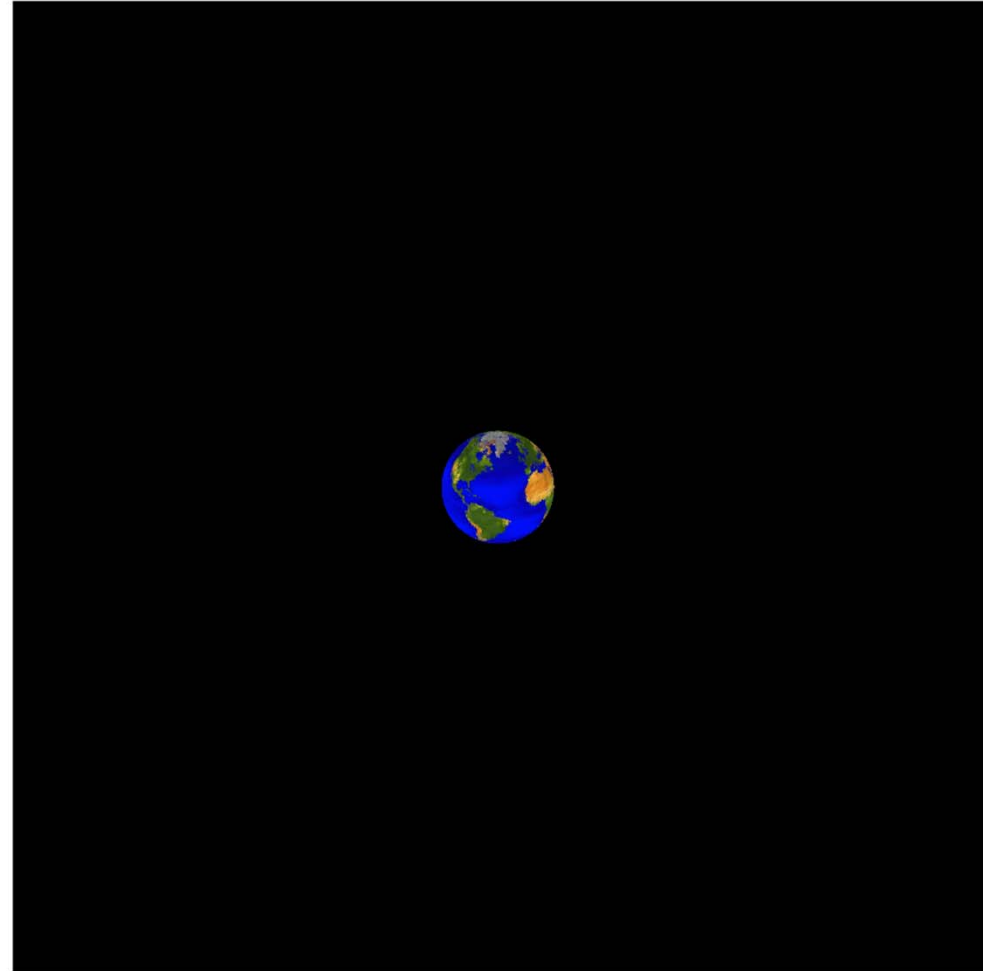
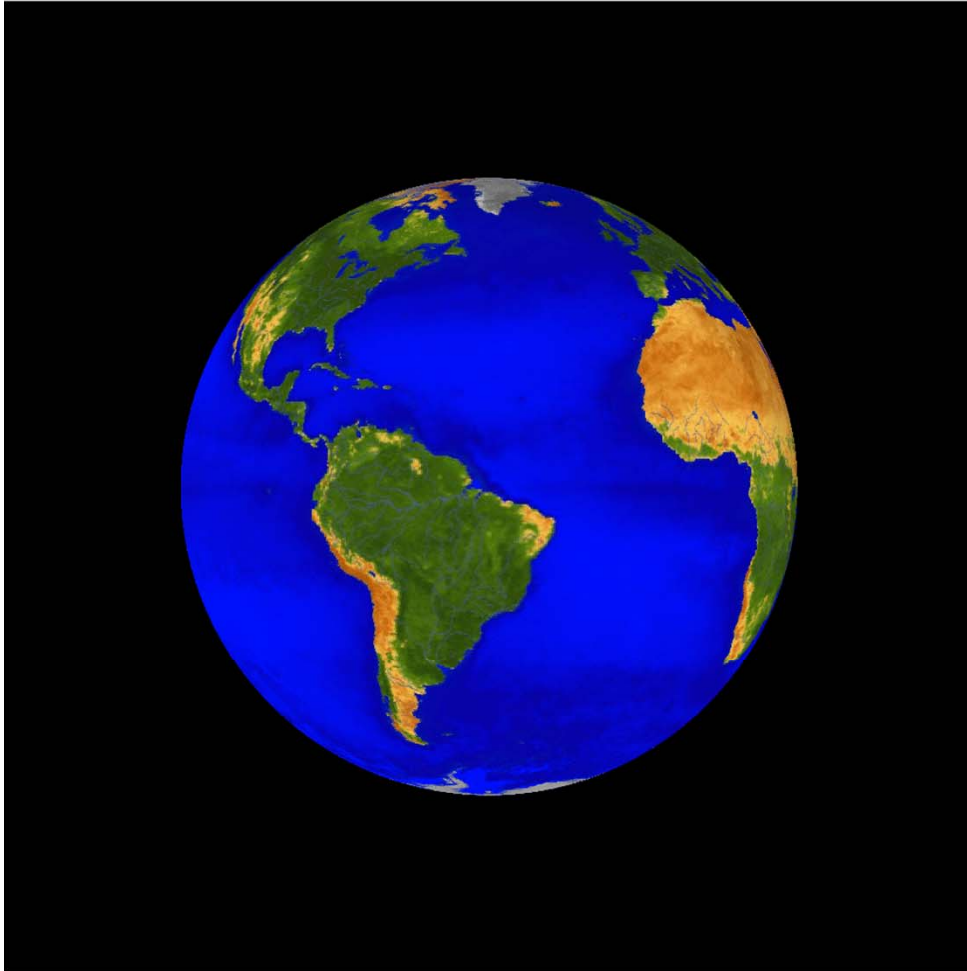
- **Buildup of the Orbital Debris Population**
- **What Are Orbital Debris?**
- **Sources of Orbital Debris**
- **Challenges to Preserve the Space Environment**





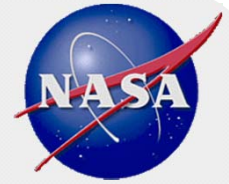
The Historical Orbital Debris Environment

1955



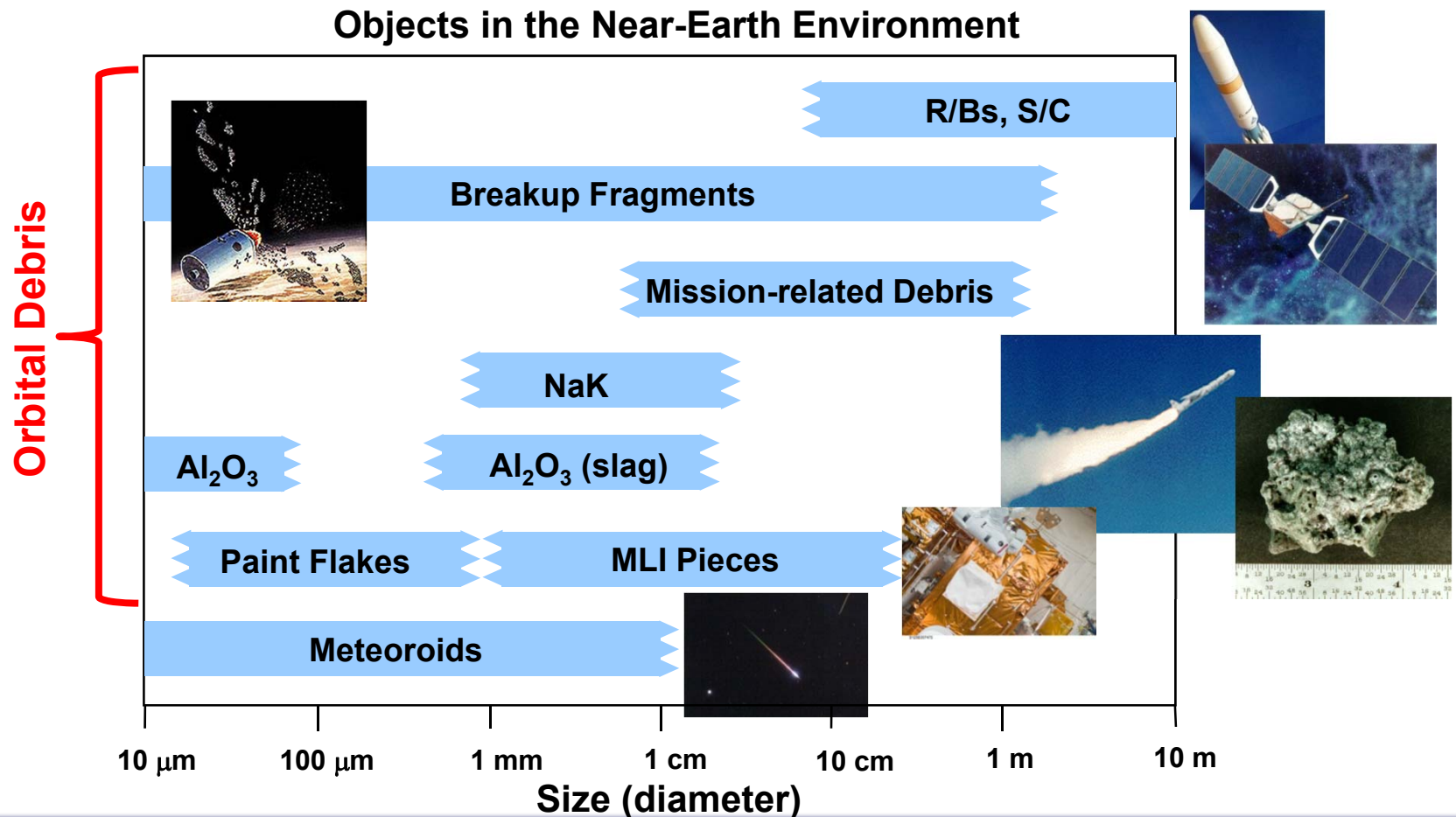
Cataloged objects >10 cm diameter

(Only objects in the US Space Surveillance Network, SSN, are shown. Sizes of the dots are not to scale.)

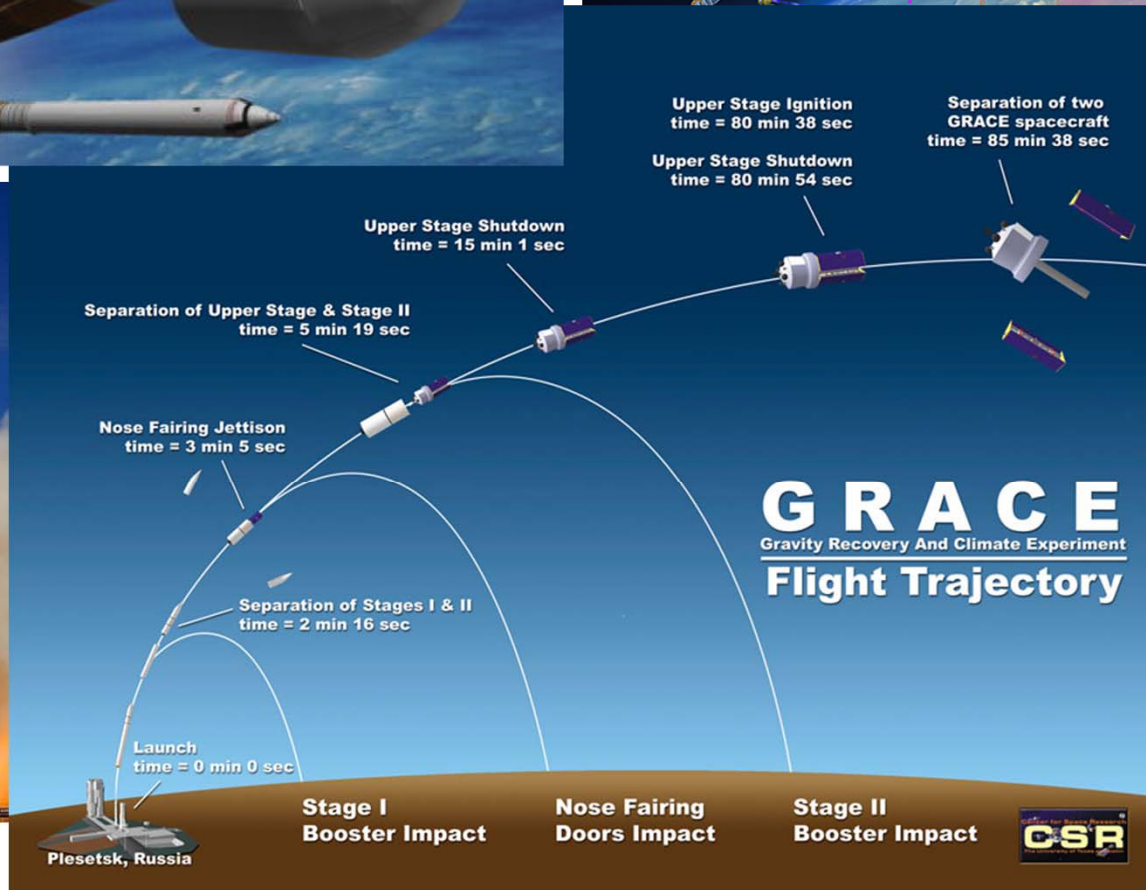
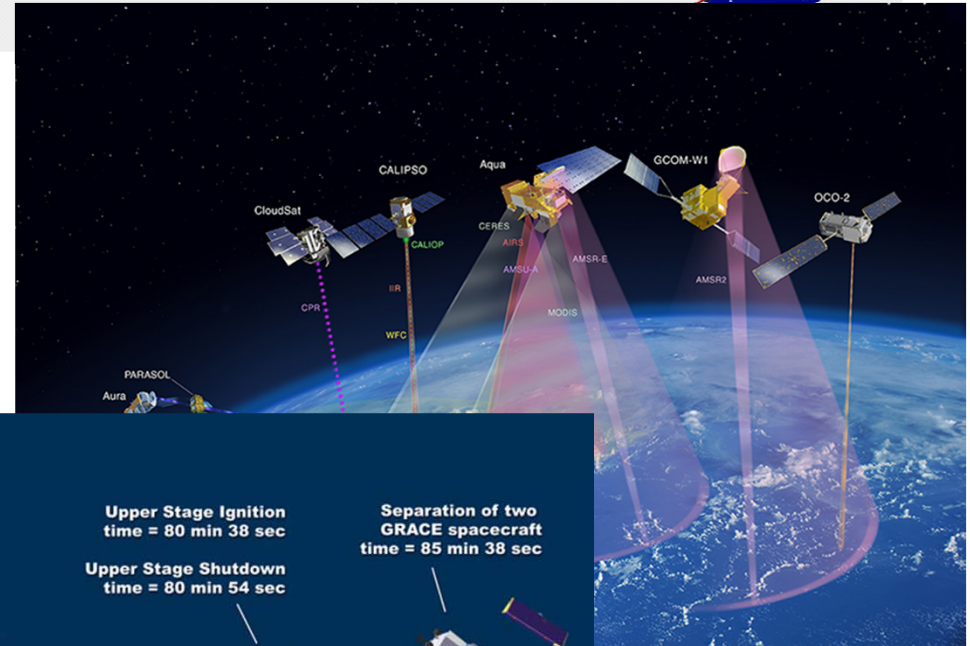


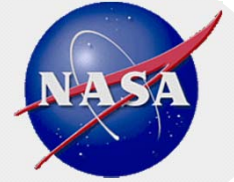
What Are Orbital Debris?

- Orbital debris are all human-made objects in orbit about the Earth which no longer serve any useful purpose



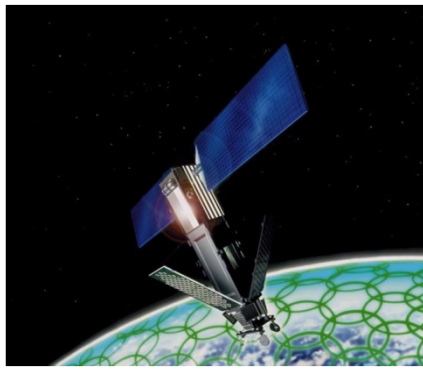
Rocket Bodies (R/Bs) and Spacecraft (S/C)



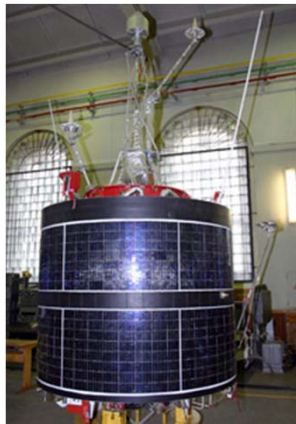


Satellite Breakups

- **More than 210 explosions have been documented since 1957**
- **Four accidental collisions among the cataloged objects have occurred so far**
 - 1991: Russian Sat (launched in 1988) ↔ Russian fragment
 - 1996: French Sat (launched in 1995) ↔ French fragment
 - 2005: US R/B (launched in 1974) ↔ PRC fragment
 - 2009: Iridium 33 (launched in 1997) ↔ Cosmos 2251 (launched in 1993)



Iridium33
(560 kg)



Cosmos 2251
(900 kg)



Laboratory-Based Satellite Collision Experiments



- **The NASA Orbital Debris Program Office has collaborated with Professor Toshiya Hanada (Kyushu University) on seven laboratory-based satellite impact experiments**

(Target: fully-equipped 20-cm cube-sat, 3-cm Al projectile @ 1.8 km/sec)





How Much Junk Is Currently Up There?

Softball size or larger (≥ 10 cm): ~22,000
(most of them are tracked by the US Space Surveillance Network)

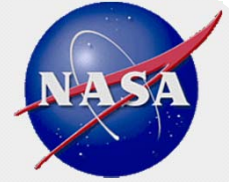


Marble size or larger (≥ 1 cm): ~500,000



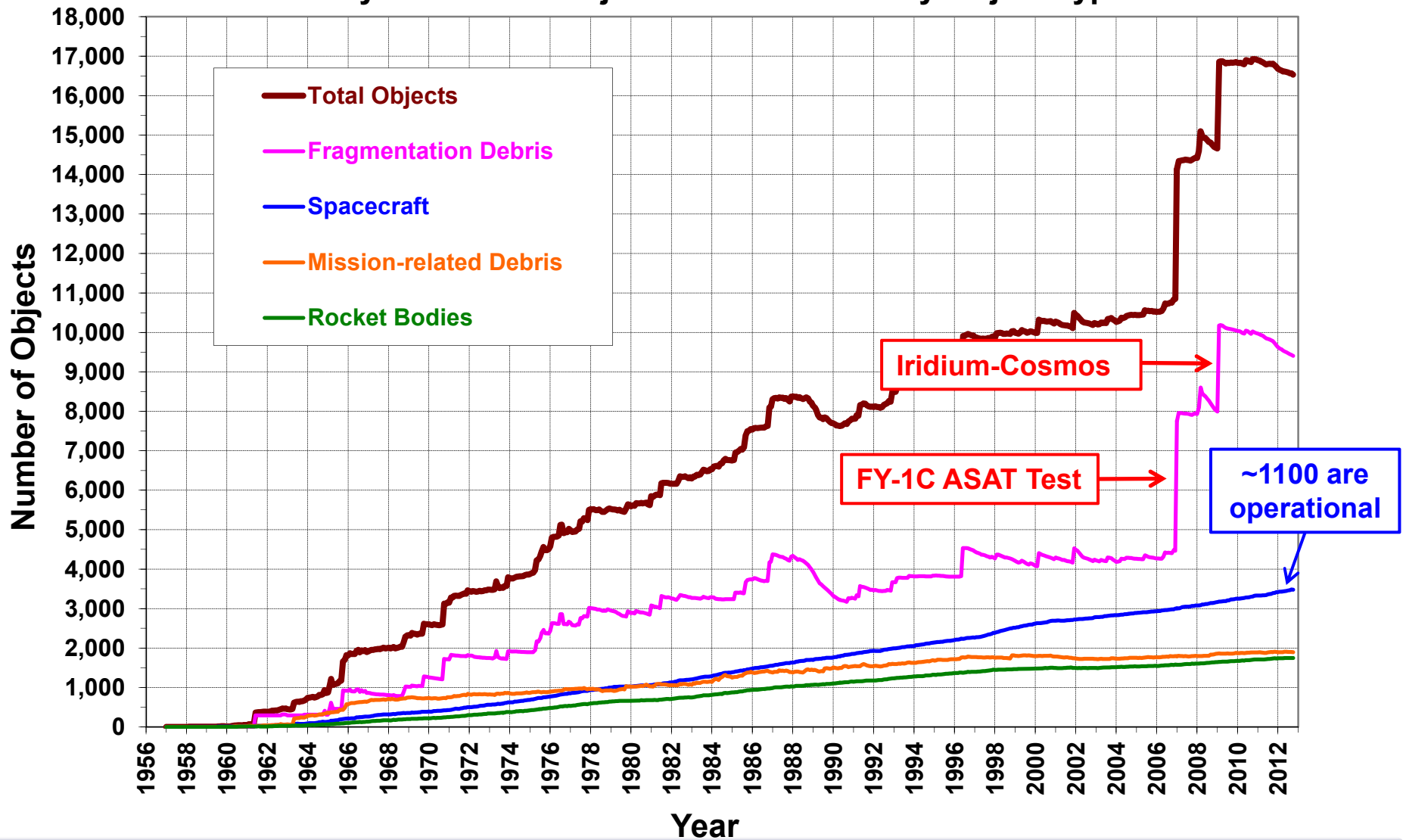
Dot or larger (≥ 1 mm): >100,000,000
(a grain of salt)

- **Total mass: ~6300 tons LEO-to-GEO (~2700 tons in LEO)**
- **Due to high impact speed in space (~10 km/s in LEO), even sub-mm debris pose a realistic threat to human spaceflight and robotic missions**



Growth of the Cataloged Populations

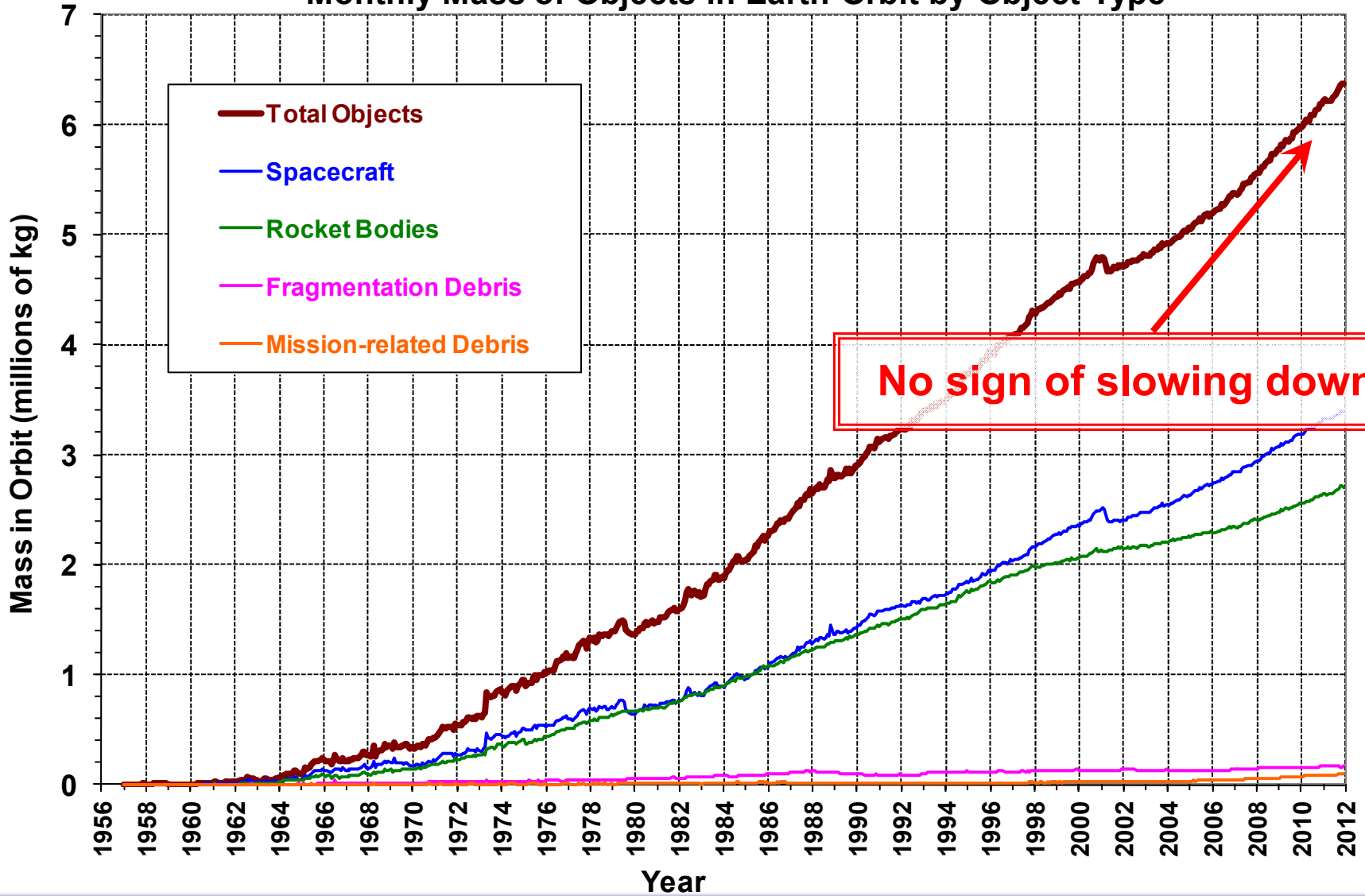
Monthly Number of Objects in Earth Orbit by Object Type

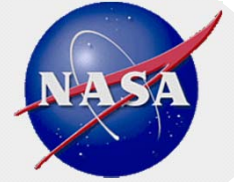




Mass in Orbit

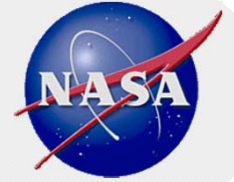
Monthly Mass of Objects in Earth Orbit by Object Type





The Big Sky Is Getting Crowded

- **Four accidental collisions between cataloged objects have been identified**
 - The collision between Cosmos 2251 and the operational Iridium 33 in 2009 underlined the potential of the Kessler Syndrome
- **The US Joint Space Operations Center (JSpOC) is currently providing conjunction assessments for all operational S/C**
 - JSpOC issues ~10 to 30 conjunction warnings on a daily basis, and more than 100 collision avoidance maneuvers were carried out by satellite operators in 2010
- **The International Space Station (ISS) has conducted 16 debris avoidance maneuvers (DAMs) since 1999**
 - 3 DAMs and 1 shelter-in-Soyuz in 2012



Preserving the Environment for Future Generations

- **The international space community should work together to (1) limit the generation of new debris and (2) consider the option to remove existing objects**
- **Scientists and engineers need to come up with innovative concepts and technologies to address the orbital debris challenges**

