Growth of Orbital Debris

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Presentation Outline

• Historical and Current Orbital Debris Environment
• Danger of Orbital Debris
• Orbital Debris Mitigation Policy
The Space Age

• The first human-made satellite, Sputnik, was launched to study the atmosphere by the Soviet Union on October 4th, 1957

• Since then, more than 4700 launches have been conducted worldwide

• Benefits of space activities
  – Communications
  – Environment and weather monitoring
  – Explorations
  – Technology advancements
  – Many others

• But…
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)
• The JSpOC is currently tracking ~23,000 large objects and maintains most of their orbits in the U.S. Satellite Catalog.
Mass in Near-Earth Space Continues to Increase

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

No sign of slowing down!
Threat from Orbital Debris - Examples

- 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 the retired Russian 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, BLITS, was damaged and shed a piece of trackable debris in January 2013
  - The European Space Agency’s Sentinel-1 was hit by a small debris, leading to some power loss and 6 trackable debris in August 2016

Image Credit: ESA
Robotic Spacecraft Collision Avoidance Maneuvers

• The U.S. JSpOC conducts conjunction assessments and provides warnings to all satellite owners/operators around the world

• 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 avoidance maneuvers
• The International Space Station (ISS) has conducted 25 debris collision avoidance maneuvers since 1999
  – Including 4 debris collision avoidance maneuvers and 1 shelter-in-Soyuz in 2015
• 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
• 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 (UN) adopted a similar set of space debris mitigation guidelines in 2007

• The International Organization for Standardization (ISO) developed its space debris mitigation requirements in 2010
Forward Challenges

• The international space community needs to follow the existing orbital debris mitigation guidelines to limit the generation of new and long-lived debris

• Proliferation of small satellites, including CubeSats and the proposed mega-constellations, presents new challenges to preserve the environment while continuing to use near-Earth space to benefits the global community