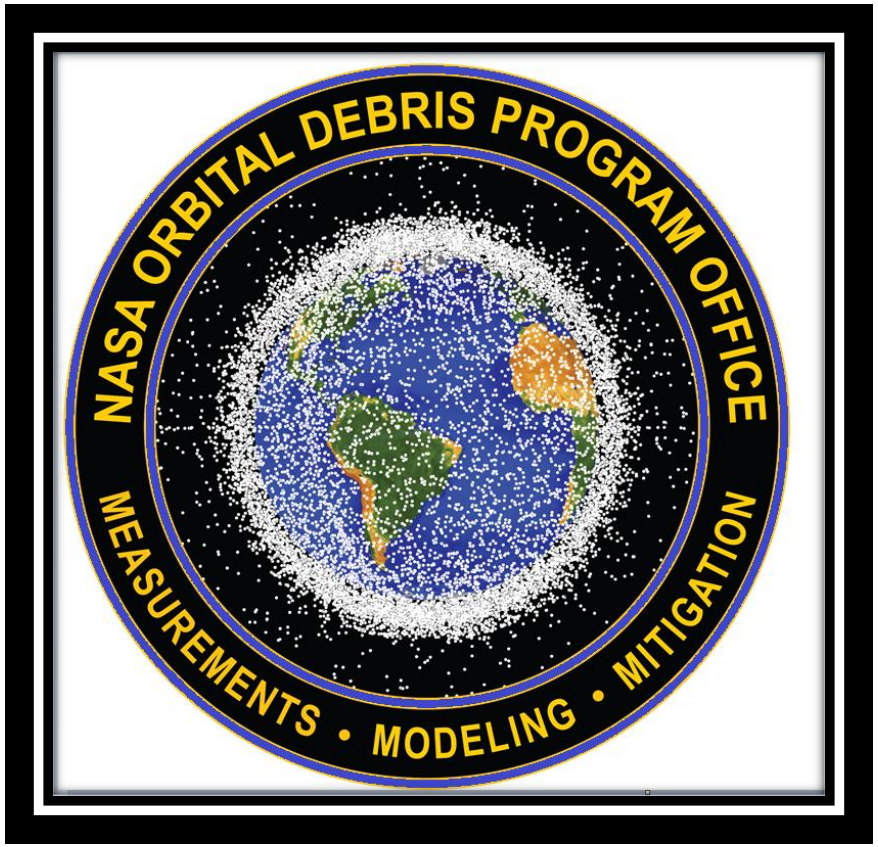
Space Debris and ISS

Nate Estell
Pointing Flight Controller
Flight Operations Directorate, Johnson Space Center

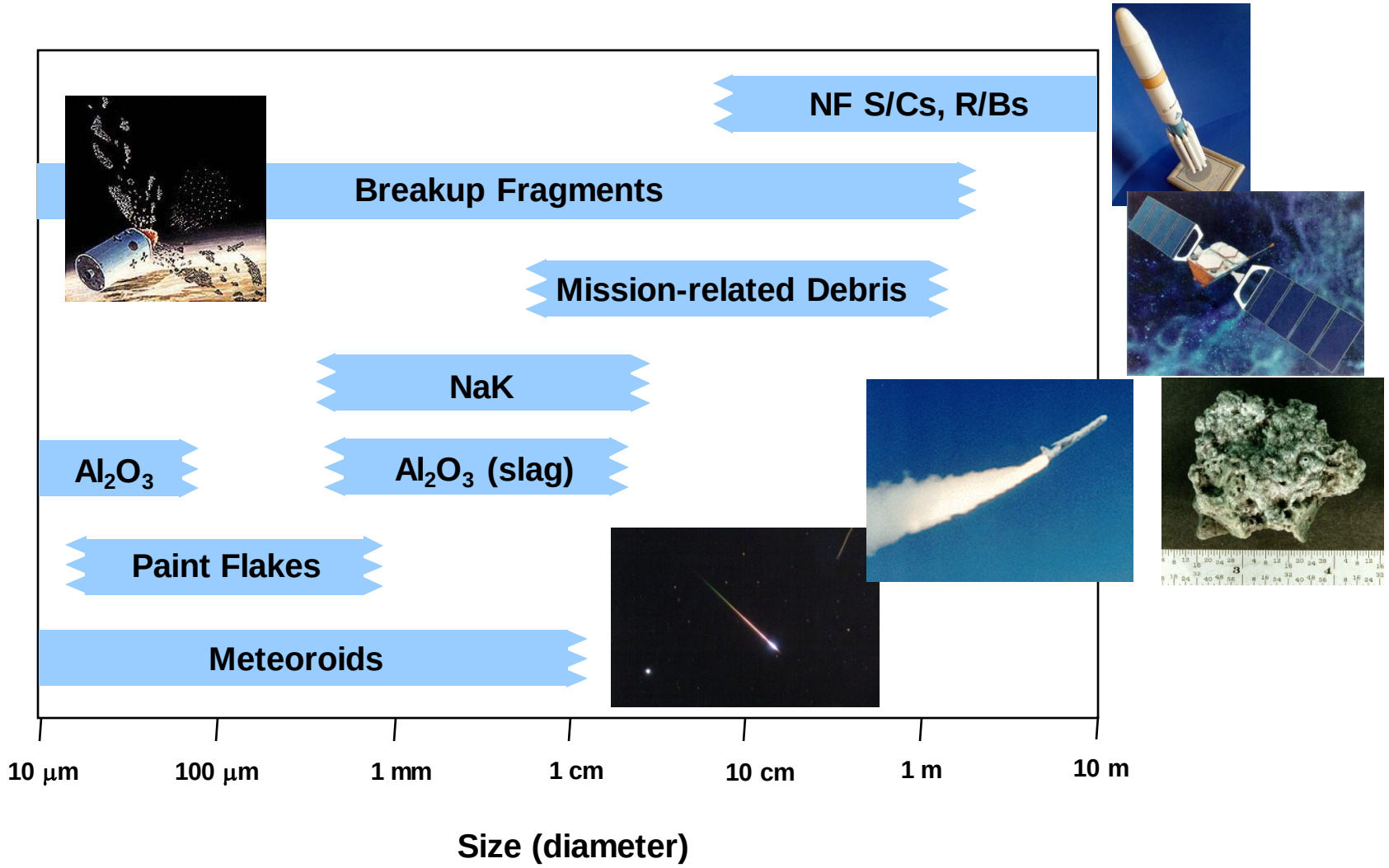
Dr. Heather Cowardin

Orbital Debris Program Office

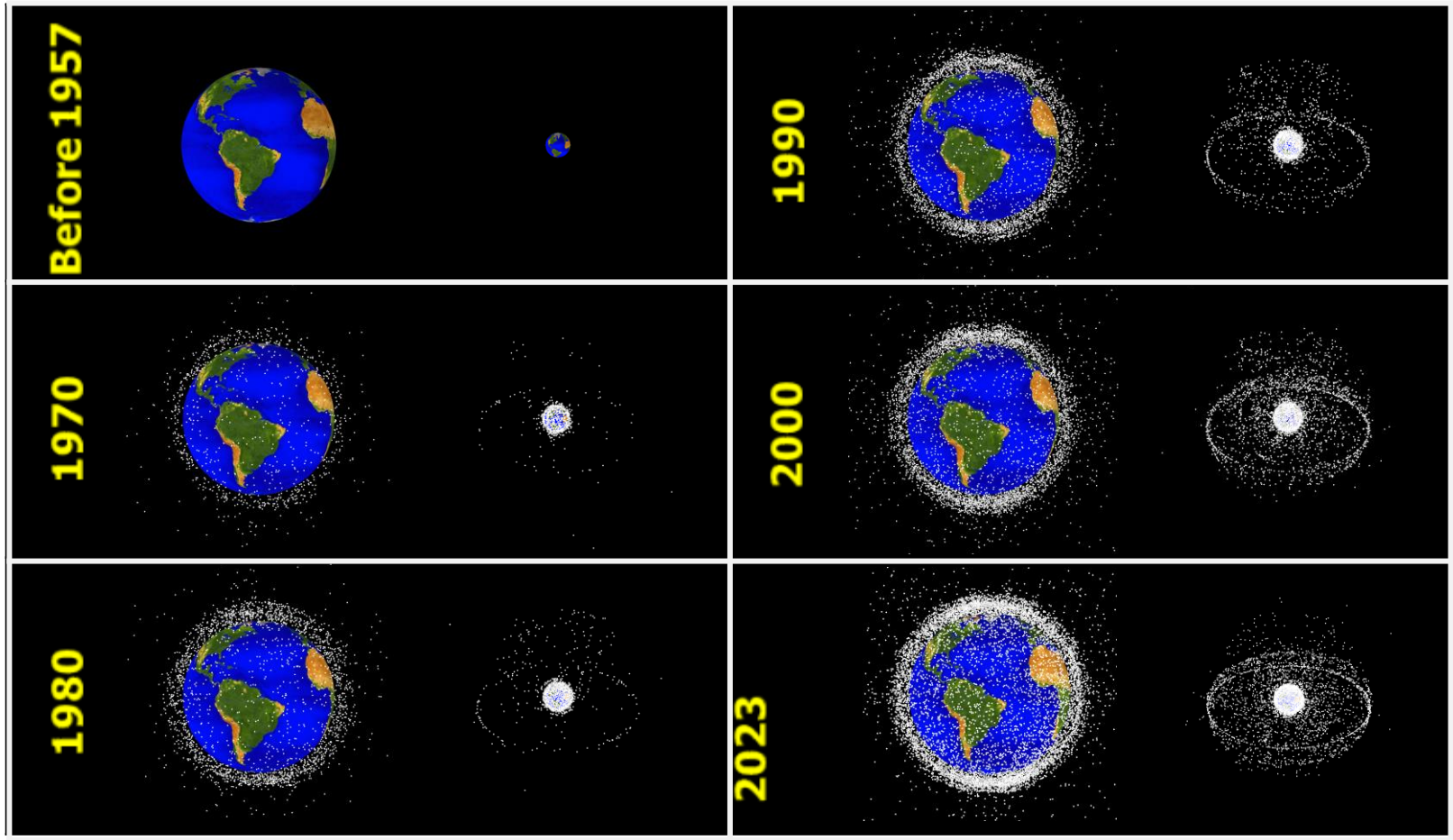


Orbital Debris and Hypervelocity Integration Portfolio Scientist
In Situ & Laboratory Lead; Business Unit Manager; ODQN Technical Editor

Orbital Debris Population Breakdown



Growth of the Orbital Debris Populations



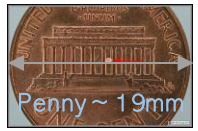
- **Only objects in the US satellite catalog (~10 cm and larger) are shown**
- **Sizes of the dots are not to scale**

How Much Junk Is Currently Up There?

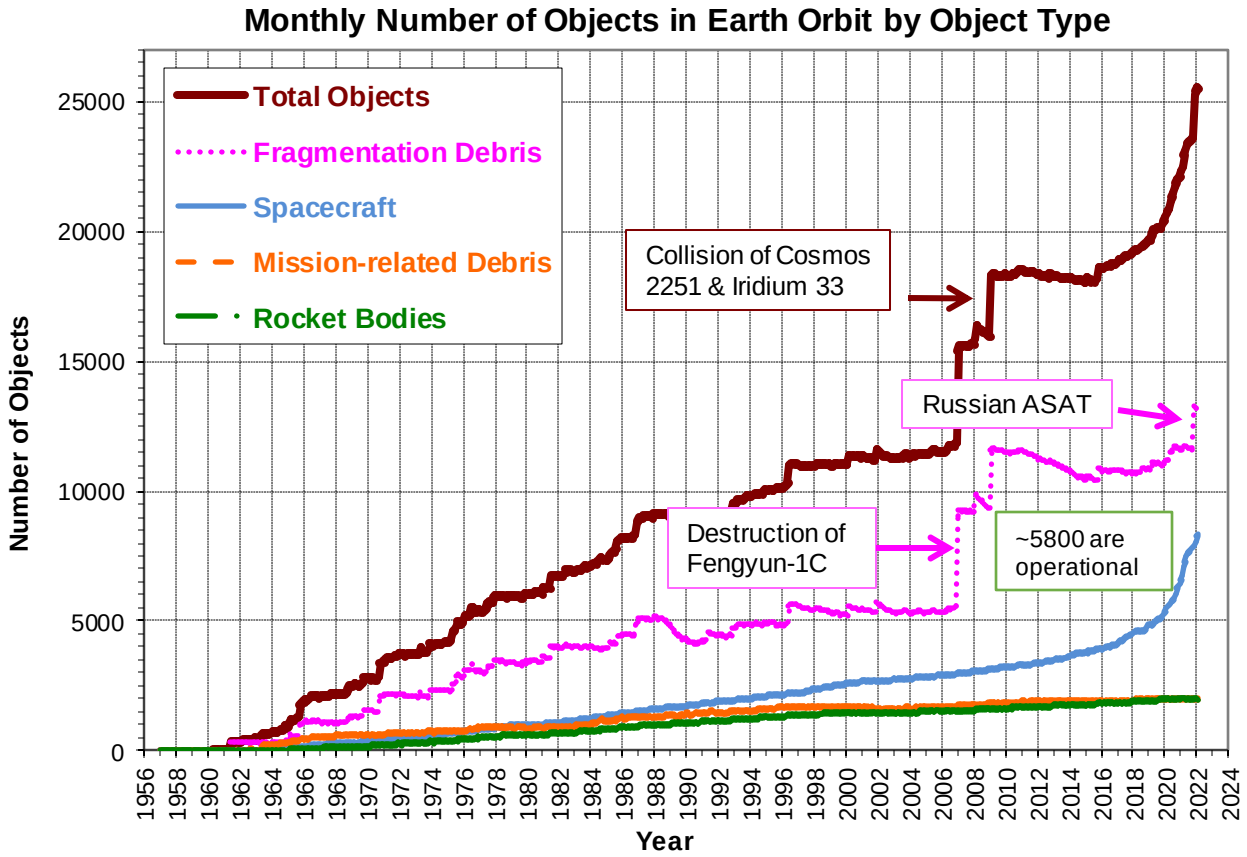
18th Space Defense Squadron (18 SDS) tracking total of ~46,000 objects
-Baseball size or larger (≥10 cm): ~26,000

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

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

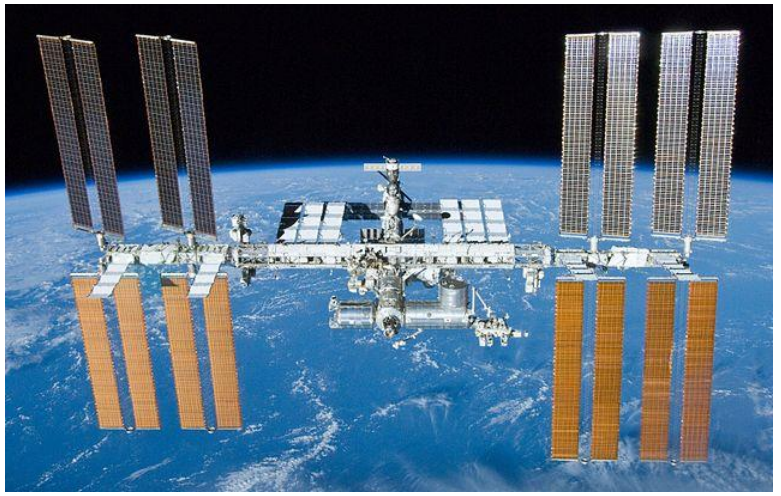


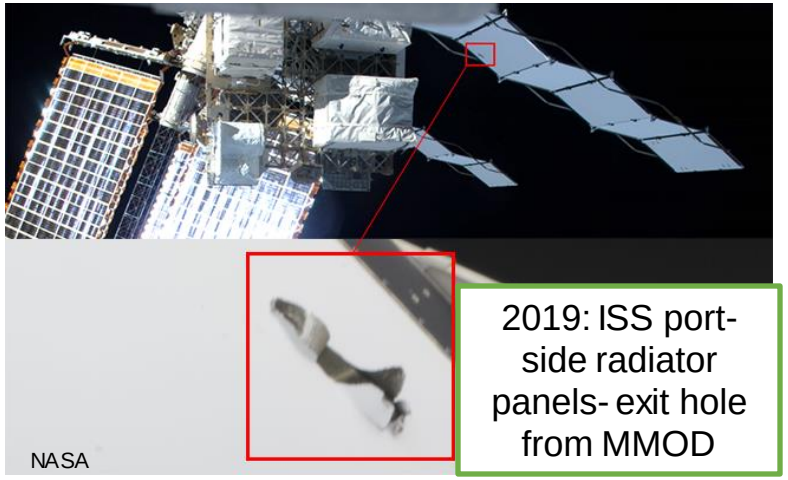
- **Due to high impact speed in space (~10 km/sec in LEO), debris as small as grain of salt could end a mission!**
  - 10 km/sec = 22,000 MPH
  - speed of a bullet ~1,500 MPH
- **Total mass: >9300 tons LEO-to-GEO (~4000 tons in LEO)**



Threat from Orbital Debris - Examples

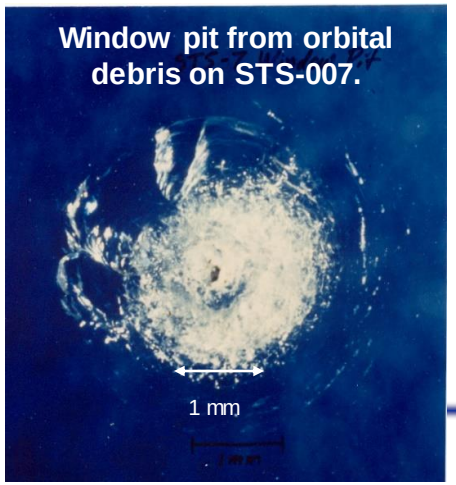
- **Satellite operators, including the International Space Station (ISS) Program, conduct collision avoidance maneuvers against the tracked objects on a regular basis**
  - ISS has conducted 35 collision avoidance maneuvers and 5 "shelter-in-Soyuz" since 1999
  - During shuttle operations, on average, two shuttle windows were replaced per mission
- **Impacts by small, untracked debris could be responsible for many satellite anomalies**
  - Collisions with large trackable objects account for less than 1% mission ending risk; risk comes from small mm size debris
  - Lack of measurement data on mm-sized debris above 600 km altitude

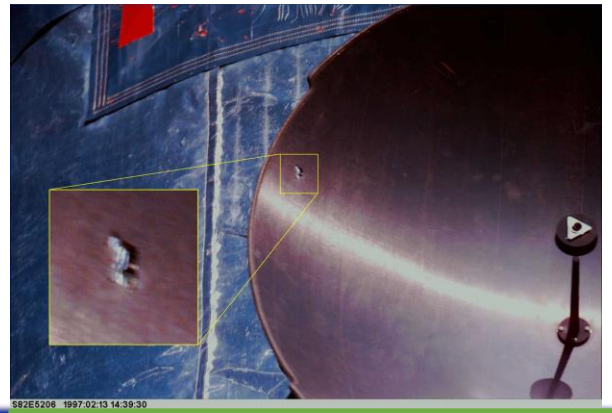




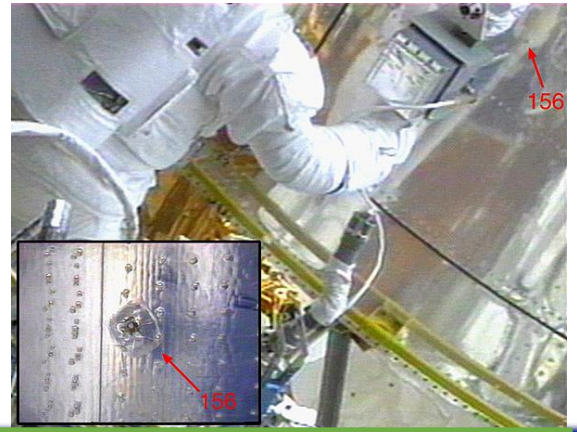
2019: ISS port-side radiator panels- exit hole from MMOD

https://hvit.jsc.nasa.gov/impact-images/international-space-station.cfm





An impact that completely penetrated the antenna dish of the Hubble Space Telescope.



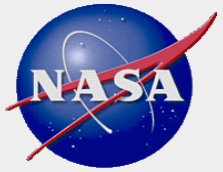
Orbital debris damage seen during Hubble Space Telescope repairs.

Hazards/Risks?

- **Debris left in orbits > 600 km normally fall back to Earth within several years. At altitudes of 800 km, the time for orbital decay is often measured in decades. Above 1,000 km, orbital debris will normally continue circling the Earth for a century or more.**

- **The smaller the particle, the higher the potential for collision.**

- **Kinetic Energy relation.**
  - A 1 kg object in LEO involved in a collision with an object traveling at 10 km/s will have the same impact energy as a fully loaded 35,000 kg truck traveling at 190 km/h.



ISS FLIGHT OPERATIONS

Untracked Debris

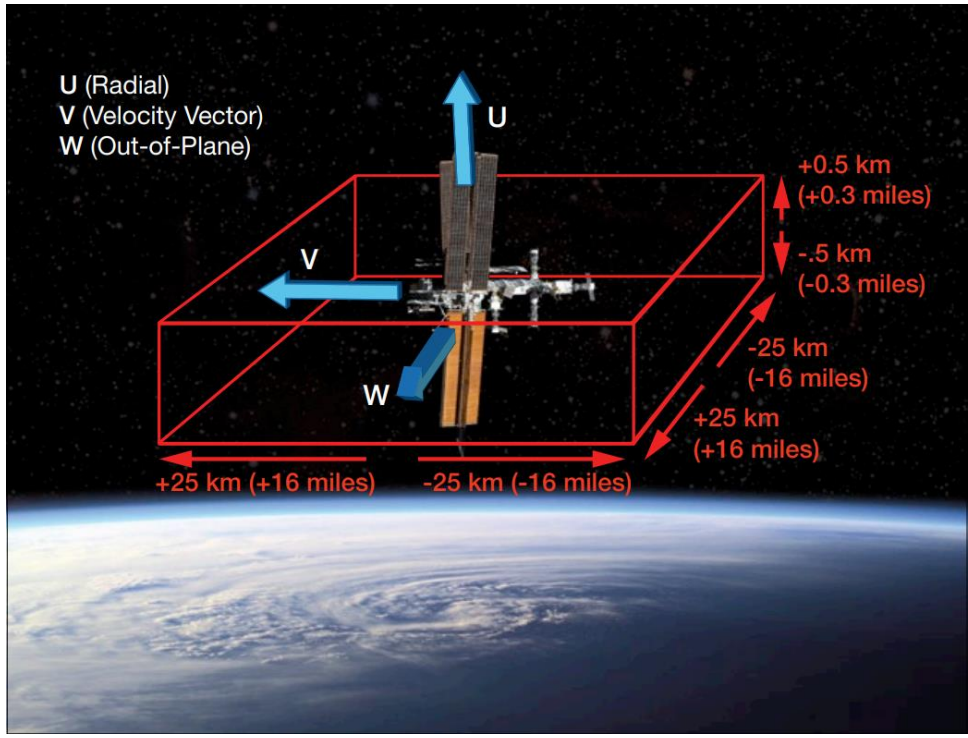
- **Whipple Shielding**
- **Effective up to 1 cm size**
- **Leak procedures**
  - **Patching**
  - **Isolation**

Debris Screening

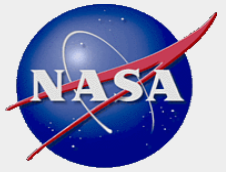
- US Space Command Space Surveillance Network
- Global network of optical and radar sensors
- Conjunction notification provided to TOPO

Probability of Collision

- Miss distance
- Orbital uncertainty
- Risk categories
  - Green
  - Yellow
  - Red
  - Black
- Additional observations

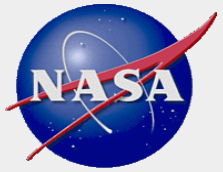


Debris Avoidance Maneuver



- **Propulsion**
- **0.3-1.0 m/s ΔV**
- **Typically ~2.5 hours before conjunction**
- **Compatibility with mission objectives**

Debris Avoidance Maneuver



- Solar array repositioning
- Power reduction
- Communication fills
- Payload safing
- Maneuver to burn attitude