

National Aeronautics and Space Administration



USA Space Debris Environment and Operational Updates

**Presentation to the 47th Session of the
Scientific and Technical Subcommittee
Committee on the Peaceful Uses of Outer Space
United Nations**

8-19 February 2010



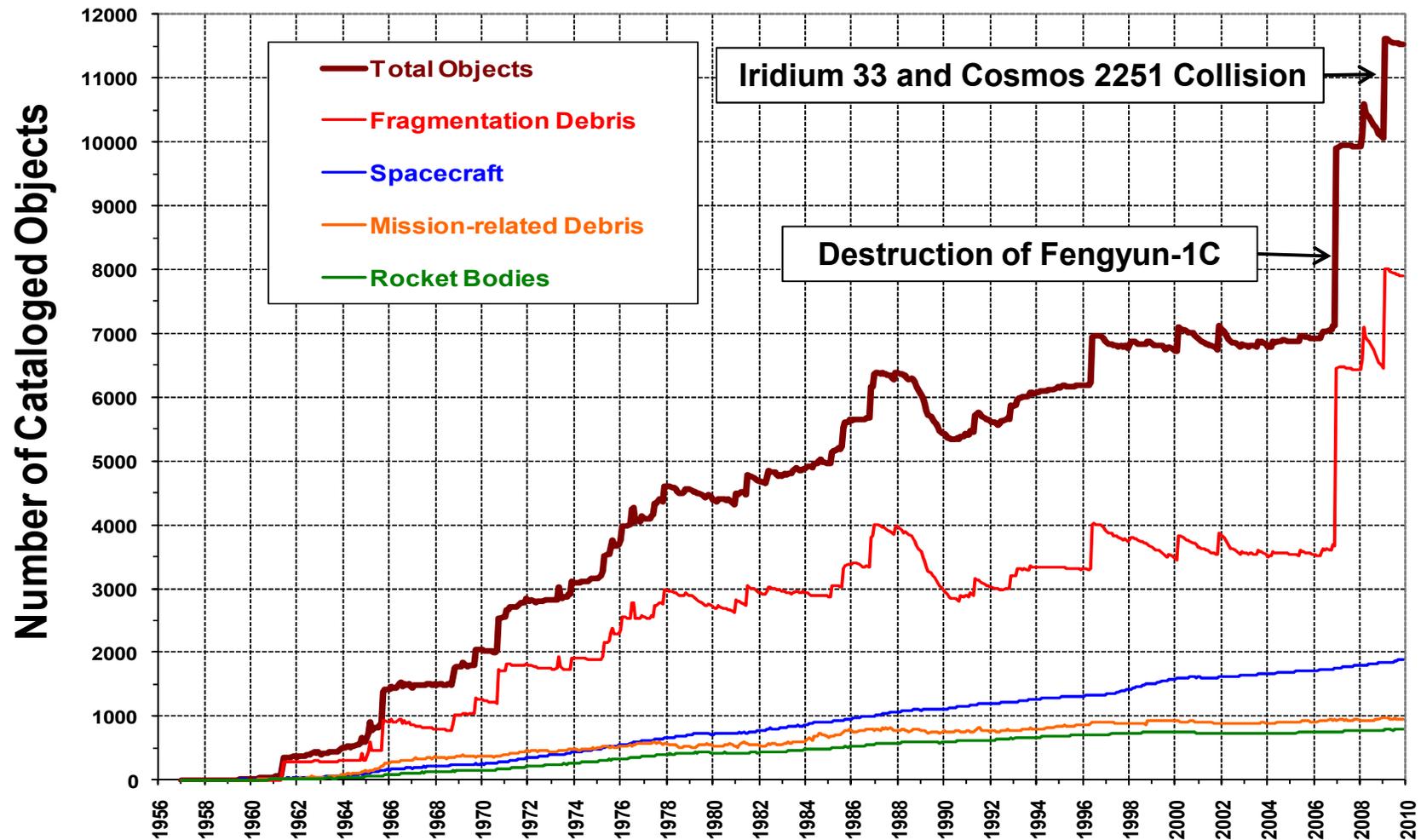
Presentation Outline

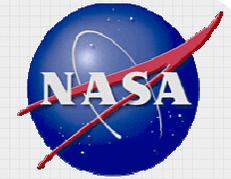
- **Evolution of Low Earth Orbit Satellite Population**
- **Space missions in 2009**
- **Collision Avoidance Maneuvers**
- **GEO Population and Retirement of USA GEO Spacecraft in 2009**
- **Satellite Fragmentations in 2009**
- **Inspection of Hubble Space Telescope**
- **First International Conference on Orbital Debris Removal**



Growth of the Cataloged Satellite Population in Low Earth Orbit: Numbers of Objects

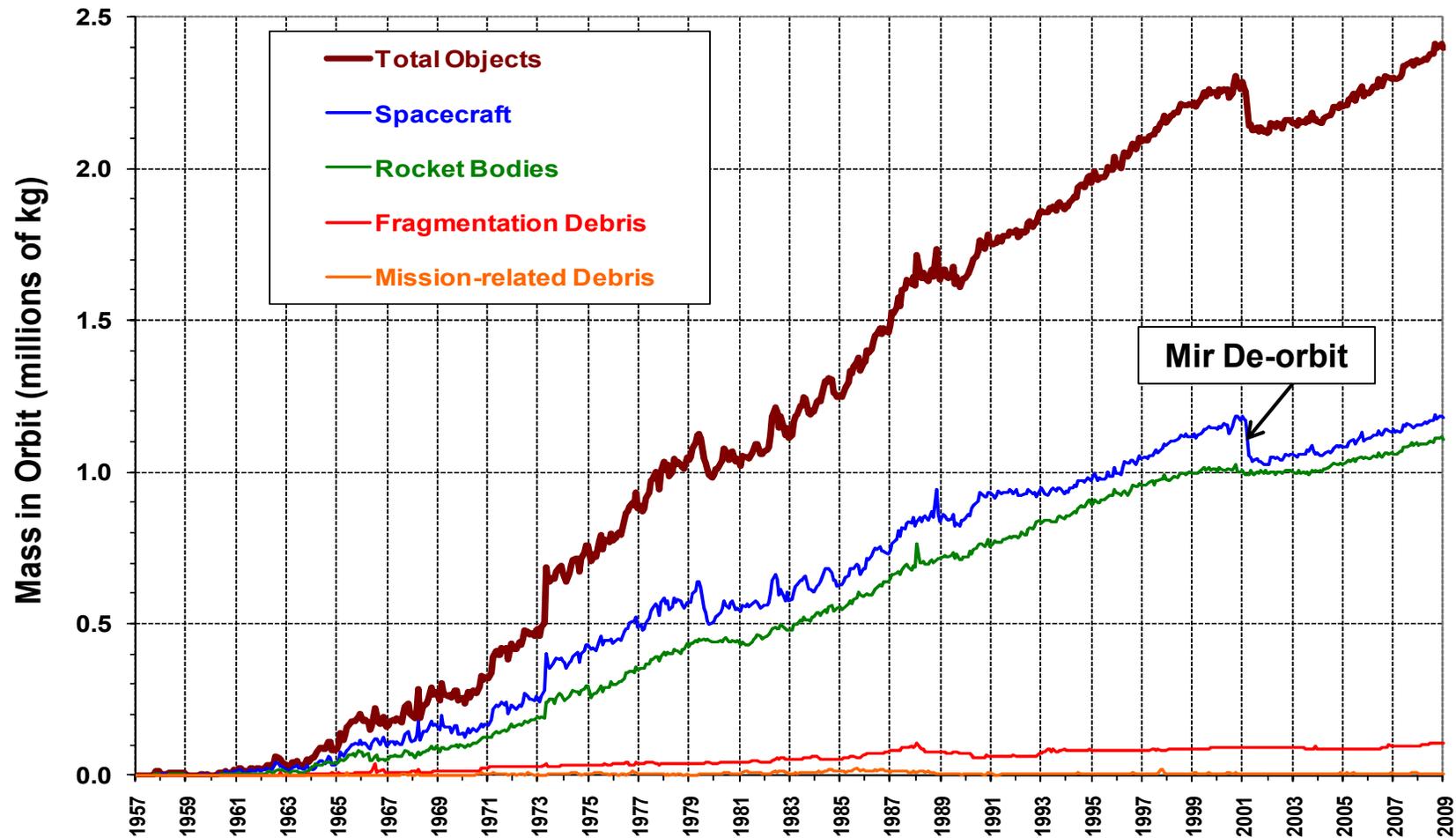
- The number of cataloged objects in low Earth orbit has increased 62% since 1 January 2007.





Growth of the Cataloged Satellite Population in Low Earth Orbit: Mass of Objects

- Recently, the rate of mass growth in low Earth orbit has averaged 50 metric tons per year. (data below does not include ISS components)





NASA Space Missions of 2009

- **Twelve NASA space missions were undertaken in 2009.**

Mission	Launch Date	Destination	Other Objects Left in Earth Orbit
NOAA 19 *	06 February	LEO	One rocket body left in disposal orbit; reentered after 2.5 months
Kepler	07 March	Heliocentric Orbit	One rocket body left in disposal orbit between LEO and GEO
STS-119	15 March	LEO (ISS)	No objects left in Earth orbit
STS-125	11 May	LEO (HST)	No objects left in Earth orbit
PHARMASAT	19 May	LEO	Other objects associated with this flight are not NASA-related, but all will have short orbital lifetimes.
Lunar Reconnaissance Orbiter	18 June	Lunar orbit	No objects left in Earth orbit
LCROSS	18 June	Lunar impact	No objects left in Earth orbit
GOES 14 *	27 June	GEO	One rocket body left in disposal orbit between LEO and GEO
STS-127	15 July	LEO (ISS)	Three small payloads and three small debris left in low altitude, short-lived orbits
STS-128	29 August	LEO (ISS)	No objects left in Earth orbit
STS-129	16 November	LEO (ISS)	No objects left in Earth orbit
WISE	14 December	LEO	One rocket body left in disposal orbit between LEO and GEO; one mission-related debris left in short-lived orbit

* Spacecraft developed and launched by NASA for NOAA

- **All spacecraft, rocket bodies, and mission-related debris residing in or passing through LEO have already reentered or will reenter within 25 years.**



Orbital Debris Collision Avoidance

- Since 2007 NASA has required all of its maneuverable spacecraft in LEO or GEO to conduct satellite conjunction assessments on a routine basis to avoid accidental collisions with resident space objects.
- During 2009 NASA conducted eight collision avoidance maneuvers and assisted France with a collision avoidance maneuver involving the PARASOL spacecraft.

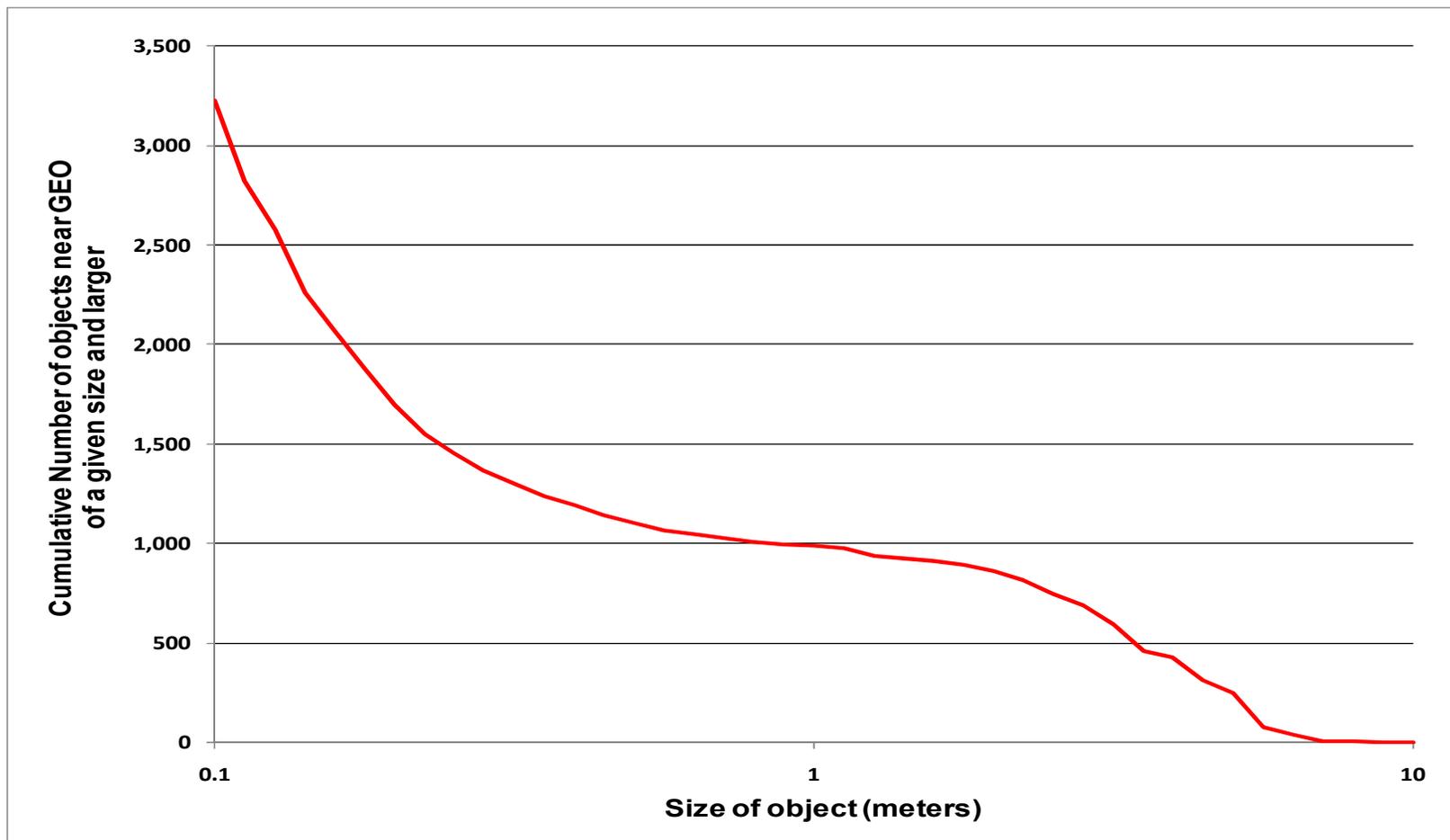
Spacecraft	Maneuver Date	Object Avoided
TDRS 3	27 January	Proton rocket body
ISS	22 March	CZ-4 rocket body debris
Cloudsat	23 April	Cosmos 2251 debris
EO-1	11 May	Zenit rocket body debris
ISS	17 July	Proton rocket body debris
Space Shuttle	10 September	ISS debris
PARASOL (France)*	29 September	Fengyun-1C debris
Aqua	25 November	Fengyun-1C debris
Landsat 7	11 December	Formosat 3D

* Operating in NASA-led Earth observation network



GEO Population Assessment

- For many years NASA has been observing the GEO uncataloged debris population. Data suggest that the population of debris between 10 cm and 1 m is at least twice that of the cataloged population.





Disposal of USA GEO Satellites in 2009

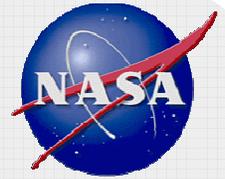
- **Eight USA civil GEO spacecraft conducted disposal maneuvers in 2009.**

Spacecraft	International Designator	Minimum Height above GEO	Maximum Height above GEO
SBS 6	1990-091A	335	395
INTELSAT 605	1991-055A	250	290
DIRECTV 1	1993-078A	340	390
INTELSAT 704	1995-001A	305	315
DIRECTV 3	1995-029A	340	380
GOES 10	1997-019A	335	355
ECHOSTAR 5	1999-050A	420	450
GALAXY 4R *	2000-020A	120	130

* This spacecraft suffered primary and secondary propulsion system failures prior to 2004.

All spacecraft except Galaxy 4R meet USA, IADC, and United Nations recommendations for GEO disposal and will not come within the GEO protected region during the next 200 years.

- **TDRS 1 also completed its mission in 2009 and will be placed in a compliant disposal orbit in 2010.**



Satellite Fragmentations in 2009

- **Iridium 33 and Cosmos 2251 Collision:**

Accidental collision on 10 February produced more than 2000 trackable debris. (update on next chart)

- **Proton launch vehicle ullage motor:**

Ullage motor from Cosmos 2139-2141 mission (1991-025) broke-up on 8 March. To date, 32 debris have been cataloged by the USA Space Surveillance Network; half have already reentered.

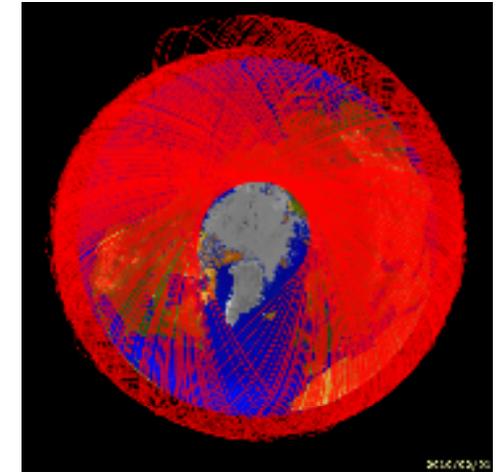
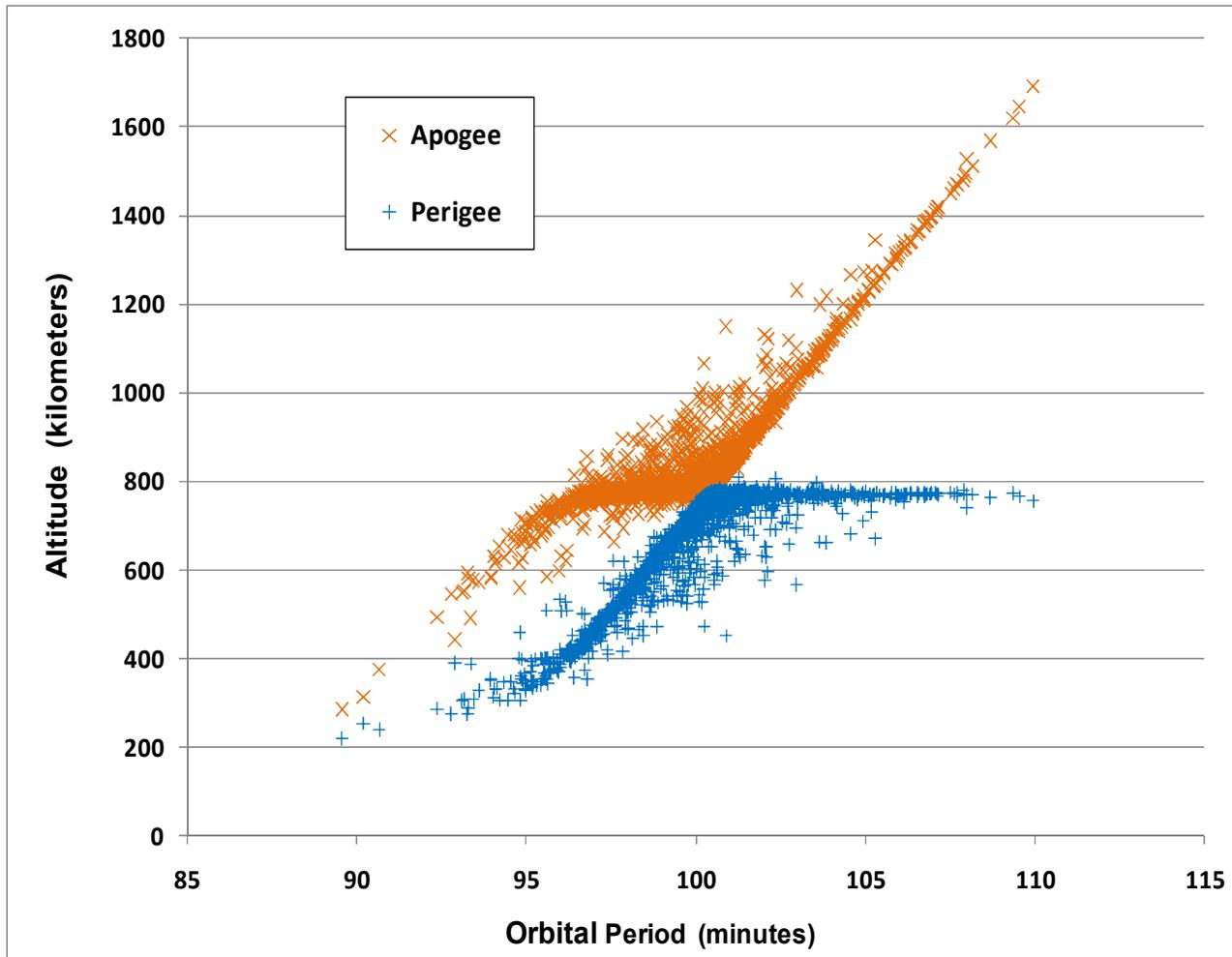
- **Cosmos 192:**

This 42-year old spacecraft (1967-116) experienced a minor fragmentation on 30 August. Less than 20 confirmed debris; only three debris officially cataloged due to high drag coefficients, and all three had reentered within two months.

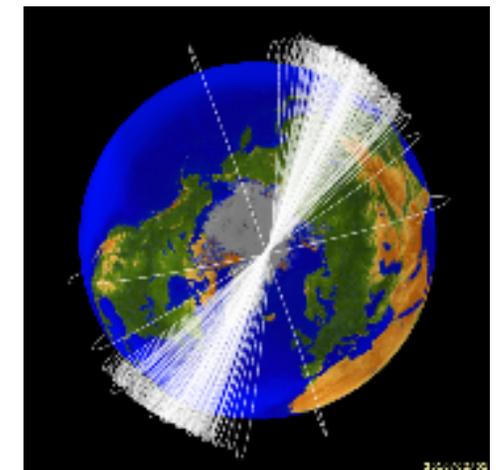


Update on Iridium-Cosmos Collision

- One year after the accidental collision of Iridium 33 and Cosmos 2251, more than 2000 large debris had been identified.



Cosmos 2251 Debris

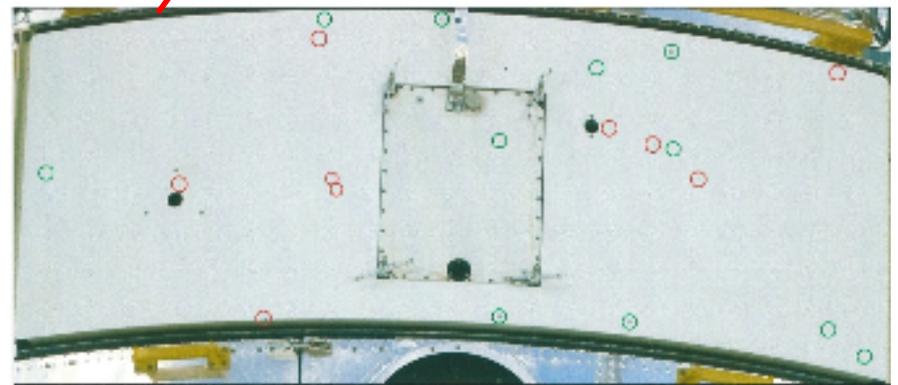
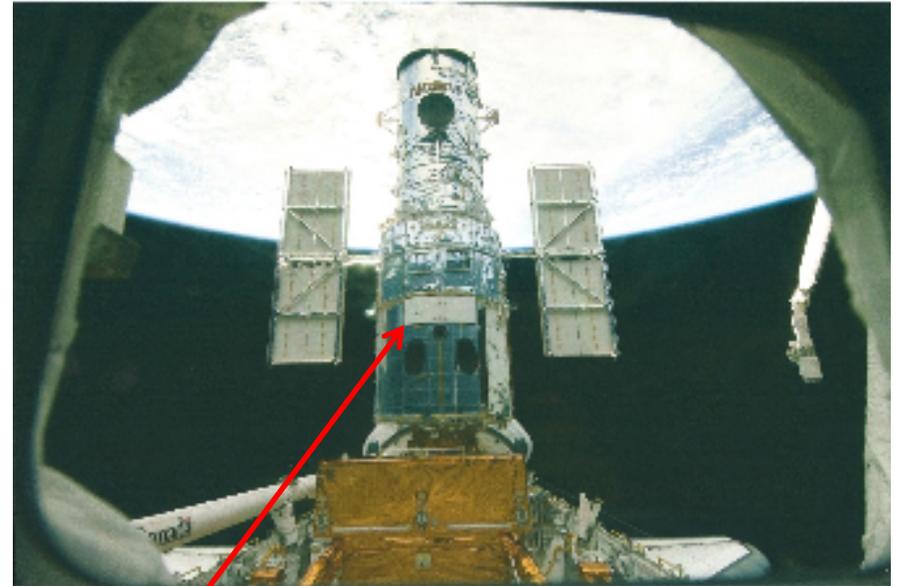


Iridium 33 Debris



Inspection of the Hubble Space Telescope

- In May 2009, Space Shuttle Atlantis visited and successfully refurbished the Hubble Space Telescope.
- The Wide Field Planetary Camera 2 was removed and returned to Earth after 16 years in space.
- Numerous large impact features (green circles) had occurred since the last servicing mission in 2002 (red circles).
- Microscopic examinations have revealed nearly 700 hypervelocity impact features greater than 0.3 mm in diameter.

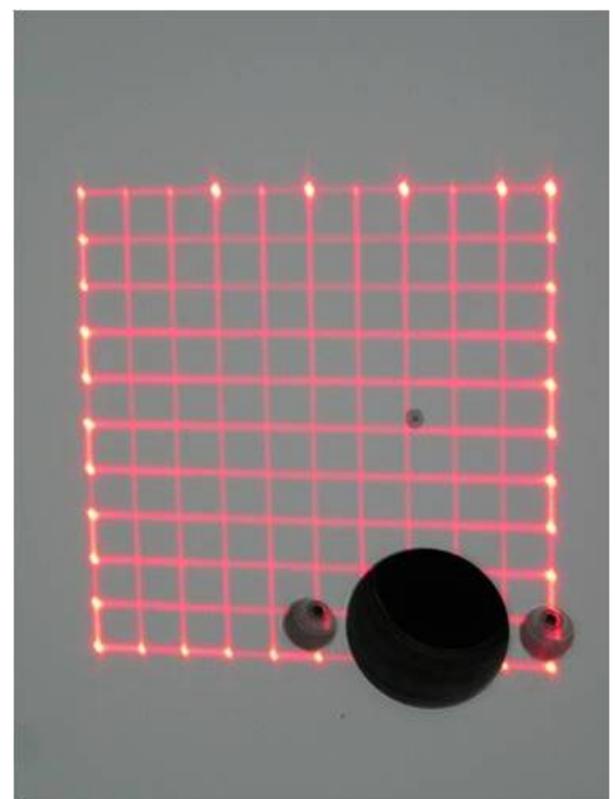
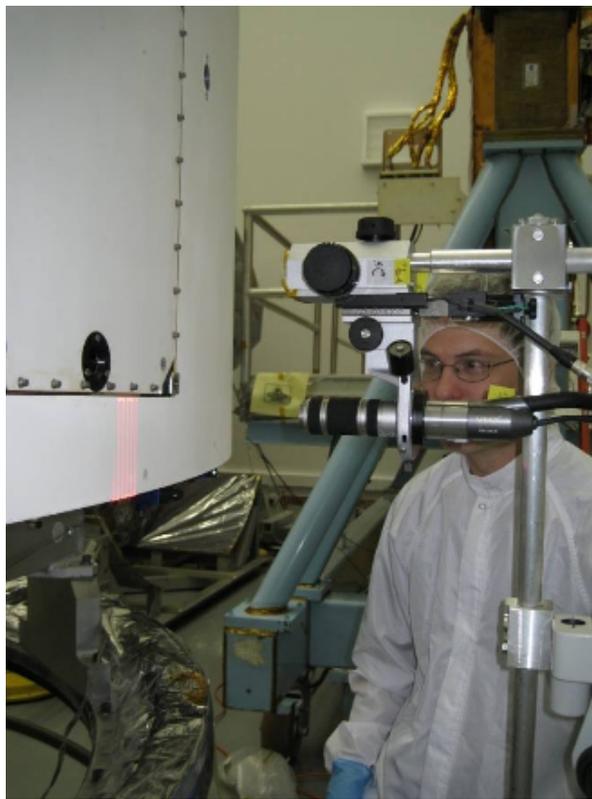


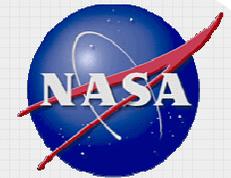
WFPC2 Radiator (2.2 m long, 0.8 m tall)



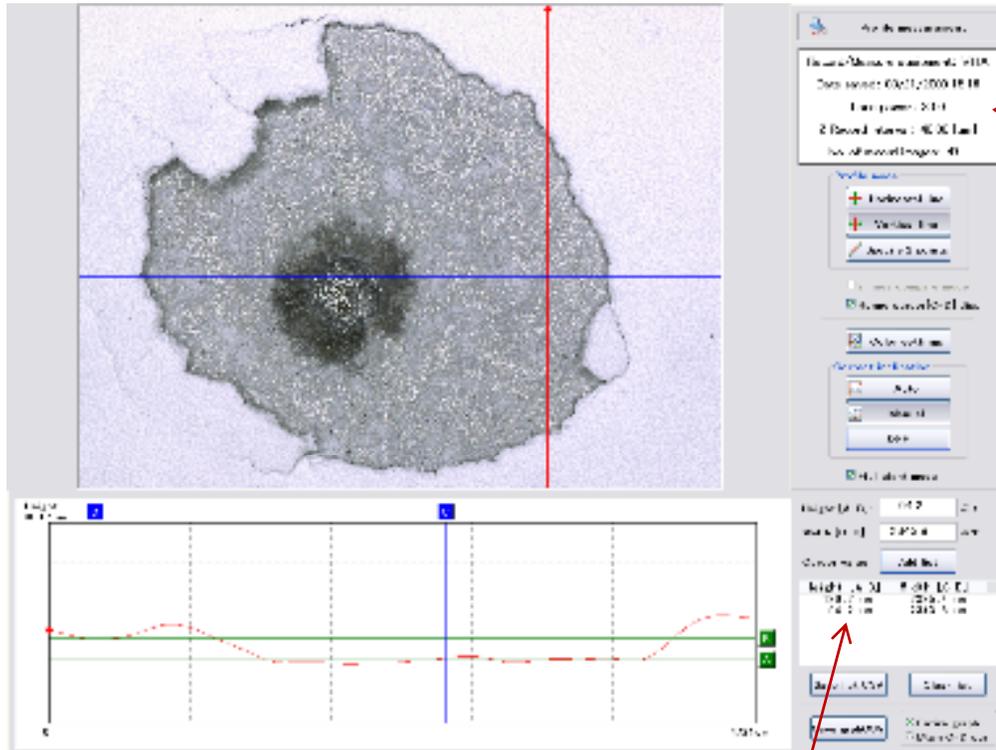
Inspection Instruments

- **Keyence VHX-600 digital microscope (up to 5000x optical, 2D and 3D)**
 - Records each impact feature's shape, size, depth, and volume
- **LAP CAD-Pro laser template projector**





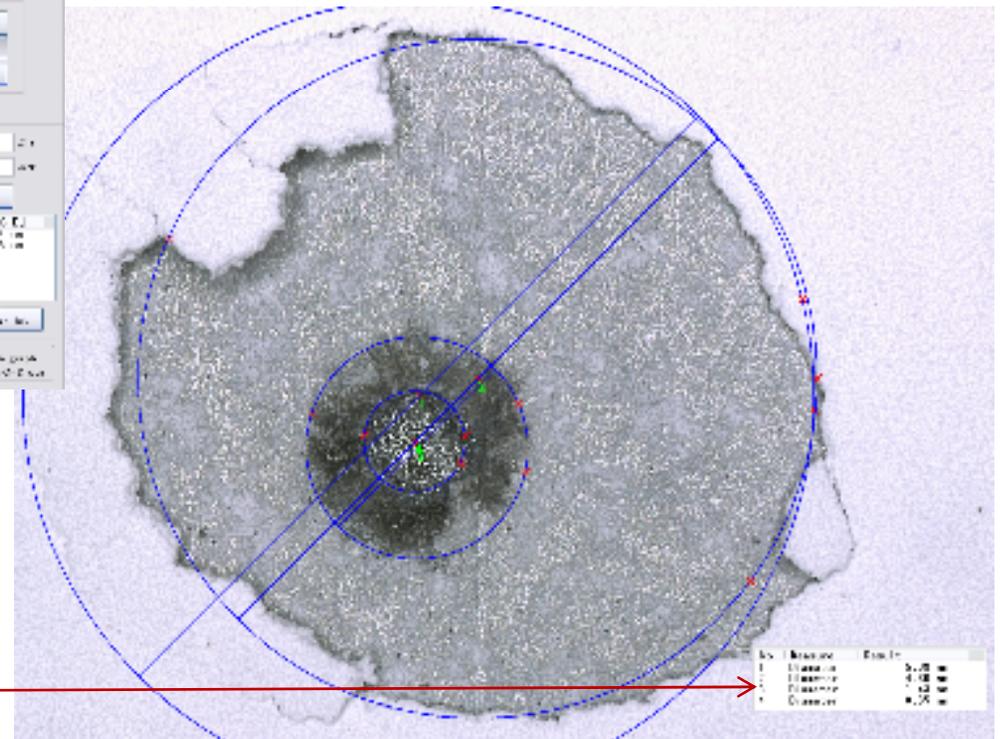
Measuring Large Craters



Inputs

Four Diameters:

- Spallation
- Bare metal
- "Burned" metal
- Lips or center



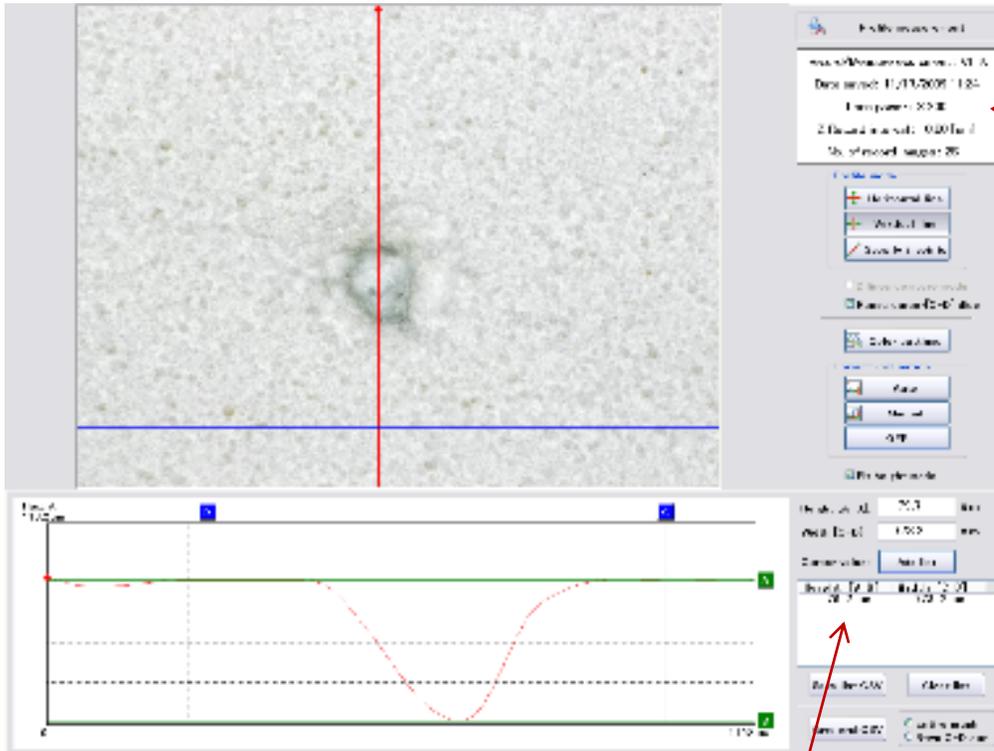
Two Depths:

- Central crater depth
- Paint thickness

Results

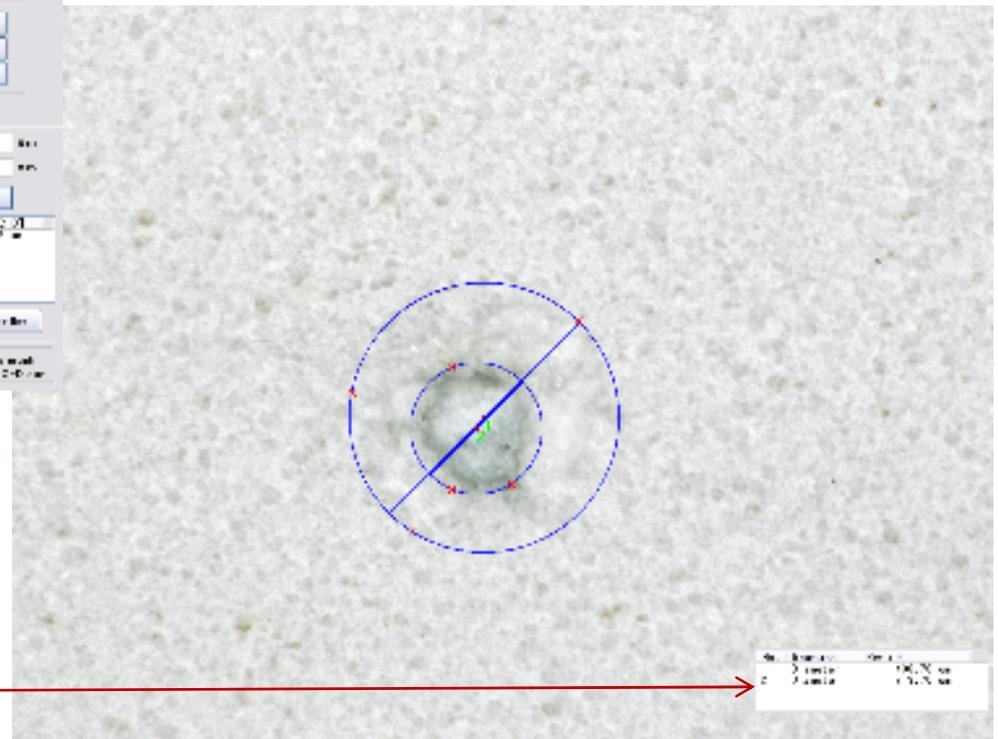


Measuring Small Craters



Inputs

Two Diameters:
– Spallation
– Center



One Depth:
– Central crater depth

Results



First International Conference on Orbital Debris Removal

- **NASA and the US Defense Advanced Research Projects Agency (DARPA) last year co-hosted the first international conference dedicated to the subject of the removal of debris from Earth orbit.**
- **The conference was held in the vicinity of Washington, DC, and was attended by more than 275 persons from nine countries.**
- **More than 50 presentations examined the technical, economic, legal, and policy issues associated with removing small and large debris in low and high altitude orbits.**

