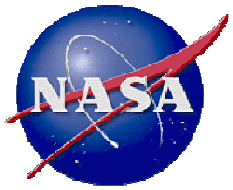
National Aeronautics and Space Administration

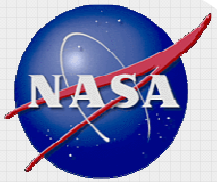


USA Space Debris Environment, Operations, and Modeling Updates

Presentation to the 50th Session of the
Scientific and Technical Subcommittee
Committee on the Peaceful Uses of Outer Space
United Nations

11-22 February 2013

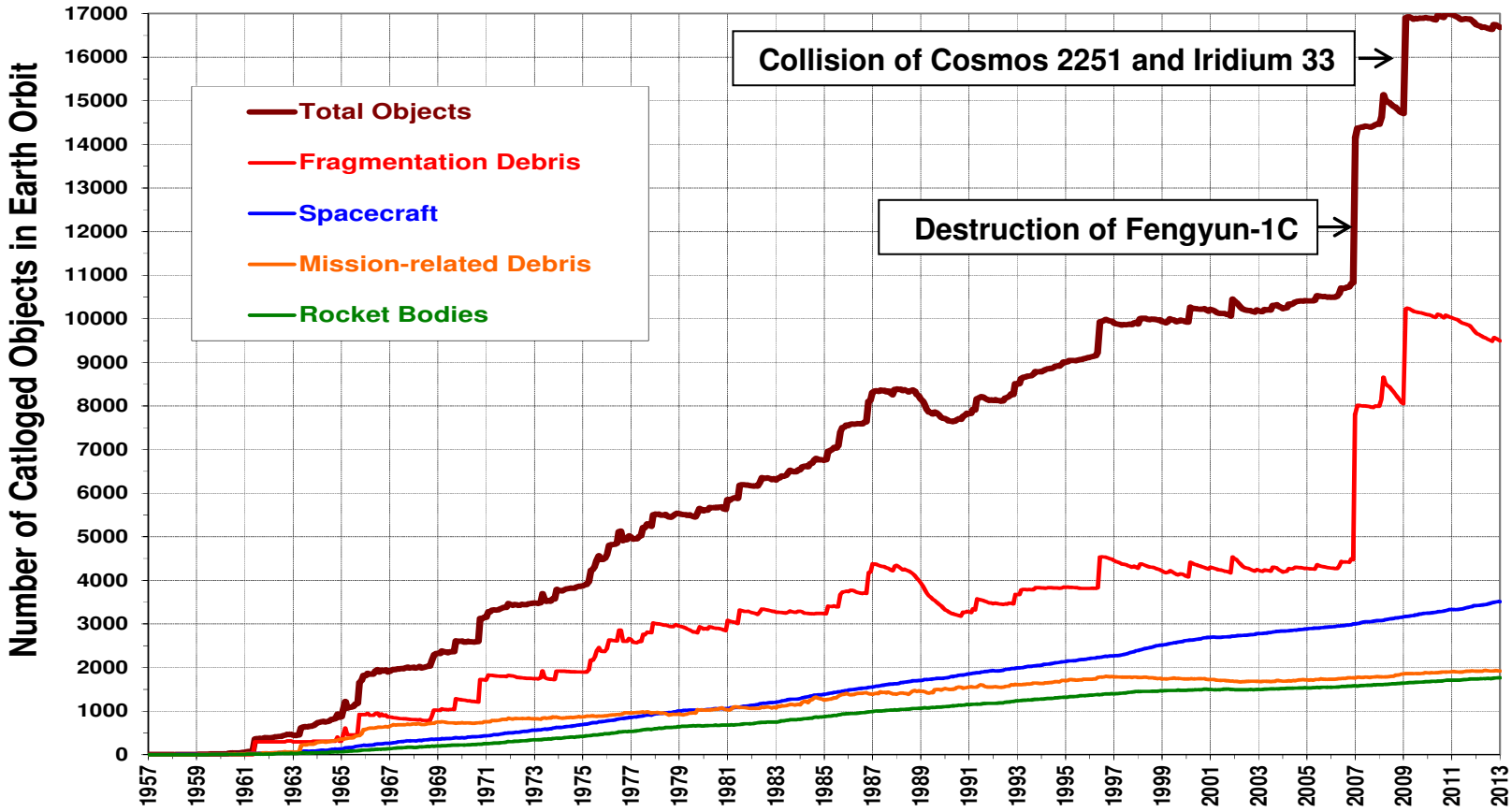
Presentation Outline



- **Earth Satellite Population**
- **Satellite Breakups in 2012**
- **Collision Avoidance Maneuvers in 2012**
- **Satellite Reentries in 2012**
- **Disposal of GRAIL Spacecraft**
- **Effectiveness of Post-Mission Disposal Compliance in Controlling the Earth's Satellite Population**

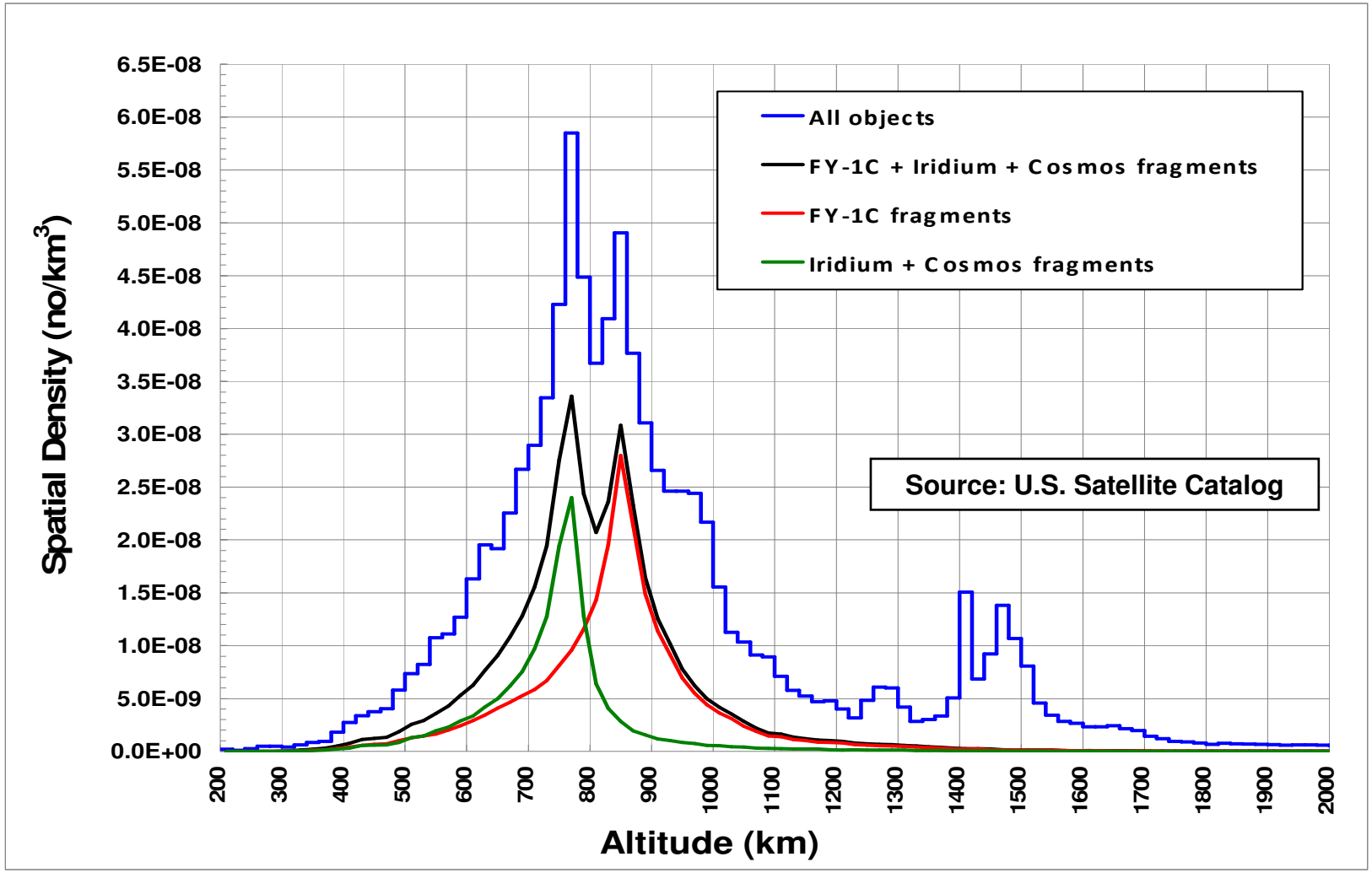
Evolution of the Cataloged Satellite Population

- **Increased solar activity, which is predicted to peak in 2013, continues to remove objects from Earth orbit at a rate faster than new objects are added via new launches and satellite fragmentations. However, this trend is expected to reverse within the next few years as solar activity decreases.**



Distribution of Objects in Low Earth Orbit

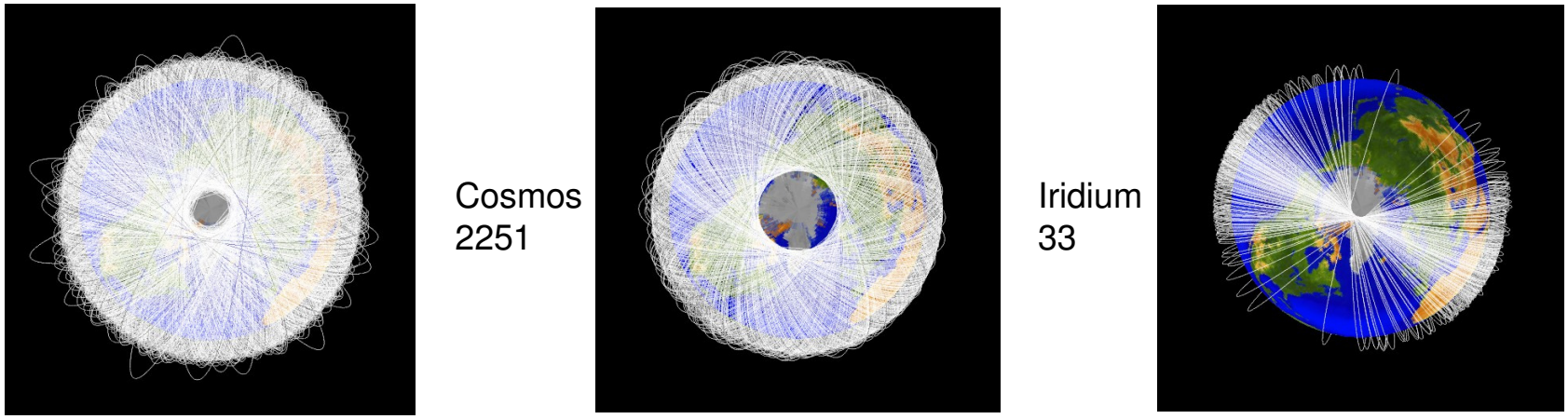
- **The most congested region in low Earth orbit is between 760 km and 860 km.**



Status of Fengyun 1C, Cosmos 2251, and Iridium 33 Debris

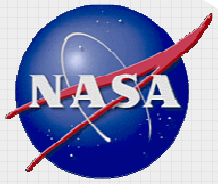
- **The destruction of the Fengyun 1C spacecraft in 2007 and the accidental collision of the Cosmos 2251 and the Iridium 33 spacecraft in 2009 remain the worst known debris generation events in Earth orbit.**

	Cataloged Debris	Cataloged Debris in Orbit (as of January 2013)
Fengyun 1C	**3378**	**3076 (91%)**
Cosmos 2251	**1603**	**1342 (84%)**
Iridium 33	**598**	**479 (80%)**



Orbital planes of Fengyun 1C, Cosmos 2251, and Iridium 33 debris in July 2012

Satellite Breakups During 2012



- **The U.S. Space Surveillance Network detected two satellite fragmentations during 2012.**

- **In February, a Chinese CZ-3C upper stage released dozens of debris two days after launch.**

  – This was the fourth CZ-3 stage in geosynchronous transfer orbit to fragment since 2007. All events occurred within two days of successful launches.

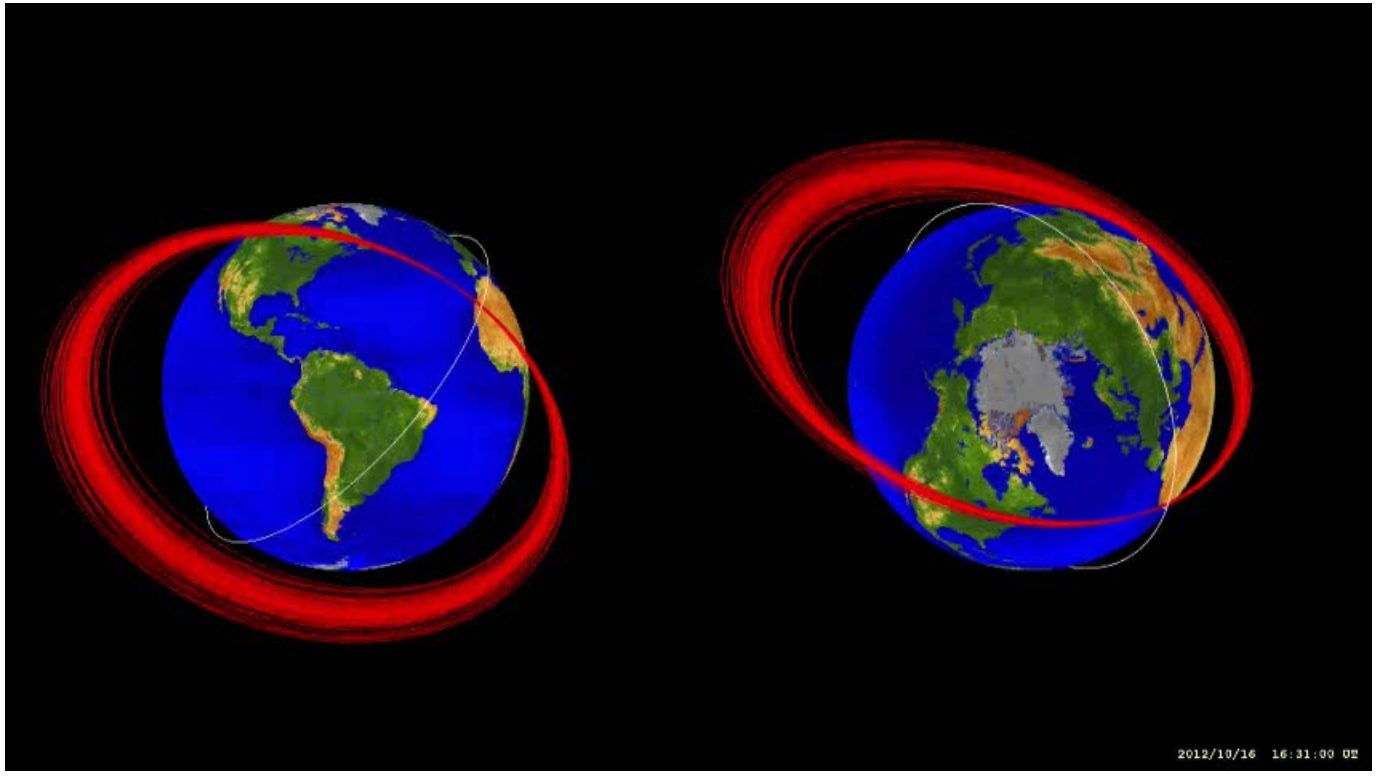
- **In October, two months after a launch malfunction, a Proton Briz-M stage exploded while in a moderately elliptical orbit of 265 km by 5010 km. More than 100 debris have been cataloged by the U.S. SSN.**

  – This was the third major fragmentation of a Briz-M stage since 2007. All stages had malfunctioned during flight and had not been passivated.

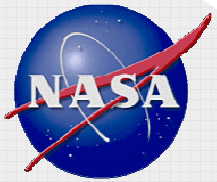
2012 Briz-M Stage Breakup

- **The debris generated by the Briz-M explosion possessed perigees below that of the International Space Station, posing potential collision threats.**

- **Initially, the orbital planes of Briz-M and ISS were nearly perpendicular, resulting in high relative velocities on the order of 10 km/s or greater.**



Satellite Collision Avoidance

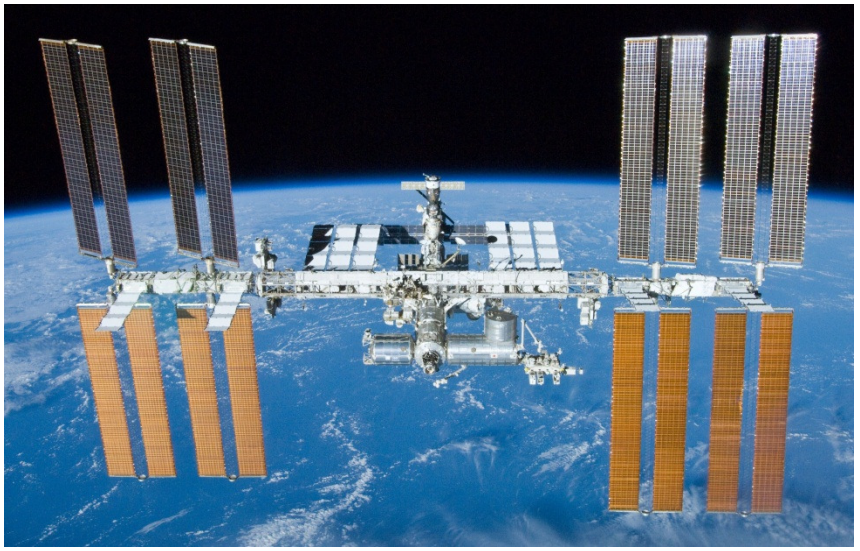


- **Since 2007 NASA has required frequent satellite conjunction assessments for all of its maneuverable spacecraft in LEO or GEO to avoid accidental collisions with resident space objects.**

- **During 2012 NASA supported 8 collision avoidance maneuvers for U.S. robotic satellites.**

Mean Altitude	Spacecraft	Object Avoided	Maneuver Date
550 km	GLAST (2008-029A)	Cosmos 1805	3 April 2012
700 km	AURA (2004-026A)	Cosmos 2251 Debris	17 May 2012
	CALIPSO (2006-016B)	Cosmos 2251 Debris	2 October 2012
	CLOUDSAT (2006-016A)	Sinah 1	8 September 2012
	LANDSAT 5 (1984-021A)	Agena D stage Debris	1 July 2012
	LANDSAT 7 (1999-020A)	Fengyun-1C Debris	9 March 2012
		Meteor 1-10 Debris	17 April 2012
825 km	NPP (2011-061A)	Agena D stage Debris	1 February 2012

ISS Collision Avoidance Maneuvers



- **The International Space Station has conducted collision avoidance maneuvers since 1999.**

- **During 2012, three collision avoidance maneuvers were executed, the most in any year:**
  - 13 January to evade fragmentation debris from Iridium 33
  - 28 January to evade fragmentation debris from Fengyun-1C
  - 31 October to evade fragmentation debris from Iridium 33

- **On 24 March the crew of the ISS was forced to retreat to Soyuz spacecraft when a fragment from Cosmos 2251 was predicted to pass too close and insufficient time was available to perform a collision avoidance maneuver.**

Satellite Reentries in 2012

- **More than 400 spacecraft, launch vehicle stage, and other debris reentries were recorded by the U.S. Space Surveillance Network during 2012.**
  – The oldest satellite to reenter was NASA's Explorer 8, which had been launched in 1960.

- **Uncontrolled reentries accounted for a total mass of > 100 metric tons from 57 payloads and rocket bodies.**

Upper stage tank fell on Brazil in February, 2012

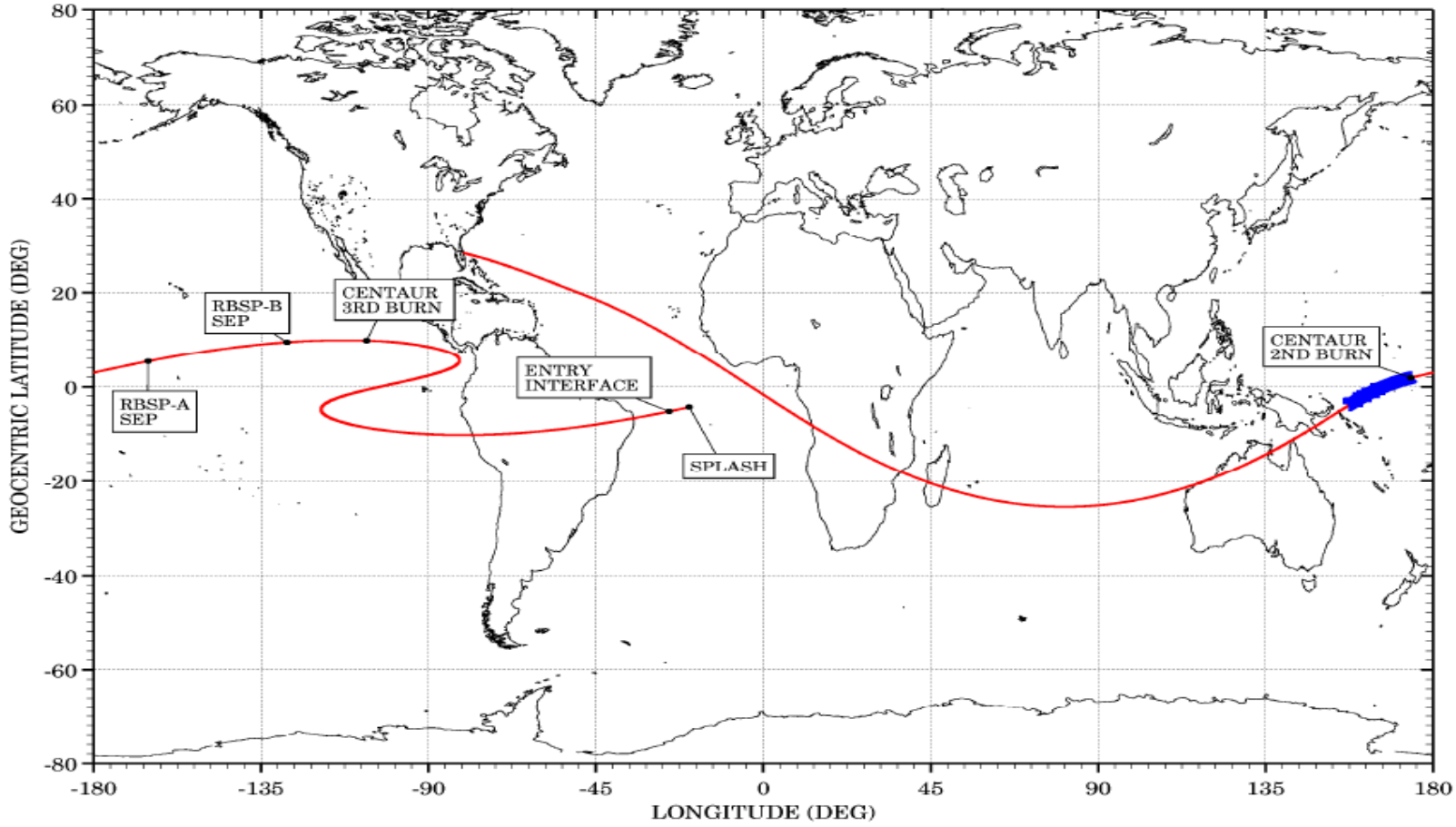
- **A total of 14 spacecraft and 11 launch vehicle upper stages executed controlled reentries, mostly to avoid personal injury or significant property damage on Earth.**

  – The 2012 controlled stage reentries were from China, France, Japan, Russia, and U.S.

  – The number of controlled stage reentries has noticeably increased from only 3 in 2010 and 8 in 2011.

Controlled Reentry of a Centaur Stage

- **During 2012 NASA demonstrated the controlled reentry of a large launch vehicle stage from a highly elliptical orbit as part of the Radiation Belt Storm Probes mission launched in August.**

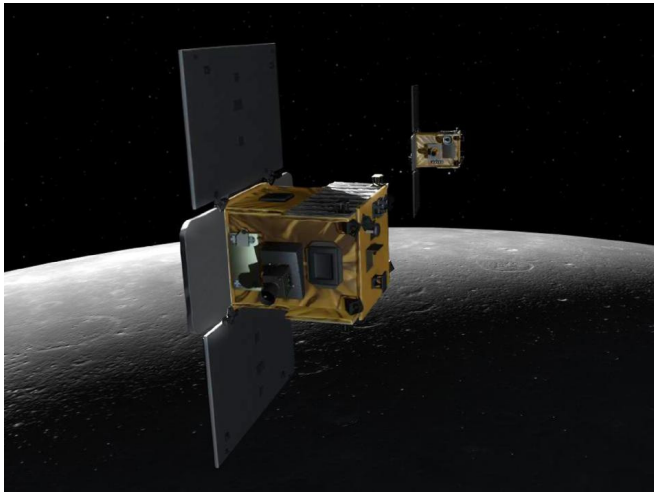


Disposal of GRAIL Spacecraft

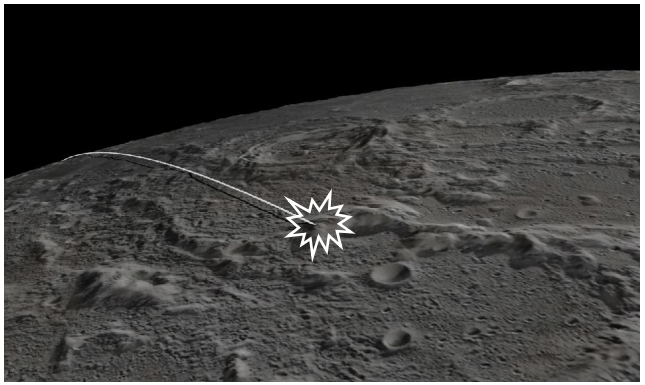
- **Two NASA Gravity Recovery and Interior Laboratory (GRAIL) spacecraft completed their year-long mission in orbit around the Moon on 17 December 2012 when they were sent on controlled impacts into a lunar mountain.**

- **This disposal action is in compliance with recommendations in NASA Procedural Requirements for Limiting Orbital Debris, NPR 8715.6A, designed to protect historic and scientifically valuable lunar surface sites.**

- **Since 2007 NASA orbital debris mitigation policies have included objects in lunar orbits.**



GRAIL spacecraft in lunar orbit.



Dual Impacts on lunar mountain.

Effectiveness of Post-Mission Disposal (PMD)

- **The future LEO space object population will be greatly influenced by the degree of global compliance with the removal of spacecraft and launch vehicle stages within 25 years of the end of mission.**