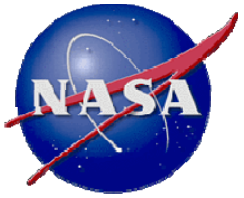
National Aeronautics and Space Administration



USA Space Debris Environment, Operations, and Measurement Updates

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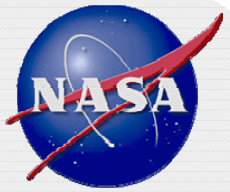
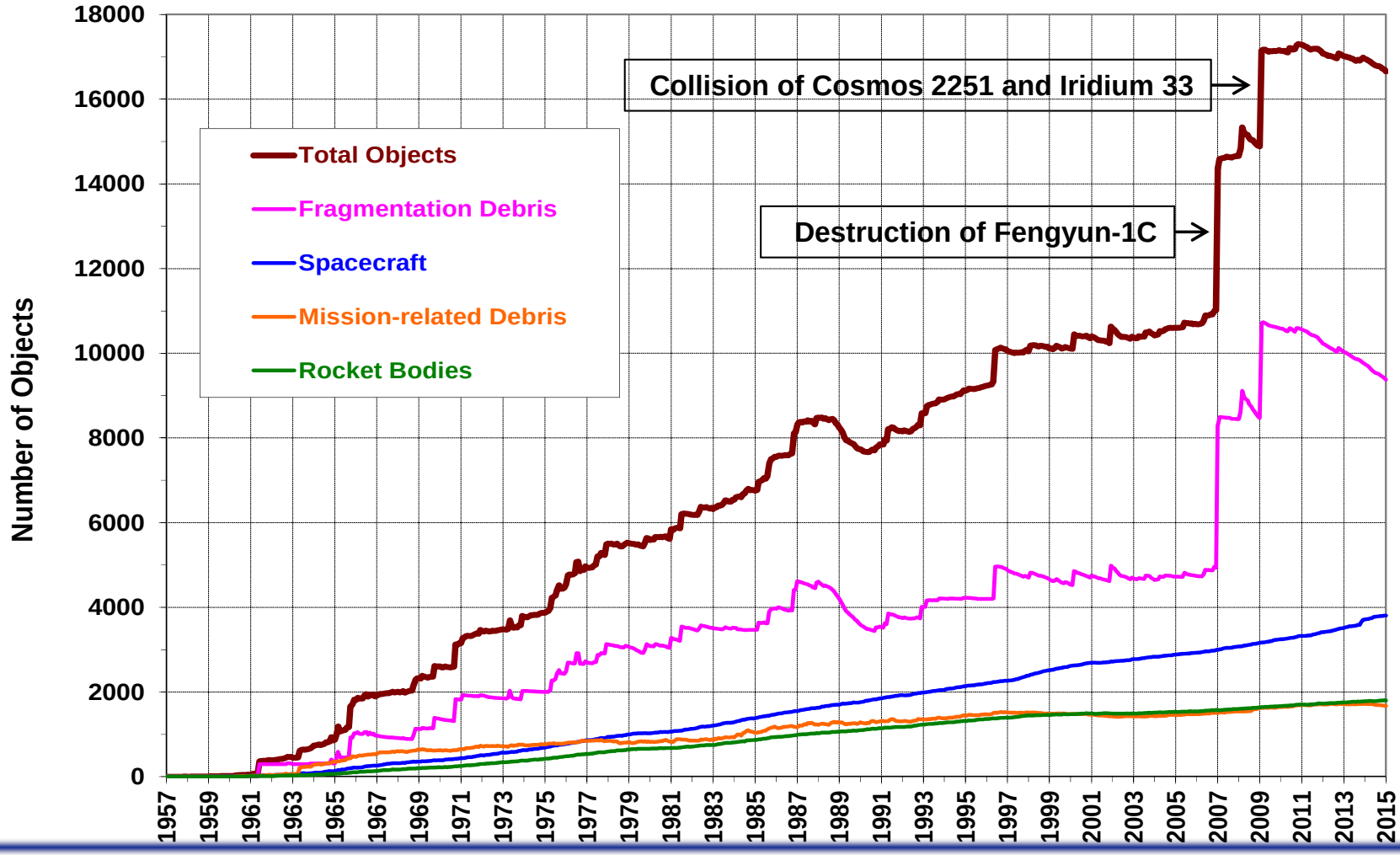
Presentation Outline



- **Earth Satellite Population**
- **Space Missions in 2014**
- **Spacecraft Disposals**
- **Satellite Fragmentations**
- **Collision Avoidance Maneuvers**
- **Satellite Reentries**
- **DebriSat, MCAT, and DRAGONS**

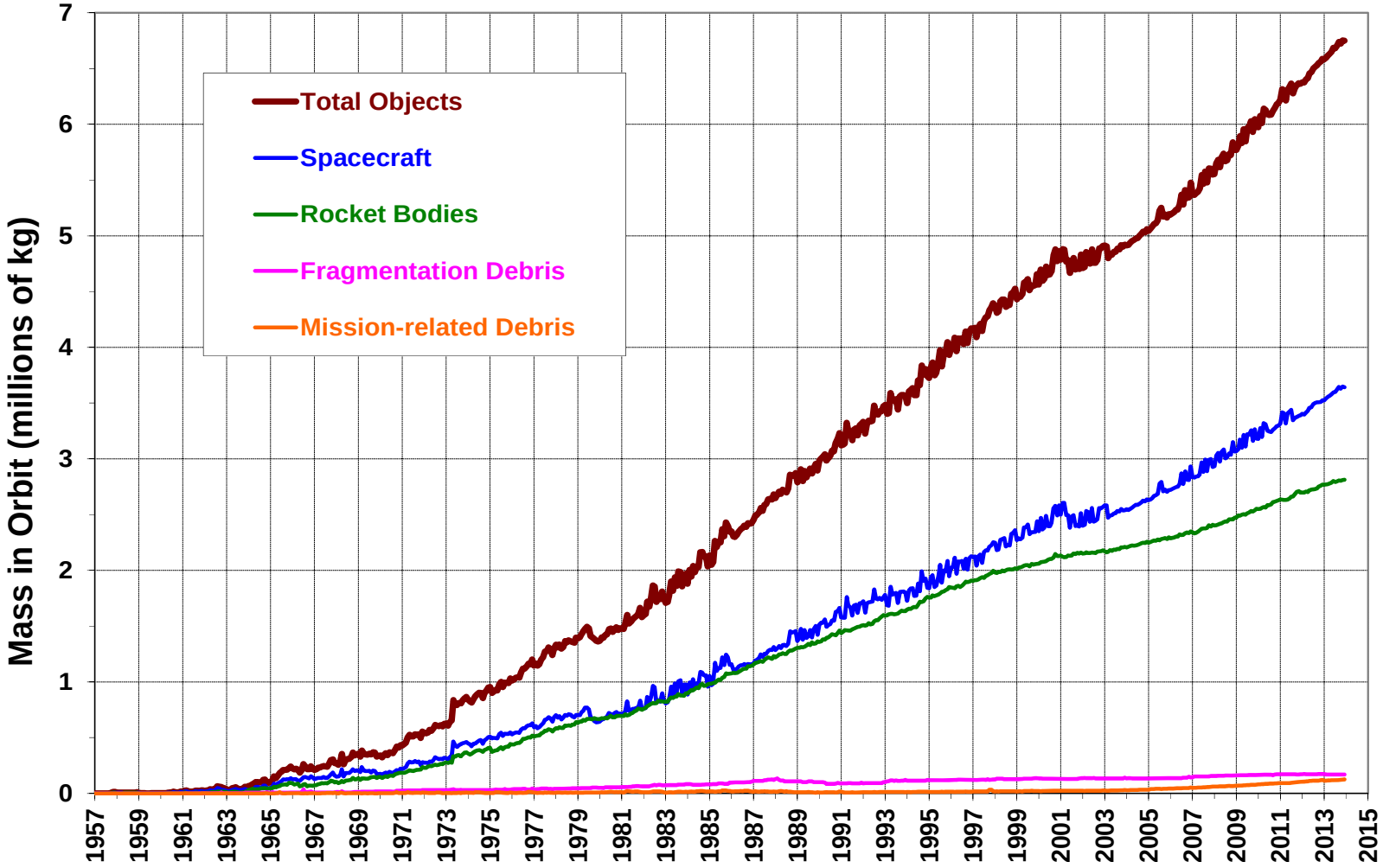
Evolution of the Cataloged Satellite Population

- **According to the U.S. Satellite Catalog, the number of 10 cm and larger objects in Earth orbit decreased slightly in 2014, driven by the decay of light weight fragmentation debris during high solar activities.**



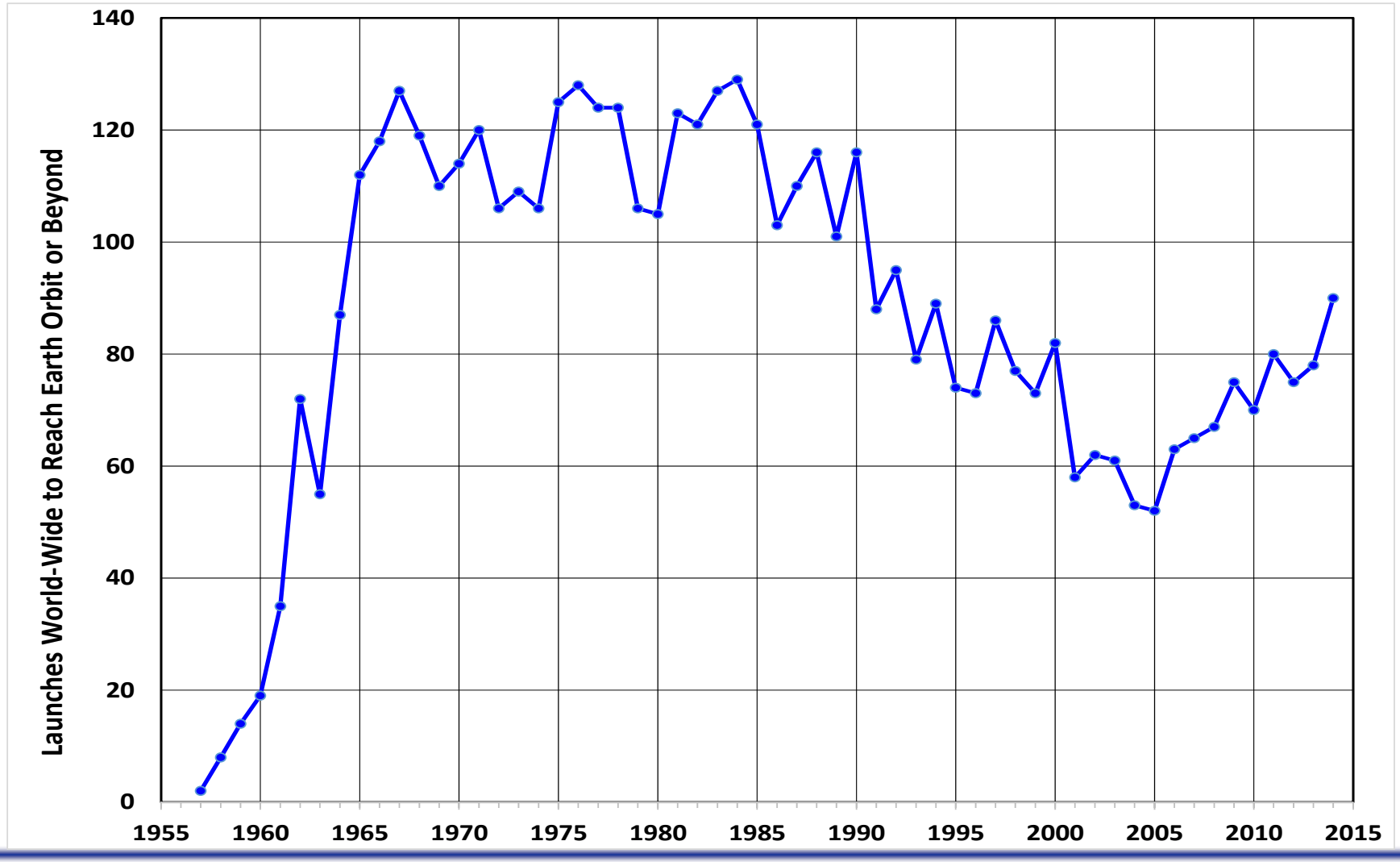
Mass in Near-Earth Space Continued to Increase

- **The material mass in Earth orbit continued to increase and reached a total of 6700 metric tons in 2014.**



World-Wide Space Activity in 2014

- **A total of 90 space launches placed more than 180 spacecraft into Earth orbits during 2014.**



Disposal of USA Spacecraft in GEO

- **Four USA civil spacecraft completed operations in the geosynchronous Earth orbit (GEO) in 2014.**

- **All were moved to disposal orbits above GEO in compliance with UN COPUOS Space Debris Mitigation Guidelines to protect the GEO region.**

Spacecraft	International Designator	Minimum Height above GEO	Maximum Height above GEO
AMC-5	1998-063B	241 km	292 km
Galaxy 26	1999-005A	331 km	392 km
DIRECTV 1R	1999-056A	355 km	390 km
XM-2	2001-012A	335 km	341 km

Satellite Fragmentations During 2014

- **Twelve minor satellite fragmentations were detected by the U.S. Space Surveillance Network during 2014. None of them contributed large numbers of long-lived debris to the near-Earth environment.**

Common Name	International Designator	Perigee Altitude (km)	Apogee Altitude (km)	Detected Debris	Cause
Cosmos 1867	1987-060A	775	800	6	Unknown
Delta II 2nd Stage	1999-008D	635	840	6	Unknown
Cosmos 2428	2007-029A	845	860	17	Unknown
SOZ Ullage Motor	1994-076G	420	18,990	15	Propulsion
SOZ Ullage Motor	2008-046H	865	18,720	7	Propulsion
Cosmos 862 Deb	1976-105F	110	14,990	3	Aerodynamic
Titan 3C Transtage	1969-013B	35,970	37,130	5	Unknown
Iridium 47	1997-082C	776	779	10	Unknown
Haiyang 2A	2011-043A	965	965	4	Unknown
SOZ Ullage Motor	2010-007G	770	18,750	16	Propulsion
SOZ Ullage Motor	2007-052F	730	18,790	70	Propulsion
Iridium 91	2002-005A	776	779	4	Unknown

Robotic Spacecraft Collision Avoidance Maneuvers

- **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 the U.S. Space Surveillance Network.**

- **NASA also assists other U.S. government and foreign spacecraft owners with conjunction assessments and subsequent maneuvers.**

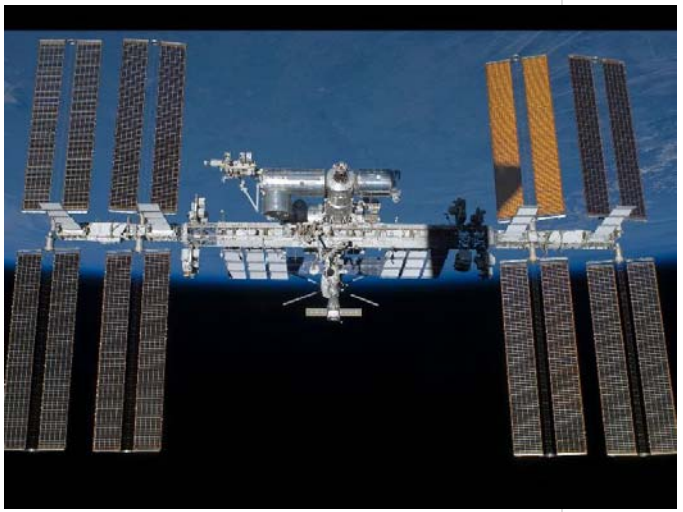
- **During 2014 NASA executed or assisted in the execution of 21 collision avoidance maneuvers by robotic spacecraft.**

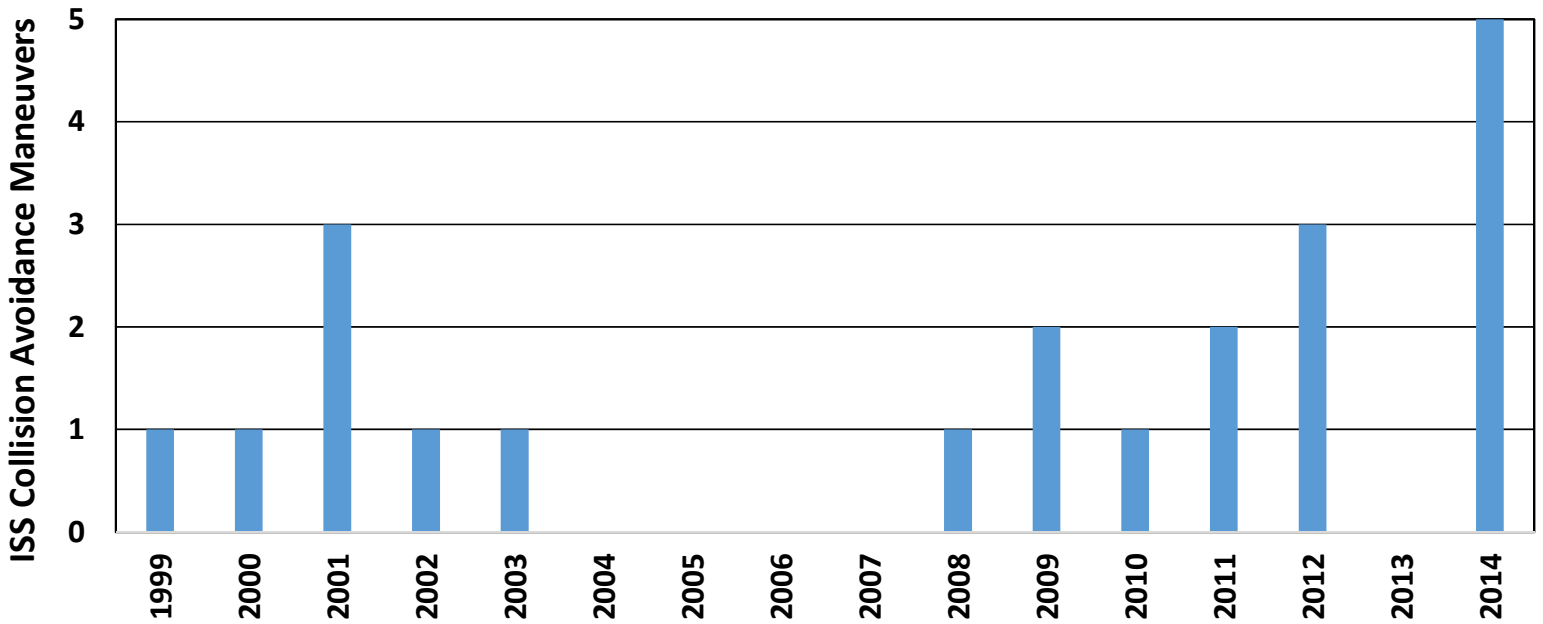
  – 2 maneuvers were needed to avoid debris from Fengyun-1C

  – 4 maneuvers were needed to avoid debris from the collision of Cosmos 2251 and Iridium 33

ISS Collision Avoidance Maneuvers

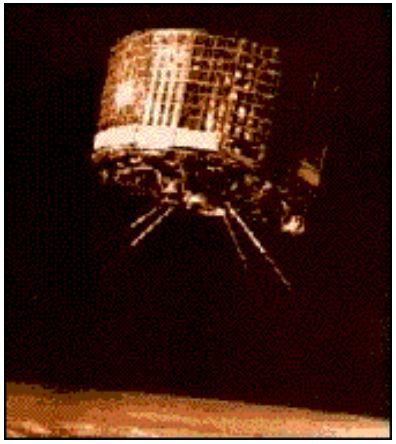
- **The International Space Station (ISS) has conducted 21 debris collision avoidance maneuvers since 1999.**
- **During 2014, a record five debris avoidance maneuvers were executed.**





Satellite Reentries in 2014

- **More than 600 reentries of spacecraft, launch vehicle upper stages, and other debris were recorded by the U.S. Space Surveillance Network during 2014.**
  - Spacecraft: 86; upper stages: 49; debris: 467 (including 243 reentries of the Fengyun 1C, Iridium 33, and Cosmos 2251 fragmentation debris).
  - The high reentry rate was due to the peak of solar maximum in 2014.
  - The oldest spacecraft that reentered was NASA's weather satellite TIROS-2, which was launched into a 619 km × 732 km orbit for a one-year mission in 1960.



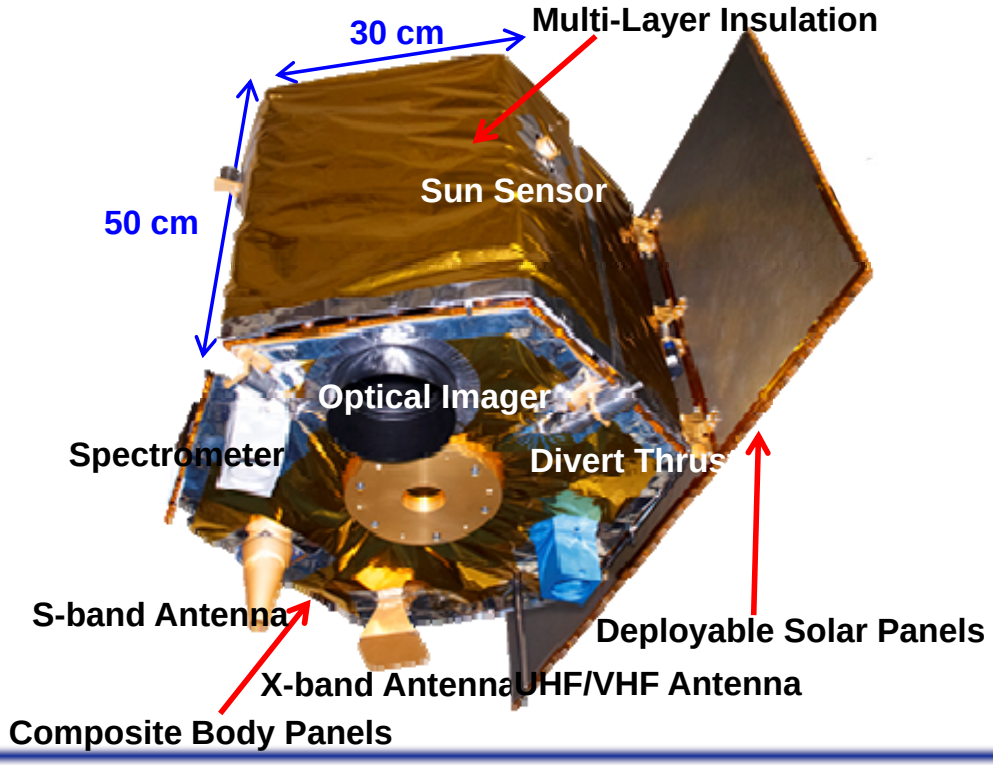
TIROS-2

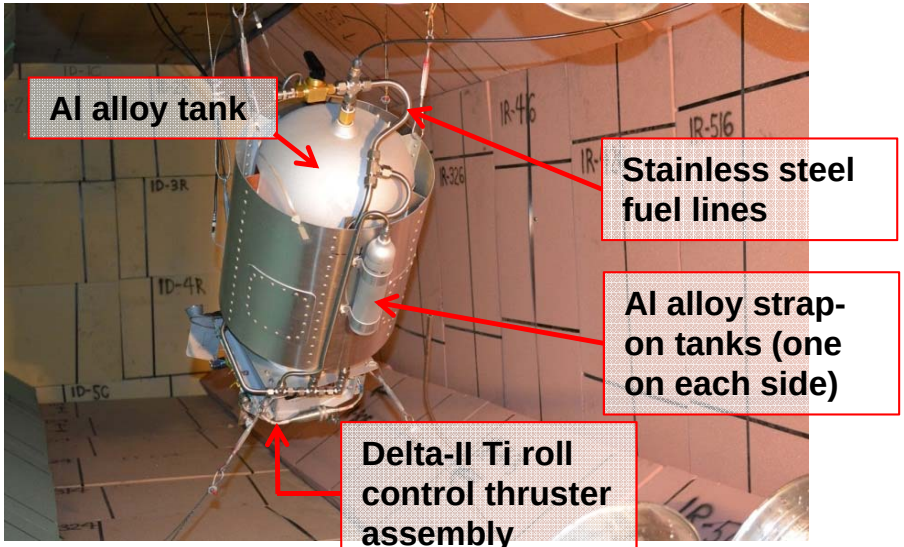
- **The total mass of the 2014 reentries was more than 100 metric tons.**
- **No accounts of personal injury or significant property damage were reported.**

Laboratory-Based Satellite Impact Experiments

- **The "DebriSat" project is a collaboration among NASA, the U.S. Air Force, The Aerospace Corporation, and the University of Florida for laboratory-based hypervelocity impact experiments on a representative, modern LEO satellite and an upper stage mockup.**

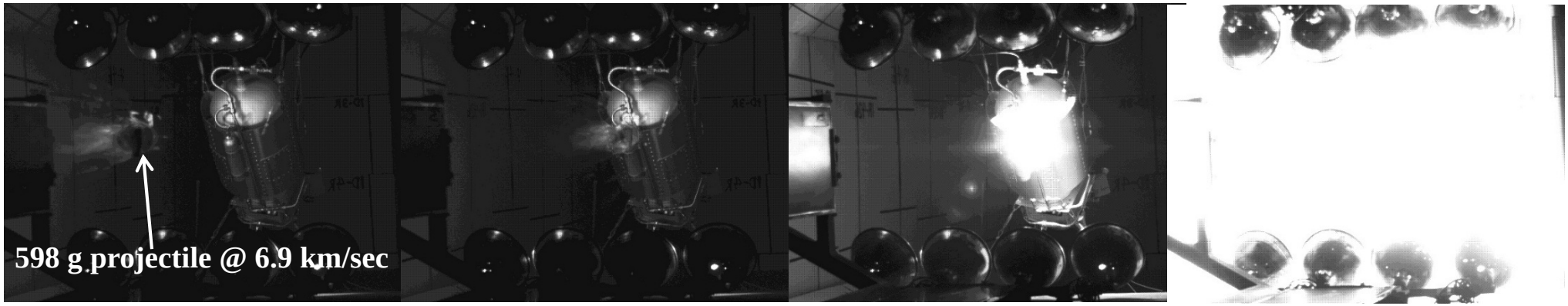
- **The objective is to characterize the physical properties of impact fragments to improve satellite breakup models and space situational awareness.**





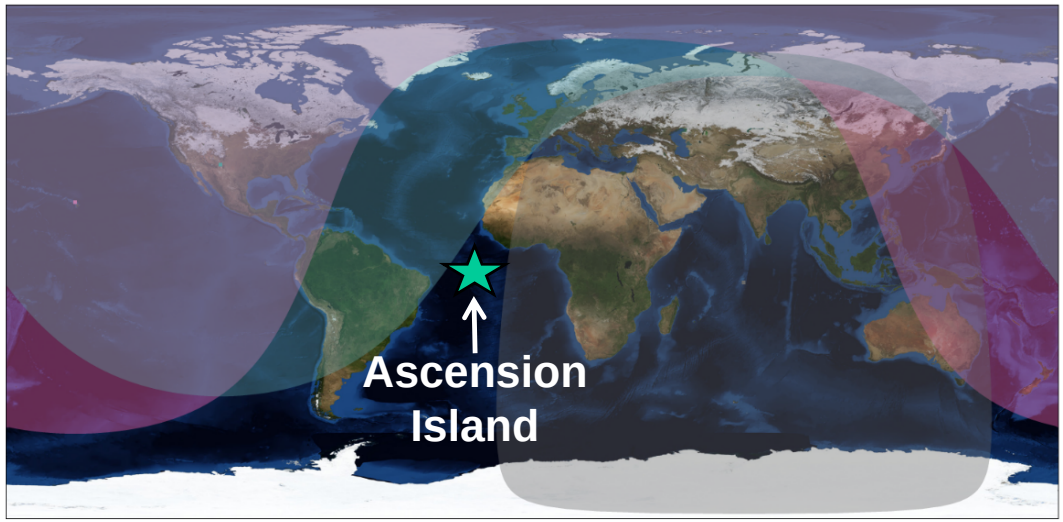
Hypervelocity Impact Sequences

- **Hypervelocity impacts of the two targets were successfully carried out at the Arnold Engineering Development Complex in April 2014.**
- **Fragment processing and measurements are currently underway.**



Meter Class Autonomous Telescope (MCAT)

- **NASA, the U.S. Air Force, and the Air Force Research Laboratory are building a new 1.3-m debris telescope to be deployed on Ascension Island.**
  - Groundbreaking for the observatory occurred in October 2014.
  - Operations will start in late 2015.
  - The telescope will be operated remotely from NASA JSC.
- **The low latitude of the site will permit observations of low inclination debris at all altitudes.**
  - Debris as small as 10 cm in GEO should be detectable.



In-Situ Measurements of Small Debris

- **NASA, the U.S. Naval Academy, the U.S. Naval Research Laboratory, Virginia Tech, and the University of Kent (Great Britain) are developing new technologies for in-situ measurements of small debris from space.**

- **A new system, Debris Resistive/Acoustic Grid Orbital Navy-NASA Sensor (DRAGONS), has been approved by the International Space Station (ISS) Program for a 2017 deployment on the ISS.**

- **DRAGONS combines several particle impact detection principles to measure time, location, speed, direction, energy, and the size of each impacting particle to improve the environment definition for the millimeter and smaller debris population.**

Planned location for DRAGONS