Overview of the Orbital Debris Problem

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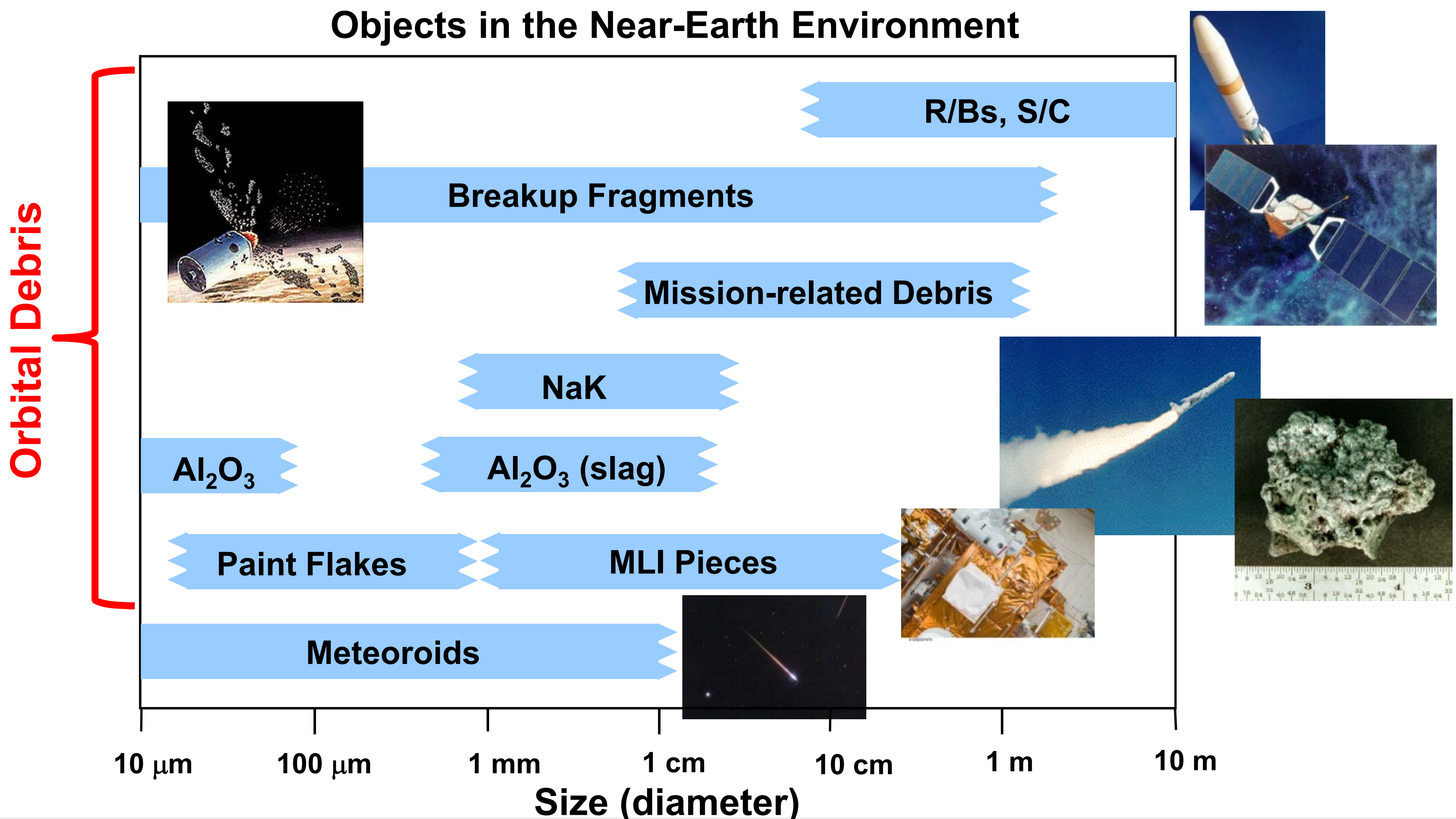
Outline

- **An Overview of the Orbital Debris Environment**
  - Historical and current environment
  - Mitigation and remediation
- **The NASA Orbital Debris Program Office and Highlights of Its Recent Activities**
  - Roles and responsibilities
  - Recent activities

What is Orbital Debris?

- **Orbital debris is any human-made object in orbit about the Earth that no longer serves any useful purpose**



How Much Junk is Currently up There?

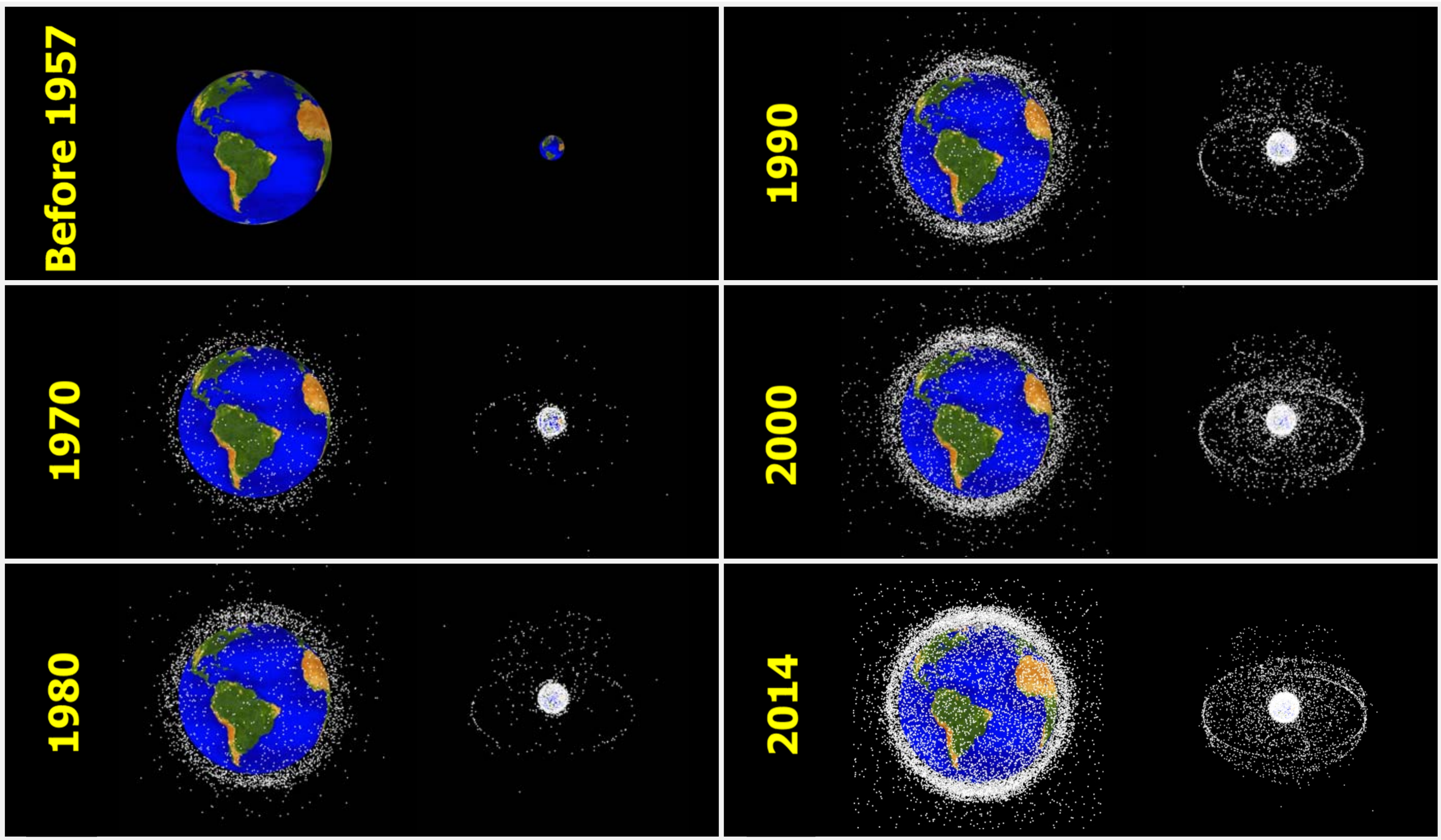
Softball size or larger (≥10 cm): ~23,000
(tracked by the U.S. Space Surveillance Network, SSN)

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

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

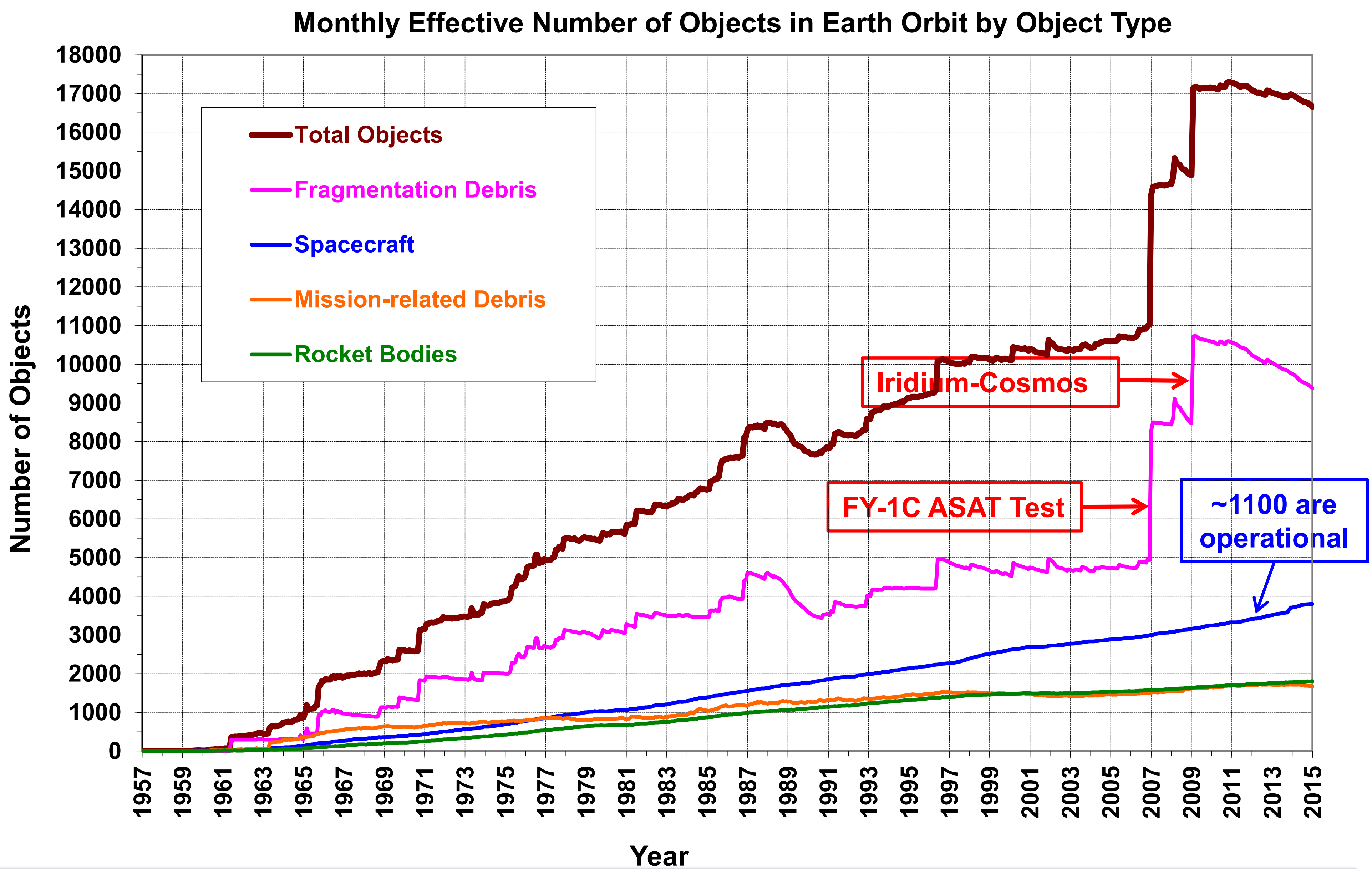
- **Due to high impact speeds in space (~10 km/s in LEO), even sub-millimeter debris pose a realistic threat to human spaceflight and robotic missions**
  - **7 km/sec = 25,200 km/hr; 10 km/sec = 36,000 km/hr**
  - **1-cm Al sphere @ 10 km/s = 200 kg safe @ 90 mph**
  - **5-mm Al sphere @ 7 km/sec could penetrate a 2.54 cm thick Al wall**
- **Total mass: ~6300 tons LEO-to-GEO (~2700 tons in LEO)**

The Near-Earth Environment (1957-2014)

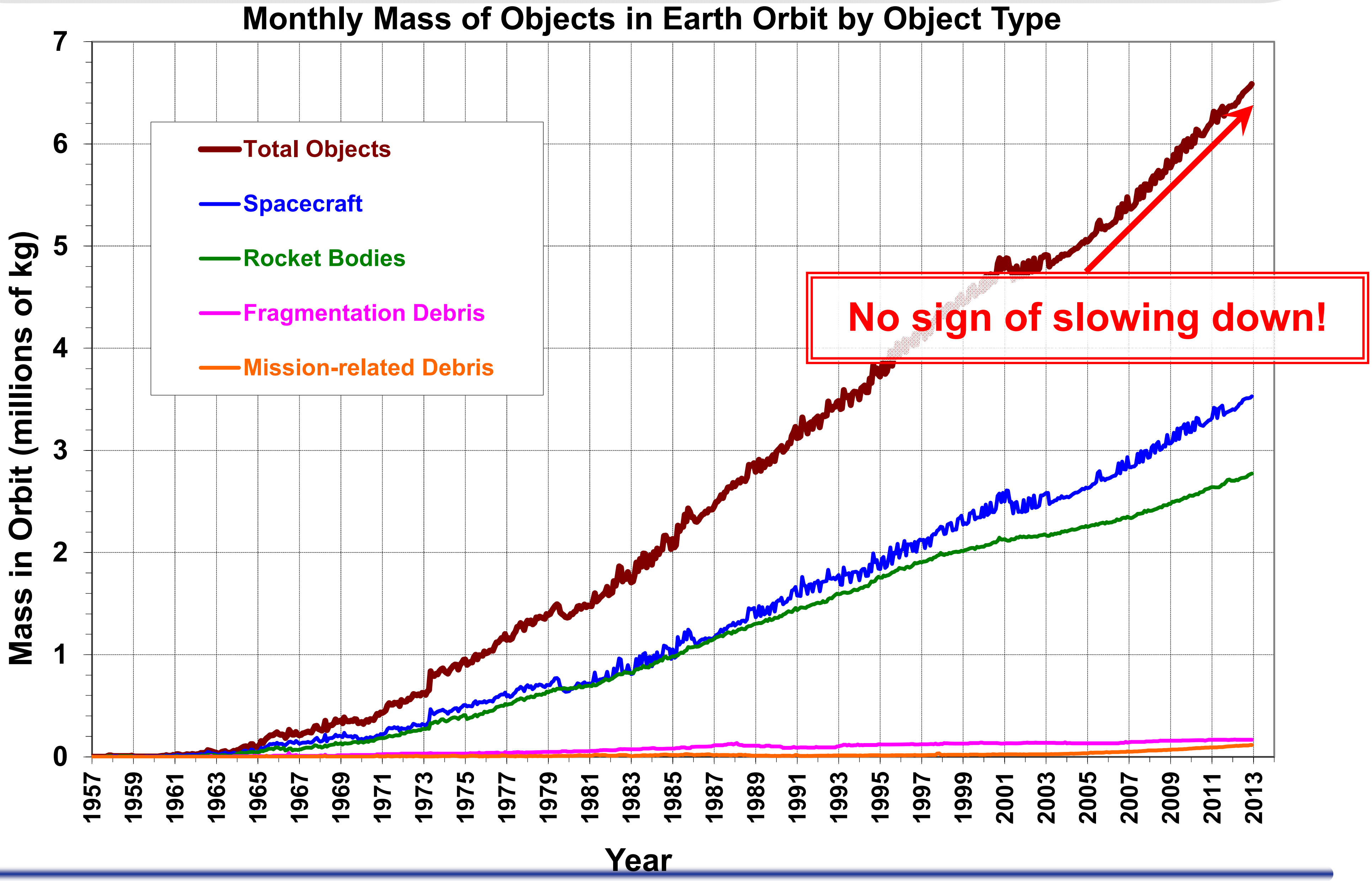


- **Only objects in the U.S. satellite catalog (~10 cm and larger) are shown**
- **Sizes of the dots are not to scale**

Growth of the Cataloged Populations

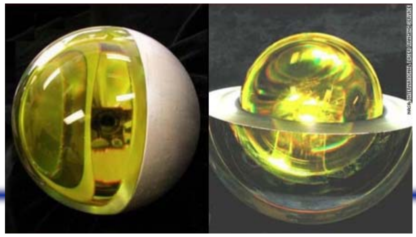


Mass in Space

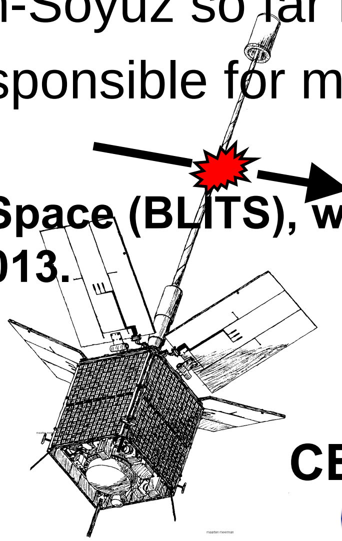


Threat from Orbital Debris

- **The threat from orbital debris is real**
  - The gravity-gradient boom of an operational French satellite (CERISE) was cut in half by a tracked debris in 1996.
  - The fully operational Iridium 33 was destroyed by a retired Russian satellite 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).
  - The ISS conducted 5 collision avoidance maneuvers (DAMs) against tracked debris in 2014; 3 DAMs and 1 shelter-in-Soyuz so far in 2015.
  - Impacts by small, untracked debris could be responsible for many satellite anomalies.
    - **A 17-cm Russian retro reflector, Ball Lens In The Space (BLITS), was damaged and shed a piece of trackable debris in January 2013.**

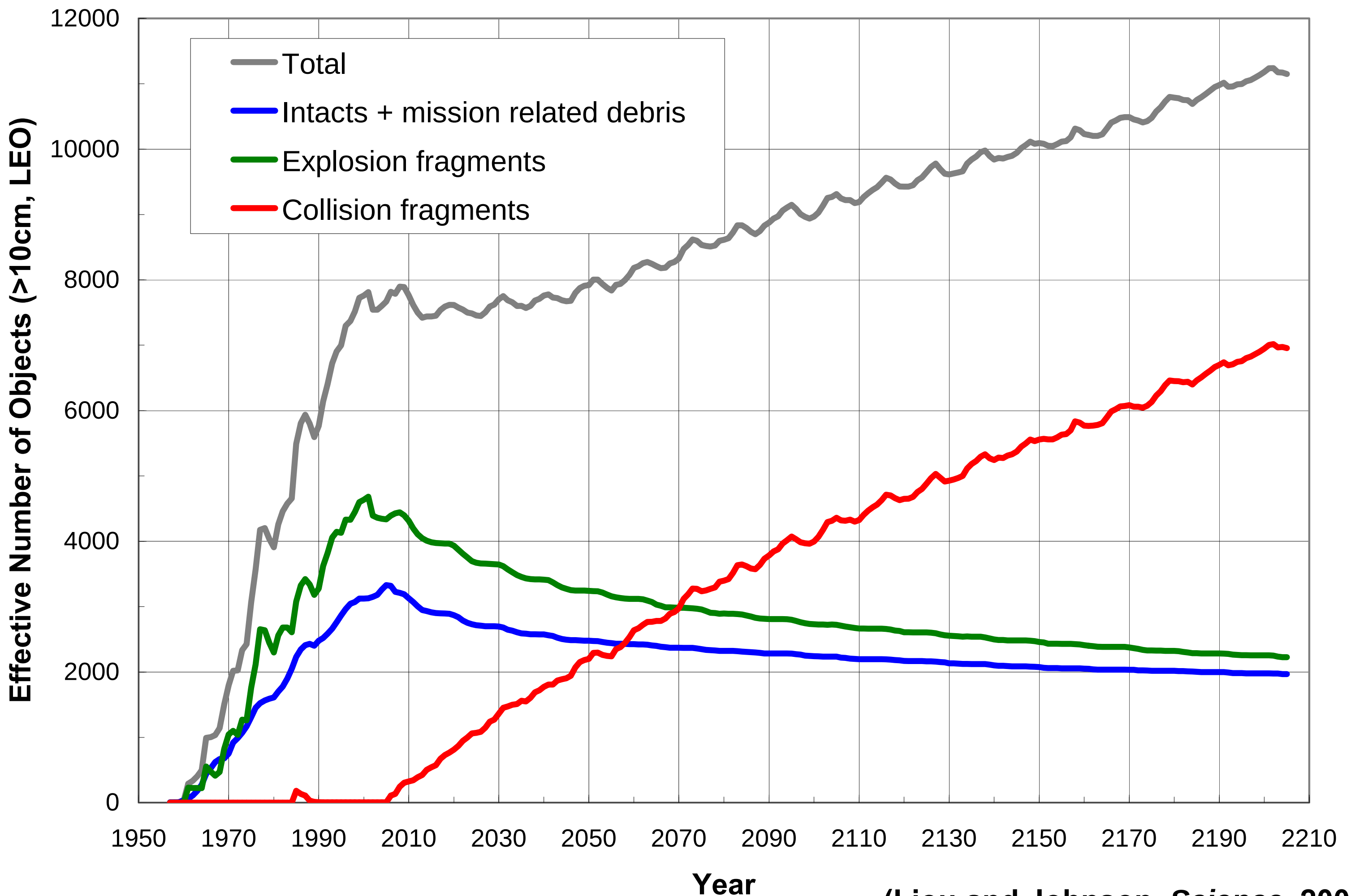


BLITS



CERISE

LEO Env Projection – the Best Case Scenario
(No New Launches Beyond 1/1/2006)



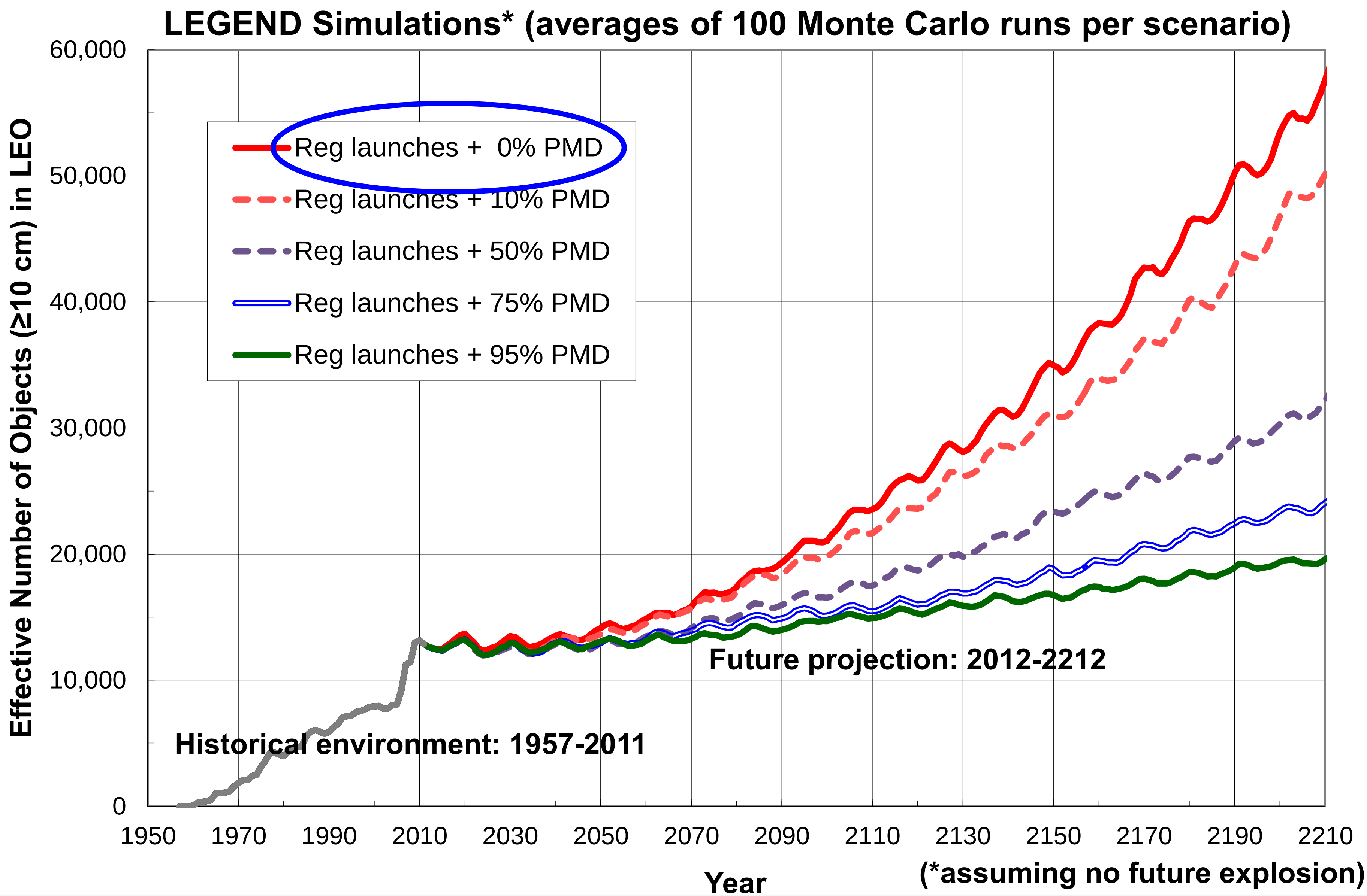
(Liou and Johnson, *Science*, 2006)

- **Collision fragments replace other decaying debris through the next 50 years, keeping the total population approximately constant**
- **Beyond 2055, the rate of decaying debris decreases, leading to a net increase in the overall satellite population due to collisions**

A Realistic Assessment of LEO Environment

- In reality, the situation will be worse than the "no new launches" scenario because global space activities will continue.
- Post-mission disposal (such as a 25-year decay rule) will help, but will be insufficient to prevent the self-generating phenomenon from happening.
- To preserve the near-Earth space for future generations, remediation measures, such as Active Debris Removal (ADR), must be considered.

Projected LEO Population Growth



Orbital Debris Environment Management

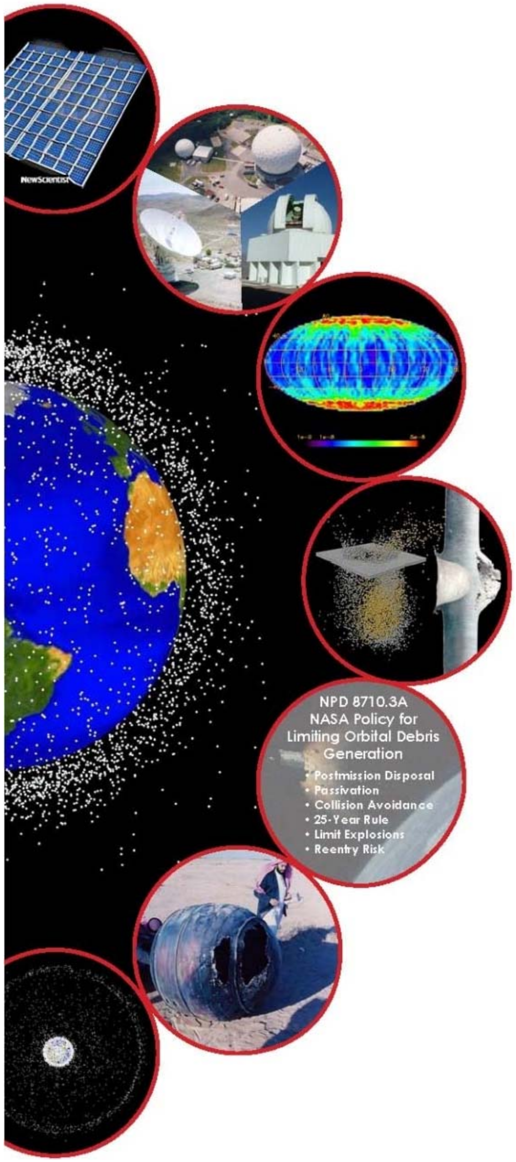
- **“Prevention is better than cure”**
  - (*Prov*.) It is better to try to keep a bad thing from happening than it is to fix the bad thing once it has happened
- **“An ounce of prevention is worth a pound of cure”**
  - (*Prov*.) It is better/cheaper to stop something bad happening than it is to deal with it after it has happened

- **Orbital Debris Mitigation = Prevention**
- **Orbital Debris Remediation = Cure**

- **The global space community must comply with existing mitigation guidelines/requirements and develop long-term remediation strategies to preserve the near-Earth space environment for future generations**

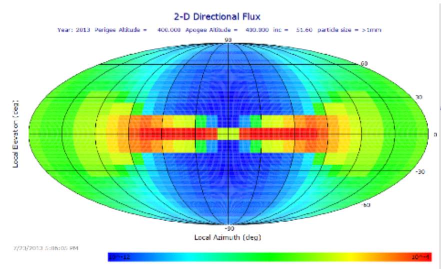
The NASA Orbital Debris Program Office

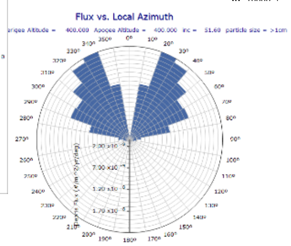
NASA’s Orbital Debris Research Program

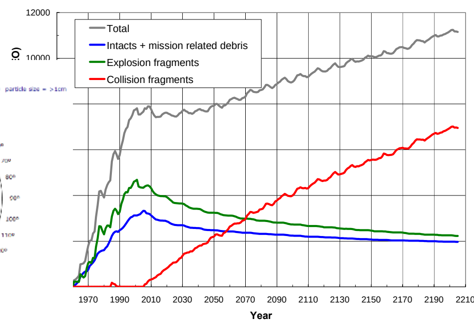


- **The NASA Orbital Debris Program Office (ODPO) is the only organization in the US Government conducting a full range of research on orbital debris**
  – This unique NASA capability was established at JSC in 1979 (D. Kessler, B. Cour-Palais, H. Zook, etc.)
  – ODPO’s roles and responsibilities are defined in NPD8700.1 and NPR 8715.6A
  – ODPO is currently funded through HQ/OSMA
- **Provide technical and policy level support to NASA HQ, OSTP, other U.S. Government agencies and the commercial sector**
- **ODPO represents the U.S. Government in international fora, including the United Nations and the Inter-Agency Space Debris Coordination Committee (IADC)**
- **Recognized as world leader in environment definition and modeling and in mitigation policy development**

End-to-End Orbital Debris Activities at ODPO







Measurements
Radar
Optical
In-situ
Laboratory

→

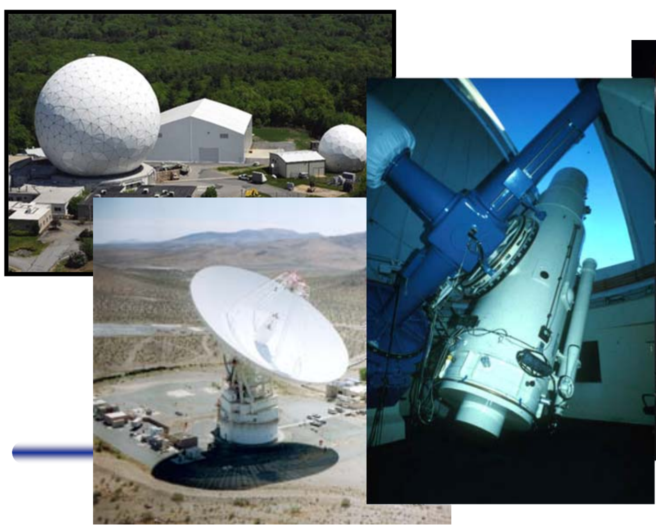
Modeling
Breakup
Engineering
Evolutionary
Reentry

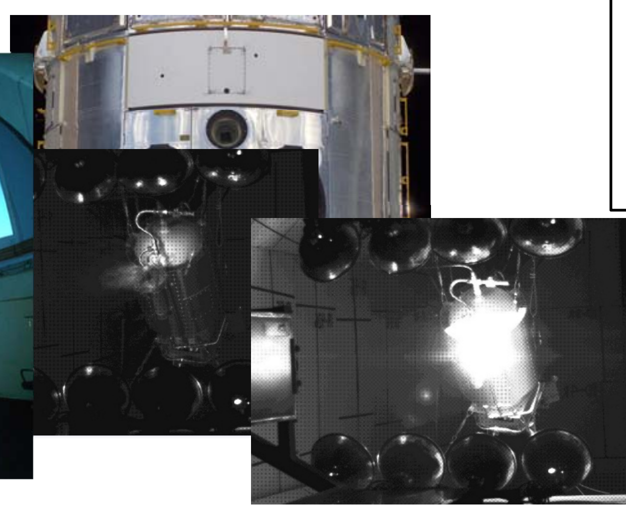
→

Environment Management
Mitigation
Remediation
Policy
Mission Compliance

Coordination
U.S. Government
IADC
United Nations

Risk Assessment
Space assets
(ISS, Orion, etc)
Reentry



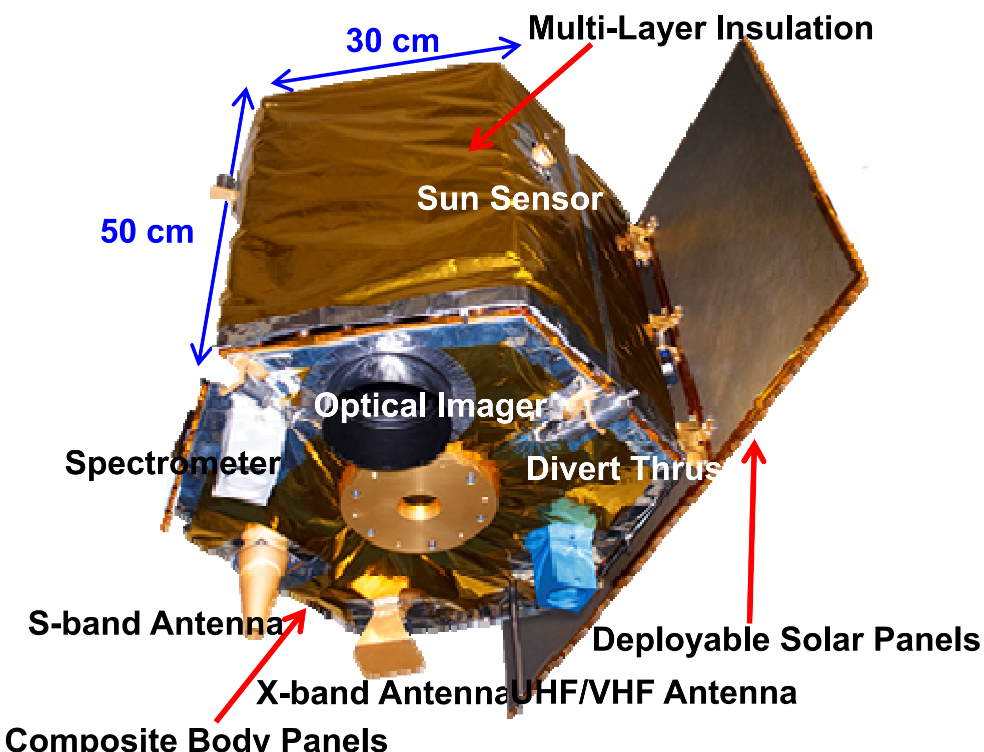


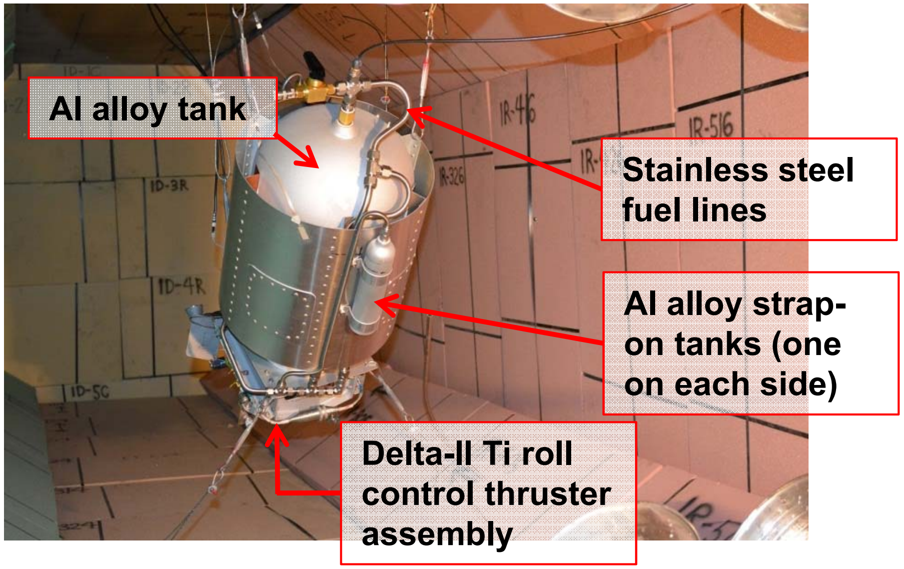
NASA Mission Requirements on Orbital Debris

- **NASA was the first organization to lead the development of orbital debris mitigation measures in the 1990s.**
- **NASA and DoD led the effort to establish the 2001 U.S. Government Orbital Debris Mitigation Standard Practices.**
  - The U.S. National Space Policy of 2006 and 2010 directs agencies and departments to implement the Standard Practices.
- **U.S. has endorsed the United Nations' Orbital Debris Mitigation Guidelines.**
- **In compliance with the above, NASA has established NPR 8715.6A, *NASA Procedural Requirements for Limiting Orbital Debris*, and NS 8719.14, *Process for Limiting Orbital Debris* for NASA missions.**
  - Formal Orbital Debris Assessment Reports (ODARs) are due to NASA HQ in conjunction with the PDR and CDR milestones.

Lab-based Satellite Impact Experiments

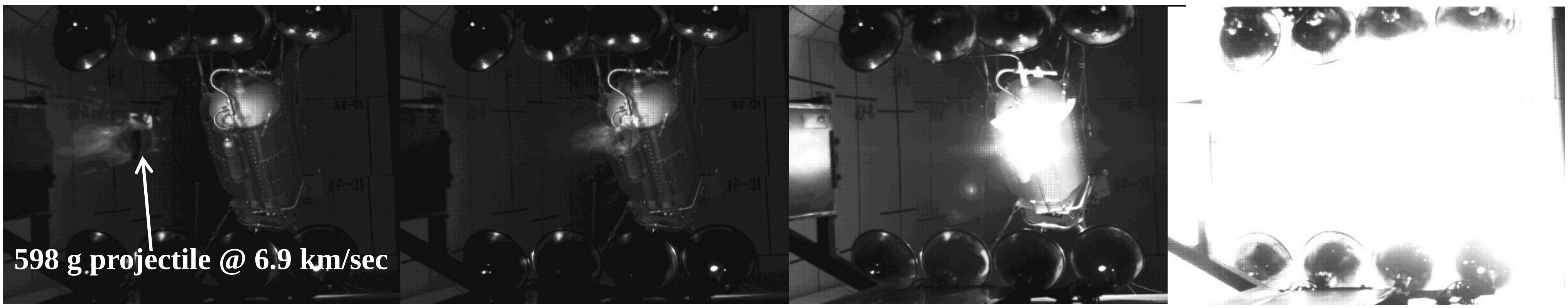
- The "DebriSat" project is a collaboration among NASA, the U.S. Air Force, The Aerospace Corporation, and the University of Florida for laboratory-based hypervelocity impact experiments on a representative, modern LEO satellite and an upper stage mockup.
- The objective is to characterize the physical properties of impact fragments to improve satellite breakup models and space situational awareness.





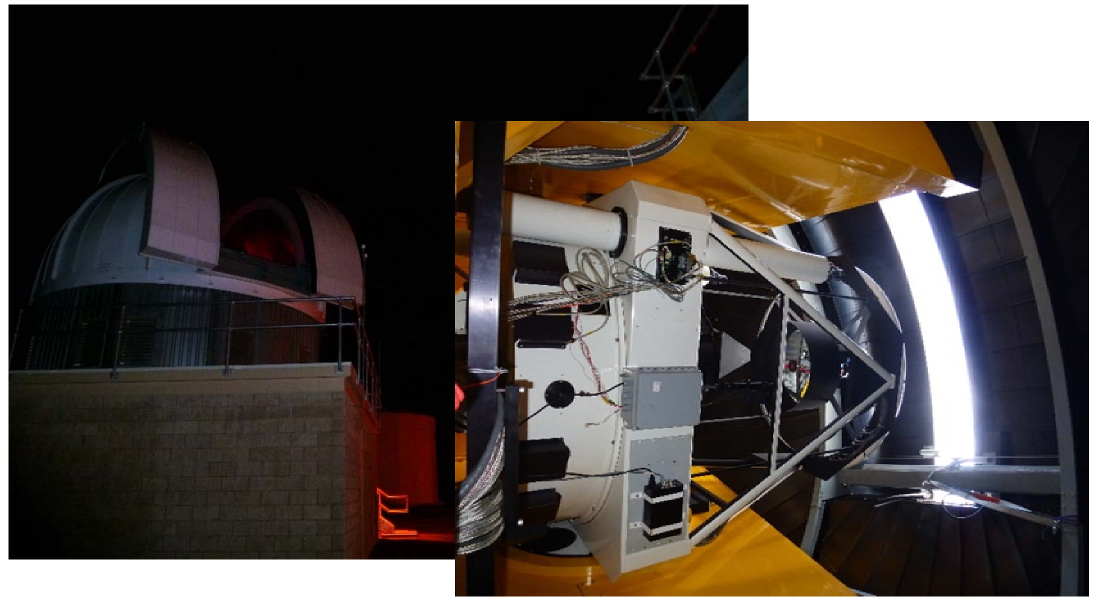
Hypervelocity Impact Sequences

- 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.



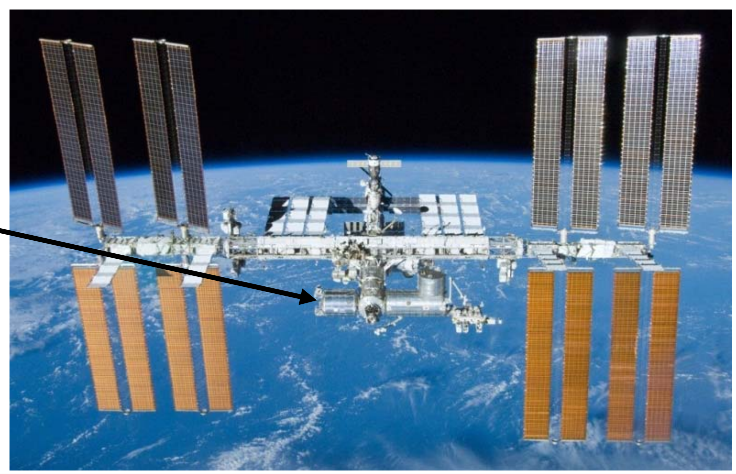
Meter Class Autonomous Telescope (MCAT)

- **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.**
  - Completed construction and acquired first light in June 2015.
  - Full operations will start in 2016.
  - Telescope autonomously collects data; remotely managed from NASA JSC.
- **The low latitude of the site will permit observations of low inclination debris at all altitudes.**
  - Debris as small as 13 cm (0.175 albedo) 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 February 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

Questions?