# USA Space Debris Environment, Operations, and Research Updates


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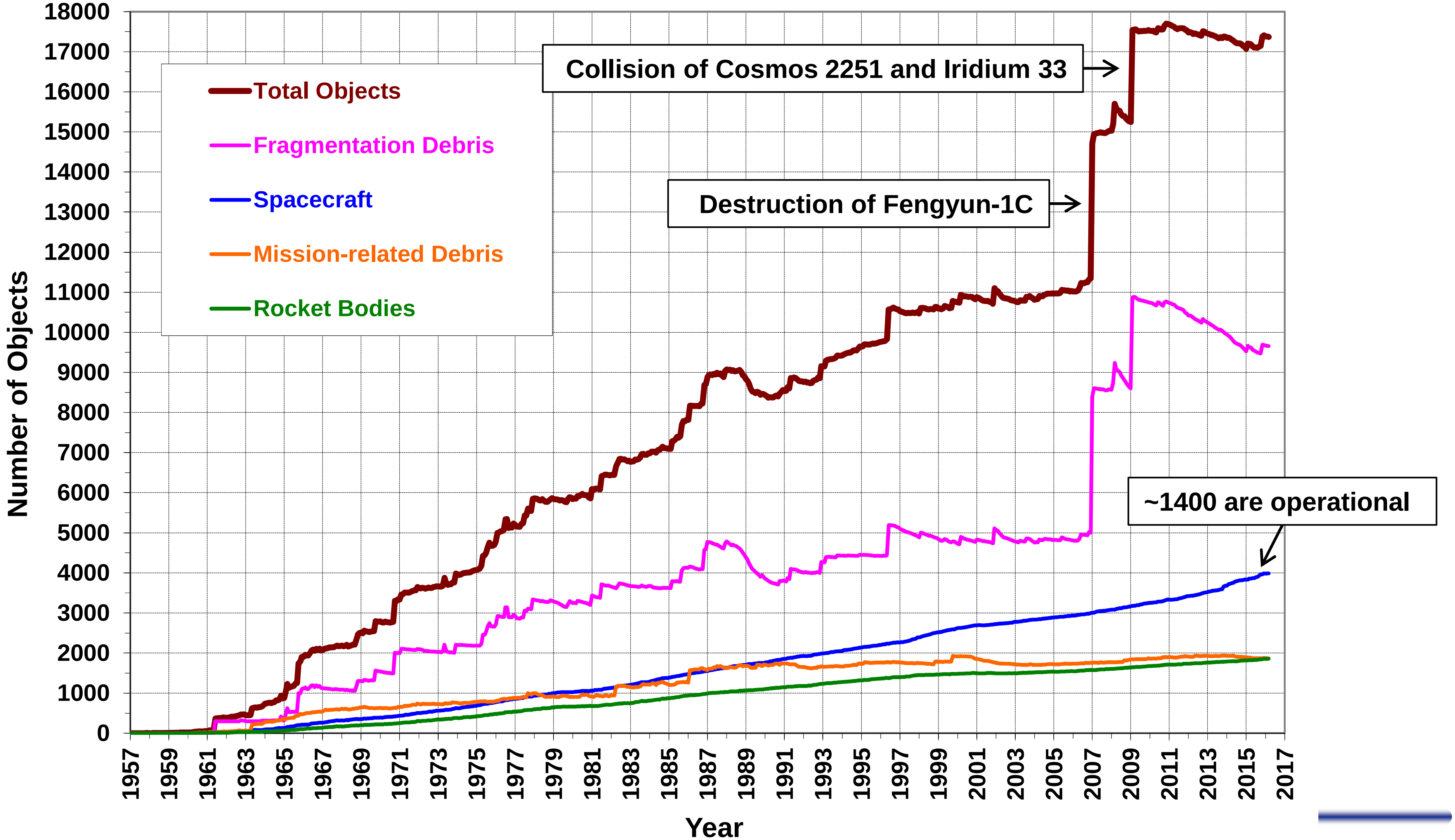
# Presentation Outline

- **Earth Satellite Population**
- **Space Missions in 2014**
- **Satellite Fragmentations**
- **Collision Avoidance Maneuvers**
- **Satellite Reentries**
- **NASA CubeSat Study and SDS Development**

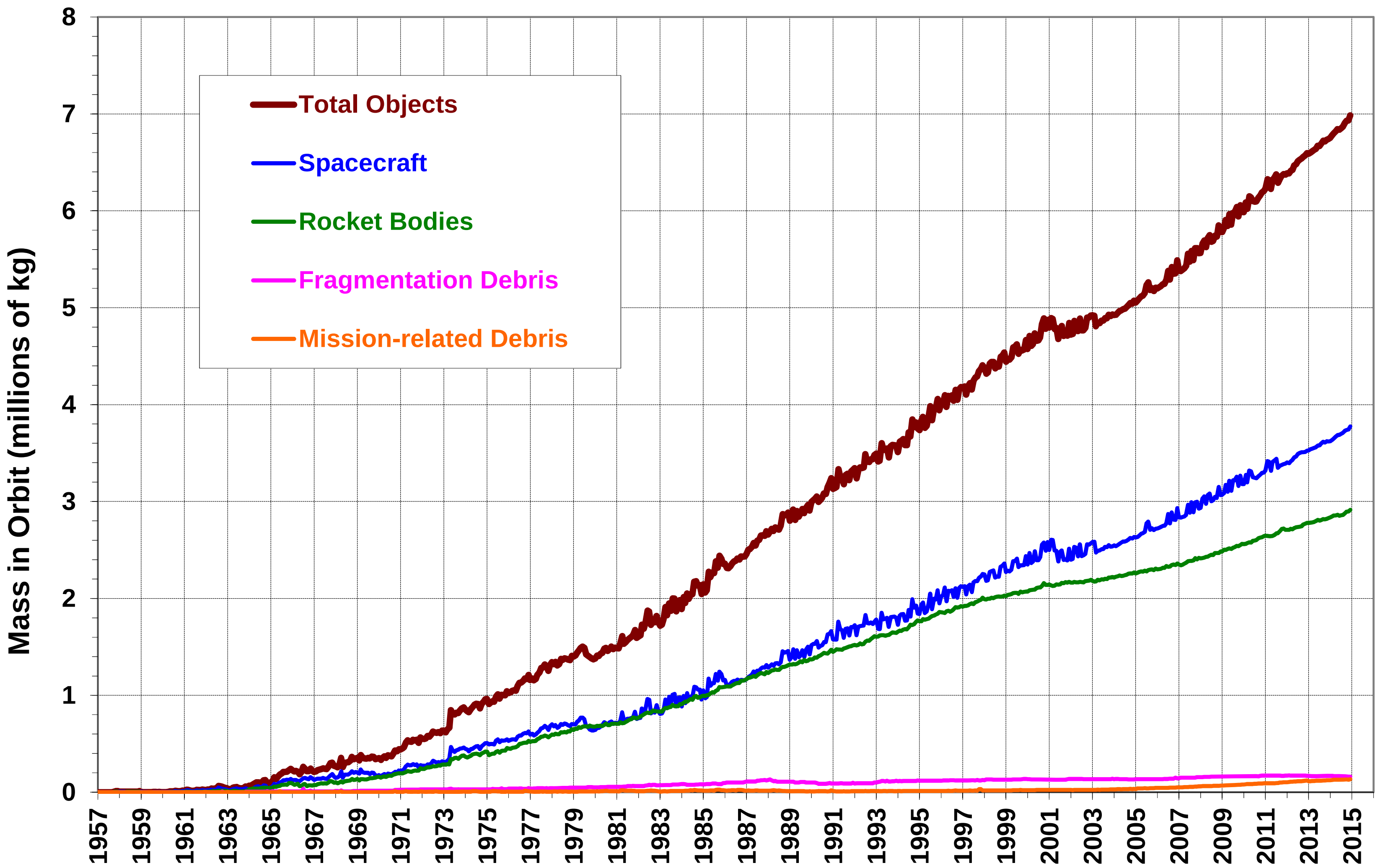
# Evolution of the Cataloged Satellite Population

- **According to the U.S. Satellite Catalog, the number of 10 cm and larger objects in Earth orbit increased slightly in 2016.**



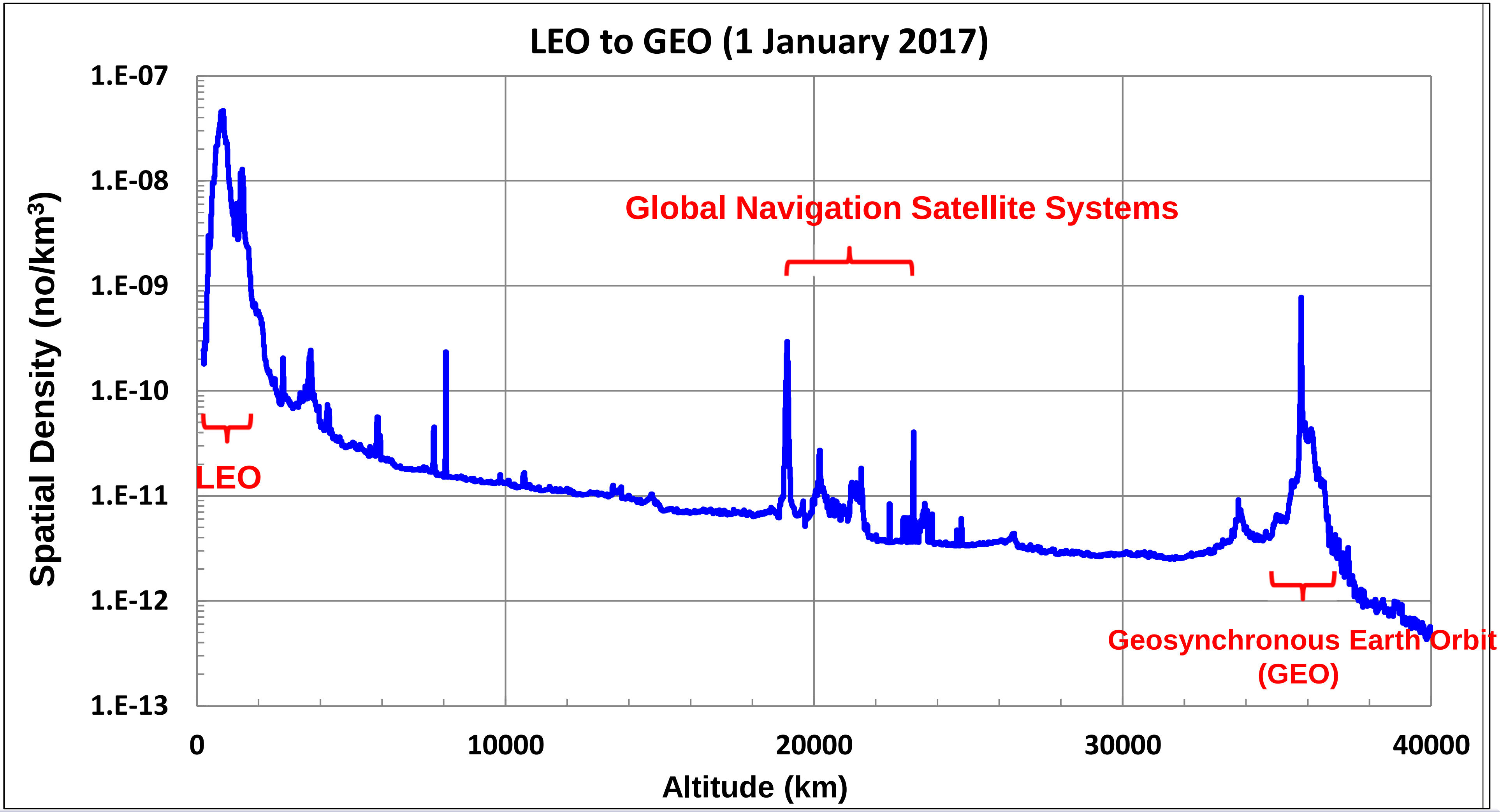
# Mass in Near-Earth Space Continued to Increase

- **The material mass in Earth orbit continued to increase in 2016.**



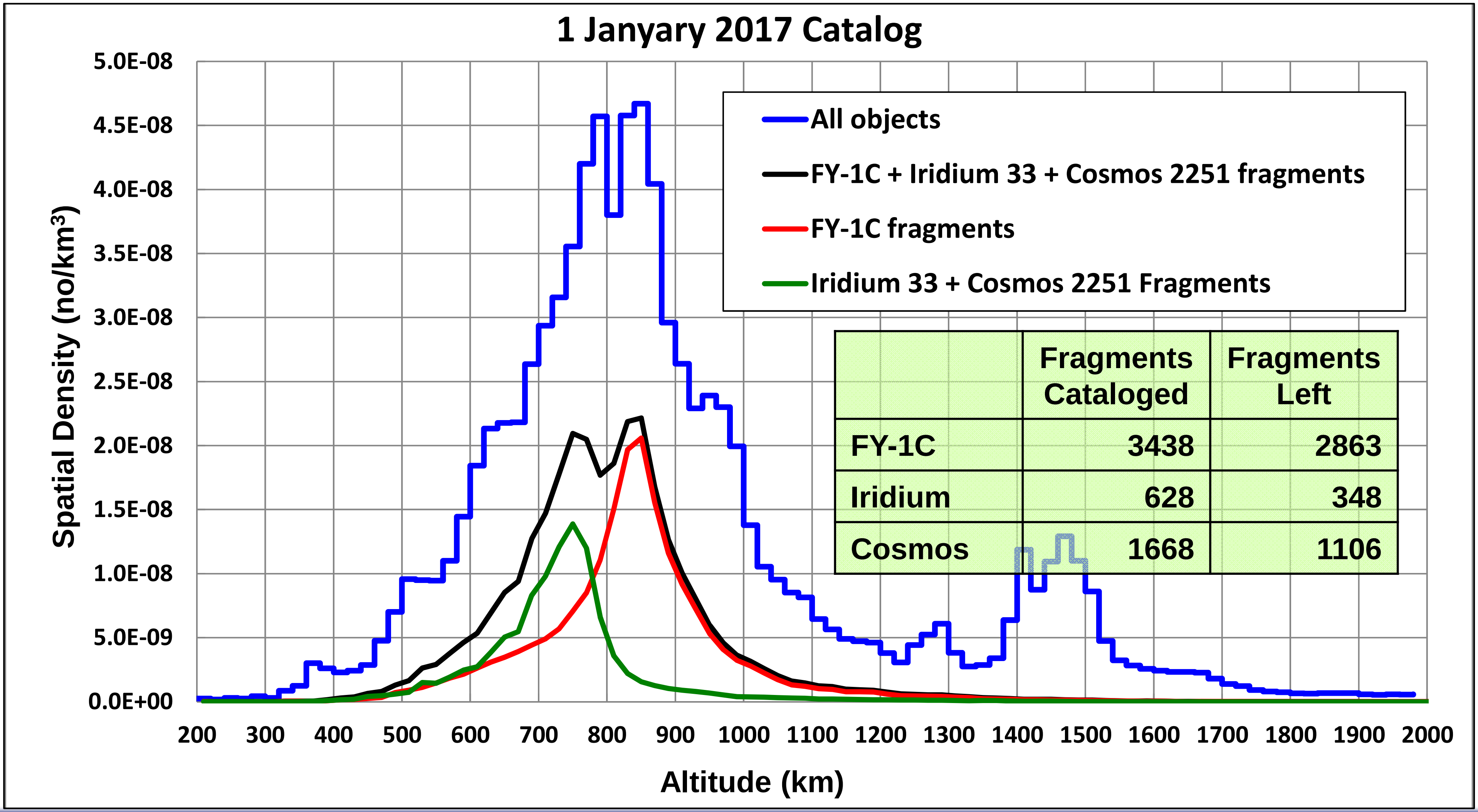
# Distribution of the Cataloged Objects, LEO-to-GEO

- **The low Earth orbit (LEO, the region below 2000 km altitude) has the highest concentration of the cataloged objects.**



# Distribution of the Cataloged Objects in LEO

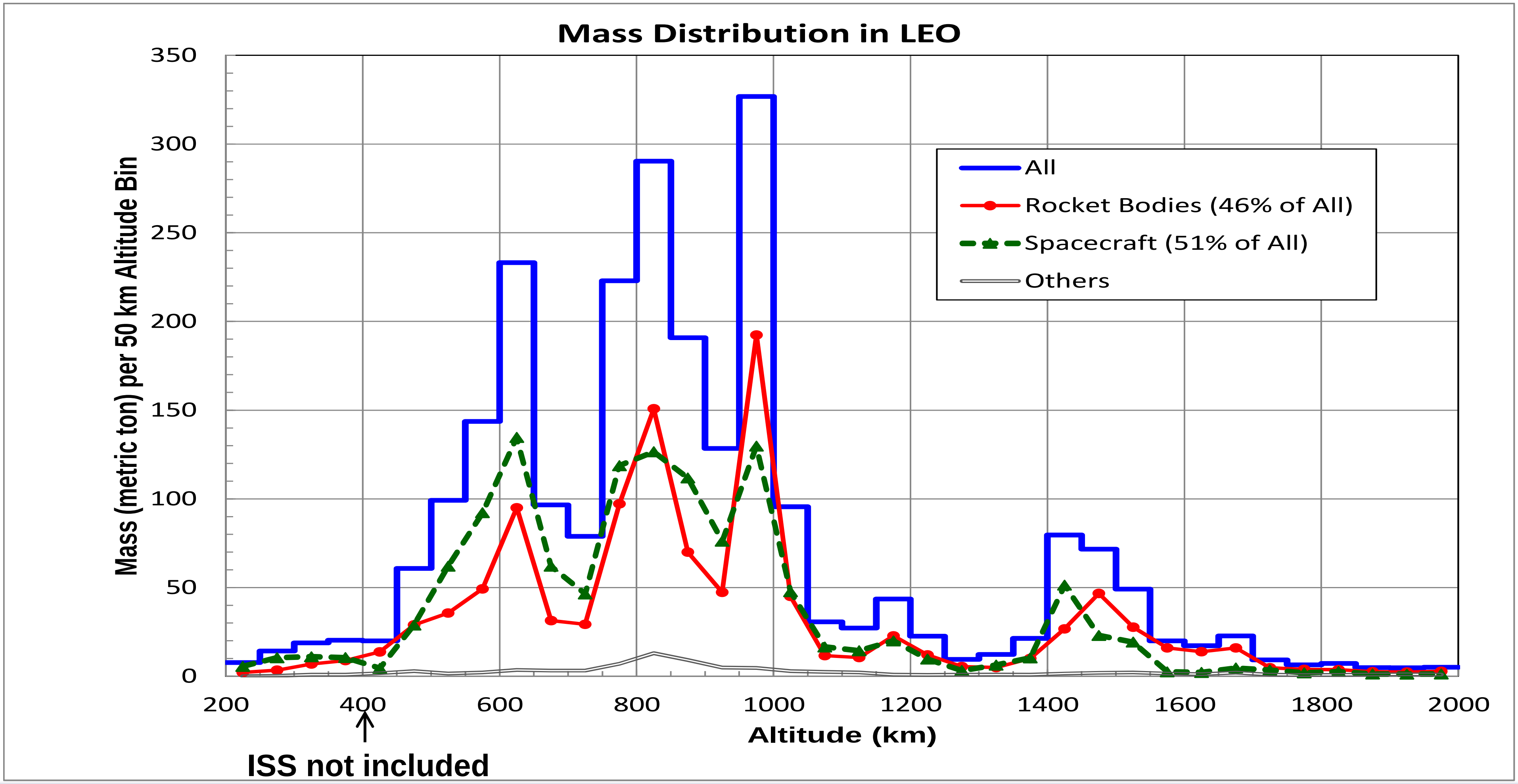
- **The LEO population is still heavily influenced by fragments from Fengyun-1C (FY-1C), Iridium 33, and Cosmos 2251.**




| | Fragments Cataloged | Fragments Left |
|---|---|---|
| FY-1C | 3438 | 2863 |
| Iridium | 628 | 348 |
| Cosmos | 1668 | 1106 |

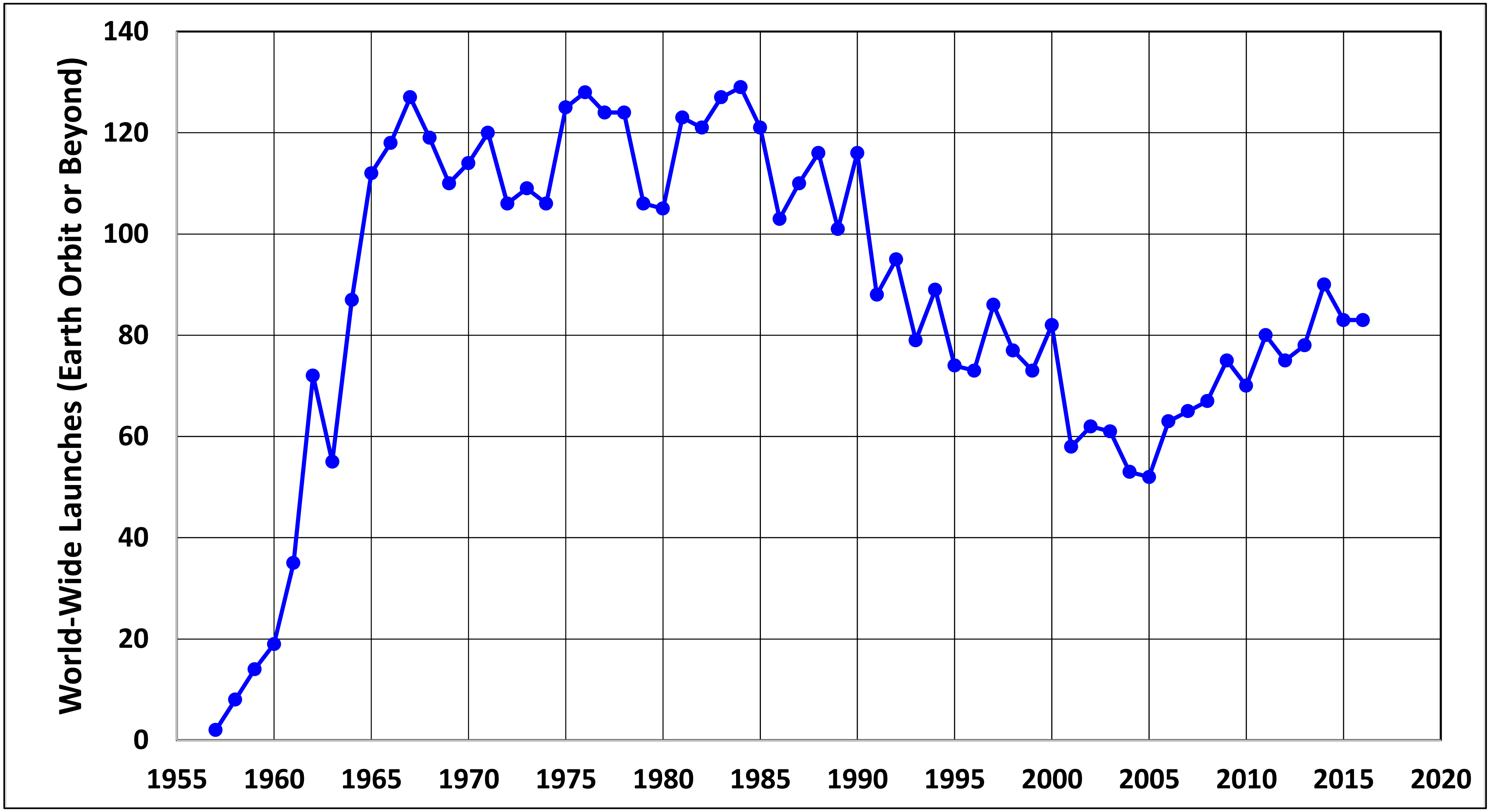
# Mass Distribution in LEO

- **Mass distribution is dominated by rocket bodies and spacecraft. The proposed mega-constellations, consisting of thousands of ~150-kg-class spacecraft, will dramatically change the landscape in LEO.**



# Worldwide Space Activity in 2016

- **A total of 83 space launches placed more than 150 spacecraft into Earth orbits during 2016, following the trend of increase over the past decade.**



# Satellite Fragmentations During 2016

- **Twelve minor satellite fragmentations were detected by the U.S. Space Surveillance Network during 2016. 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 |
|---|---|---|---|---|---|
| Breeze-M R/B | 2015-075B | 33,484 | 35,730 | 6 | Unknown |
| Astro-H (Hitomi) | 2016-012A | 566 | 580 | 10 | Unknown |
| SOZ Ullage Motor | 2008-067G | 679 | 18,845 | 21 | Propulsion |
| Molniya 1-93 | 2004-005A | 77 | 2,145 | 13 | Aerodynamic |
| SOZ Ullage Motor | 2008-067H | 728 | 18,801 | 30+ | Propulsion |
| Beidou G2 | 2009-018A | 35,384 | 36,137 | 2 | Unknown |
| Worldview 2 | 2009-055A | 765 | 767 | 9 | Unknown |
| SOZ Ullage Motor | 2006-062G | 458 | 19,067 | 8 | Propulsion |
| Sentinel-1A | 2014-016A | 695 | 697 | 7 | Small debris impact |
| RISAT-1 | 2012-017A | 535 | 544 | 16 | Unknown |
| FY-1C fragment | 1999-025KF | 809 | 902 | 8 | Unknown |
| DMSP 5D-2/F12 | 1994-057A | 833 | 849 | 1 | 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 2016 NASA executed or assisted in the execution of 20 collision avoidance maneuvers by robotic spacecraft.**
  - Four maneuvers were conducted to avoid debris from Fengyun-1C.
  - Four maneuvers were conducted to avoid debris from the collision of Cosmos 2251 and Iridium 33.

# Satellite Reentries in 2016

- **More than 250 reentries of spacecraft, launch vehicle upper stages, and other cataloged debris were recorded by the U.S. Space Surveillance Network during 2016.**
  - Due to the low solar activities, the number of reentries was lower than previous years.
  - Spacecraft: 68; upper stages: 39; other debris: 146 (including 58 reentries of the Fengyun 1C, Iridium 33, and Cosmos 2251 fragmentation debris).
  - One of the reentered fragments appears to be the largest fragment from the disintegration of PAGEOS-1 (Passive Geodetic Earth Orbiting Satellite), a 30.5-meter diameter inflatable balloon initially deployed to 4200 km altitude in 1966.

**Test inflation of PAGEOS**

- **The total mass of the 2016 reentries was more than 50 metric tons.**
- **No accounts of personal injury or significant property damage were reported.**

# Disposal of USA Spacecraft in GEO

- **Four USA civil and commercial spacecraft completed operations in GEO in 2016.**
- **All of them, including the Geostationary Operational Environmental Satellite 3 (GOES-3), were launched years to decades before the establishment of the UN COPUOS Space Debris Mitigation Guidelines in 2007.**
- **All four spacecraft maneuvered to disposal orbits above GEO in compliance with the UN COPUOS Space Debris Mitigation Guidelines to protect the GEO region.**

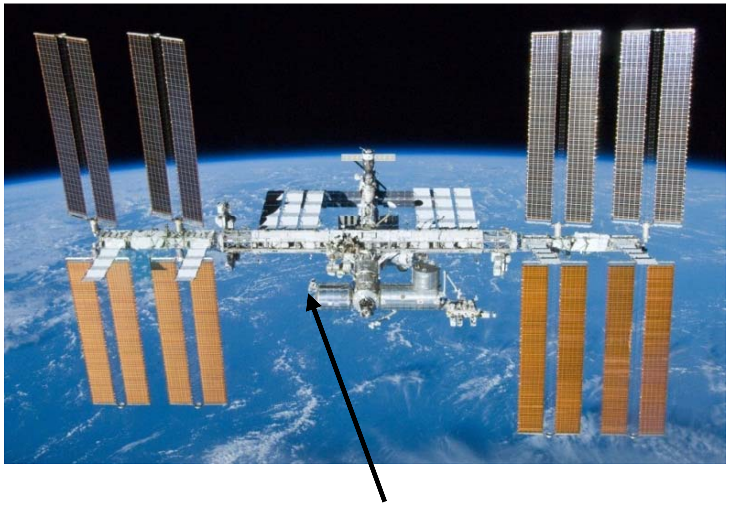
| Spacecraft | International Designator | Minimum Height above GEO | Maximum Height above GEO |
|---|---|---|---|
| Intelsat 7 | 1998-052A | 577 km | 599 km |
| XM-1 | 2001-018A | 360 km | 364 km |
| Intelsat 8 | 1998-065A | 165 km | 3043 km |
| GOES-3 | 1978-062A | 245 km | 267 km |

# NASA CubeSat Study

- **The NASA Orbital Debris Program Office recently completed a study to quantify the potential negative effects to the future LEO environment from large deployments of CubeSats.**
  - Two benchmark cases with different 25-year decay compliance levels, but with no CubeSats deployed in the future, were established as baseline.
  - Comparison cases included adding various CubeSat future deployment scenarios to the nominal background.
  - The NASA orbital debris evolutionary model, LEGEND, was used for the simulations. Each scenario was carried out for a 200-year projection and repeated with 100 Monte Carlo runs.
  - Based on the study scenario comparisons, (1) CubeSats contribute very little to the future mass increase in LEO and (2) a good compliance of the 25-year decay rule appears to be an effective means to mitigate the effects from CubeSats to the environment.

# Measurements of Small Debris From the ISS

- **NASA has led the development of innovative small debris in-situ measurement technologies since 2002**
  - Integration and pre-flight testing of the Space Debris Sensor (SDS) have been completed. SDS is ready for deployment on the International Space Station (ISS) in late 2017 or early 2018.
  - The mission will collect sub-millimeter debris data near the ISS and mature the technologies for future mission opportunities to collect millimeter-sized debris data at high LEO altitudes.



Planned SDS location


SDS flight unit

SDS ready for launch at NASA KSC