An Analysis of Recent Major Breakups in the Low Earth Orbit region

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61st International Astronautical Congress
27 September – 1 October 2010

Outline

- **Four recent major breakup events**
  - Fengyun-1C (FY-1C), Briz-M, Cosmos 2421, Iridium 33, Cosmos 2251
  - The analysis is limited to objects in the SSN catalog and is based on data available as of September 2010
    - **Fragment size and A/M distributions**
    - **Orbital lifetime and long-term environment impact**

A Summary of the Events

Satellite	Breakup Time	Satellite Mass (kg)	Altitude (km)	Debris Cataloged (Left)	Cause
FY-1C	Jan 2007	950	850	3037 (2944)	Deliberate Collision
Briz-M	Feb 2007	2600	7600	92 (88)	Explosion
Cosmos 2421	Mar 2008	3000	410	509 (13)	Unknown
Iridium 33	Feb 2009	560	790	528 (499)	Accidental Collision
Cosmos 2251	Feb 2009	900	790	1347 (1287)	Accidental Collision

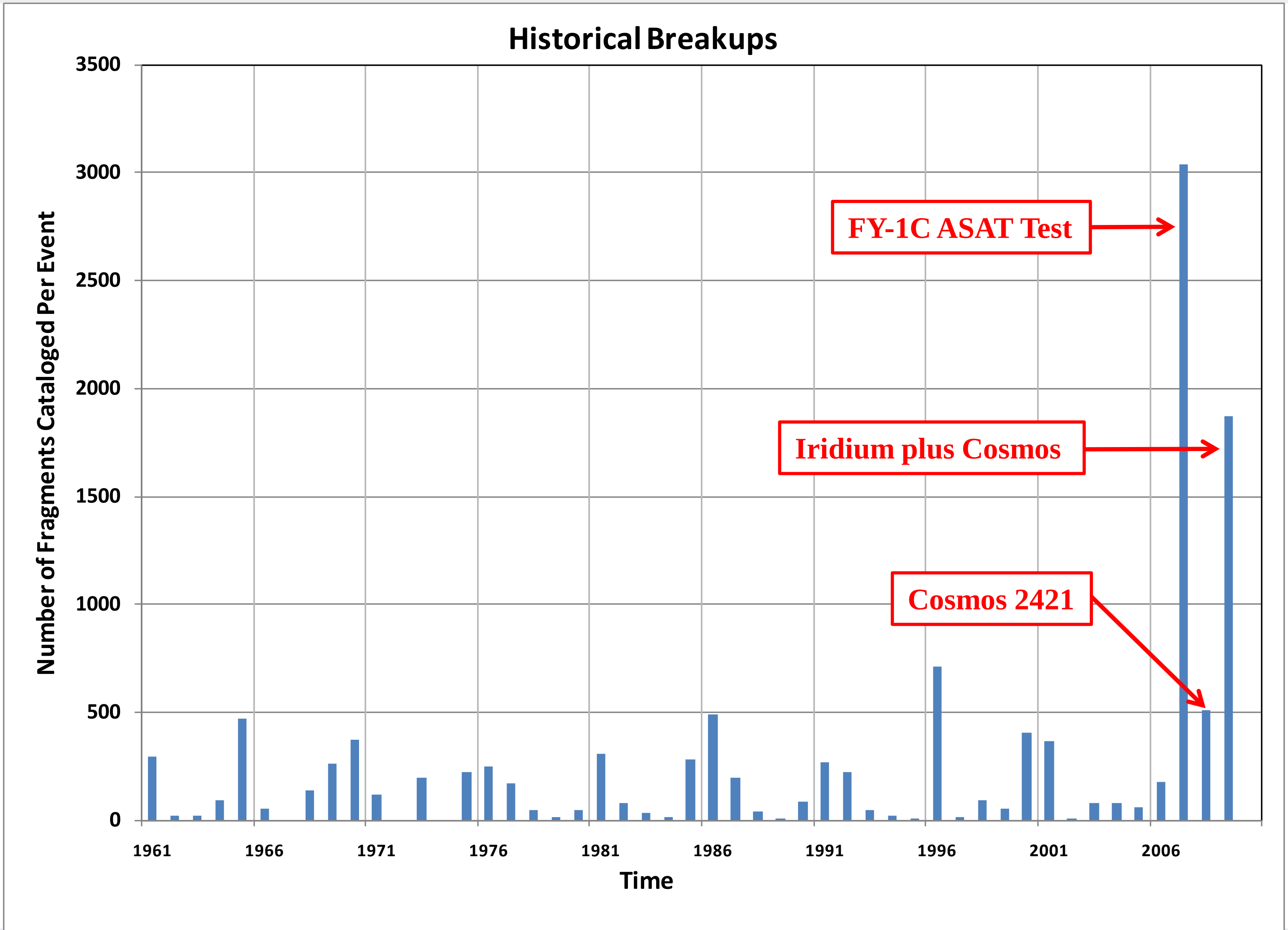
Brief Descriptions of the Events (1/2)

- **FY-1C anti-satellite test**
  - Worst on-orbit fragmentation ever
  - Due to the high breakup altitude, fragments will remain in orbit for decades to come
- **Briz-M explosion**
  - Initial observations suggested more than 1000 detectable fragments were generated
  - Due to man-power limitation and sensor availability, only 92 fragments have been cataloged
- **Cosmos 2241 fragmentation**
  - Last member of the Russian Cosmos 699-class spacecraft with a long history of fragmentation due to unknown causes
  - Majority (>97%) of the fragments have decayed

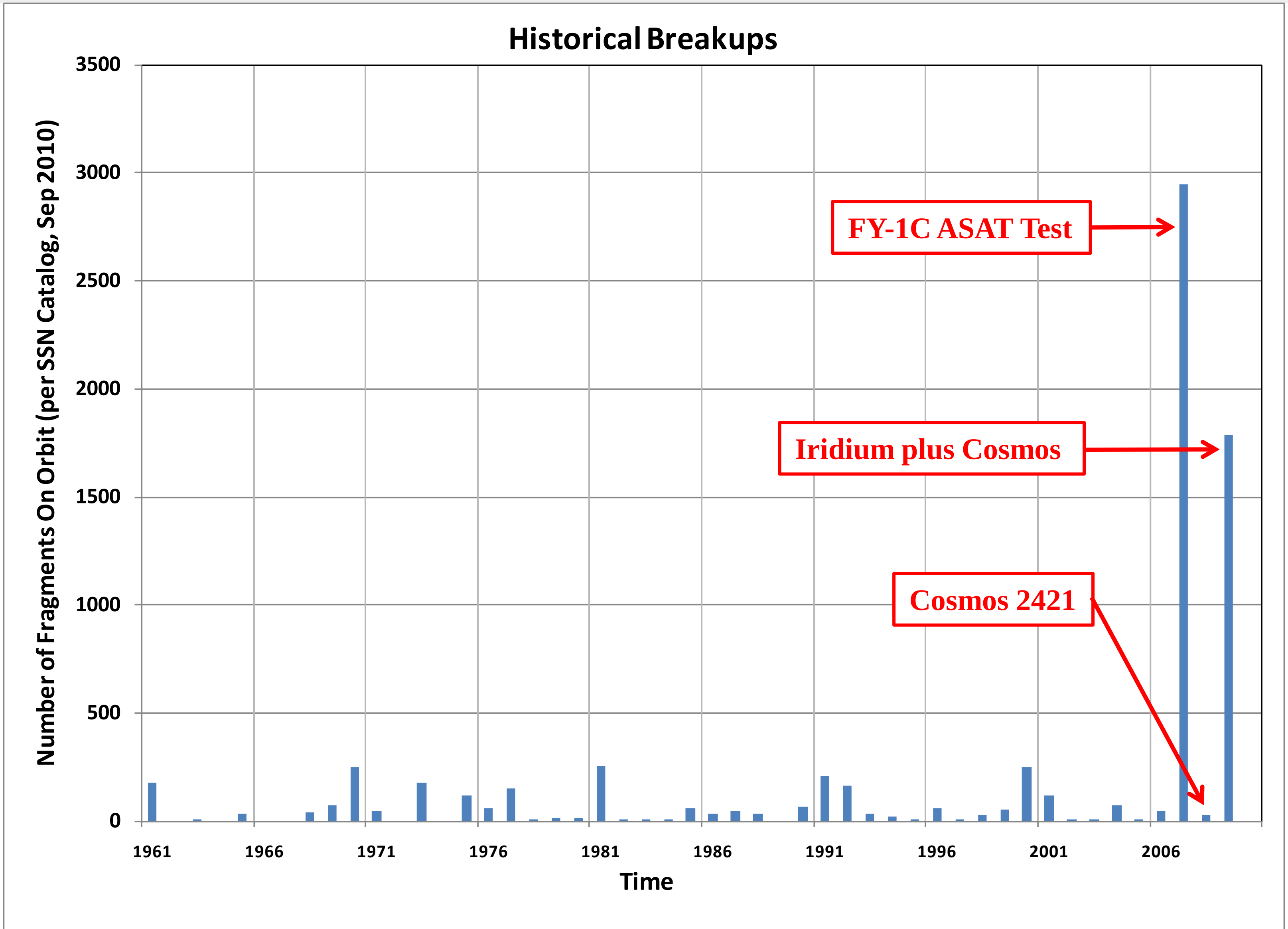
Brief Descriptions of the Events (2/2)

- **Collision between Iridium 33 and Cosmos 2251**
  - First ever accidental collision between two intact satellites (one was still active at the time of the event)
  - Highlights the orbital debris problem and underlines the serious consequences of the "Kessler Syndrome"

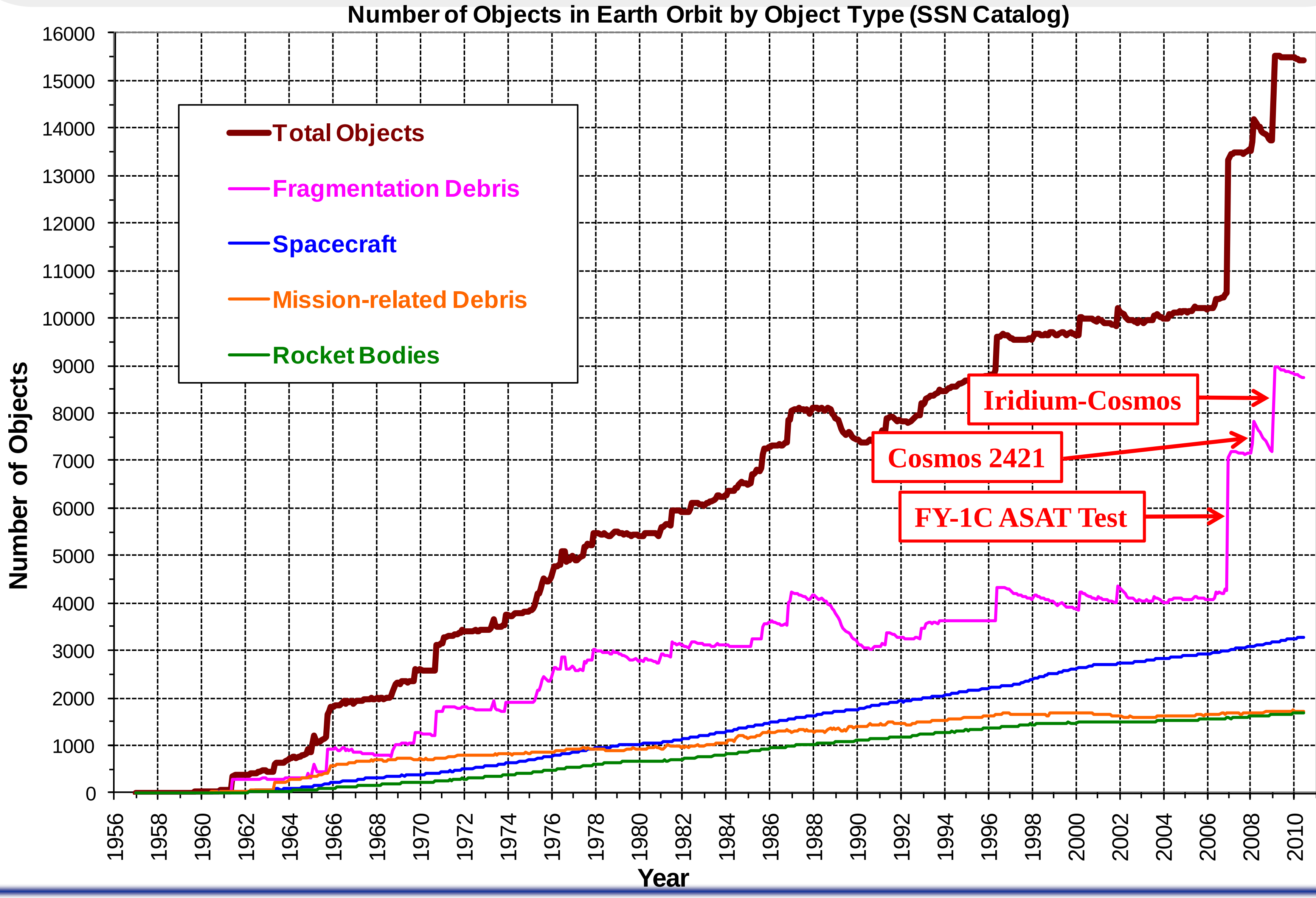
Historical Breakups - Debris Cataloged



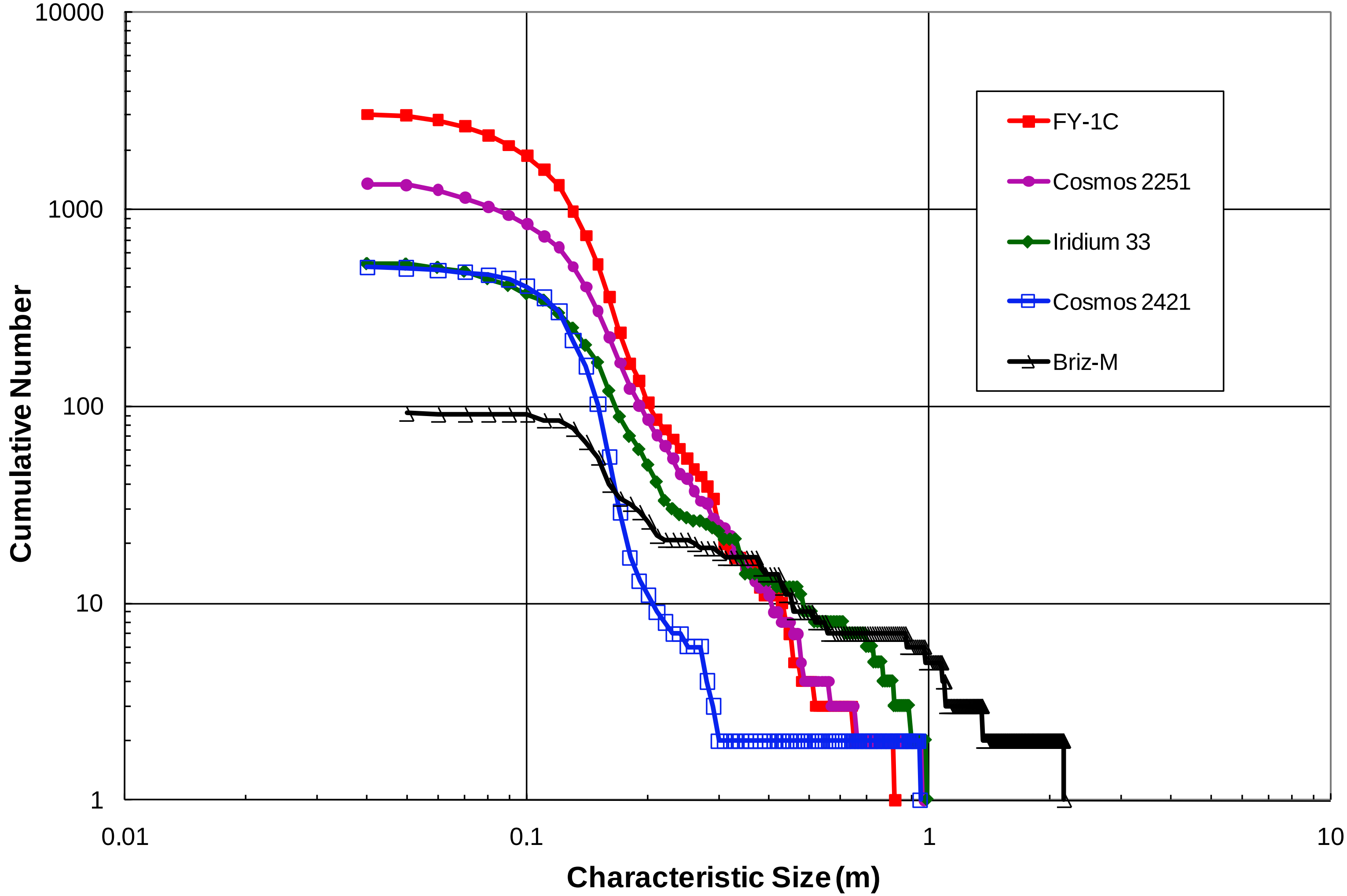
Historical Breakups - Debris Left (Sep 2010)



Growth of the Historical Debris Populations

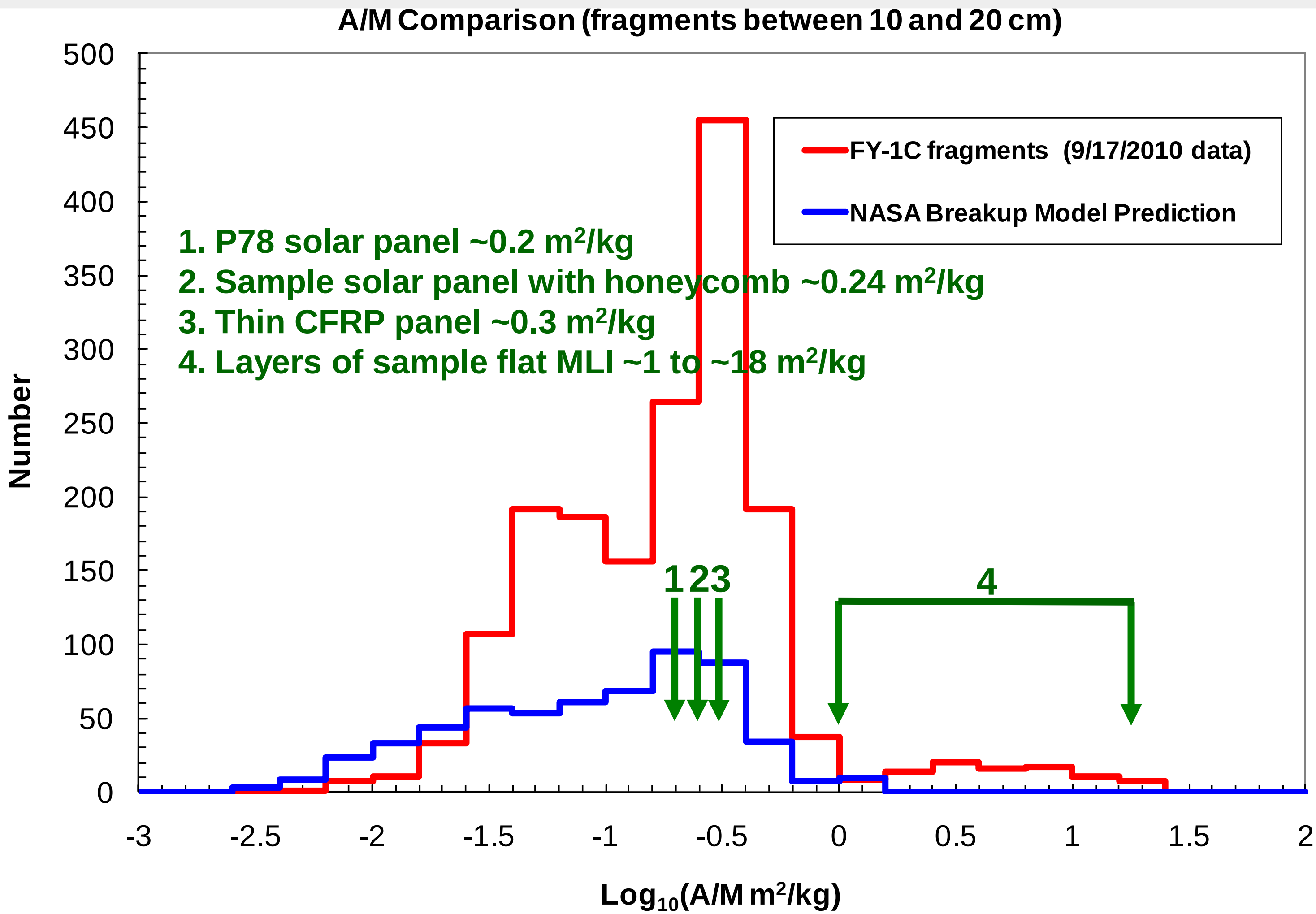


Fragment Size Distributions
(8 September 2010 RCS data)



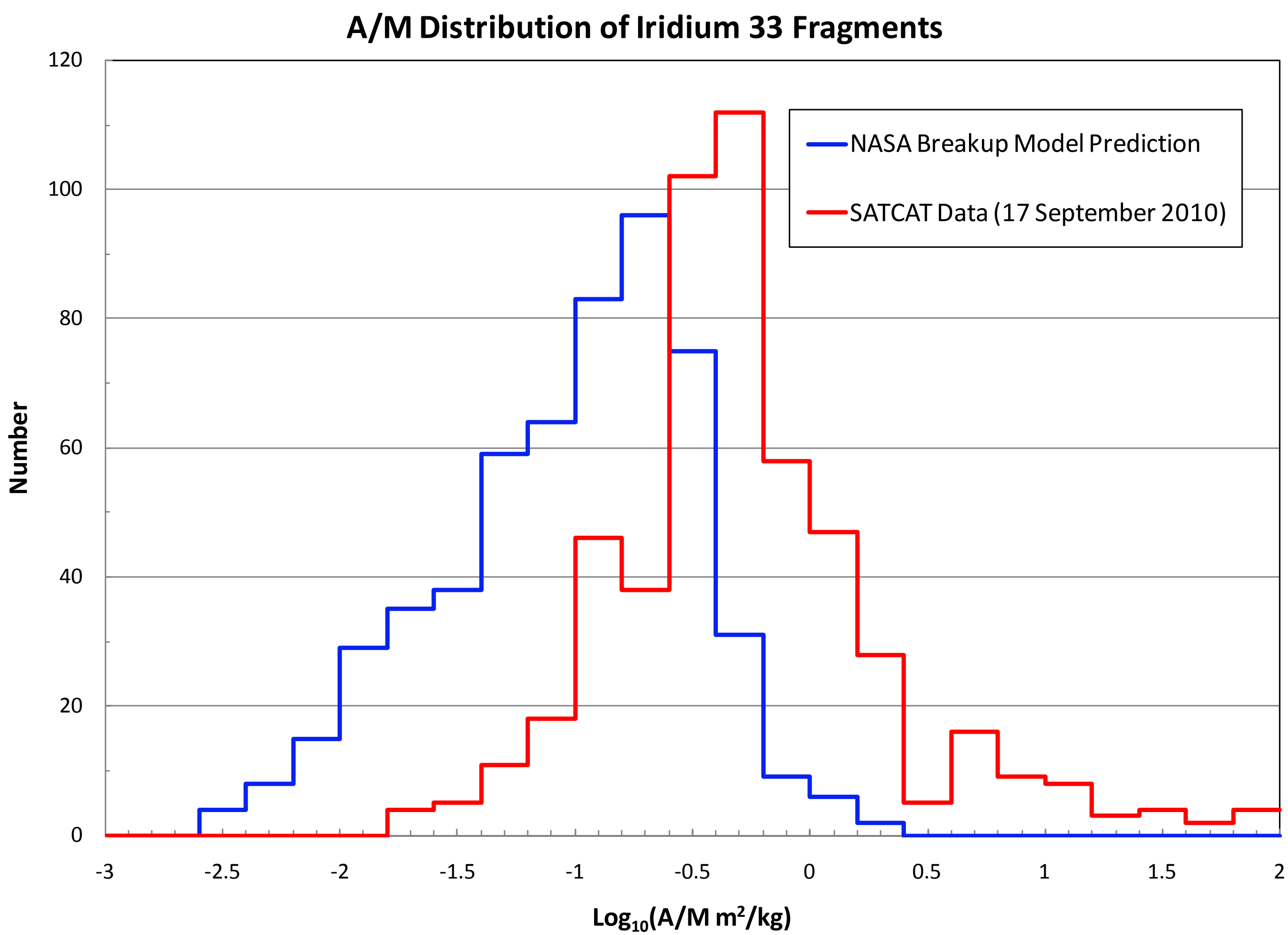
- All fragment clouds follow a power-law size distribution with a level-off around 13 cm
- Some uncertainties in the slope are expected due to RCS calibration and size conversion

A/M Distribution of FY-1C Fragments



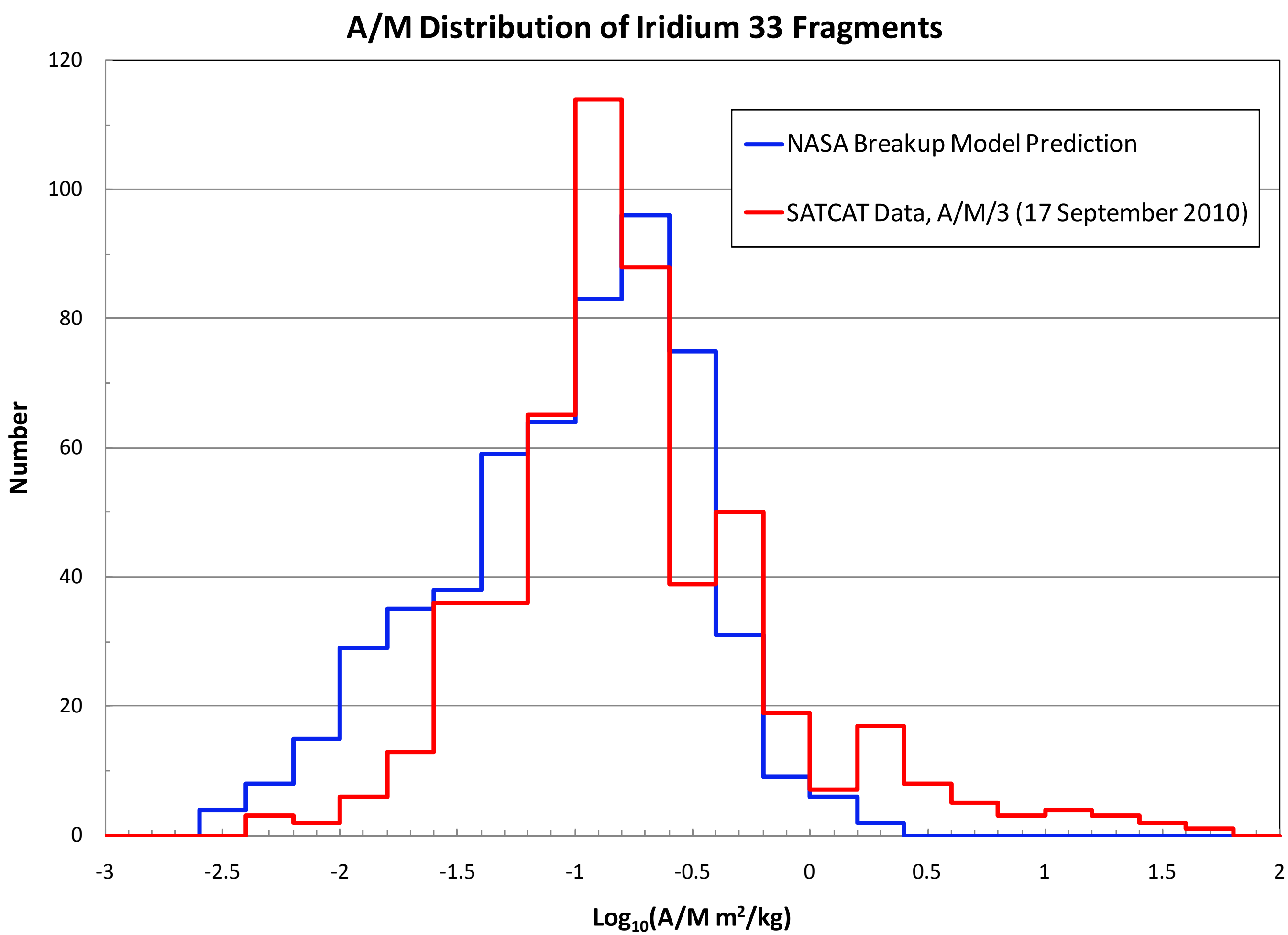
- **There are more fragments, and more light-weight materials (plastic, solar panel, MLI pieces) in the FY-1C cloud than in the NASA model prediction**
- **FY-1C was covered with MLI and equipped with two 4 m × 1.5 m solar panels**

A/M Distribution of Iridium 33 Fragments (1/2)



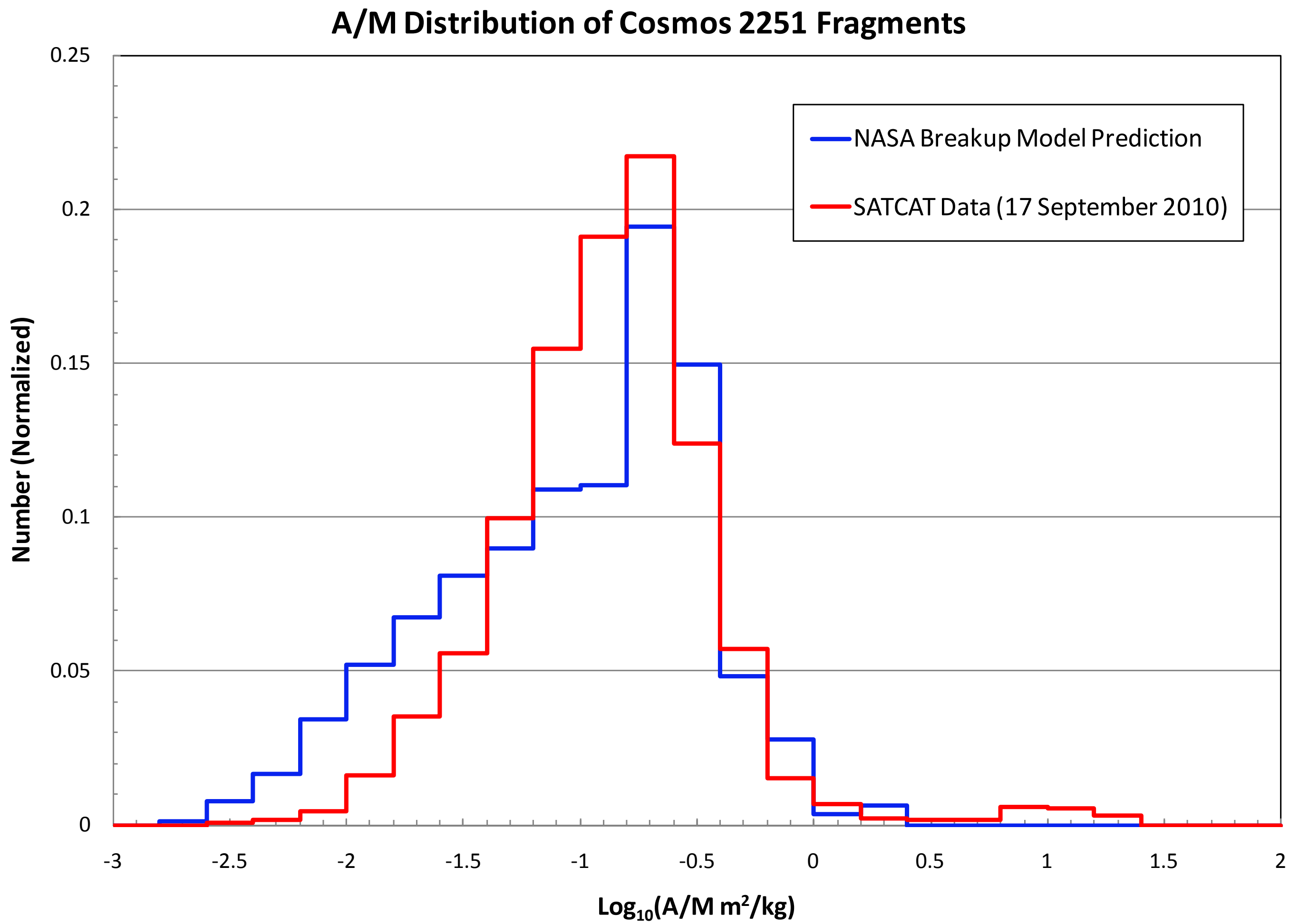
- **The A/M distribution of the Iridium 33 fragments appears to be systematically higher than the NASA model prediction**
- **Lightweight composite materials were extensively used in the construction of the vehicle**

A/M Distribution of Iridium 33 Fragments (2/2)



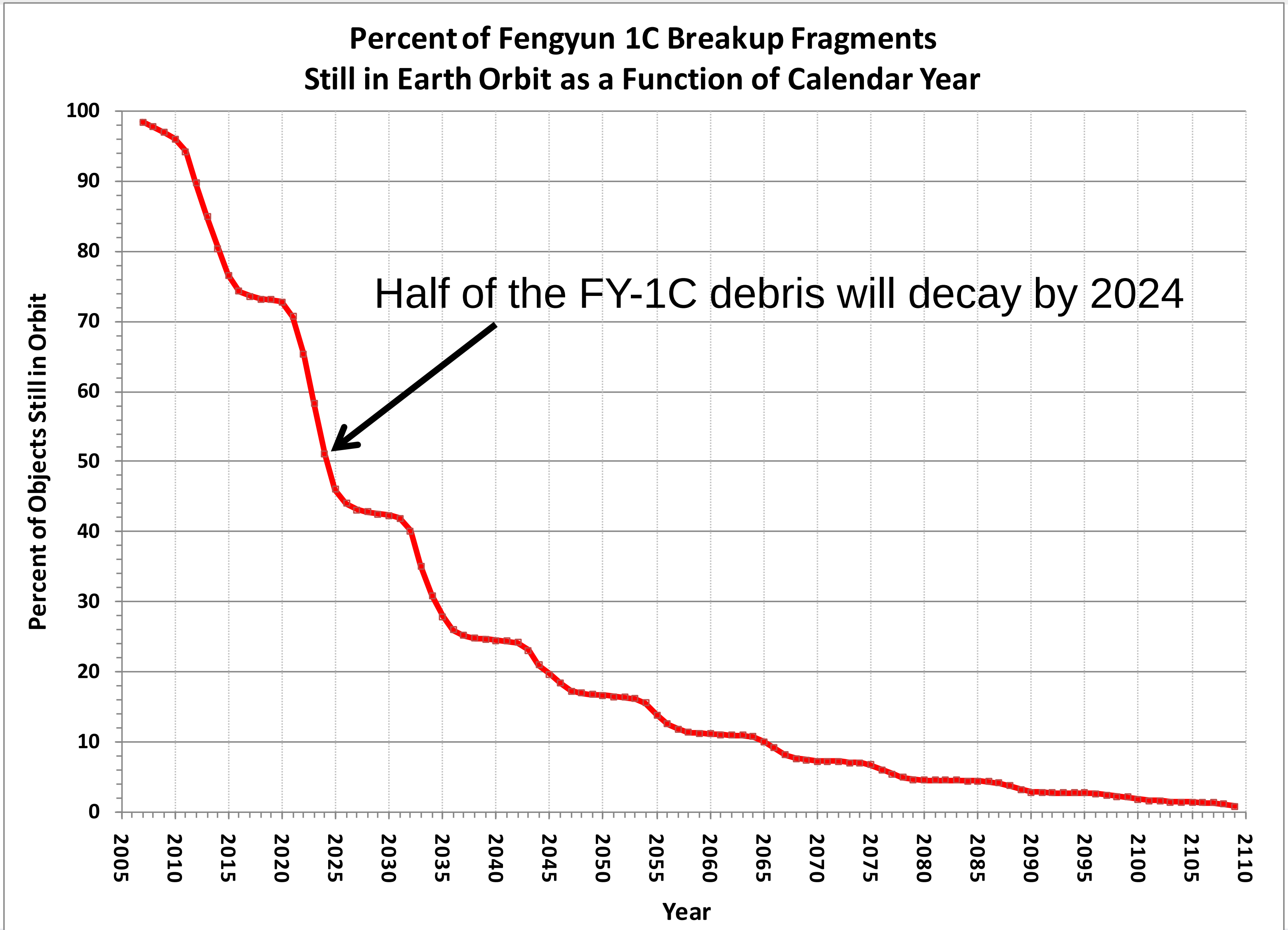
- The A/M distribution of the Iridium 33 fragments is approximately a factor of 3 higher than the NASA model prediction

A/M Distribution of Cosmos 2251 Fragments

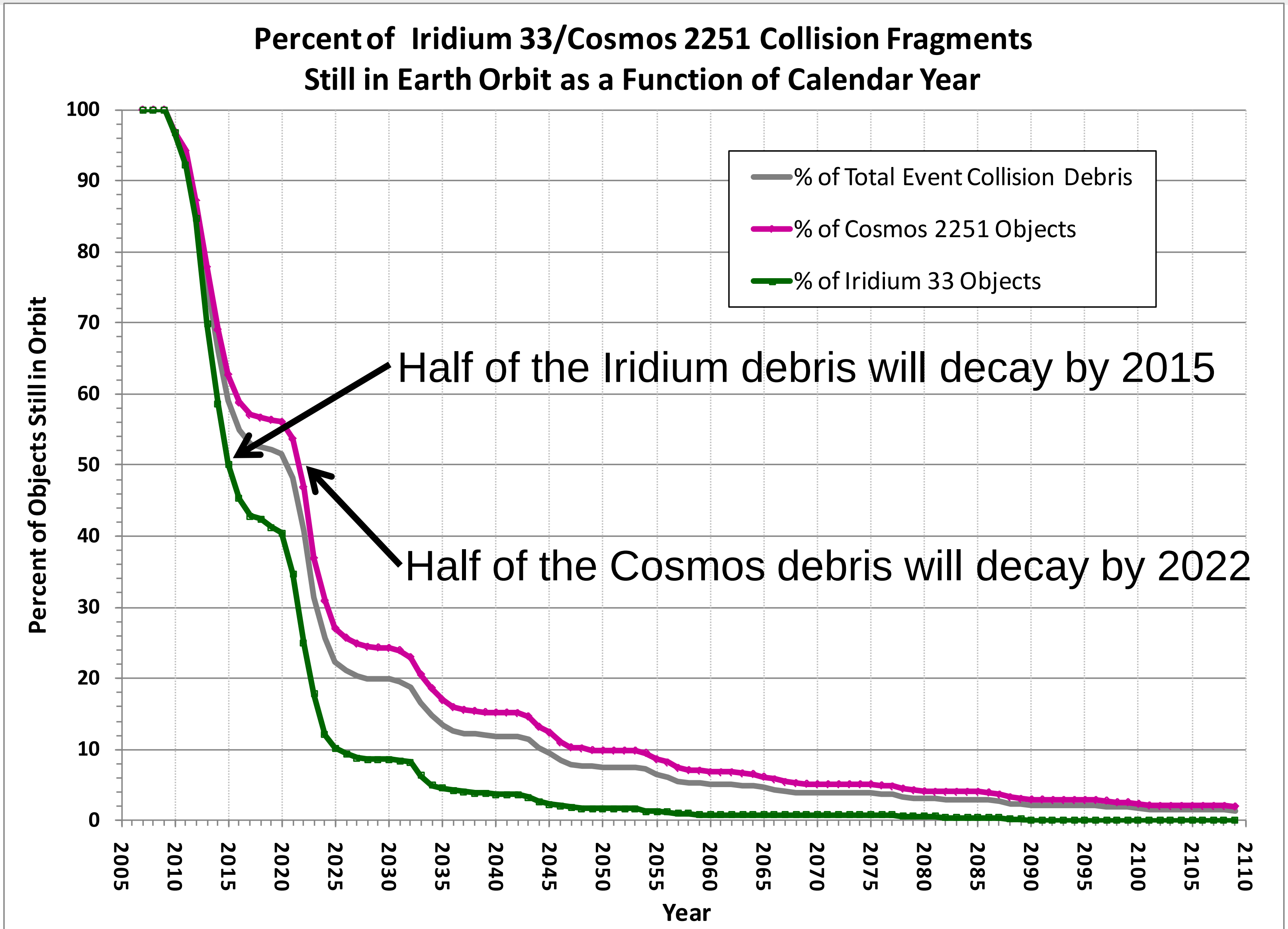


- The A/M distribution of the Cosmos 2251 fragments matches well with the NASA model prediction

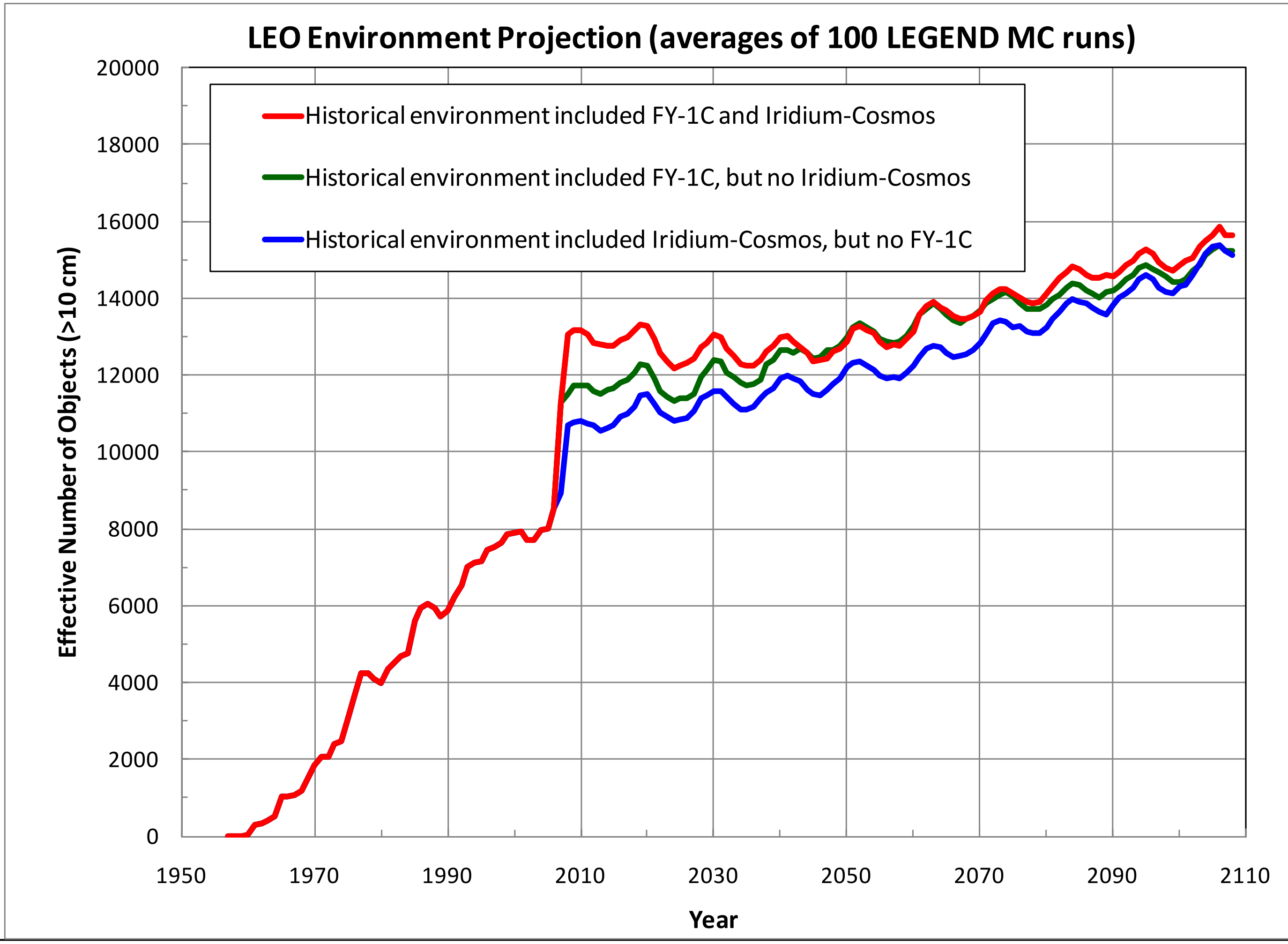
Long-Term Evolution of the FY-1C Debris Cloud



Long-Term Evolution of the I/C Debris Clouds



Long-term Environmental Impact of FY-1C and Iridium-Cosmos Fragments



- The impact of the Iridium-Cosmos fragments is limited to the next 40 years
- FY-1C fragments have a higher and more long-term effect to the LEO environment

Summary

- **Of the 4 recent major breakup events, the FY-1C ASAT test and the collision between Iridium 33 and Cosmos 2251 generated the most long-term impact to the environment**
  - About half of the fragments will still remain in orbit at least 20 years after the breakup
  - The A/M distribution of the Cosmos 2251 fragments is well-described by the NASA Breakup Model
  - Satellites made of modern materials (such as Iridium 33), equipped with large solar panels, or covered with large MLI layers (such as FY-1C) may generated significant amount of high A/M fragments upon breakup