An Analysis of the FY-1C, Iridium 33, and Cosmos 2251 Fragments

J.-C. Liou

The beginning of the year 2013 marks the sixth anniversary of the destruction of the Fengyun-1C (FY-1C) weather satellite as the result of an anti-satellite test conducted by China in January 2007 and the fourth anniversary of the accidental collision between Cosmos 2251 and the operational Iridium 33 in February 2009. These two events represent the worst satellite breakups in history. A total of 5579 fragments have been cataloged by the U.S. Space Surveillance Network (SSN), and almost 5000 of them were still in orbit in January 2013 (see figure 1). In addition to these cataloged objects, hundreds of thousands (or more) of fragments down to the millimeter size regime were also generated during the breakups. These fragments are too small to be tracked by the SSN, but are large enough to be a safety concern for human space activities and robotic missions in low Earth orbit (LEO, the region below 2000 km altitude). Like their cataloged siblings, many of them remain in orbit today.

These two breakup events dramatically changed the landscape of the orbital debris environment in LEO. The spatial density of the cataloged population in January 2013 is shown as the top blue curve in figure 2. The combined FY-1C, Iridium 33, and Cosmos 2251 fragments (black curve) account for about 50 percent of the cataloged population below an altitude of 1000 km. They are also responsible for the concentrations at 770 km and 850 km, altitudes at which the collisions occurred. The effects of the FY-1C, Iridium 33, and Cosmos 2251 fragments will continue to be felt for decades to come, as illustrated in figure 3. For example, approximately half of the generated FY-1C fragments will remain in orbit 20 years from now.

In general, the Iridium 33 and Cosmos 2251 fragments will decay faster than the FY-1C fragments because of their lower altitudes. Of the Iridium 33 and Cosmos 2251 fragments, the former have much shorter orbital lifetimes than the latter, because lightweight composite materials were heavily used in the construction of the Iridium vehicle, leading to the higher area-to-mass ratios of the fragments.

Name	Cataloged Debris	Debris Decayed	Debris in Orbit
FY-1C	**3378**	302	3076
Cosmos 2251	**1603**	261	1342
Iridium 33	**598**	119	479
Total	**5579**	682	4897

Figure 1.– A summary of the FY-1C, Cosmos 2251, and Iridium 33 breakup fragments (as of January 2013).

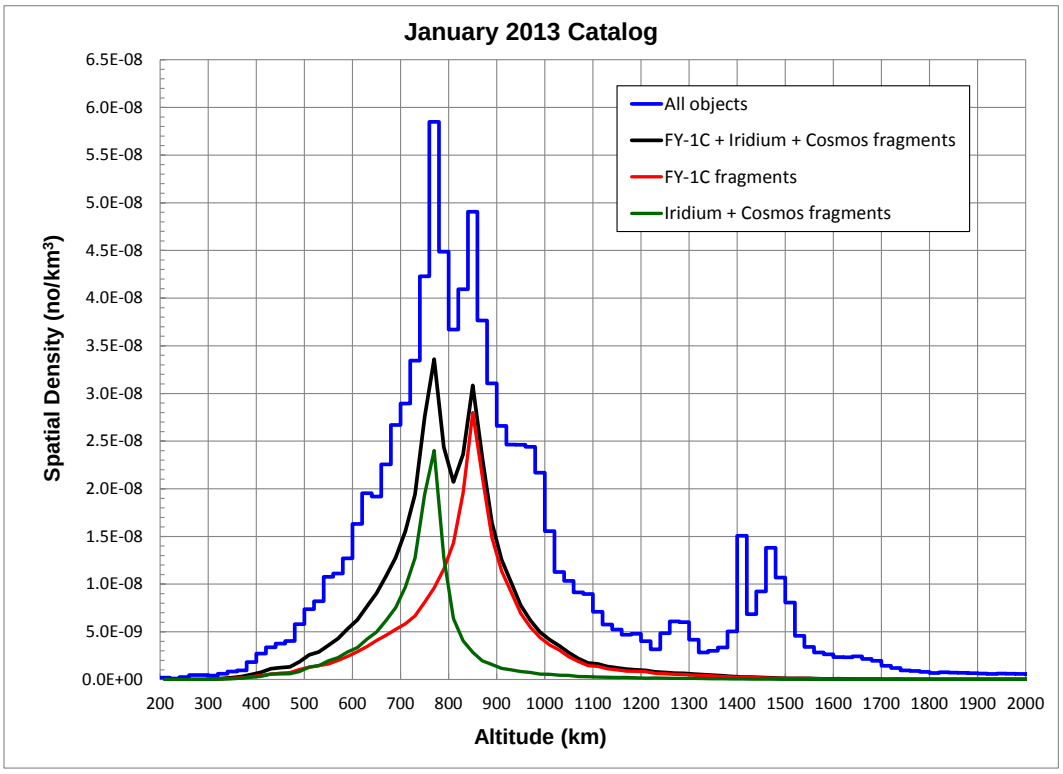

Figure 2.– Spatial density distribution of the cataloged objects as of January 2013.

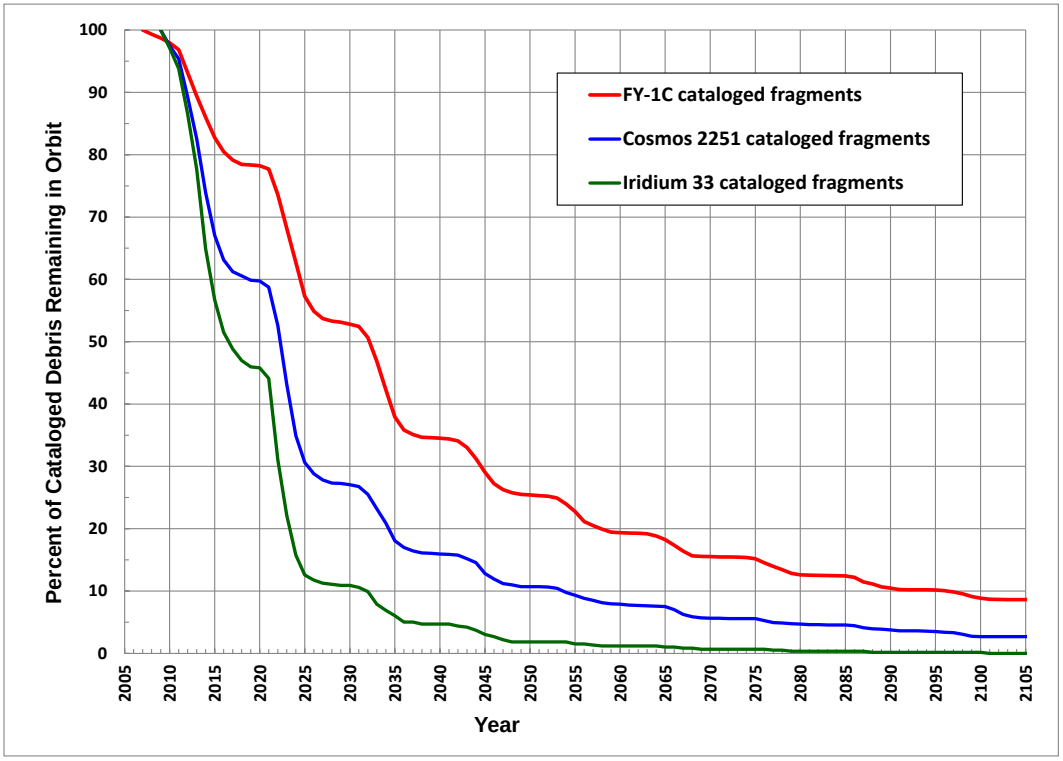

Figure 3.– Projected decay of the cataloged FY-1C, Iridium 33, and Cosmos 2251 fragments. Projection assumes a return to normal solar activity beginning in 2020.