November 2021

Satellite Collisions Have the Same Consequences as ASAT Tests

Viasat™

Introduction

A recent ASAT test has focused attention and discussion on the consequences of space debris at LEO and the fragility of near-earth orbits. This paper compares the aftermath of an accidental satellite collision to that of a successful ASAT test. The results are indistinguishable. For the same orbits and masses, the resulting debris fields have the same characteristics. In both cases, the debris field consists of large numbers of lethal trackable (LT) fragments[1] and an even larger number of lethal non-trackable (LNT) fragments[2], all dispersed across the LEO altitudes. A collision with any of these fragments will be catastrophic, fragmenting the satellite they collide with. The altitude dispersion means that a portion of these fragments will continue to pose a threat to LEO satellites, the ISS, and other space systems for decades, or even centuries.

Consequences of Historical Collisions and ASAT Tests

Gabbard diagrams[3] showing the actual tracked fragments remaining in orbit[4] from the 2009 Iridium – COSMOS collision[5] and the 2007 Chinese ASAT test[6] follow. These are the consequences 12 years later and 14 years later, respectively.

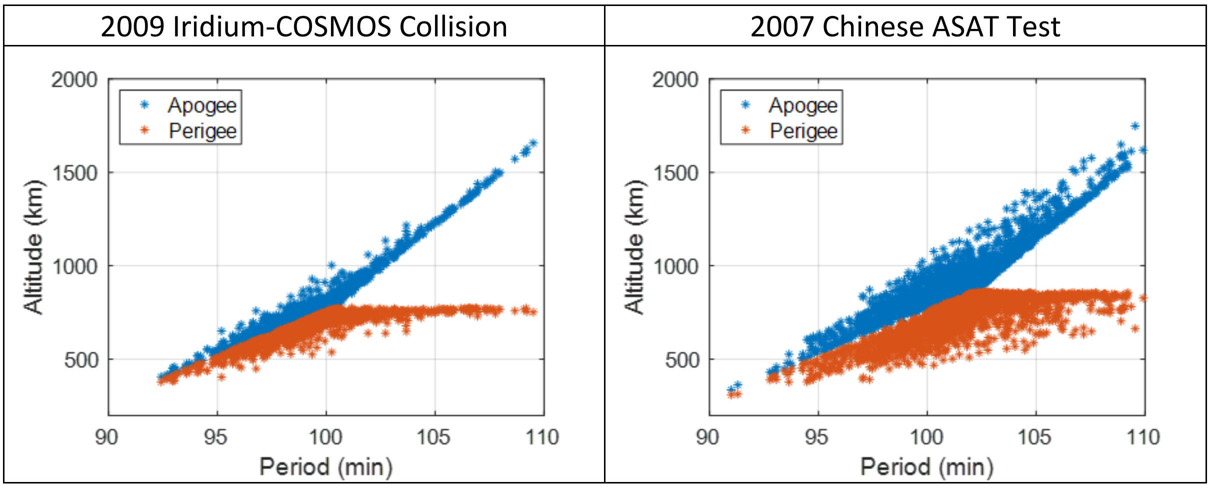

Figure 1 – LT Fragments from 2009 Iridium-COSMOS Collision (1,420 LT fragments) and 2007 Chinese ASAT Test (2,861 LT fragments) as of November 2021

[1] Fragments larger than 10 cm are typically observable by ground-based radars and telescopes, and hence are trackable. They are also massive enough to fragment any satellite they collide with. These are the lethal trackable (LT) fragments.

[2] Fragments in the 1 cm to 10 cm range are not trackable but still have sufficient mass to fragment satellites they collide with. These are the lethal non-trackable (LNT) fragments.

[3] The Gabbard diagram is the standard for fragmentation analysis. Developed by John Gabbard in 1981, it is a scatter plot of apogee and perigee heights versus period. It allows rapid identification of the fragment's orbit types, and the direction and intensity of the fragment's spread.

[4] Fragment apogees and perigees were obtained from the Space-Track Satellite Catalog and downloaded on 20 November 2021.

[5] On 10 February 2009, the 689-kg Iridium 33 satellite accidently collided with the 900-kg COSMOS 2251 satellite approximately 800-km above Siberia.

[6] On 11 January 2007, a Chinese SC-19 interceptor destroyed the 958-kg Fengyun 1C satellite orbiting at 865-km with a ~600-kg KKV.

The LNT fragments resulting from the Iridium-COSMOS collision and the Chinese ASAT test cannot be tracked, however, their distribution can be modeled using the NASA Breakup Model[7]. The following Gabbard diagrams show the modeled LNT fragments as of November 2021.

2009 Iridium-COSMOS Collision | 2007 Chinese ASAT Test

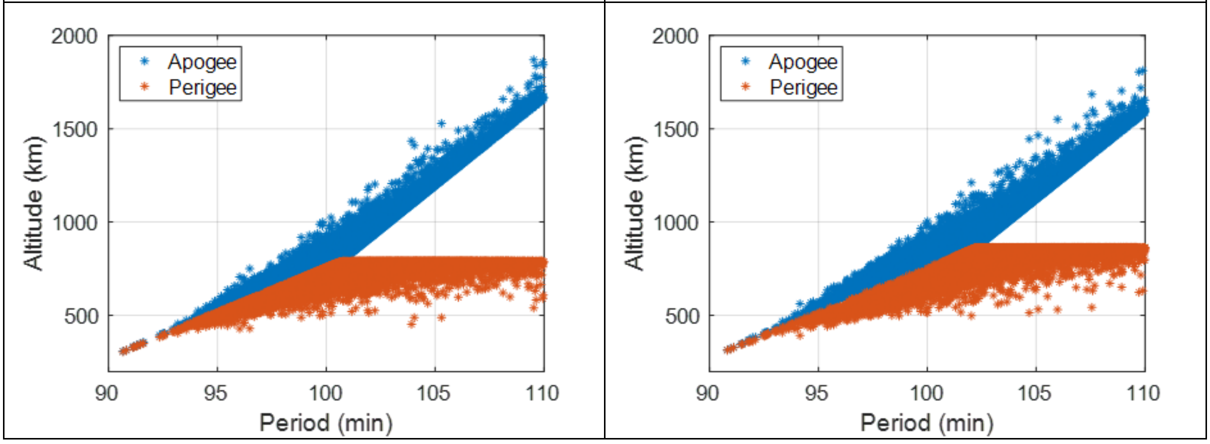

Figure 2 – Modeled LNT Fragments from Iridium-COSMOS Collision (57,822 LNT fragments) and Chinese ASAT Test (59,809 LNT fragments) as of November 2021[8]

Consequences of 2021 Russian ASAT Test and Possible Future LEO Collisions

On 15 November 2021, the COSMOS-1408 satellite was destroyed by an ASAT:

> *The 18th Space Control Squadron has confirmed the breakup of COSMOS-1408 (INTLDES 1982-092A, SCC 13552). Data indicates the breakup occurred on NOV 15, 2021. As of 1720 UTC, NOV 15, 2021, 18 SPCS estimates that there are at least 1,500 associated pieces, ...*[9]

The LT fragments from the destruction of COSMOS-1408 can be modeled as depicted below, and then compared with those from a simulated collision of two Starlink satellites[10].

[7] N. L. Johnson, P. H. Krisko, J.-C. Lieu, and P. D. Am-Meador, NASA'S NEW BREAKUP MODEL OF EVOLVE 4.0, *Adv. Space Res*. Vol. 28, No. 9, pp. 1377-1384, 2001.

[8] The NASA breakup model is known to underestimate the number of fragments from the Chinese ASAT test by over a factor of 2. It has been suggested that the possible causes are: 1) differences in construction and makeup of the spacecraft; 2) differences in the geometry of the collision; and 3) statistical or random variation. *See* Stansbery, G., Matney, M., Liou, J., and Whitlock, D., "A Comparison of Catastrophic On-Orbit Collisions", *AMOS Conference*, 2008.

[9] Space-Track.Org

[10] Starlinks are used for illustration, as they are the most numerous of the large LEO constellation satellites with 1,842 already launched, and licenses from the FCC for over 10,000 more. Very simplistically, given the numbers, if two satellites were to collide, they would more likely than not be Starlinks.

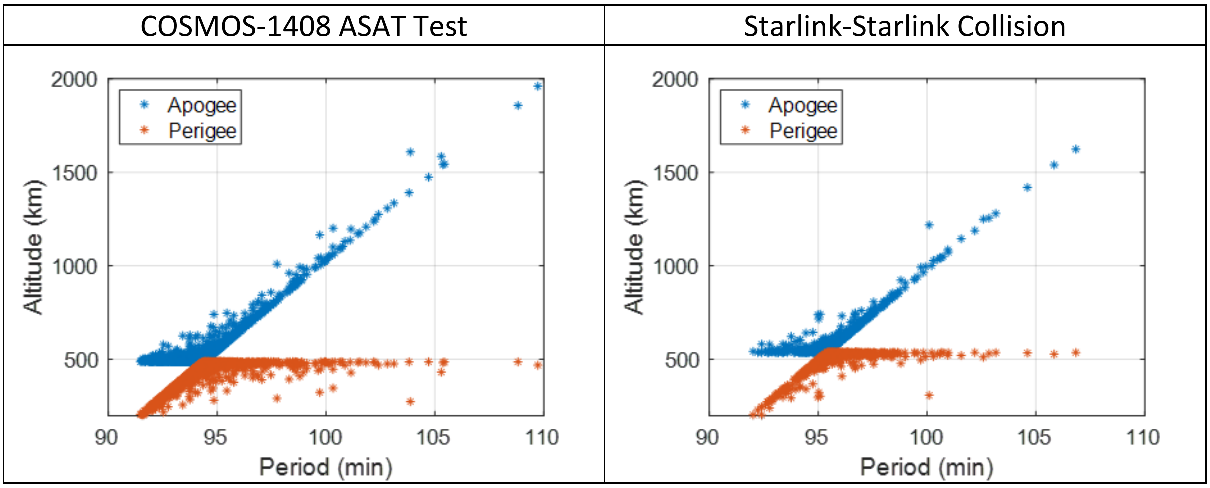

Figure 3 – Modeled LT Fragments from COSMOS-1408 ASAT Test (1,514 LT fragments) and Starlink-Starlink Collision (531 LT fragments)

The modeled LNT fragments from the COSMOS-1408 breakup and from the collision of two Starlink satellites are shown in the following diagrams.

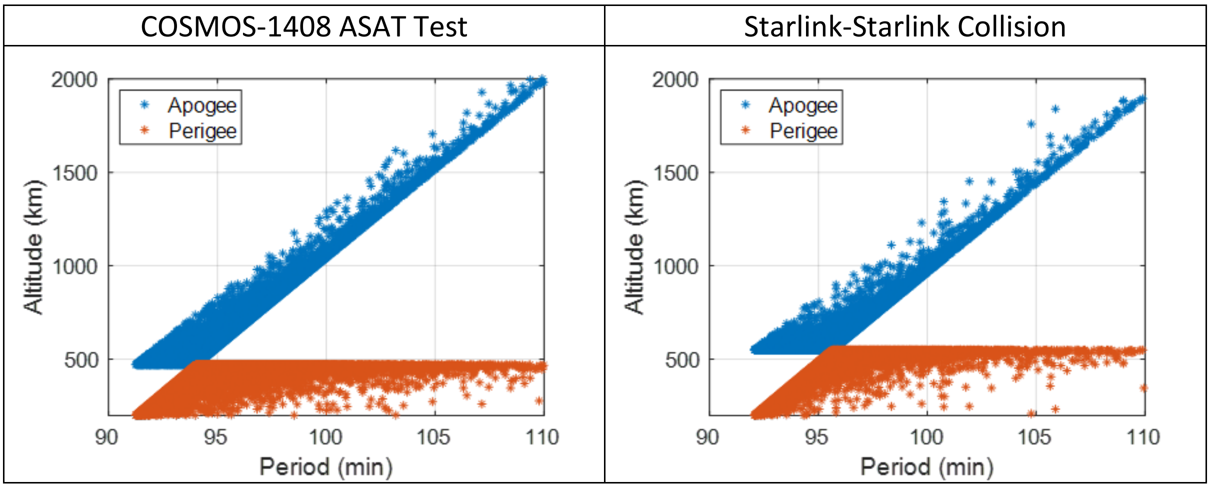

Figure 4 – Modeled LNT Fragments from COSMOS-1408 ASAT Test (77,706 LNT fragments) and Starlink-Starlink Collision (26,968 LNT fragments)

Conclusion

Debris fields of large numbers of LT fragments and even larger numbers of LNT fragments are characteristics of both accidental satellite collisions and successful ASAT tests. The exact numbers of fragments vary with multiple factors, including orbits and masses. With all factors identical, the consequences of satellite collisions and successful ASAT tests are indistinguishable, posing a threat to LEO satellites, the ISS, and other space systems for decades, or even centuries.