Russian ASAT test: A preliminary discussion

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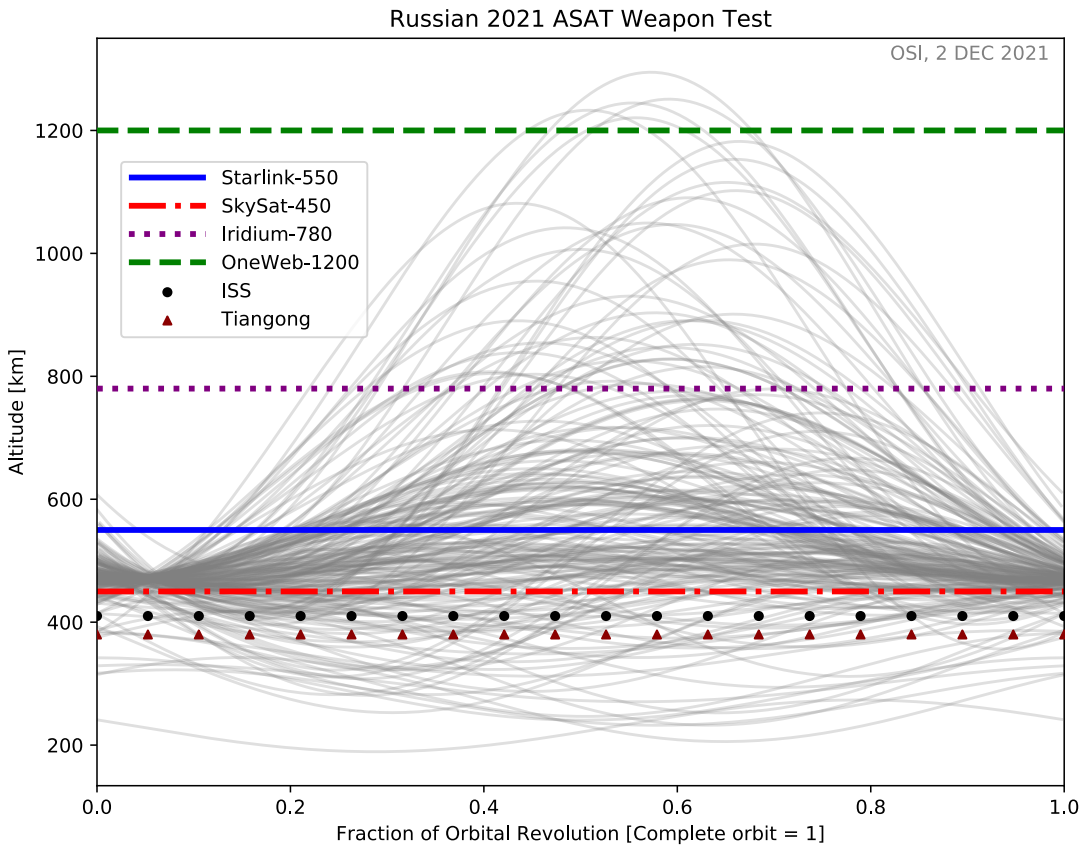
The Russian military used a ground-based missile to strike Kosmos-1408 on 15 November 2021. The defunct Soviet-era satellite had a mass of about 1750 kg and was orbiting at an altitude of about 480 km. Due to the high impact energies involved, debris from a kinetic anti-satellite (ASAT) test such as this end up on highly eccentric orbits that cross the orbits of 1000s of other satellites twice per revolution.

The following figure highlights how debris from the Russian military's test cross the orbit of the International Space Station, China's new Tiangong space station, and the orbits of several large satellite constellations made up, collectively, of 1000s of satellites.



This plot has been produced using Kosmos-1408 debris from two-line elements (TLEs) available in the USSPACECOM satellite catalogue as of 2 December 2021. The grey curves show the path of each object based on its first available TLE. Select satellite constellation orbital shells are also

shown, with the approximate altitudes given in the legend. Only about 200 of the estimated 1500 tracked debris pieces are included at this time.

As should be expected, the energy of the impact placed the debris on apogees well over 1000 km. While the debris field is quickly evolving, the orbits still converge on the impact altitude of about 480 km in about the same phase of their orbits. As the debris de-orbits over time, it will all pass through the altitudes of the two space stations.

Of particular concern is the non-trackable debris, which will be more abundant than the trackable debris by at least an order of magnitude. Since small debris cannot be detected, collision-avoidance maneuvers cannot be used to protect against them. And at typical relative speeds of about 10 km/s (36,000 km/hr), even a tiny piece can disable a satellite or kill an astronaut.

Moreover, every collision increases the cross-sectional area of the material involved and therefore the risk of further collisions. The most extreme outcome is the well-known 'Kessler Syndrome'. There are other serious, less dramatic concerns.

Even at low-altitude orbits, sudden pulses of material will proliferate small debris through knock-on collisions that could significantly interfere with satellite operations and human spaceflight. These effects and concerns are exacerbated by the dramatic increase in the number of satellites along with the expected growth of those satellites and crewed space missions.

Some of the debris from the Russian ASAT test will deorbit quickly. Indeed, debris curves in the above plot that appear to be "detached" from their birth altitude have already experienced substantial orbital evolution due to gas drag. But a significant fraction will remain in orbit for years or longer, with the precise clearing time dependent on the characteristics of the fragments and the behaviour of the atmosphere. It is also important to remember that the data have observational biases and that they are incomplete.

The Russian military is not the only military to have tested a kinetic ASAT weapon in manner that was certain to create long-lasting debris. What makes the recent test of greatest concern is that the fast-changing orbital environment has made such activities significantly more perilous than before. There are currently about 6000 satellites (active and defunct) in Low Earth Orbit, as compared to just over 3000 two years ago. This number is projected to grow very quickly, to over 100,000 satellites by 2030, largely because of the construction and completion of numerous satellite mega-constellations.

The Soviet Union was the first country in space and Russia remains a leading spacefaring nation. We find it difficult to imagine that ROSCOSMOS was fully involved in a decision that put the lives of two cosmonauts on the International Space Station at risk, along with five other astronauts and the most-expensive machine ever constructed by humanity. Russia is, after all, one of the two main partners in the International Space Station.

There are opportunities readily available for the Russian government to exercise leadership in addressing the crisis of space debris and the clear and present danger that any additional kinetic ASAT tests would pose to the interests of every spacefaring nation. In October 2021, the First

Committee of the UN General Assembly voted to create an Open-Ended Working Group to consider responsible behavior in space and the possible development of new norms. A total of 163 states supported this move.

The new Working Group provides an appropriate forum for the negotiation and adoption of a ban on kinetic ASAT testing. We urge the Russian government, through the Russian Foreign Ministry, to play a central and positive role in those negotiations.