Reentry of ATV-1 in 2008, the ESA's first automated ISS supply mission (Credit: ESA)

Planetary Defense II: Protecting Space and Earth from Our Own Satellites

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There are external threats that our planet faces from asteroids that could impact the Earth and cause damage to our cities. However, there is another planetary threat that is often overlooked; The harm that we do to space and our own planet resulting from our overabundance of satellites. The copious amount of satellites that are in space (and that are continuing to be put in space) could have several unknown consequences on our access to space, and on our atmosphere.

There are currently about 10,000 Spacex Starlink satellites in Low Earth Orbit (LEO) since the program started in 2019,[1] with plans to launch as many as 30,000 more.[2] Many other companies and countries have ambitious plans to launch their own satellite networks as well, such as

Amazon's Project Kuiper, OneWeb, and China. The growth of the number of satellites in space isn't slowing down, and it can make the problems that will be discussed in this blog worse as time goes on.

According to Harvard-Smithsonian astrophysicist Jonathan McDowell, about 1-2 Starlink satellites fall to the atmosphere per day.[3] Most of the time, Starlink satellites fully burn up in the atmosphere upon reentry,[1] so that at the end of their lifespan, they are able to remove themselves from space. This has a few complications, even though it helps to keep clutter out of space and avoid creating debris hazards. When a satellite burns up in the atmosphere, its material has to go somewhere. By completely burning up, the aluminum, copper, and other metals that make it up are mixed directly with air particles. It creates aluminum oxides (alumina) and other metallic aerosol particles[4] that can affect the atmosphere in ways that we aren't even sure about yet, since there hasn't been a sufficient amount of data modeling or data collection of satellites burning upon reentry.[5]

A study done by Christopher M. Maloney et al. published in March 2025 attempted to do such modeling by using aluminum oxide (Al_2O_3) as the aerosol being produced from satellites upon reentry. The study found that that between 20,000 to 40,000 metric tons of alumina are building up in the atmosphere between the altitudes of 10 to 30 km due to falling satellites.[5] They do mention that there is no definite nor known direct radiative impact of Al_2O_3.[5] However, indirect impacts from the aerosol could lead to temperature fluctuations by as much as 1.5 kelvin in the middle atmosphere at high latitudes,[5] as well as impacts on stratospheric ozone.[5] There still isn't

a lot known about the impacts of alumina, but other studies have attempted to learn more about them with other research methods.

With the SABRE mission, NOAA scientists attached an instrument to a NASA WB-57 aircraft, and found an abundance of aluminum and exotic metals in the stratosphere.[6] They also found an unnaturally large amount of copper, lithium, aluminum, and other metals that exceed the concentration expected to originate from natural meteors.[6] The study emphasizes that the percentage of stratospheric sulfuric acid particles mixed with metals from burning spacecraft can increase from 10% to up to 50%.[6] It's also stressed here, just like in the previous paper, that the long-term impacts and implications of the increasing amount of metals in the upper atmosphere is still unknown and needs to be further studied.[6]

The unknown effects on the atmosphere could get worse as more satellites burn up every day, and as they do so at an increasing rate. Some natural anomalies can actually accelerate the rate of satellite burn-up. In an unexpected scenario in 2022, 40 Starlink satellites burned up the day after they were launched due to a geomagnetic storm.[7] During a period of high solar activity, the Earth's upper atmosphere can heat and expand,[3] which makes the regions of space that satellites usually pass through more dense with air, increasing friction with the satellites. In this scenario, atmospheric drag was around 50% higher than other launches,[7] which led to 40 of the 49 launched satellites to burn up within a day after launch.[7]

The total number of satellites in low earth orbit has the possibility of growing to as high as 60,000 by 2040,[5] due to the efforts of various companies to grow their satellite networks. Our

current rate of 1-2 starlink satellites burning up per day has a high chance of increasing by that year. All of this could accelerate us closer to the hypothetical Kessler Syndrome, a scenario where the enormous amount of space junk would prevent anything else from being able to make it into space safely. However, there is a lot of disagreement on how close we are to this possibility or if it is even possible. Even with the issue of space junk removed (if it all just burned up), the atmospheric effects from these burning satellites are not established enough to take the necessary action. Hopefully these effects will be better understood as more studies are conducted, and before they are accelerated by the influx of growing satellite networks.

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