Issue Brief: Space Sustainability: Orbital Debris

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In January 2021, SpaceX launched 143 payloads setting the record for number of satellites sent to space on a single rocket. [6] The number of objects launched into space has increased exponentially over the past 60 years due to decreases in launch costs, resulting in greater accessibility to space. Mega-constellations are on the rise, such as SpaceX's Starlink constellation. In 2018 the FAA approved SpaceX to launch 11,943 satellites. By January 2021, over 1,000 satellites have been launched. Other companies like Amazon and OneWeb also have plans to launch mega-constellations in the near future. Low, medium and geostationary Earth orbits are home to satellites which provide a range of services including science, telecommunications, GPS, weather monitoring, and military applications. According to the European Space Agency (ESA) as of January 8, 2021 there are 6,250 satellites in space, 3,600 of which are still functioning. Debris orbits the Earth at approxmatley 17,500 miles per hour so even small debris pose a threat to missions. It is estimated that there are 34,000 objects greater than the size of a softball that could cause catastrophic damage to a mission. And, there are over 128 million objects ranging from the size of a marble to a grain of rice that could cause significant damage and loss of mission if a collision occurred with critical mission infrastructure. [3] This debris includes upper stages of launch vehicles, mission related objects, and solid rocket motor particles. It also includes fragmentation from in-orbit collisions; for example, the first accidental collision in 2009 between an active American Iridium communications satellite and a defunct Russian military satellite generated more than 2,300 trackable fragments. [5]

Doubling the number of objects in space will increase the collision risk by a factor of four. [5] Collisons pose a global risk to stakeholders in public, civic and private sectors. The ultimate consequence of an unstable orbital debris environment is *Kessler Syndrome*, where the density of objects is high enough to cause a runaway cascade of collisions that damage all space infrastructure and make low earth orbit completely inaccessible. Humans would be trapped on Earth due to this immense debris field. [3] The NASA Office of Inspector General released an audit in January 2021, which concluded that mitigation-only strategies and prevention would not be effective in stabilizing the rapidly-growing orbital debris environment. LEGEND, a debris evolutionary model used by the NASA Orbital Debris Program, predicts that even if no future launches occurred, collisions between existing objects would increase orbital debris faster than atmospheric drag would remove objects. [1] The global compliance rate for end-of-mission disposal after 25 years has averaged between 20 and 30 percent. By leaving decommissioned or failed satellites in space the cost of tracking and executing maneuvers to avoid collisions increases. There are also additional resources spent shielding spacecraft from orbital debris damage. NASA concluded that stabilizing the orbital debris environment would require a 90% global post-mission disposal rate in addition to removing at least 5 inactive spacecraft per year. [3]

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Developing technology and international systems for orbital debris mitigation and remediation involves many policy and economic challenges. There is a challenge to incentivise orbital debris clean up and fund debris removing projects. Additional fees for consumers of satellite services have been proposed which would make services like the internet more expensive. There could be fees for companies launching new spacecraft; however, if an international consensus is not made about fees and regulations then launch providers could move to operate in a country with fewer restrictions. Additionally, fees could increase the cost of a launch and make space less accessible. However, these fees could also be used to fund projects that reduce the amount of space debris and are only applied when companies don't abide by end-of-mission best practices. [9]

The United States, China and Russia are major contributors to orbital debris. Geopolitical tensions between countries are overcome when collaborating on the International Space Station (ISS). The ISS could serve as a testbed for debris remediation technology and international collaboration but is scheduled for decommissioning in 2024. The 2011 Wolf Amendment bars NASA from science exchanges with China preventing orbital debris collaboration. International collaboration and sharing space situational awareness information regarding military satellites is also complicated by international sensitivities and regulations. [4]

Orbital debris problem is currently managed though politics and relationships established by agencies like NASA and ESA. There also exist multi-national groups such as the Interagency Space Debris Coordination Committee which publishes agreed-upon guidelines for best practices. Being only guidelines, there exists no way in which to enforce any of the principles outlined by the committee.[8] Stakeholders are multinational and diverse because they include policy makers, research institutions, operators in space-faring nations and service-providing companies with a for-profit business model. The command and control structure of regulations can be less effective in controlling stakeholders with diverse interests and can be expensive and time consuming to enforce and update to accommodate emerging technology. [2]

Technology to remove debris is only early development for both commercial and international agencies. [3] Remediation technologies and operations which track, rendezvous and service a satellite are being developed however, these systems could also function as anatisatellitle systems which complicates international law. [10] Other proposed orbital clean up technologies include ground based lasers to deflect/remove objects, space based lasers, spacecraft rehabilitation and reuse, electromagnetic disposal of debris. These technologies could be tested and deployed from the International Space Station. [4] NASA has explored robotic refueling technologies which provide additional fuel to extend missions and relocate or deorbit satellites. [3]

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