Space Debri[s]ef: Mitigation

The “Tragedy of the Commons” is a concept developed by American ecologist Garrett Hardin to explain the depletion of a shared resource due to its overuse by selfish individuals, a theory that consistently recurs throughout history. These individuals, and sometimes groups, tend to “make decisions based on their personal needs, regardless of the negative impact it may have on others” (Spiliakos). This phenomenon can be seen with overfishing in the ocean and air pollution in the atmosphere. Inevitably, the “Tragedy of the Commons” has reached outer space in the form of space debris: small scraps and particles of metal that have detached from their original structures.

When different devices such as rockets or satellites are launched into Earth’s orbit, space debris detaches and lingers throughout orbit. According to Beihang University Astronautics’ Shenyan Chen, these “small particles can be very destructive in a collision due to their high orbital speed.” Objects in low-Earth orbit travel at speeds “greater than 7 km/second”, easily fast enough to pierce a space suit and the human body. Yet private companies and national governments backed by their citizens continue to escalate space activities, destroying the orbital atmosphere over selfish desire, leading to the inevitable depletion of space availability. It is obvious that space debris is a crucial problem, but there aren’t any concrete solutions in place. I propose private companies use alternative space development methods such as retrograde thrusters and active/passive debris removal while national governments adopt debris mitigation laws and programs to sweep away the growing debris problem in outer space.

A recognizably similar dilemma to space debris, environmental deterioration also exhibits the “Tragedy of the Commons”, seen through the long-standing catastrophes of global warming and water pollution. Global warming is the long-term trend of Earth's increase in temperature. Anya Biferno, a writer for NASA, described how the organization observed the budding of global warming "since the pre-industrial period (between 1850 and 1900) due to…fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere". As humans burn fossil fuels, greenhouse gasses destroy the ozone layer and allow more heat to enter Earth's atmosphere, causing increased risks of infectious disease, "worsen[ing] human health conditions", and "many serious alterations to the environment", according to Iowa UN President Paritosh Kasotia. Simultaneously, bodies of water around the world have been victims of everlasting pollution. Science writer and editor Alla Katnelson shares how microplastics "less than 5 millimeters in size are becoming increasingly common in the ocean." These miniscule, almost unnoticeable pieces of plastic damage marine life and hinder social and economic human activities like fishing, preservation, and exploration. The negative effects of environmental deterioration are evident, yet humans continue to destroy their surroundings and harm their health. Even with these catastrophes, little has been done, the exact path space debris seems to be following.

In an attempt to return to a space devoid of debris, companies should adopt the concept of retrograde thrusters. Introduced by Brooke Shellabarger's thesis at Morehead State University, "this subsystem would use thrusters in the opposite direction of the propulsion system." By doing this, the satellite or rocket's velocity decreases, lowering its orbital altitude. A lower altitude would allow the spacecraft to enter Earth's gravitational field more easily and decay naturally. The system relies on the idea of useless devices being able to leave orbit and reenter the Earth's atmosphere. Earth's gravitational pull then accelerates that object's velocity to the point where it creates enough heat to disintegrate itself. Shellabarger also details how this concept “would not allow [a] satellite to enter Earth’s atmosphere right away…[but] at a much quicker rate than the 25-year rule.” The 25-year rule requires companies to push dead satellites to outer orbit within 25 years of their completed mission. Retrograde thrusters make an impact immediately and are automatic, while the 25-year rule can keep an object in Earth’s orbit for up to 25 years, and even longer if not followed. Just this year, “Dish, the television provider…[failed] to thrust its defunct EchoStar-7 broadcast satellite to a higher altitude” (Mayorquin), resulting in a $150,000 fine from the Federal Communications Commission. If the satellite had retrograde thrusters implemented, it could’ve automatically decayed after completing its mission. Not only would this have saved the company from its punishment, but also denied any chance for space debris to fall off the satellite into the orbital atmosphere. This is just one of many ideas that hope to combat space debris.

More generally, active and passive debris removal are two primary techniques that hope to mitigate space debris. Active debris removal (ADR) consists of large-scale missions conducted to remove larger pieces of space debris. The ESA and NASA have attempted to define ADR as a mission that “involves launching a spacecraft that can rendezvous with, capture, and deorbit or relocate non-cooperative targets.” ADR hopes to launch unique machines into space with the sole purpose of identifying, selecting, and removing major debris. These selected objects will likely have high masses and pose the largest environmental risk and collision probability. ADR also chooses devices that are in high altitudes where the orbital lifetime is long because they won’t decay by reentry anytime soon. Sending large-scale devices into orbit with the sole mission of removing large debris is one of the most direct and efficient ways to mitigate space debris. But not all space debris jobs are large-scale, there is a different solution for smaller cases

Passive debris removal (PDR) is used for smaller pieces of debris in space and is much less specific as many techniques can be used. Drag sail deorbiting technology is an example of PDR that attaches a drag sail to space devices. At the Purdue University School of Aeronautics and Astronautics, David Spencer describes how "once the vehicle reaches the end of its operational lifetime, the sail would deploy, using aerodynamic drag as a deorbiting force…work[ing] independent of spacecraft propulsion." Essentially, a dead device will deploy its drag sail to send it back into Earth's atmosphere without the use of thrusters or propulsion. This is similar to the concept of retrograde thrusters, but instead of a space device only removing itself from orbit, it is able to capture and remove other small pieces of debris. This ensures that no small debris fragments that would normally enter orbit from thruster pushes can detach or be removed later.

As ideal as they would be, establishing these technologies and developments is an ambitious task. Regular people suggest that it is too early to worry about space debris. They may add that it is an issue that doesn't regularly, if even at all, affect them in their daily lives. Space exploration and debris mitigation are responsibilities of the government and privately funded companies and should not concern the common citizen. Scientists and economists may have concerns with debris mitigation and its abundant finances, time, and labor requirements. Yet all these concerns are warranted as the Organization for Economic Co-operation and Development published a report that space mitigation consists of "5-10% of total mission costs, which could be hundreds of millions of dollars." At the same time, a majority of the population can say that space debris has no effect whatsoever on their daily lives.

As warranted as these concerns may be, statistics can tell the truth. People have argued the financial costs of space mitigation far outweigh its benefits, yet NASA "estimated annual costs on [satellite] operators of only $58 million a year." Compared to the $4.2 trillion spent on healthcare and $2.2 trillion spent on Social Security and Medicare, debris mitigation is an insignificant expense. In addition, the operation costs of satellite collisions are practically irrelevant. Bhavya Lal, NASA associate administrator for technology, policy, and strategy said that "most satellite operators do not incur much cost from conjunction assessments or collision". Economically, the costs of space debris are virtually non-existent, but the social situation is much more complicated.

From the Space Race in the early 1950s to the Starlink satellite launch just this year, space exploration has become an increasingly urgent task. In 2004, President George Bush announced a new policy, the "Vision for Space Exploration", which would "[extend] a human presence across the solar system" and "explore the solar system and beyond" (Zubrin 5). There is an agreed-upon understanding that Earth is the only known planet to sustain life, but as President Bush and many others think, humanity's ability to adapt could allow us to inhabit other planets. Fast forward almost two decades, the European Space Agency explains the need for space exploration the best: "Without the ability to reach out across space, the chance to save ourselves might not exist" (ESA). After experiencing the horrors of global warming and ocean pollution and their consequences, resolving this issue sooner rather than later will always be the right decision.

With the uncertainty of the future, space exploration may be humanity's one saving grace. At the current rate of space exploration, the "Tragedy of the Commons" looms on the horizon, ready to take effect if space mitigation efforts are not elevated. Different countries and companies from around the world continue to launch new satellites and rockets with no hesitation, building up debris in a space environment that will soon be unusable to all. Private companies and governments must adopt alternatives such as retrograde thrusters, and active and passive debris removal to ensure a clean orbit. These groups must work together to push for advancements while considering economic, social, and political factors. An uncertain future is no future at all, so as many times as people may wonder about the next generation, the questions of how space debris will be cleaned and who will clean it must be answered first.

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