The Impact of Satellite Data Retrieval on the Space Debris Crisis

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract

The over 500,000 pieces of space debris orbiting Earth could be cataclysmic for the future of space travel as well as life on Earth. Disposal methods for inoperative satellites are minimal and not quite ideal. The spacecraft cemetery, located in the South Pacific Ocean, is the main area old spacecraft are sent when they return from space. This is a designated location in the middle of the ocean, away from human civilization--but not from marine life. An alternative to this method is recycling satellites in orbit, allowing for more satellites to be constructed from old ones, all in space. Another idea, which is garnering popularity, is reusing old spacecraft for future missions. By drawing on evidence presented by the spacecraft cemetery and recyclable spacecraft systems, one can see that despite the necessity of satellite data retrieval for societal advancement, disposal of satellites when they become inoperative can cause social problems. Therefore, through analysis using the frameworks of technological fix and wicked problem framing, an alternative to current methods will need to be developed and proven to eliminate waste.

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Introduction

There are more dead satellites orbiting the Earth than there are functioning ones. Hundreds of thousands of unusable satellites orbit as space debris, which is quite dangerous for future spacecraft traveling into space (O'Callaghan, 2019). There are upwards of 500,000 space debris objects circling the only known habitable planet (Garcia, 2017). These pieces of debris are progressing through their orbit at a maximum rate of 17,500 miles per hour. The accumulation of spacecraft fragments began with the Soviet Union's launch of Sputnik 1 in 1957 and has only increased since this catalytic event (Starr, 2020). Continued satellite launches further this debris conglomeration, sustaining this problem.

Satellites are not expected to be in orbit for longer than ten to fifteen years—and some may only last for five (Werner, 2018). These satellites are then rendered useless, so where do they go? Creating satellites with short lifespans could be more efficient, since this would be less expensive over time (Werner, 2018). Some manufacturers believe that satellites with shorter lifespans prove more effective when examining cost, since the satellites would tend to be smaller and easier to transport to space. However, if these satellites are not returned to Earth to burn in the atmosphere upon re-entry, then they are left in space, retreating farther and farther from Earth (*Where Do Old Satellites Go When They Die? | NASA Space Place – NASA Science for Kids*, 2019). By utilizing the STS frameworks of technological fix and wicked problem framing, the societal implications of space debris and how this issue has been addressed is examined. Further looking into what space debris means for society is imperative in identifying methods of amending this problem. Thus, the following question must be considered: what are the societal implications of satellite data retrieval?

Methods

Wicked problem framing and technological fix are concepts that were utilized in this research process in order to organize the underlying causes of the space debris issue. The theory of technological fix is applied using research on the spacecraft cemetery and the Great Pacific Garbage Patch as well as considering wicked problem framing in this respect. Wicked problem framing was addressed to emphasize the importance of finding a feasible solution that all space endeavors across the globe could incorporate in their missions.

To understand how inoperative satellites are disposed, researching the aforementioned "spacecraft cemetery" was necessary (*Where Do Old Satellites Go When They Die? | NASA Space Place – NASA Science for Kids*, 2019). For comparison, studies were conducted on the "Great Pacific Garbage Patch" as well (National Geographic Society, 2019). Further research was conducted regarding recyclable spacecraft and current initiatives with this concept. Specifically, Northrop Grumman and SpaceX operations were utilized as prime examples. More information was found through searching "recycling spacecraft." Several articles were pared down to prioritize the ones most relevant to the subject.

Ethics Perspectives

The ethics perspectives of utilitarianism and deontology are particularly relevant when considering the orbital debris crisis. Utilitarianism involves one's ability to predict the consequences of something, so it works best in situations with high information. For the utilitarianism perspective, the choice that yields the greatest benefit to the most people is most ethically correct. Utilitarianism's argument for the space debris situation would most likely be to focus on clearing the debris prior to continuing with space development. Unfortunately, this would result in an extended period of time without any space advancement. However, long-term, this solution would benefit more people, since future generations would be able to access and explore space easier than we can currently. The extra time waiting for the space debris crisis to end could also allow for more time to plan for future exploration missions. While present-day civilizations may suffer from this decision, utilitarianism argues the benefits for future civilizations would be tenfold.

Deontology expects people to adhere to their obligations when making decisions. For the deontology perspective, decisions made whilst upholding one's responsibilities are the most ethically correct. These decisions also have a tendency to be consistent, since they are based on someone's preset duties. In relation to the space debris crisis, there are two practical options. The first is to follow the orders of one's employer or company. Following the duties of one's employment position would be the most ethical decision according to deontology. Another option is to follow a universally accepted and dutiful act to assuage the orbital debris issue. This option may be more difficult to follow, since few actions are universally accepted as correct. Regardless of which option is chosen, the main idea is to make decisions by following a set list of responsibilities. As long as one does that, deontology will approve the decisions as ethically correct. This is interesting considering the Nuremberg Trials regarded soldiers following their orders, yet those soldiers were still sentenced for their actions. This "Nuremberg defense" of following a superior's orders is not a defense according to the law, so deontology's ethical and practical accuracy could be questioned. Deontology might be a better policy to follow when the company's intentions and instructions are ethical in their own nature. Therefore, perhaps deontology works better alongside other ethical perspectives, rather than alone.

Evidence Pertaining to the Effects of Space Debris

The ever-increasing collection of space debris in Earth's orbit has produced a major problem for advancement in space missions. Impact with space debris is now a consideration when launching spacecraft. Many propositions have been made regarding recyclable spacecraft usage, particularly by major spacecraft manufacturing companies.

The National Aeronautics and Space Administration (NASA) has guidelines in place to prevent impact with space debris when launching spacecraft (Garcia, 2017). Evasion operations have been created in the case of impact with debris. However, while mission control tracks the debris and is prepared to alter the spacecraft's course, debris pieces can be missed: no system is impervious to error. Moreover, evasive maneuvers will only be utilized if there is a high probability of collision that would result in mission complications. Therefore, the space debris accumulation has grown so severe that NASA and the Department of Defense had to create plans to avoid impact. In fact, these maneuvers have been used many times over the past fourteen years (Garcia, 2017). How many more years must pass before the probability of collision is always high? As the space debris conglomeration grows, the probability of collision will inevitable increase as well. Therefore, if a solution is not found and implemented, then the likelihood of collision will be drastic.

Evidence Pertaining to Space Debris Crisis Solutions

An idea that has surfaced to reduce space debris is a recycling system, which would be incorporated into Earth's orbit (McKinney, 2019). This concept suggests the system would be set up in a fixed location within the orbit, and expired satellites would be sent there. Then, new satellites would be created from the old satellites, resulting in a fully recyclable system for satellites. The system would allow for more basic satellite designs to be utilized, since they would not need to withstand the gravitational forces associated with being launched into space. Howard Eller, who is an Advanced Mission Systems Technical Fellow for Northrop Grumman Aeronautics Systems, stated, “If we can figure out a way to convert dead satellites from a waste product into an economic benefit, recycling in space will happen” (McKinney, 2019). However, until there is a direct economic benefit to recycling satellites, this process will remain a pipe dream. Ideally, countries will see this process as viable long-term and perhaps governments will subsidize projects such as this with the intention of preventing further damage in the future.

The Space Shuttle was created by the United States (U.S.). It is the first reusable spacecraft, designed as a facility to launch humans into Earth’s orbit safely (*Space Shuttle: First Reusable Spacecraft*, 2021). This vehicle was developed to reduce government costs, since it was manufactured to be a reusable product. While the Space Shuttle has a variety of purposes, its reusability stands out in the context of reducing space debris.

Space Exploration Technologies Corporation (SpaceX), an aerospace manufacturing company, has practice with recycling spacecraft. SpaceX is known as a leading space exploration company, specifically due to its ability to rapidly produce and test spacecraft. This company, led by Elon Musk, has managed to reuse a rocket booster three separate times (Thompson, 2018). Moreover, in 2018, two out of three of the Falcon Heavy’s boosters returned to Earth unharmed. This was a groundbreaking feat for recyclable spacecraft. The Falcon Heavy is a more advanced version of the Falcon 9, a reusable rocket with the objective of delivering assets into space (SpaceX, 2021). Its reusability decreases the cost of space projects, resulting in a more economical endeavor. SpaceX’s missions to recycle spacecraft have created tangible results, paving the way for future innovations. The reusable rocket technology SpaceX has developed could lead to a method of rectifying the orbital space debris problem.

Continuing with SpaceX's space exploration initiatives, NASA has approved SpaceX's request to reuse Crew Dragon spacecraft on future missions (Foust, 2020). Benji Reed, SpaceX's director of crew mission management, announced that SpaceX "[intends] for Crew Dragon to…be fully reusable" (Foust, 2020). This development occurred in 2020, meaning progress is being made to recycle spacecraft. The more spacecraft that are reused, the less waste and feckless space debris will exist.

China is also at the forefront of space endeavors. In 2020, this country successfully launched and recovered a spacecraft, proving its reusability (Lendon, 2020). China was tight-lipped about their spacecraft; however, they seemingly have similar goals as the United States. To elaborate, both countries wish to continue the exploration of space and discover if Mars would be a suitable planet to one day inhabit. Another country's involvement in the reuse of spacecraft may very well increase the U.S.'s momentum and encourage further development of recyclable spacecraft.

Applying the Framework of Technological Fix

The primary method of reducing space debris at this time is the spacecraft cemetery. The problem with this creation is that it is a temporary solution. In short, this concept is a technological fix. The theory of technological fix comprises the utilization of technology to solve something with a deeper problem. Professor Byron P. Newberry discussed technological fix in his encyclopedia entry for the *Encyclopedia of Science, Technology, and Ethics*. He outlines how utilizing technology as a quick solution to bigger problems can be dangerous. Furthermore, he questions if all situations can be solved using technology (Newberry, 2005). Technological fixes do not explore the root of the problem, which results in temporary fixes, rather than long-term solutions. Using technology to create a shortcut to a bigger problem is very apparent in the creation of the Great Pacific Garbage Patch (National Geographic Society, 2019). This collection of debris in the middle of the ocean is comparable to the aforementioned spacecraft cemetery that was created for large spacecraft debris to be deposited—also in the middle of the ocean (*Where Do Old Satellites Go When They Die? | NASA Space Place – NASA Science for Kids*, 2019).

Seventy percent of debris in the ocean travels down to the ocean floor (National Geographic Society, 2019). Considering this, the spacecraft cemetery's debris is most likely littered across the ocean floor there in the South Pacific Ocean as well. Marine life is negatively affected by trash in the ocean, as many animals mistake plastic for food (National Geographic Society, 2019). According to the National Geographic Society, no country will take it upon itself to clean the Great Pacific Garbage Patch, since the entire planet is truly responsible for its creation. Similarly, due to decades of intense competition in space exploration, several countries have contributed to permeating Earth's orbit with debris. Because of this, long-term solutions are more difficult to implement. It would take a universal effort. The spacecraft cemetery was designed as a technological fix, like the Great Pacific Garbage Patch. As decades pass, the debris in oceans will accumulate, resulting in loss of sea life and poisoning of oceans. A solution implemented outside the planet Earth would be more environmentally agreeable for Earth.

Analysis Using Wicked Problem Framing

Wicked problem framing is another applicable framework to this problem of space debris. Wicked problems are inherently controversial and create differing opinions. Sustainability issues fall into this category of wicked problems quite often. Therefore, space debris and satellite disposal have the requirements to analyze from a wicked problem standpoint. Considering the ineffectiveness of the aforementioned technological fix, analyzing this problem of space debris from a wicked problem framing perspective is beneficial to discuss a solution.

Since the solutions to wicked problems are inherently disagreed upon, collective approaches to resolve the problems are needed (Elia & Margherita, 2018). This means that, despite differing opinions as to how to ameliorate the issue, countries should come together to discuss another option for the future of spacecraft. Otherwise, the space debris accretion issue will continue to grow and become insurmountable, creating a higher probability of collision for future space travel projects.

Analysis Regarding Recyclable Spacecraft Systems

The solution to this societal problem most likely lies in recyclable spacecraft systems. As mentioned earlier, a possible orbital satellite recycling system has been discussed by Northrop Grumman. This concept would assuage future space debris build-up and possibly begin the process of clearing space debris already in Earth's orbit. By recycling satellites in space, satellites would not need to be sent from Earth in the future; they would be created from old satellites in space. The success of this would be astronomical for space exploration, since resources could be utilized for human space travel rather than transportation of satellites into Earth's orbit.

While recycling satellites in-orbit is an excellent future solution to clear and limit space debris, a popular idea that has been tested is returning spacecraft undamaged to Earth to use again. This concept began with the Space Shuttle and has been continued by SpaceX with great fervor. Being able to reuse spacecraft will not only end the continued accumulation of space debris, but it will also ultimately decrease costs in relation to space travel and exploration. This could escalate new discoveries and innovations regarding space. Overall, recyclable spacecraft usage should be prioritized to eliminate this continued aggregation of space debris in Earth's orbit.

Societal implications that could result from a lack of action primarily include space debris impeding future space travel and the spacecraft cemetery potentially damaging planet Earth. Increasing the agglomeration of space debris in Earth's orbit increases the risk of harm to spacecraft and passengers. Relying on a system to determine if the probability is high for collision with space debris leaves room for mistakes to be made, and, as a result, for people to get hurt. While creating this system is incredible as a temporary solution, it is only a temporary solution. Northrop Grumman's concept of recycling satellites in Earth's orbit and creating new ones from the old configurations is genius. However, this may take some time to be put into action. Therefore, the key solution to this predicament is utilizing recyclable spacecraft—returning spacecraft to Earth to use again for the next mission.

The spacecraft cemetery continues to exist as a source of consternation. All of the fragments from spacecraft that must accumulate from striking the ocean does not bode well for sea creatures. Perhaps humans are protected because it is contained far from civilization; however, if protecting marine life is a priority, changes will need to be made.

Counter-Argument

Some objections may be posed when considering the previous analysis. Overarching arguments regarding worldwide participation, necessity—or lack thereof—for recyclable satellites, and the relevance of space debris to humankind are a few of the major ones. What if other countries do not wish to participate in developing recyclable products? The fact of the matter is that any country producing spacecraft that elects to utilize recyclable products as opposed to ephemera will be assisting in the reduction of space debris agglomeration in Earth's orbit and beyond. Any country willing to alter their spacecraft designs, materials, and mission plans in pursuit of environmental welfare will not just be benefiting the planet as a whole, but its own citizens as well. Using recyclable products can be seen as a selfless endeavor, since the environment does not affect just one singular country.

As noted by Philippe Galland, who works as a manager for Airbus Defence and Space, it can be better economically to make satellites with transitory lifetimes (Werner, 2018). There is an ease in simply creating more satellites to launch into space, rather than inventing an operation to recycle them in-orbit, as suggested by Northrop Grumman. However, long-term, having a method of recycling satellites in space, rather than sending up new ones every five to fifteen years, actually appears a more economically feasible solution.

Thirdly, some may wonder how space debris even affects humanity in the first place. According to Luis Villazon from Science Focus Magazine, the danger of space junk is indirect (Villazon, 2018). The conglomeration of debris surrounding Earth can eventually impede weather satellite readings as the debris cluster grows. Therefore, humans would be unable to detect weather alterations. Another key problem of space debris agglomeration is the possibility of large debris impacting the Earth, causing horrendous catastrophes (Luke, 2020). In fact, discarded debris from Russian Proton rockets crashed in Siberia each time one would launch (Vassilieva, 2012). Some debris carried toxic fuel, resulting in possible health risks. Thus, space debris impacts more than just the unknown area outside of planet Earth: it impacts incognizant humans every day and will only grow in influence.

Other methods for reducing space debris have been discussed, in addition to recyclable spacecraft. The key proposal that could be considered is minimizing the debris discarded during spacecraft deployment and mission operations (*Orbital Debris*, 1995). The difference between this concept and the possibility of recyclable spacecraft is the former would not produce as large of an impact on the environment. Completely reusing spacecraft will have a more substantial effect overtime. However, this concept of reducing debris wherever possible is still a valuable idea to incorporate with the main objective of recycling spacecraft.

Conclusion

This research paper sought to learn how satellite data acquisition affects society, specifically through discussing the implications behind space debris and debris agglomeration on Earth. By expanding the number of recyclable spacecraft systems, the accumulation of space debris in Earth's orbit will decelerate. Moreover, it would render the spacecraft cemetery useless, since the spacecraft would return to Earth to be used again later. Thus, the accretion of battered spacecraft in the waters of the South Pacific Ocean would also decrease.

The ethics perspectives of utilitarianism and deontology were considered when approaching the problem. Utilitarianism strives to make decisions that benefit the most people, while deontology suggests making choices that follow a set of duties previously determined. Although utilitarianism would suggest pausing space activity all-together until the orbital debris crisis is solved, this solution is not entirely feasible, since competition among countries is too high to halt operations. Alternatively, deontology would say that following the orders of an employer or company is the correct decision. Therefore, employees and space companies involved with space development would be making the correct decision by proceeding with space exploration. Regardless, the best option would combine the two: finding a solution to the space debris problem whilst creating a new method of developing spacecraft to prevent accumulation of space debris in the future.

The frameworks of technological fix and wicked problem framing were utilized to discuss reasons why a solution is required as well as form possible avenues for ameliorating the issue. Recycling satellites in Earth's orbit and spacecraft to use for future missions is a worthwhile solution, both economically and environmentally. Potentially, this could be the answer to reducing space debris and increasing space travel.

Space debris accumulation is a major issue for the future of this planet's environmental stability. A joint effort from all countries participating in space exploration is ideal, though cannot necessarily be expected. By incorporating recyclable spacecraft into a space company's operations, other companies may decide this is a better solution for them as well. Therefore, one company or country can influence others. Delving into this topic has brought light to the issue of wasted and non-recyclable products. Ideally, this will allow society to consider improvements upon current technologies to assuage environmental concerns and encourage future space exploration missions. Because of the increase in space exploration initiatives, utilizing recyclable spacecraft is a feasible option for countries, and some have already begun working on this concept. Considering this, the space debris crisis can realistically be slowed through recyclable materials, allowing more time to develop methods of clearing the debris, like the in-orbit satellite recycling system. Another possibility is the institution of government regulations to require the utilization of recyclable spacecraft. However, this proposed solution is less likely to be implemented. Overall, by taking advantage of the ability to reuse spacecraft systems, the possibilities could be endless for future exploration.

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