A Utilitarian Ethics Analysis of the collision between Iridium-33 and Cosmos-2251

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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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Introduction

On February 10, 2009, Iridium 33—an operational United States communication satellite—was struck by a defunct Russian communication satellite, Cosmos 2251. While several mitigation strategies to detect future locations of space objects had been in place by multiple countries, no country had publicly detected an impending collision leading up to February 10. Unfortunately, at the predicted time of the close approach Iridium 33 went silent. Approximately two hours later, reports of debris clouds from the two satellites populated countries' space agencies—the first ever active satellite collision occurred. The Iridium-Cosmos collision served as a wake-up call for many launch providers on how to not be a good steward of the near-Earth space environment (Kelso, 2009). While there is little on why the collision occurred or who shoulders the blame for the incident, there is an abundance of research documenting the plethora of political, economic, and scientific repercussions following the aforementioned fateful collision.

I believe that analyzing the Iridium-Cosmos collision with the use of utilitarian ethics will allow one to better determine the morality each satellite operator's actions leading up to the collision in a concrete manner and emphasize Russia's immorality in leaving a decommissioned satellite in space through highlighting the violation of John Stuart Mills' "freedom principle" and Jeremy Bentham's "utility principle". Furthermore, I seek to provide insight into how employing a utilitarian approach to future space missions is crucial to the evolving space industry. Failure to consider the ethical ramifications of satellite operator actions can augment the risk of pursuing new space missions in a debris-filled environment and hinder further scientific investigation and progress. Additionally, neglecting to view satellite operators' actions through a utilitarian lens will hinder scientists from understanding the increasing risk a debris-filled environment poses for

future space missions. Through use of peer-reviewed academic journals regarding international space law current events, reports on the debris fallout following the collision, and the principles of utilitarian ethics by Ibo van de Poel and Lamber Royakkers, I intend to show Russia's choice to leave Cosmos 2251 in orbit after the end of its service life was immoral.

Background

The Iridium-Cosmos satellite collision occurred on February 10, 2009 when Russia's derelict Cosmos satellite hit Iridium's communication satellite at 15:02 UTC over Siberia. This event was the first of its kind between two satellites, as until then all other collisions involved satellites and pieces of space debris. Iridium served as a US telecommunications provider through the use of 66 satellites in Low Earth Orbit (LEO). Cosmos 2251 was commissioned in June 16, 1993 as a military communications satellite for Russia and out of service by 1998, at the end of its 5-year designated lifespan.

Traditionally, conjunction analyses, or reports that predict how close satellites are to other space objects such as debris or satellites, are drawn up and delivered to satellite operators to warn them in advance of potential maneuvers they should consider to avoid an accident. Preceding the Iridium-Cosmos collision event, multiple reports predicted a close approach between the two satellites had been published and delivered, however due to the rapidly variable nature of the data, it was hard to determine accurate positions of the two satellites in real time. Data that showed approaches under a kilometer—which was within an accepted range of proximity for satellites—changed to show approaches of over a kilometer in the next day.

The collision between the two satellites prompted multiple studies of the debris created and how it would disperse into an already densely populated LEO environment to assess

collision risks given the popularity of using LEO for a variety of science and defense applications. Furthermore, it prompted a discussion on how existing policies and treaties should be amended to mitigate the overpopulation of space and future collision risks in LEO.

Literature Review

A plethora of analyses exist regarding the collision between Iridium 33 and Cosmos 2251. A majority of scholars, such as Brett Hemenway and Shane Chaddha, detail the increased collision risks with debris for other spacecrafts following the Iridium-Cosmos event. These same scholars also cover the preceding events of both spacecraft until collision occurred as well as suggestions for policy changes regarding international space law. Documentation regarding post-collision impacts allude to preexisting policies on outer space law and their relevance to the accident, however there remains no focus on viewing the collision event through an ethical lens to better understand which party acted immorally.

In "Achieving Higher-Fidelity Conjunction Analyses Using Cryptography to Improve Information Sharing," Hemenway prefaces his proposal on the implications of the Iridium-Cosmos collision on the increased risk of space debris collision and the use of cryptography to improve information sharing between satellite operators. Hemenway posits there has been a 40% increase in debris objects following the Iridium-Cosmos collision (Hemenway et. al, 2014) and later goes on to describe several procedural changes government agencies, such as the Space Surveillance Network (SSN) have made in response to the increasing threat of an overcrowded space environment. Additionally, several conjunction analysis results are outlined from using Hemenway's proposed new secure data collection method and recommended for implementation by satellite operators. In further breakdowns of his calculations on algorithm run time estimates

and probability calculations on accuracy of the conjunction calculations, Hemenway urges adoption of these more secure data collection tools as means of sharing orbital information across satellite operators to ensure collisions like that between Iridium 33 and Cosmos 2251 do not occur again. While Hemenway proposes insightful methods on how to provide more accurate positioning data for conjunction analyses, no argument is made evaluating the morality of the satellite operator.

Similar to Hemenway's proposal, Shane Chaddha highlights the increased collision risk with space debris following the Iridium-Cosmos collision event through proposing a better method for space debris mitigation through policy reform. In Chaddha's "A Tragedy of the Space Commons?", he outlines the growing threat of space debris for the international space community through the use of a metaphorical model between the age of space exploration—and space debris growth, coincidentally—with Garrett Hardin's 'The tragedy of the commons'. In doing so, Chaddha suggests that the solution for space debris mitigation would require ceding our freedoms to the state and ensure mutual responsibility for a widely-shared resource. More specifically, Chaddha alludes to Hardin by dictating that since space has become a domain that is used by military, commercial entities, private entities, and governments, it is essentially a 'commons', or resource shared among users within a larger community. Chaddha later references the Iridium-Cosmos collision in the context of the rise in interference to future space operations, stating that "the rise in space congestion poses the risk of interference to current and planned commercial space endeavors" (Chaddha, 2010). Furthermore, other consequences from the collisions were noted, such as how other NASA satellites and the ISS had to make maneuvers to avoid colliding with the Iridium-Cosmos debris (National Aeronautics and Space Administration, 2009). Chaddha outlines the severity of the space debris pollution problem

created by multiple countries and establishes a call to action for a more responsible use of space by all countries through the use of Hardin's 'Tragedy of the Commons', but does not take into consideration any ethical frameworks to evaluate the orality of specific satellite operators. he While numerous arguments were developed to contend that the current LEO environment will reach a point where it is unstable and collisions will become the most dominant debris-generating mechanism in the future, no arguments were made in this report to evaluate the morality of the satellite operator.

There are imperative lessons to be learned from the Iridium-Cosmos collision, such as the requirement of having higher fidelity conjunction assessments for both satellites—whether U.S. based or not. Unfortunately, the majority of scholarly work focuses on proposals for policy changes and new data processing guidelines following the Iridium-Cosmos collision. There is a lack of analysis that regards the ethical underpinnings of the satellite operators' actions. In addition to analyzing the preceding actions of both satellite operators to the collision, this paper will provide a unique judgement on the actions of the satellite operators involved in the Iridium-Cosmos collision .

Conceptual Framework

The morality of the satellite operators can best be evaluated through the ethical framework of utilitarianism, developed by Jeremy Bentham. utilitarianism is a dialect of Consequentialism, in that morality is judged based on the consequences of actions. However, with utilitarianism, the consequences of actions are measured against one value: human pleasure, happiness, or welfare (Poel and Royakkers, 2011). As a result, actions that result in pleasure/happiness, or avoid pain/unhappiness, are viewed as moral. This framework, as a result,

relies on hedonism as the foundation for several key philosophers who developed and honed the framework, such as Jeremy Bentham and John Stuart Mills. Drawing upon its hedonistic background, there are two key principles that help evaluate the morality of actions: the freedom principle and the utility principle.

The utility principle, developed by Bentham, augments the foundations of utilitarian ethics through dictating that one should choose those actions that result in the greatest happiness for the greatest number. One can view actions to be "proper", "responsible", and "correct" if said actions agree with the utility principle. To better quantify how useful actions are, Bentham came up with the concept of a moral balance sheet, in which certain factors such as intensity, duration, certainty, and extent of action would affect how useful an action is.

Utilitarianism was further developed and gained the freedom principle, also known as the No Harm principle. Developed by John Stuart Mill, the freedom principle states that "everyone is free to strive for his/her own pleasure, as long as they do not deny or hinder the pleasure of others" (Poel and Royakkers, 2011). This principle was founded upon the thought that humans are to choose actions that provide the most pleasure without sacrificing dignity or humanity.

For the purpose of this paper, I will contend that the Cosmos satellite operator acted immorally as the consequences of their actions did not bring about happiness/pleasure. Furthermore, I will analyze the operators' actions in the context of utilitarianism's freedom principle and the utility principle to stress the immorality of the aforementioned actions.

Analysis

As it stands, international space law has been constructed to ensure that the lawful uses of space objects are peaceful and beneficial to mankind (Christol, 1980). Space commercialization

in the last few decades has yielded opportunities for the advancement of human knowledge and quality of life. Communication satellite constellations, CubeSat research missions, and national security endeavors all take advantage of the benefits of the LEO space environment with hopes to benefit mankind. However, the risk of collision continues to grow due to the rapid growth and occupancy of these altitudes. Collisions that occur in LEO pose a compounding threat to other constellations and spacecraft due to the volatile nature of satellite collisions—such as that seen with Iridium 33 and Cosmos 2251.

The actions of the Cosmos satellite operator can be considered immoral and irresponsible in the context of the collision event through the violation of utilitarianism's freedom principle and utility principle. Furthermore, decisions cannot be deemed moral in the realm of utilitarianism if the consequences of said actions do not produce pleasure. Therefore, it can stand to reason that actions that result in pain, or a lack of pleasure, should be avoided due to their immorality. In the context of the Iridium-Cosmos collision, it can be ascertained that Cosmos' actions did not produce pleasure and violated the freedom and utility principles. Viewing the incident in the lens of utilitarian ethics allows for one to deem Cosmos' actions immoral. In the upcoming sections of this text, the actions and consequences of Cosmos will be analyzed to determine their immorality in the context of utilitarianism and the two aforementioned principles.

Utility Principle

The utility principle was violated in the context of the collision event between Iridium and Cosmos in that the actions of Cosmos did not bring about happiness for any number of people. More specifically, it caused service interruptions to Iridium's customers who were

attempting to make calls. To further understand how Cosmos' violated the utility principle and acted immorally, there requires familiarization of the actions of both satellite operators leading up to the Iridium-Cosmos collision. Preceding the collision event, reports were generated that predicted a close approach of 584 m between the two satellites, however no action was taken by either operator.

Iridium's satellite was part of a functional constellation to provide communications service to customers, whereas Cosmos 2251 was a defunct Russian military satellite. With multiple reports being generated ahead of time regarding conjunctions of Iridium and Cosmos, Iridium had prior knowledge to the impending positions of the two satellites, however none of the reports were heeded due to the high deviation of data and unreliable nature of the data on which the reports were formulated from.

Both operators had the right to occupy the LEO orbit yet the immorality of the Russian Cosmos satellite arises after its service life ends. Once Cosmos had completed its mission and deactivated in 1999, it was left in orbit for nearly 10 years until the collision event (Earl, 2009). Cosmos was left without any capability to actively maneuver in orbit to avoid collisions or orbit changes. Iridium, in contrast, was still in service and continued to serve customers on Earth before and after the collision. As Earl states, "the damage to Iridium's 66 satellite infrastructure was minimal. After the loss of Iridium 33, the Iridium company immediately moved one of its orbiting spares to take Iridium 33's place. Regular service was restored in a matter of a few days" (Earl, 2009).

When viewing this event in the lens of utilitarianism, the morality of an action can be viewed by its ability to result in the greatest happiness for the greatest number (Poel and Royakkers, 2011). Due to the fact that Cosmos was derelict, it was unable to prove of use to the

Russian Intelligence community following its decommissioning. Furthermore, Iridium 33 was continuing to provide utility and pleasure to many from occupying the LEO altitude. From this standpoint, it is evident that the decision to leave Cosmos in orbit after its service life was immoral due to its inability to be of use anymore.

Freedom Principle

The second principle that was violated by Cosmos' operator was the freedom principle. This principle was violated in large part due to the decommission of Cosmos after its service life. Once deactivated, Cosmos had no capabilities to maneuver to maintain orbit or avoid collisions. Iridium, on the other hand, had multiple reports regarding the potential of close approaches with Cosmos ahead of the time of collision. There was a choice to disregard these reports due to the high variability of the data used to generate the conjunction reports—some reports predicted close approaches of 117 m, whereas the same reports showed approaches of 1.243 km the very next day (Kelso, 2009). The high variability of the data makes it hard for the operator to decide with certainty if a collision would happen. If Iridium had made the decision to maneuver the satellites based on this data, it would have resulted in extra fuel spent and possible service interruptions for its customers.

Due to its inoperable status, Cosmos had no use for conjunction reports, whereas Iridium did. Additionally, Iridium's satellites had adequate capabilities to plan and perform a maneuver safely due to the acknowledgement of a potential collision between the two satellites. Consequently, it is contested by several scholars that due to Iridium's functioning status as well as the presence of multiple conjunction reports, Iridium acted immorally by choosing to not perform any collision avoidance maneuvers, hence having caused harm to Cosmos. However,

this perspective fails to acknowledge the aforementioned utility principle. Cosmos was not operational at the time the collision happened or was even predicted—Iridium was of use. It follows logic that a satellite that is unable to maneuver and is not actively performing actions or providing service cannot be responsible for crashing into another satellite that has the capabilities and preparation to avoid such a collision. However, Hanspeter et. al indicates that performing debris avoidance maneuvers drives up fuel costs and the satellite down-time, which in turn would reduce science return and revenue (Schaub et. al, 2015). The consequences outlined by Hanspeter et. al would apply to Iridium, causing its customers to experience service outages, and in doing so would illustrate a loss of utility. By hindering another actor's ability to provide pleasure to a group of people through utility, a rogue satellite—Cosmos—violates the freedom principle through its lack of action.

The violation of the freedom principle can also be seen through analyzing the implications of the Iridium-Cosmos collision on future space missions and satellite debris collision probabilities. As David Wright notes, "Because of the high density of satellites and debris in this 700 to 1000-km region, this is the most likely place for a collision to occur" (Wright, 2009). As a result, any collision or event that would generate additional debris would crowd an already dense environment, leaving less space for satellites to orbit freely without the risk of collision. The Iridium-Cosmos collision has even been shown to increase the number of conjunctions, or predicted collisions, for many other satellites in the decades to come, as Kelso notes, which could endanger their respective ability to maintain orbit and utility to the end customers without increased fuel costs and service disruptions. In addition to the increased conjunction reports caused by the collision, the number of debris is significantly higher from the collision. In line with what Wright argues, this further exemplifies the violation of the freedom

principle through introducing more debris in the aforementioned region. This domino effect was further modeled by Alessandro Rossi and Giovanni Valsecchi, who simulated that the fragments of a satellite in one plane of a constellation would drift to the next plane of satellite and have a higher probability of impact at an even higher speed (Rossi and Valsecchi, n.d.). By highlighting the impending threat of intra-constellation collisions, one can ascertain that the freedom principle was violated because the Iridium-Cosmos collision would not only endanger the ability for Iridium to provide utility and maintain service, but also harm the ability for any other company within the region to operate safely without the impending danger of collision with debris from the collision.

The increased threats of space debris collision, as brought about by the Iridium-Cosmos collision event, illustrate the violation of the freedom principle through the increased risks satellite operators face for future missions. Furthermore, these increased risks would force operators for future missions to spend more time and money on maneuvers to ensure they can maintain operational. If Cosmos' operator had deorbited its satellite following the end of its service life, there would have been less space debris in an already crowded altitude as well as lower risks for collisions for future missions.

Conclusion

As it stands, there is not substantial information on the motives or intent of either satellite operator involved in the Iridium-Cosmos collision, hence it is not possible to declare who is at fault through simple analysis of mission events. However, through the employment of utilitarian ethics, one is able to ascertain the morality of each operators actions—more specifically, one is able to deem Cosmos' operator to have acted immorally in this ethical framework of utilitarianism due to the violation of the freedom principle and utility principle. More

specifically, Cosmos' choice to leave a derelict satellite in orbit without the ability to maneuver around other space objects violated the freedom and utility principles. This was derived from the increased risk satellites and future missions face from collision with debris from the Iridium-Cosmos incident in an already dense space environment. Additionally, the temporary outage that Iridium faced, while not permanent, illustrates the violation of the utility principle as several Iridium customers on Earth were unable to make calls when the collision happened. In contrast, Russia did not face any consequence from the collision and experienced no advantage from having Cosmos 2251 in space at the time of the crash.

This collision has illustrated how the "Big Sky Theory", which posits that the vastness of space makes the chances of a collision between two orbiting satellites negligible, is no longer valid as an assumption (Ansdell, 2010). There is a need for widespread policy adoption that emphasizes space debris removal and the responsible use of space. With new satellite operators, such as OneWeb, SpaceX's Starlink, and Amazon's Project Kuiper, proposing mega-LEO constellations comprised of thousands of satellites to provide more ubiquitous internet access, it is of paramount importance that there is a playbook that ensures space remains a place of utility and peaceful exploration, rather than a junkyard of scientific exploration.

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