CECIL, 1U Amateur Radio CubeSat

(Technical Paper)

On the Dangers, Implications, and Future of Low Earth Orbit Pollution

(STS Paper)

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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

Introduction

When was the last time you went a significant amount of time without connection to the internet, using your GPS to get where you need to go, or checking the weather for the week? Whether users actively realize it or not, the operation of manmade, Earth orbiting satellites is what enables us to use an incredible amount of technologies, including those just mentioned, every day (Satellites in Our Everyday Lives). Outside of providing technology and communication services to the developed world, satellites also serve a key role in helping developing countries do things such as improve their educational systems and expand general connectedness to important information (Gottschalk). That being said, it is fairly obvious the social and societal relevance that satellites play in our 21st century world. The importance that satellites play in the lives of so many people on Earth is what made me pursue them as the prime technology topic for both my technical capstone and STS research paper. In the technical capstone project, I will be working alongside a team of fellow University of Virginia undergraduate aerospace engineering students to complete the preliminary design stages of a small satellite, called a CubeSat, set to launch in the next two years. In the STS research paper, a discussion of the dangers of pollution of manmade objects in low Earth orbit will be conducted alongside an analysis of the problem and its link to key societal actors.

Technical Topic

Within the technical portion of the capstone project, I will be assisting, along with a team of fellow UVA engineering students, in the designing phases of a CubeSat intended for radio communication between the satellite and various positions on Earth. CubeSats are small, reasonably priced satellites of predetermined size that allow Universities and their students

affordable access to space (Chin, J. Et. Al.). The design, production, and launch of CubeSats since their inception has been pivotal in providing students in higher education programs across the world with real, hands-on experience working with space flight hardware. As of late 2018, over 510 CubeSats have been launched to space by 50 different countries, demonstrating an obtainable goal (What is a Cubesat?).

The primary objective and mission statement of this technical capstone is to create a satellite system that is able to reliably communicate with both a student run UVA ground station, and other amateur ground stations around the world. These objectives will be accomplished at a low cost and with low risk of failure. To allow for data sharing and collaboration, the satellite will be designed to function within the bounds of an amateur radio license. The development of this radio enabled satellite system will give experience in both spacecraft design and project management to myself and the other fourth year aerospace engineering students of the University of Virginia. Detailed design and development are expected to be completed by Spring 2020, with a ten-month period of building and testing to follow, and a projected launch date of approximately February of 2021. The development of this CubeSat is crucial in promoting space-exploration interest and real-world technical skills in the University of Virginia's next generation of engineers.

STS Topic

Since the first satellite, Sputnik, was launched by the Soviet Union in October of 1957, the use of satellites in our everyday lives as beacons of communication has skyrocketed. These devices have completely changed the way people gain and relay information in the modern technological world, and they serve as key links in digital society (Labrador, V). With the cultural and societal impact that satellites have, it is important to know the risks that these devices face in the current

day, and how these risks can and should be assessed moving forward. Currently, one of the biggest risks to our satellites- and thus our connectedness- is the issue of low Earth orbit pollution.

Currently, there are more than 500,000 objects in orbit being tracked by NASA. These objects, essentially "space junk," move at incredible velocities and prove absolutely devastating if any of them come into contact with other objects in orbit (Garcia, M). While NASA does track these pieces of debris and develop flight maneuvers ahead of time to prevent spacecraft from being struck, this tracking system does not entirely solve the issue. While these half a million objects are tracked, there lie millions more particles in orbit that are too small to be traced; particles that prove to be as great a threat as the larger fragments. Figure 1 below, from a NASA presentation on Space Security, shows just how much growth the larger fragments in orbit have undergone over the years. The space associated with low Earth orbit is undeniably big, but as time progresses and this number of particles and fragments increases more and more, so too does the risk of losing spacecraft or lacking the ability to launch more.

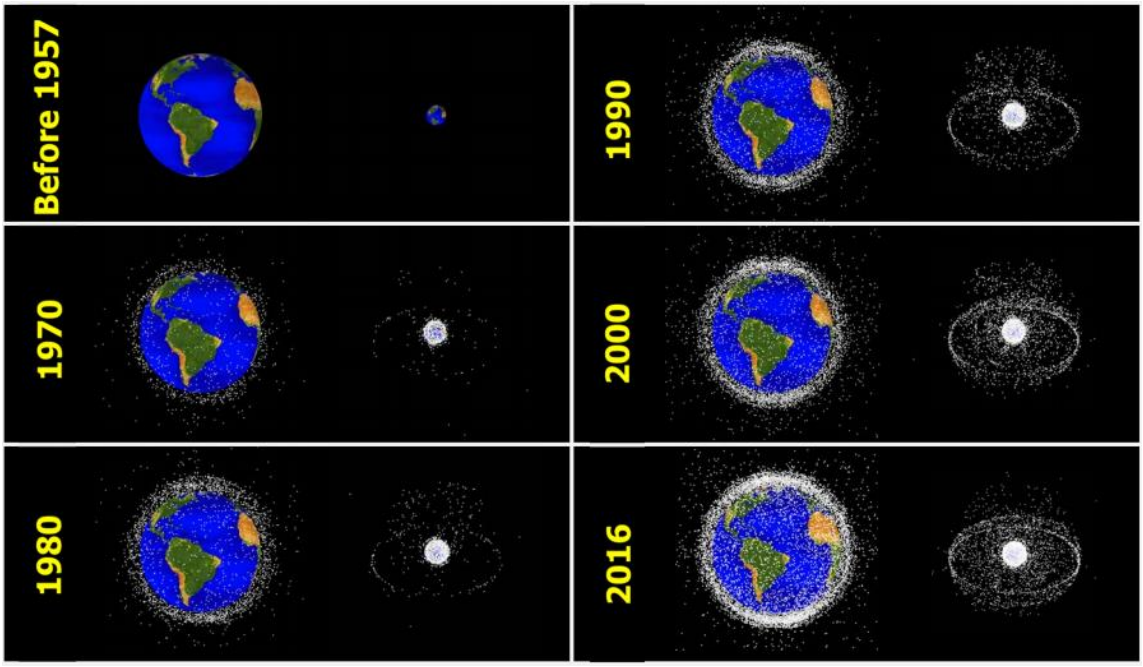

Figure 1: Increasing number of objects (>10cm) orbiting Earth since 1957 (dots not to scale)
Retrieved from NASA, by Liou, J. C

This risk is something that has already begun to manifest itself as real disasters. For example, the 2009 collision of U.S Satellite Iridium 33 and Russian Satellite Cosmos 2251: an interaction which took two spacecraft and effectively created a cloud of thousands of speeding bullets out of them (Wei-Hass, M). The International Space Station, an Earth orbiting laboratory that has been the home of countless astronauts and a hub of many groundbreaking science experiments, was even struck by a particle of space debris in 2018 (Knapton, S). While the total number of collisions that have occurred in low Earth orbit at this time are fairly low, warning signs such as those just listed above need not be taken lightly, as risk to satellites is a risk to modern society as a whole.

The STS theory that frames this research is Actor Network Theory (ANT). While Actor Network Theory is notoriously hard to summarize, based on my own interpretation and the words of Professor Darryl Cressman from Simon Frasier University, ANT is a framework which defines a technological problem by a network of interconnected relationships between different actors (Cressman, D). Actor-Network Theory is vital to the analysis of this research paper as there are many players at stake in the complex network that makes up the low Earth orbit pollution problem. From scientists studying the issues, to the public who use satellites daily, to legislators whose role it is to form strict rules to protect against future pollution, there are many sides which need to be analyzed here.

Research Question and Methods

Research Question: What are the societal dangers of low Earth orbit pollution?

In order to conduct the research described in the previous section, a combination of documentary research and use of Actor-Network theory coupled with network analysis will be applied. Documents, in the form of news articles, scientific journals, and the like from the

perspectives of each of the players described previously will be collected and analyzed to gain a full picture of the intricacies of the problem at hand.

Examples of such documents include a German article introducing Donald Kessler, a key figure in the scientific world studying low Earth orbit pollution and its growth (Seidler, C). Also to be analyzed is a scientific document from the European Space agency, showing how ESA scientists go about tracking objects in orbit and showing that the issues at hand concern all nations (D. Mehrholz et al). Many more documents and perspectives will be considered in order to frame the problem and its interconnectedness to society in as great detail as possible.

Conclusion

While the technical portion of this thesis is the design phase of a low Earth orbit, small scale satellite known as a CubeSat, the STS research component examines how low Earth orbit spacecraft, such as the CubeSat, are both at risk and pose risk to society. A full analysis of the issue of low Earth orbit pollution will result in some clarity as to how the problem can be addressed moving forward. I expect that the technical portion of this thesis will prove as useful, hands on experience with a large scale, team-oriented project, ultimately amalgamating in a successful launch. Meanwhile, I expect that the research component will shed light on a key issue related to the technical portion, and spark ideas as to how society can react to the problem in the coming years

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