Designing a Method for Using Spacecraft to Monitor and Improve Truck Parking
(Technical Paper)

The Historical and Future Societal Impacts of Satellites
(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

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Introduction

Starting in the second half of the 19th century, satellites have continuously allowed humans to surpass the previous limitations related to how they communicate and explore. In fact, satellites have changed the way modern society functions, with a large swath of the population using or benefitting from this technology daily in some way. As a testament to the impact satellites can have, the technical portion of this project will be concerned with using satellites to improve truck parking management along major highways. A major problem in the United States due to illegal parking on the sides of highways, parking on exit ramps, or even drowsy driving by truck drivers due to there being no place to park, truck parking management can easily be solved using satellite imaging and recognition of trucks.

The STS portion of the project will aim to investigate the profound, long-term effects satellites have had on politics, military operations, commercial enterprises, and scientific discoveries since their incorporation into society. This portion will also seek to predict future effects of satellites and possible policy changes due to their prevalence. The paper will use the STS framework of Social Construction of Technology to describe the intertwined relationship that society and satellite technology have had, with each advancing the other in numerous ways.

Technical Topic

Freight-truck driving is a very important, yet very dangerous, profession that many companies and individuals are reliant on to continue commercial operations. It requires focus and attentiveness to be able to respond to changing road and traffic conditions and to avoid causing an accident, which, considering the size and weight of the vehicles being driven, could be catastrophic. However, even the best drivers can succumb to fatigue and drowsiness, especially after driving shifts up to 11 hours in a row, as limited by trucking laws. As well, at the end of their 11-hour shift, drivers have approximately 15 minutes to park and stop driving for the day (Acker). Therefore, ensuring that there is a near and safe place for truckers to park their vehicles at the end of their shifts and during breaks should be of utmost importance to transportation authorities and is an issue of societal safety as well as infrastructure. Yet, due to mismanagement and lack of legal truck parking in areas along key highway systems, truckers have taken to parking on road shoulders, supermarket parking lots, and other illegal places as a substitute. This technical project seeks to alleviate the problem by designing a system for satellites to recognize and track movement of trucks at truck stops. This information would then be sent to the state-respective departments of transportation and to truck dispatches in order to give drivers information concerning distance to the nearest rest stop and how many open parking spaces there are at said stop.

In accomplish this task, students from UVA have teamed up with engineers from MITRE to create a detailed systems-engineering plan and to prototype technology for the project, such that, afterwards, it can be put into motion with little to no additional planning. These students include Victor Yang, Alex Griffin, Andie Daniels, Anish Vegesna, Brandon Ghany, Dominic Pinnisi, Ian Wnorowski, Jimmy Smith, Luke Dennis, and me. Additionally, similarly sized groups of students will be tackling the problems of tracking real-time weather data to improve roadway safety and remote-sensing-enhanced non-destructive evaluation of roadway infrastructure. All three groups were advised over the course of the semester on how to approach their respective problems by the MITRE representatives to better come up with a solution that meets MITRE’s needs.

To research this topic, students were tasked initially with interviewing key stakeholders and subject matter experts to identify the main problems associated with truck parking and to become more educated about what is already being done to combat these problems. These stakeholders include organizations such as the I-81 Corridor Coalition, the Eastern Transportation Coalition, the American Trucking Association, and many more, which all have their own perspectives on the most prevalent problems and how to solve them. For instance, the I-81 coalition, while resolving many other areas of transportation unrest, has been focusing on pinpointing areas along the I-81 highway where truckers are most likely to stop. This information would then be sent to state departments of transportation or private investors so new truck stops can be made or existing stops can be expanded (Alden).

Following this research, the Truck Parking Management group devised a problem statement, which was to devise a satellite-based technology capable of tracking truck movements and parking along major highways. This information would also need to be easily transferrable to state DOTs, truck dispatchers, and any other involved party. Using a set of criteria, with a focus on maximizing data utility, spatial coverage, and reliability, and minimizing cost, risk, and complexity, different solutions to this major problem were devised by the team and ranked accordingly. The proposed solution to MITRE, therefore, is a constellation of satellites providing real-time imaging of trucks along major highways. Additionally, truck-detecting software will be implemented to allow the attached cameras to accurately identify moving, legally parked, and illegally parked trucks. This data will then be sent to an official mobile app for truckers, it will be used in various map plugins, and it will be posted on an official website to inform truckers of potential available parking and to inform other drivers of truck movements.

Over the course of the Spring 2021 semester, this proposed solution will be refined, prototypes of all technologies involved will be produced by April 2021, and a final report and presentation will be given to MITRE for review. This will culminate in the creation of a Cube Satellite (CubeSAT), a small (10x10x10 cm), cheap research satellite able to carry up to 1kg of payload, carrying not only the imaging technology from the Truck Parking Management team, but also those from the other two teams under MITRE's guidance. To accommodate the added technology from all 3 teams, the satellite may instead be a double cube (10x10x20 cm) or a triple cube (10x10x30 cm), with each 10 cm increase in length allowing for an extra 1kg of payload (Loff 2015). This satellite will then be launched into Low Earth Orbit, rudimentary data will be collected on truck movement within localized highway sections, and said data will be streamed to a developed app or website for testing and review. Following this initial test, the design will be critiqued based on the aforementioned project criteria (cost, utility of data, etc.). With prototypes in place, simple data collected, and proof-of-concepts completed, MITRE will be able to implement this technology on a larger scale if they so choose.

STS Topic

The primary goal of this research study is to evaluate the past and potential future effects of satellite technology on politics, military operations, commercial enterprises, and scientific discoveries since its inception in the mid-20th century. To adequately describe the impact that satellites have had, I will go in depth into each aspect discussed without taking a stance on the morality or ethics within each area. In addition, the role of all these factors in the development of satellites will also be investigated, falling under the STS framework of Social Construction of Technology (SCOT). This framework, which will be a basis for the change that satellites have caused and have been a product of, encapsulates the ingenuity of the space race period into today.

The SCOT framework, in essence, refers to the creation and acceptance of technology by relevant social groups over the course of its existence. This also implies the existence of an acceptance threshold at which the technology can be considered "widely accepted". In the case of satellite technology, social groups relevant to its creation and improvement include national governments and militaries, impartial scientists focused on exploration, telecommunication companies, and other private commercial entities interested in using satellites. Widespread acceptance of this technology, however, is also reliant on the opinion of the average informed citizen of interested countries, as they eventually determine what elected officials stay in power. These officials can either approve or disprove satellite research, determining the outcome of its acceptance. As well, since the technology is not readily available to the average consumer, for satellites to be "widely accepted", they only need to be accepted by the scientific, commercial, and political community at large, which has already been achieved.

The first man-made satellite was SPUTNIK 1, which launched in 1957 from the USSR and provided important information concerning the density of Earth's upper atmosphere and the ionosphere through the drag it experienced upon launch and reentry. It also sensed and recorded the radio signals produced by each layer of the Earth's atmosphere (Broadband). This launch then spurred the decades-long space race between the United States and the USSR due to the ongoing Cold War, leading to a period of space-related scientific discovery and innovation, especially concerning satellites (Nedkova). The space race is a perfect example of the SCOT framework, defining how the need for better technology caused satellites, which may not have been explored in depth until later otherwise. Without the labor and financial resources provided by governments and other, non-scientific, parties, the scientific community may not have focused on this project, opting for other goals withing their available means. Due to this interest, however, the uses for satellites have expanded to political and military use, and finally into use for deep space exploration and by telecom companies in more modern times.

Political, Military, Scientific, and Commercial Uses

Since they are so connected throughout history, the political, military, and scientific uses for satellites will be discussed in tandem. This way, the I will start at the very beginning of successful satellite launches, as the resultant space race led to a period of espionage and competition between nations, but also to a period of unprecedented exploration. To show how satellites have complimented this phenomenon, I will go in detail about the numerous spy satellites used by countries during the Cold War and the impact they had, both physically and psychologically, even when not present. Additionally, satellites were a political status symbol during the cold war, with space being the next groundbreaking field. The country with a larger number of more-technologically-advanced satellites in space was seen as "ahead" in the space race. Other than for stature and military operations, satellites have also been used for government scientific research through NASA and similar organizations, the results of which have shaped modern space exploration possibilities.

During the Cold War, the U.S. sent many reconnaissance planes to reveal the weapon developments of opposing nations like the USSR and China. Especially because such countries kept their projects and advancements a secret, it was important to learn if such advancements could be a threat to the U.S. mainland and interests beyond. However, after a U-2 spy plane was shot down over the USSR, the U.S. began to rely more on satellite imagery for information, namely the CORONA missions. With a total of 145 missions launched and more than 120 successful, these satellites would bring a large amount of film into space for a few day span to allow the film to be properly exposed, and then fall back to Earth to be retrieved by catcher planes (Norris). These satellites, and others, may have sparked distrust between nations, but they also confirmed and disproved many rumors about hostile technological advancements, reducing overall tension and potentially saving many lives. In modern times, reconnaissance satellites are being used in a similar manner, but with different and more efficient technology, consisting of digital imagery and a data transfer system that prevents the need for devices to return to Earth.

While many government satellites were used for wartime and political efforts, NASA has sent many satellites into space with the purpose of researching other planets, stars, and neighboring systems. Beginning during the space race, NASA has continuously sent satellites into space to monitor conditions and to research neighboring planets for composition, signs of life, the potential for manned missions. These missions have not been limited to one target in many cases, such as the MESSENGER satellite mission, which performed fly-bys of Earth and Venus, as well as its main target Mercury, collecting atmospheric and surface data along the way (Talbert, 2015). Due to these missions and many others since the mid-20th century, interest in space travel and exploration, as well as science in general, has continuously increased as satellite technology has become cheaper and more reliable, as well as threats to national security have become more global (Abbany, 2020).

The first instance of satellite technology for commercial use was the Telestar satellite, launched by NASA for AT&T (Telestar). This satellite, while only in space for a few months, was able to transmit television signals showing such videos as speeches by John F. Kennedy, sporting events, and the American flag waving. From there, commercial communication expanded to include satellite phones, satellite dish TV, and, more recently, internet services. These advancements alone have paved the way for the commercialization of space and have helped Earth to become more of a global community. Additionally, private space exploration companies like SpaceX have taken charge of space research, with planned manned missions to Mars and future commercialized space efforts, all with the help of private funding.

Case Studies and Further Use of STS Framework

To research this topic, I will consult many sources concerning historical uses of satellites, as well as several journals and articles. In addition, I will investigate articles that predict the future of satellite usage such as *Space Exploration in a Changing International Environment* (Lewis, 2014) and *Synthetic Satellite Imagery for Current and Future Environmental Satellites* (Grasso, 2008). These articles will provide me with examples of possible futures for satellite technology advancements, especially through the lens of the Social Construction of Technology (SCOT) framework. For instance, these case studies touch on the premise that, as the need for satellite imaging and research increases due to the desire to extend global security and space exploration, more effort will be placed into improving and developing new technologies to facilitate these endeavors.

Conclusion

The technical section of this project aims to take advantage of developed satellite technology to solve several problems associated with illegal truck parking through orbital imagery on key highway systems. These images would be used to inform truck drivers of nearby open parking spots at truck stops and prevent these drivers from parking illegally on exit ramps or elsewhere or from driving drowsy. This in turn would prevent many catastrophic crashes as a result of any of these factors. At the conclusion of the project in April 2021, the group plans to have a working CubeSAT prototype with imaging capability to present to MITRE for their further advancement and research. The aim of the STS research project is to adequately explain in detail the political, scientific, military, and commercial effects of satellite technology, as well as their effects on satellites over time. In addition, the outcome of both aspects of this project will allow readers to have a well-rounded view of satellite technology, as well as insight into the modern implications of satellites on transportation.

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