Prospectus

Amateur Radio CubeSat
(Technical Topic)

Sputnik's Impact on the United States Explorer 1's Launch
(STS Topic)

By

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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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Socio-Technical Problem

As the University of Virginia strives to be “the best public university in 2030, and one of the best in the world, whether public or private”, technical projects being tackled at UVa should not just deliver a technical fix but also a solution that contributes to society and the community (Hester, "Ryan's 'Great and Good' Strategic Plan Wins Board Endorsement", 2019). With this vision in mind, my team will design, build and operate a CubeSat that will serve as both a technical solution to demonstrate UVa’s ability to reliably launch operational satellites into orbit as well as serve as a communication and experimental platform for the amateur radio community around the world and as a source of inspiration for the next generation of STEM students in Virginia.

Our technical project is to develop a low cost, low risk 1U CubeSat that will reliably communicate through an amateur radio frequency to the UVa and other amateur ground stations. This satellite will serve primarily to develop hands on experience of UVa engineering students designing, building and operating a real satellite.

Although hands-on experience for engineering students is critical in developing the skills necessary to succeed in their field, the social and cultural implications of this project might be greater than its technological value. Similar to how Sputnik-1’s extremely simple and plain design had multiple and, in some cases, extreme implications, this project has the capability of reaching and possibly motivating a much larger group than just UVa engineering students.

The technical objective of the CubeSat project is simple and does aim to innovate, however the real value of this project relies on the educational and motivational implications it brings to students’ and Virginia’s community. Simply focusing on the technical aspect of the CubeSat project will give the illusion of a rather simple design undertaking, however this

perspective overlooks the impact it can have in current UVa engineering students education, future UVa engineering students ability to take on larger, more complex projects and also in promoting space-exploration application among amateur radio enthusiasts and students all across Virginia.

The CubeSat project will solve not just the technical challenge of designing, building and launching a small satellite, but will also serve as a social catalyst for the next generation of STEM students in Virginia. Below I will discuss how the $10\ cm^3$, 1.33kg satellite designed and built almost entirely by UVa students will provide both a wealth of data and opportunities for both UVa students and the amateur radio community. Additionally, using the U.S.' Explorer-1 launch and how it was affected by Sputnik-1's success as an example, I will explain how superficially simple technological achievements can have a great impact on society and, in the case of Sputnik-1, how they can both motivate and expedite the technological development of an entire nation (Howell, 2017).

Technical Project

CubeSats are a type of miniaturized satellite for space research that is made up of multiple 10 cm × 10 cm × 11.35 cm cubic units. CubeSats comprised of one unit are called 1U, and go up to 3U (NASA). These satellites have a mass of no more than 1.33 kilograms per unit, and often use commercial off-the-shelf components for their electronics and structure. These standardized sized satellites allow for relatively low complexity and high reliability satellites to be launched at low costs. These satellites present an opportunity for organizations such as the Virginia Space Grant Consortium, which aims to promote interdisciplinary space-related research infrastructure, education, and cooperative initiatives, to promote and subsidize space missions in local universities with limited funding (VSGC, 2019) . With this objective in mind,

the Virginia Space Grant Consortium previously funded UVa and two other universities in Virginia to design and build three 1U CubeSats that will be launched simultaneously to perform a joint atmospheric experiment (Segal, 2019).

This project presented an opportunity for engineering students at the University of Virginia to both acquire hands-on experience designing and building a satellite and to make a meaningful contribution to the space industry (Goyne, 2019). Additionally, if the mission was successful it would serve as proof that the UVa engineering students can potentially take on more complex, higher profile missions in the future (Goyne, 2019). The University of Virginia students designed a 1U CubeSat that could communicate with and be tracked by UVa's own ground station through an experimental licensed frequency.

However, although the University of Virginia's CubeSat was deployed in July 2019, there has been no successful communication between the CubeSat and the ground station at UVa so far. The Virginia Polytechnic Institute and State University, while attempting to communicate with its own Cubesat, was able to briefly communicate with UVa's satellite, suggesting that the CubeSat was indeed functioning as intended and the problem instead was with UVa's ground station. Unfortunately, UVa has a license from the FCC allowing its CubeSat to communicate through an experimental frequency, and if a ground station not operated by UVa wants to communicate with the satellite, it must get approval from the FCC.

The inability of cross-communications with other ground stations has put the University of Virginia in quite a predicament. On one hand, the problem could be hardware and/or software malfunction with UVa's ground station, something UVa engineering students had minimal involvement with. On the other hand, the problem could be entirely with the CubeSat, which could have adverse consequences with UVa's reputation and future projects.

The goal of the technical project is to design and build a low cost, low risk CubeSat that will reliably communicate with ground stations at UVa and elsewhere through an amateur licenced frequency. The project's objectives will be to solve two major problems with the current design in orbit. The first objective is to bring the project to fruition at a low cost by using commercially off the shelf components and acquiring an antenna from the amateur radio association. The second is to ensure a high probability of successful communications and for the communications to be through an amateur frequency so any ground station can freely communicate with the satellite without approval from the FCC. This project will serve to demonstrate that UVa engineering students are capable of successfully launching a fully functioning satellite, regardless of UVa's current ground station status.

Moving forward, my team will begin to outline a budget that draws from previous experience in order to reduce cost and will reach out to the FCC to initiate the amateur licence procurement. Additionally, my team will reach out to the amateur radio association to inquire about donating an antenna, which will further reduce the cost of the project and will start to explore mission architectures and concepts.

STS Project

On October 4th, 1957, the Soviet Union inaugurated the "Space Age" with the successful launch of Sputnik-1, the first artificial satellite in orbit (History.com, 2009). Sputnik-1, a large spherical satellite with four large antennas, was close enough to earth that it could be seen by anyone around the world with binoculars, and its mission objective was to transmit radio signals back to earth that any amateur radio operator could hear (History.com, 2009). In response to the launch of Sputnik 1, the United States launched the Explorer 1 satellite onboard the Jupiter C rocket on January 31st, 1958. The Jupiter C rocket was designed by a German scientist Wernher

Von Braun, who was previously part of the Nazi party and worked on the V-2 missile program that sent bombs to England during World War II.

Most Americans today believe that the first U.S. rocket that launched Explorer-1 was designed and built as a natural progression of the technological development of American scientists and engineers. From this point of view, Sputnik was little more than a wake up call to America that the Soviet Union was just as technologically able and it was going to compete for space. This gives the impression that it was America's ingenuity and perseverance that made the launch of the Explorer 1 and subsequently the American space program a success.

However, this idea dismisses two major actors that significantly affected the U.S. space program: Sputnik-1 and Wernher Von Braun (Dickson, 2007). This misinformed view of American techological development before and during the space race disregards the socio-political pressure that Sputnik-1 put on the American government and society as well as the fear it incited, and it also ignores the instrumental roles that ex-nazi engineers such as Wernher Von Braun played in the U.S. success.

If we continue to remain unaware of these two key actors in the U.S. space program's development, we will be unable to fully appreciate how fear and the need for America to demonstrate that it was not lagging behind the Soviet Union technologically changed the direction of the U.S space program (Moskowitz, 2012). Although "Sputnik was basically a hunk of metal" (Wall, 2011), its implications were far greater than its accomplishments. According to historian Asif Siddiqi, "A lot of people at the time called Sputnik a technological Pearl Harbor" (Wall, 2011). Sputnik was so frightening to the American public shortly after the launch of the satellite that "politicians and the press had spun it into a shocking symbol of Soviet superiority that could soon lead to nukes falling on American cities" (Begley, 2010).

Using actor-network theory I will argue that the success of the U.S.' Explorer 1 launch and subsequent space program was due to two main actors in the network, Sputnik-1's success and implications and the contributions of ex-nazi engineer Von Braun (Garber, 2007). Actor-network theory is an approach to understanding the technology-society relationship that examines power dynamics in heterogeneous networks (Callon, 1987). A heterogeneous network is comprised of both human and non-human actors brought together by a network builder to accomplish a goal. I will be using Callon's concept of translation, which explains how networks form, to analyze technical and social actors that affected the launch of the first American rocket.

Conclusion

This paper discusses how my team will design an improved CubeSat that takes lessons learned from previous projects at UVa to deliver a new system which is more reliable and inexpensive, while at the same time having a broader reach. The CubeSat will be designed and built almost entirely by UVa students to provide fundamental hands-on experience as they transition into the professional sector. Additionally, the CubeSat will communicate through an amateur radio frequency to allow ground stations all around the world to communicate with the satellite and also to promote STEM and space exploration in Virginia.

Although the project is technically simple, as explored on the STS section of this paper a very simple device like Sputnik-1 can have incredibly strong social, cultural and political implications. By exploring Sputnik's impact on America and the American space program, I argued how our project can be used to promote space related technologies among the amateur radio community as well as a teaching tool and source of inspiration for the next generation of Virginia engineers.

The technical and STS projects serve to solve the broader socio-technical problem promoting space exploration technology among the amateur radio community as well as inspiring source for the next generation of Virginian engineers.

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