Undergraduate Thesis Prospectus

Software Development for the UVA HEDGE Cubesat on Board Computer

(technical research project in Aerospace Engineering)

The Cost of Knowledge: Securing Funding for Abstract Research

(sociotechnical research project)

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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General Research Problem

How may the lag between regulatory regimes and technological innovation be curtailed?

Many technological fields are suddenly experiencing exponential growth. The benefits of which can't be understated; however, it's naïve to think that innovation provides boundless good. Penicillin is accredited to saving over 200 million lives (Dosani, 2005). Yet, antibiotic use in farming has allowed livestock quality of life to deteriorate (Landers et al., 2012). One cannot expect a cattle farmer to abstain from using antibiotics on their livestock if it means risking their death, however. This is why regimes must impose this will on their people as it sees fit. A perfect regime would diagnose problems brought by technology ahead of time and enforce change before catastrophe. However, no governing body has perfect foresight, nor total control of its people. Combined with the explosion of technology, this could mean our innovations forever outpace our attempts to restrain them. A future in which we are controlled by our own attempts at betterment is uncertain at the least, and catastrophic at the worst.

Software development for the UVA HEDGE Cubesat on board computer

How can the on-board computer of a satellite in orbit be made to communicate with, and relay data to a computer handled remotely in Charlottesville?

Problem Outline

The Hypersonic ReEntry Deployable Glider Experiment (HEDGE) is a CubeSat that will be launched into orbit and reenter the Earth's atmosphere at hypersonic speeds to collect data. A CubeSat is a small satellite that uses standard size and form factor (Caldwell, 2023). The Software and Avionics subteam is to design the hardware and software systems of HEDGE so that it can collect, store, and transmit data during the mission. Specifically, our subteam will be connecting the onboard computer (OBC) to hardware components which nearly all other subteams connect, interact, and communicate with. The team is working under Professor Chris

Goyne for the class “Spacecraft Design” in the Mechanical and Aerospace department. The project incorporates over thirty students working in multiple subteams, of which the software and avionics team has five members.

Objective of Research Work

The objective of our research this year is to construct and test a prototype that contains essential hardware and software components for the HEDGE mission. The challenge will be ensuring communication amongst components and guaranteeing that data is effectively transmitted back to Earth.

Building upon previous years, we must also develop the required software that allows real-time data acquisition, processing, and transmission during operation. This software must synergize with the avionics, addressing challenges inherent in different mission stages. Once the prototype is finalized, a subsequent objective will be testing. Tests will validate the software’s functionality and the hardware's resilience under the conditions of hypersonic re-entry.

Alongside these responsibilities, we must schedule and manage software operations across all functional teams. Our objective is not just technical precision but also showcasing the efficacy of university-led projects in producing industry-aligned research.

Approach and Methods

The first step is integrating the selected components. The team will collaborate with electrical engineering students to design and fabricate circuit boards that connect the thermocouple, pressure transducer, and transceiver. These circuit boards will be based on the flowchart in Figure 1.

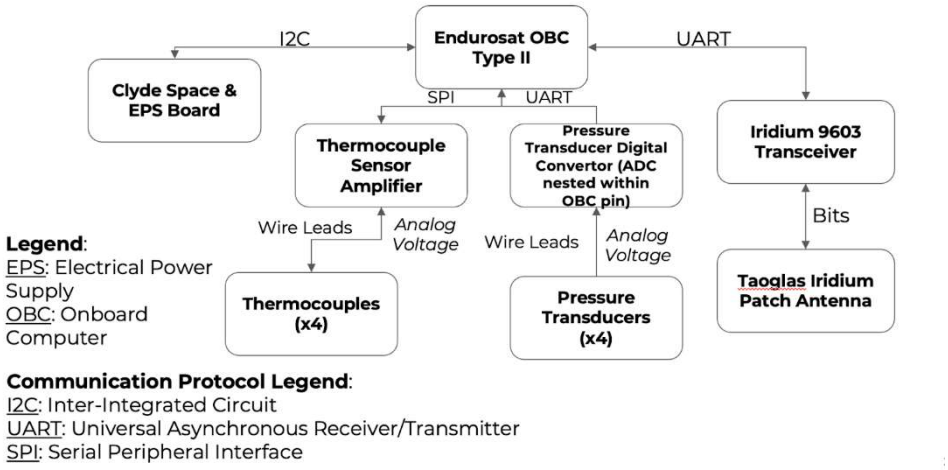

Figure 1: Hardware data flowchart (UVA MAE 4700 2023 Students, 2023)

The software, which consists of FreeRTOS, COSMOS, and CFS, will be developed to communicate with two PCB chips, for which multimeters and microcontrollers will test to ensure OBC communication is working. The team will showcase and discuss the final design with other teams to streamline the integration process for the final HEDGE prototype.

Resources

For command and control, the Endurosat onboard computer will be used. Its user manual holds key information about hardware integration, application programming interface documentation, configuration procedures, troubleshooting, and safety guidelines (Endurosat, 2018). To manage onboard processing, NASA's core flight system, a reusable software framework, will be used due to its reliability and portability (NASA, 2021). The COSMOS interface will be used to set up the ground system and run simulations on components (Ball Aerospace, 2023). University of Virginia professor Mike Mcpherson has worked in industry for many years and is helping the team with technical details. Lastly, a group of electrical & computer engineers are collaborating with many HEDGE sub teams, and are helping develop hardware components.

Objectives for Spring Semester

By the end of the Fall 2023 semester, the Software and Avionics team plans to deliver the hardware components for the MSP300 pressure transducer and the Iridium 9603 transceiver. Because the OBC will not arrive for testing until the Spring, the software the team will deliver will be on a Raspberry Pi 4b, which will be ported to a smaller microcontroller running FreeRTOS (TImada, 2023). This program will interface with two analog to digital circuit boards constructed by a team of ECE students through GPIO (General Purpose Input/Output) pins to allow for communication with the pressure/temperature and transceiver subsystems.

The biggest objective of the Spring 2024 semester is to port the CFS software to the OBC and ensure that input/output (IO) between the software subsystems and their respective hardware components functions correctly. To do this, OpenC3 COSMOS provides a framework for cubesat testing that the team will utilize to simulate the working environment of the satellite (Ball Aerospace, 2023). Furthermore, the team will update the CFS project to align with changes made to the information transfer / data storage mechanisms described in the HEDGE documentation. Finally, we will collaborate with the structures and integration team to construct a virtual mapping of the inside of the satellite to ensure all avionics have space to perform their tasks, and communicate with the OBC.

Type of technical paper

For the first semester, the software and avionics team will work together to prepare for a Technical Interchange Meeting (TIM) with the rest of the subteams. For the second semester, all subteams will collaborate to make a System Integration Report (SIR) and one technical thesis.

The Cost of Knowledge: Securing Funding for Abstract Research

In the US, how do competing social groups seek to influence National Science Foundation funding policy to favor or disfavor theoretical research projects?

In 2023, the NSF was provided with $9.877 billion of funding. (NSF, 2023). Because this is public money, the NSF is under pressure to promote research of prompt and practical benefit (Solovey, 2020). More theoretical work results in less funding. In this competition, the social and behavioral sciences have lagged (CNS, 2010; NSF, 2023). This problem has been identified for years, with change only coming reactively. In 1925, Robert Moses created the Southern State Parkway, where he purposefully made bridges too short for buses. Half a century later this, and many other of Moses' actions, was exposed to be racially discriminatory (Caro, 1974). At this point, racial and economic discrimination had been built into the roadways of America for 50 years. A more robust education system could have curtailed this, but ethics of engineering would not be an established subject until 1970 (Martin et al., 2021). While making good steps, the US still lacks financial support for social sciences. How can this be helped?

Research has already been done in this area. Hicks (2012) argues that performance-based research systems serve as a status symbol that is coveted amongst universities, causing them to compromise values such as equity and diversity. Brankovic (2017) argues that the "status games" universities play with each other harm the populus. Prestigious colleges get copious funding, while smaller universities get little. Internally, the most prestigious programs see most of this money, which rarely includes the social sciences. Mosley (2012) illustrates the correlation between advocacy and funding, showing organizations that can reach a wider audience often secure more funding, and the best way to secure funding is to advocate policies to more people. At which point, the money can be reinvested into expanding influence. In this structure, an

organization has no control over their own research. Ball and Jin (2020) claim that meritocracy is a substantial cause of class disparity, resulting in research becoming a gateway into the elite. On the contrary, Gläser & Velarde (2018) argue that research funding being reliant on proposal quality, research performance, and the stature of the research organization allows the scientific communities to have more power in shaping their fields. While the conclusions of these papers differ, they both hinge on a notion of success, posing a new question. How should one quantify the success in technology? Rao (2010) proposes a method for "scoring" innovations based on fourteen metrics. While a helpful framework for determining success, it doesn't account for potential consequences. Such a system would likely overvalue more concrete technologies and provide low scores to abstract ones. The implications of these ideas reach far, and have the potential to affect the lives of people and organizations from any background.

Participants include UTEP's Computer Science program, which wants to maximize student graduation (MC Staff, 2023). They state the grant will "expand opportunity for highly motivated students in high-demand STEM areas.", and that it's "speeding up the process of developing marketable skills, including research and computational thinking skills." (MC Staff, 2023). While valuing student success, the teaching they can provide is heavily influenced by the NSF. The UMass Social Sciences department exemplifies this same desire, but for a "less attractive" science (ISSR, 2023). Their Institute for Social Science Research, ISSR, characterizes themselves as "a place where faculty and students gather to engage in methodological training, learn about and discuss new and exciting research, work together to develop grant proposals, and create new interdisciplinary collaborations". While not receiving as much funding as competing research institutions, the institute states that "Science policymakers now recognize that social science is critical to solving the most pressing social problems". The Association of American

Universities is a group created to ensure the best interests of higher learning (AUU, 2014). In a statement from 2014, the association opposes the FIRST Act, writing "[the FIRST Act] also does some things to widen [the nation's innovation deficit], including significant funding cuts to social, behavioral and economic research.". Afterwards, the association calls for action, as it "encourages Members of Congress to vote against it unless substantial revisions are made.". Taxpayers United of America is a group that advocates for less taxes, and government transparency in spending. (Schultz, 2019). In their mission statement, they say "TUA works on behalf of taxpayers to reduce local, state, and federal taxes". Their existence puts pressure on the government to reduce taxes, and justify their spending habits. One of their members declares that "On behalf of Illinois Taxpayers I demand that Illinois lawmakers tell the public what the money is really being used for.".

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