**CUBESATS: A NEW APPROACH TO COST-EFFICIENT HYPERSONIC TESTING**

**RESEARCH THAT REFLECTS VALUES: GRANTING STUDENTS THE RIGHT TO INFLUENCE UNIVERSITIES' TECHNOLOGICAL RESEARCH**

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By
Lauren Murphy

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Technical Team Members: Hussain Assad, Aidan Case, Kaiya Saunders

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.

ADVISORS

Rider Foley, Department of Engineering and Society

Chris Goyne, Department of Mechanical and Aerospace Engineering

## The Problem with Hypersonic Testing

The presence of hypersonic flight vehicles in both civilian and military settings has grown increasingly since its introduction to the world in 1949. Everything from long-range missiles to the Apollo space capsules travels at hypersonic speeds (Anderson, 2012). Hypersonic flight is defined as any vehicle that reaches a minimum Mach number – the ratio of object speed to the speed of sound – of five, which translates to speeds of 1375 m/s to 1700 m/s depending on target elevation, (Kirtskhalia, 2012). The additional physical phenomena associated with these high velocities separates hypersonic speed from lower speeds. Dissociation of air molecules, creation of plasma by ionization, changes in chemical reactions, and excitation of electric energy levels are some common, yet complicated effects. Ultimately they cause breakdowns in common fluid flow models (Van Wie, 2021). These complications mean that in order to design and create a flight vehicle capable of reaching beyond hypersonic levels, extensive testing of the temperatures, pressures, shocks, and material reactions is required.

Despite the increasing popularity of hypersonic vehicles, the methods of testing in this extreme environment remain an extremely costly endeavor. Hypersonic wind tunnels are currently the most common method of simulating the needed conditions. Wind tunnels are ground-based facilities that generate flows of air, with either fans or pressure differences across a plate, and accelerate the stream with nozzles and diffusers (Woodford, 2021). There are a wide variety of hypersonic tunnels available, but none come cheap. For example, the Ludwig tunnel is one variation that is known for being a relatively cost-efficient option, yet the University of Alabama still spent one million dollars making one (Wichner, 2022). These wind tunnels are not economical, and they severely limit the scale at which hypersonic testing can be done. With the race for increasingly fast and powerful missiles between world militaries, along with the increasing interest in cheap, civilian space travel, the need for a new, low-cost hypersonic testing method is at an all-time high.

The University of Virginia is currently addressing this problem by designing a new hypersonic glider. The project is a positive step forward in technological progress, but the human and societal aspects behind it are not as straightforward. Questions regarding students' right to belong to a university that reflects their views and values come into play. Few students are aware of the hypersonic testing being conducted, and fewer still understand the implications it could have in military settings. Overall, the University of Virginia's dive into CubeSats offers a new cost-effective method to test hypersonic environments, but in return, it raises concerns over the larger problem of universities acting without the consent of their students.

**Small, Fast, and Cheap**

A possible solution to the high costs associated with hypersonic testing that the University of Virginia is currently investigating takes testing from the ground to the sky, or more accurately above the sky, with miniature satellites called CubeSats. CubeSats are made of one or more 10 cm cubed units that can be outfitted any way the designer wishes.

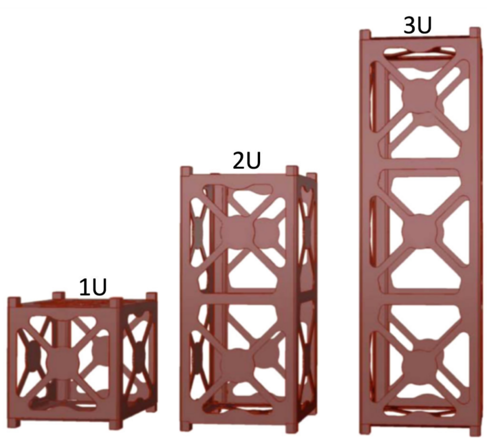


Figure 1. Standardized shells of 1 unit, 2 unit, and 3 unit CubeSats (Golkar & Poghosyan, 2017)

The standardization of CubeSats makes launching them into low earth orbit – 250 km to 2,000 km altitude (May, 2022) – from established launchers on the ISS a cheap and accessible option (Shiroma et al., 2011). They are transported to the ISS as secondary payloads on existing rockets. After launch, the small satellite orbits the earth anywhere from a couple days to a couple years, relaying data back to researchers on the ground, before completing its mission. Past CubeSat missions have included disaster response, weather monitoring, parachute testing, and much more (Howell, 2018). The University of Virginia has also participated in many CubeSat projects in the past such as pollution testing, atmospheric data gathering, and radiation testing (UVA CubeSat News, n.d.).

Figure 3. CubeSat launcher on the ISS (Goyne, 2022)

The HEDGE (Hypersonic ReEntry Deployable Glider Experiment) CubeSat is a new variation of this 22 year old technology with the goal of creating a new, cost-effective method of conducting tests in hypersonic environments. It is being developed by the University of Virginia's entire Spacecraft Design class. The CubeSat is 3 units large, and once it is sent into orbit, the outer shell of the structure springs open creating fins and revealing an inner nose cone. This reconfiguration turns the box into an effective glider (Goyne, 2022). The CubeSat will be in a low earth orbit for around 14 days before re-entering the earth's atmosphere at hypersonic speeds. It is here that all data will be collected. On the outside of the body, there will be thermocouples to measure temperature and pressure, two key pieces of information for hypersonic testing. Inside the main body will be a battery, an attitude and direction controller, and a communication system. All data will be sent from the CubeSat to another commercial satellite that will relay the information back to a ground station. This communication system is the focus of the author's team in this overall project. The information gathered will then be used in the same manner as wind-tunnel-collected data: to help design hypersonic flight vehicles.

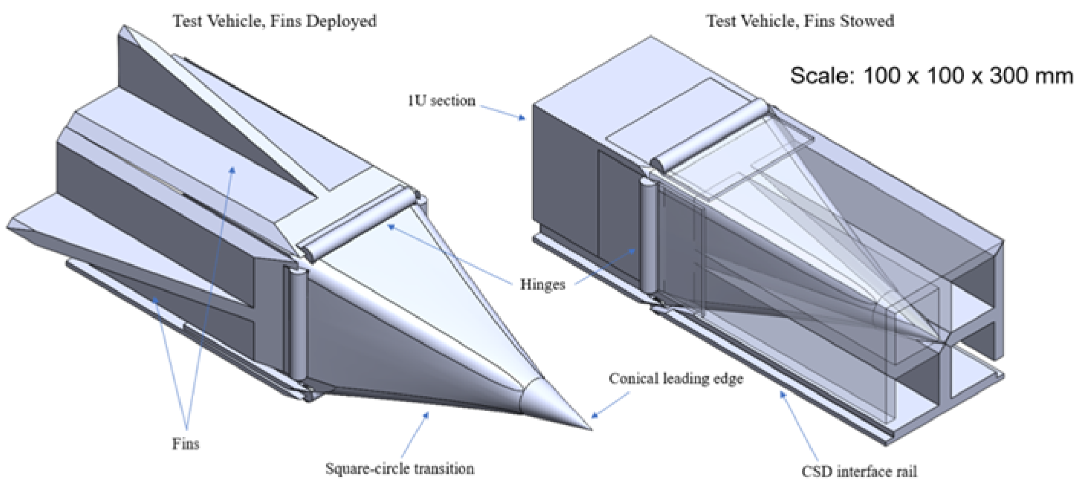


Figure 2. HEDGE CubeSat design concept (Goyne, 2022)

Three factors make the CubeSat more cost-efficient. First, the components for Cubesats are generally found commercially off the shelf. This means that anyone can purchase the technologies, and the mass production of these components means they are relatively cheap (Trick, 2022). Secondly, CubeSats are small. Being less than 10 kg means there is not much room to add excessive and expensive components, as well as making the cost to secure its place on a rocket relatively small. Lastly, the standardized size of CubeSats negates the need to make a custom launch system that any other satellite would need. The launcher on the ISS is readily available for a fraction of the price it would be to build a separate launch system (Poghosyan & Golkar, 2017). Overall, the price of the HEDGE CubeSat method of hypersonic testing is considerably lower than that of existing methods.

**Unimpeded and Unmonitored University Research**

Cheaper may be better, but when looking at the HEDGE project through the lens of the technological citizenship (TC) framework, non-obvious problems come to light. TC is based on the principle that technology has the power to shape societies in the same way that legislative acts can, yet there is no legislative body to monitor and keep the increase of innovations in check (Andrews, 2006). Many people ignore technological consequences because they trust technologic experts, but they fail to realize that differing interests, differing traditions, and design errors are ingrained in the technology at hand (Feenberg, 2011). Thus a new method of accountability should be put in place. Building off political citizenship, TC presents a set of rights and responsibilities that should be granted to everyone in a community that interacts with a technology. In this research study, two rights will be analyzed: the right to information – defined as every member having enough knowledge about the technology to input their opinions on it – and the right to participation – defined as members having access to methods of implementing their opinions (Frankenfeld, 1992). With these rights in mind, technology can be monitored by those affected by it and lead to better communities.

The HEDGE CubeSat project displays the lack of TC the University of Virginia grants its students. The US military is heavily involved in hypersonic research and the weapons it can help design. This year alone, the Department of Defense increased its budget for hypersonic research by hundreds of millions of dollars, making it the leading investor in the field (Gould, 2022). The

US Navy has already expressed interest in being a customer for the HEDGE CubeSat, a fact that few students outside of the Spacecraft Design class are aware of. This project continues despite the high probability that most students do not support increasing military power. A plurality of individuals aged 18 to 29 believe that the military budget should be cut back, and only 18 percent believe it should be expanded (Kaurfa, 2020). The university never acknowledged the thoughts, values, and beliefs of its student body when implementing this project. Knowledge about the project was not readily available to students, and there was no method for anyone outside of the class to impact the course of this research. Even students in the Spacecraft Design class had no choice on the matter. Being technological citizens was never an option, and this was not the only instance: for fiscal year 2022 alone, the University of Virginia obtained two new military research grants (US Department of Defense, 2022).

When students choose a university, they actively attach their names to it and the values it holds. Thus, the students are deeply rooted in the realm of these research technologies but are not given any rights to hold the university accountable. Two important aspects of a community are belonging and communication (Chowdhury, 2019). If universities want to claim they make up a community, both of these aspects must be met with respect to TC. Further, most universities have mission statements that contradict the reality that they do not openly disseminate information on research or open channels for students to affect research. The University of Virginia states they are defined by “a free collegial exchange of ideas [and] values of honor, integrity, trust, and respect” (“Mission Statement of Virginia”, 2014). As it stands, free exchange of ideas does not extend to high-level research, and trust and respect are not applicable to students' values. While high-level research may not directly affect students, there are still important human and social components regarding students when it comes to these technologies. For the most part, there is little evidence of universities granting their students, the public, or other members of the community rights to knowledge and rights of participation, as is an important part of having technological citizenship and regulating the technologies being created.

**Researching the Research**

From all this, a question forms: how can universities implement a better way for students and communities to learn about and influence the technological research being conducted? To answer this question, two methods will be used with the University of Virginia acting as the prime subject: interviewing and surveying. Interviews will first be conducted with research principal investigators – along with the people they work with in the research process – with questions such as the following. How do you interact with the everyday student regarding your research? Do you think your research embodies students' values? What do you think would happen if students had the right to influence your research? Then, interviews with average students will be conducted. Questions regarding their thoughts on controversial research and how heard they feel regarding this research will be asked. Lastly, surveying of students will be conducted to get widespread information on how well-versed students are in research projects and their general values. By looking at the situation from both the students' and professors' sides, a comprehensive analysis can be made. The goal is to first find the overall opinions of community members on the idea of implementing TC and finding possible methods of implementing TC principles. Another aspect will be finding and noting facts about how research specifically would be affected, and working those facts into methods that would not completely harm the research process.

**Conclusion**

Hypersonic research is an expensive endeavor, but the HEDGE CubeSat provides a new, alternate, cheap method for gathering hypersonic data. This technology, being designed by the Spacecraft Design class at the University of Virginia, will explore the efficacy of using the reentry period of a nanosatellite to obtain usable hypersonic data. While it is a solution to one problem, it brings a separate problem to light: students' values and ideas are not acknowledged in their universities' technological research. The presence of technological citizenship for students with respect to high level research is virtually non-existent, and it disrupts the community universities' strive to build. The research proposed above will hopefully help guide universities' in creating more open and involved technological research, and it can help find the balance between technological innovation and students' values.

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