Undergraduate Thesis Prospectus

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)
(technical research project in Mechanical Engineering)

Implementing an Automated Strike Zone in Major League Baseball
(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 on Thesis-Related Assignments.

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Technical Advisor:	Chris Goyne, Department of Mechanical and Aerospace Engineering
STS Advisor:	Peter Norton, Department of Engineering and Society

General Research Problem:
How can advanced technology impact decision making and performance?

System success depends upon performance, cost efficacy, and social acceptance.

Hypersonic Flight: A CubeSat's Optimal Structural Integration
What is the optimal structural design of a CubeSat to function at hypersonic speed?

Hypersonic capabilities in the defense industry is a paramount challenge that promises advancements in speed, maneuverability, and overall military effectiveness (Veragun, 2023). The term 'hypersonics' refers to the field of study of projectiles that operate at speeds exceeding five times the speed of sound, or Mach 5 (Seldin, 2022). However, hypersonic development is hindered by the high cost involved in the specialized materials, propulsion systems, and control systems required, as well as the costs associated with rigorous testing and complex security measures (Kramer et. al. 2023). The University of Virginia's Hypersonic ReEntry Deployable Glider Experiment (HEDGE) (fig. I), aims to develop a means of conducting hypersonic flight research while maintaining low cost and high accessibility. The HEDGE mission implements the deployment of a CubeSat into Low Earth Orbit (LEO) in which it will collect and transmit data. At the conclusion of the CubeSat's orbit lifetime, it will re-enter the atmosphere to collect data before it burns up.

The S&I subteam is tasked with providing the overall mechanical integrity of the spacecraft, ensuring that all components are securely enclosed and protected, and guaranteeing that inner components can withstand the loads endured in handling, launch, and flight in freefall (Garino, 2009). The team must also collaborate with other subsystems within HEDGE to ensure the most efficient and effective configuration of the spacecraft is achieved.

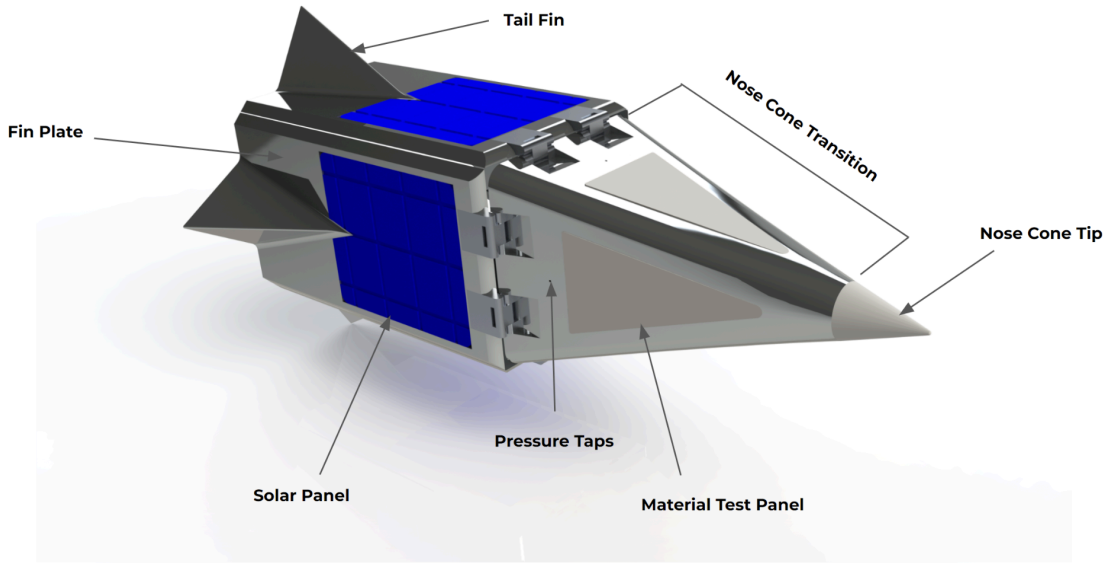

Figure I. 3D modeled design of HEDGE that lists each major component (Fisher, Daniel, et al., 2022)

Methods

HEDGE will be receiving new components from each subteam this year. This changes the design laid out by previous S&I teams. Components must be placed in a method that allows for a large enough static margin. Having the correct static margin is important because it ensures the stability of the spacecraft during reentry (Coleman and Faruqi, 2009). A method we will employ to ensure proper and clear communication with other teams is delegation of a specific teammate or group of teammates to collaborate with a specific team. Our team must work closely with the Software and Avionics team to determine placement, wiring, and logistics of the solar panels on the spacecraft. In determining the static margin of the spacecraft, we are required to work with the ADACS and Orbits team, Software and Avionics team, and Communications team. Each team is responsible for hardware that will affect the center of gravity of the spacecraft, in which we will determine orientation.

We plan to use CAD and FEA software (SolidWorks and ANSYS) to alleviate current structural designs such as solar panel location, cable management, location of internal components, hinge design, and transceiver and thermocouple layout. This software will also aid in the risk management of the structural integrity and capabilities of the spacecraft.

Available resources

There are various resources that have been made available for HEDGE and our subteam. The CubeSat lab is available for us to ask questions and make progress on our established goals. The computers located in the Mechanical and Aerospace Engineering building are equipped with helpful software for our purposes. SolidWorks is a CAD software that will be a huge asset for us as we work to better the structural design and organize the interior components to optimize space and balance of the CubeSat. Ansys is a very helpful software that will allow us to perform finite element analysis and simulate the reentry conditions that the CubeSat will experience. These simulations will help us estimate the current state of our structural design in terms of its strength and temperature distribution. A member of our team has a connection to an individual with a machine shop and this could potentially be an extremely valuable resource for us once we have the inconel prototype. The technical advisor for the HEDGE project, Professor Christopher Goyne, has been working to obtain funding from the US Navy. Various materials manufacturers have also agreed to partner with our team to provide financial support in exchange for installing material test slabs to the CubeSat.

Objectives for Spring semester

The goal of this project in the upcoming spring semester is to finalize and 3D print the HEDGE CubeSat design in order to create a functional model following the Technical Interchange Meeting (TIM) that will occur during the fall semester. This model should be able to

perform all of the functions that the final CubeSat design will be able to, including deploying the fins, collecting reentry data, transmit and receive signal using Iridium satellites, as well as test materials under hypersonic conditions. This technical project's mission will rely on certain events occurring successfully, such as the deployment of the CubeSat and hypersonic glider as a unit, the stability of the glider during flight, and data being properly relayed during reentry. By creating and demonstrating the feasibility of CubeSats for hypersonic glider flight tests, this technical project will open new doors for low-cost hypersonic research with conditions that are not achievable from the ground. Another goal is to garner greater appreciation and attention for aerospace and hypersonics research for other undergraduate students

Type of Technical Paper

The final paper will be a comprehensive description of the design creation that will be sent to coordinators Professor Goyne and the University of Virginia, detailing our creation of a hypersonic glider vehicle experiment using a CubeSat for submission to the navy for funding. The class will be finalized by a System Integration Review (SIR) that will go over each team's work throughout the semester.

Evolution of Sports: The Automated Strike Zone

In the U.S., how have social groups divided over the problem of how best to pursue implementation of an automated strike zone in Major League Baseball?

The MLB will inevitably implement an automated strike zone system using a computer vision system. The debate of the system's justness remains ongoing, where the question arises if the significance of accurate calls trumps the authenticity of baseball.

Existing Literature

Research has been conducted on the psychological reactions to both robot umpires in baseball and to robots replacing humans in general. Wonseok et. al. (2021) found that people had more trust in human umpires than robot umpires and viewed their pitch calls as fairer and more credible. Humanized robot umpires, however, increased the general public's trust. By giving an automated strike zone system a name, people tended to have more positive reactions to the introduction of robot umpires. In research on the psychological effects of human jobs being replaced by robots, Granulo et al. (2018) found that individuals preferred humans replacing jobs over robots when it was not themselves being replaced. When it was themselves being replaced, they preferred a robot's replacement due to the sole reason of self-worth. Delving deeper into robot anthropomorphism, Wang et. al. (2023) determined that "humanlike features of robots in the workplace can increase employees' perceptions of job insecurity" (Wang et. al., 2023).

Participants

Participants involved with the MLB have taken differing stances in regards to the implementation of robot umpires. In 2019, the MLB Umpires Association agreed upon a five year labor contract allowing Major League Baseball to develop and test an automated ball-strike system (Walker and Blum, 2019). In 2022, some minor league ballparks implemented a process in which home plate umpires wore earpieces connected to a pocketed iPhone that communicated each pitch call, identified by Trackman technology, for the umpire to then call physically (Acquavella, 2019). Atlantic League umpire Freddie DeJesus, the first umpire to utilize Trackman in calling pitches, states that "It's a great opportunity and it's good for the game" (Acquavella, 2019).

Among MLB Players Association members, catchers oppose “robot umpires.” MLB commissioner Rob Manfried states that the group is referred to as “‘framing catchers,’ that kind of make their living in the major leagues on their ability to frame pitches” (Manfried, 2023). A robot umpire strips catchers of a skillset that puts some in a level above the rest. According to a study performed by Dan Turkenkopf, “the difference between the best framer (Gregg Zaun) and worst (Gerald Laird) had been equal to 25 wins in ’07” (Baccellieri, 2023). Former framing specialist Jeff Mathis says that robot umpires throw the artistic side of catching “out the window,” and that as a catcher you “Just catch it; put yourself in position to block or possibly throw, and let the robots take over” (Baccellieri, 2023).

The Minor League and Arizona Fall League implemented a process regarded as the ABS challenge system in 2022, where umpires made pitch calls as usual, but gave hitters, catchers, and pitchers the opportunity to challenge a call using Hawk-Eye tracking technology. Players supported this system and emphasized that it improves the accuracy and marketing of the game (Mayo, 2022). Brewers infield prospect Tyler Black explained that the challenge system also brought a new exciting element to the game: “The other day I challenged one and it was correct and the boys were giving it to me.”

Many Major League Baseball fans strongly dislike the idea of an automated strike zone. Fans that resorted to twitter to express their opposition wrote: "Baseball used to have charm. And we will miss the interaction of managers and the home plate umpire," and "If the MLB implements robot umpires I won't watch Baseball anymore" (Brinsford, 2023). Although many fans want to stick to baseball’s roots and keep the game authentic, a large group of MLB fans are leaning towards the implementation of robot umpires due to the seemingly increasing number of bad calls. In a single night in May 2023, questionable pitch calls altered the outcome of two

separate games, spurring tweets like “I've never been in favor of the robot umps, but I'm slowly starting to change my tune…” (Rasmussen, 2023).

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