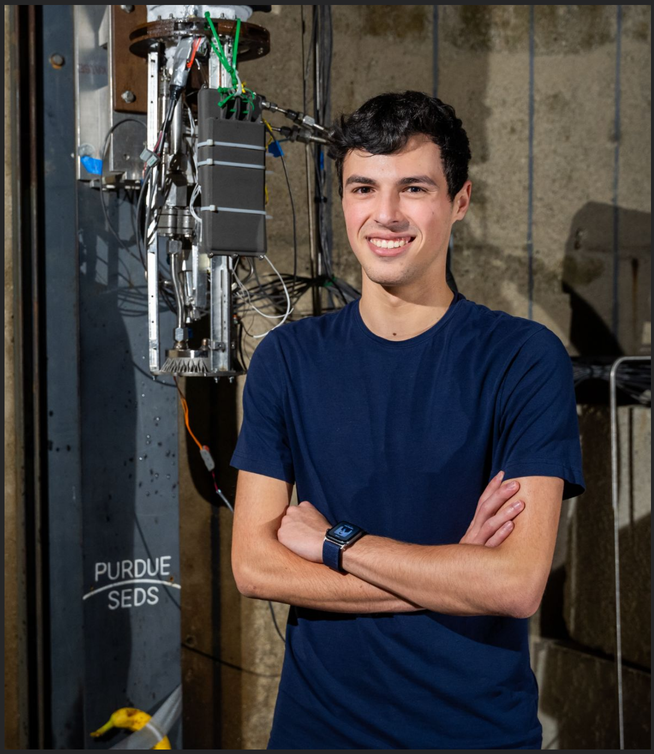
Jack Sloan

Engineering Portfolio



I’m a sophomore at Purdue University studying Aeronautical and Astronautical Engineering. I have always had a passion for space, the technology that helps us get there, and pushing the boundaries of what we consider possible.

I am heavily involved with Purdue Space Program Liquids, focusing primarily on our propulsion system while also gaining broad experience across all aspects of our vehicle. Additionally, I enjoy taking on a wide array of projects and developing solutions to real-world challenges.

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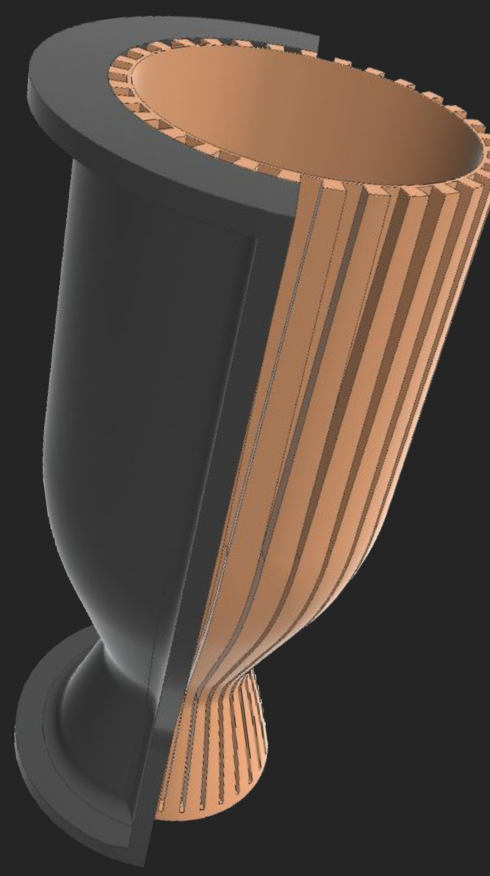
Purdue Space Program Liquids

I am a member of Purdue Space Program Liquids, a student rocketry team that designs, builds, tests, and flies bipropellant liquid rockets. Currently, we are preparing to launch CraterMaker Special, a LNG/LOX rocket. We are also in the design phase of Copperhead, which will feature an electric pump-fed, regeneratively cooled engine.

Thermal + Structural Analysis

I used a thermal resistance model to analyze thermals of our engine's outer cooling jacket, which in turn enabled a structural analysis to determine optimal thickness. My thermal model was iteratively solved using Python, and relied on resistor networks to model conduction and convection from coolant, through the outer wall, to the atmosphere. Beginning with a guessed temperature, my script used steady state assumptions to validate or update the guess until a solution converged. This temperature data is then used for my structural analysis script, which uses equivalent von Mises stress to determine the required wall thickness. I was able to minimize wall thickness and reduce mass by more than 50% from initial designs.



Startup Transient Analysis

Using electric pumps and regenerative cooling massively increases the complexity of our vehicle's startup sequence. I used a Python script to simulate startup transients using iterative CEA runs while tracking mass in the chamber over discrete time steps. This also integrates pumps, using data from testing and analysis to predict mass flow rates. This transient analysis allows for more accurate predictions of system behavior on startup, and enables the team to test more efficiently without compromising safety. Predictions will be compared with test data to continually refine the model for future use.

Purdue Space Program Liquids

Operations Experience

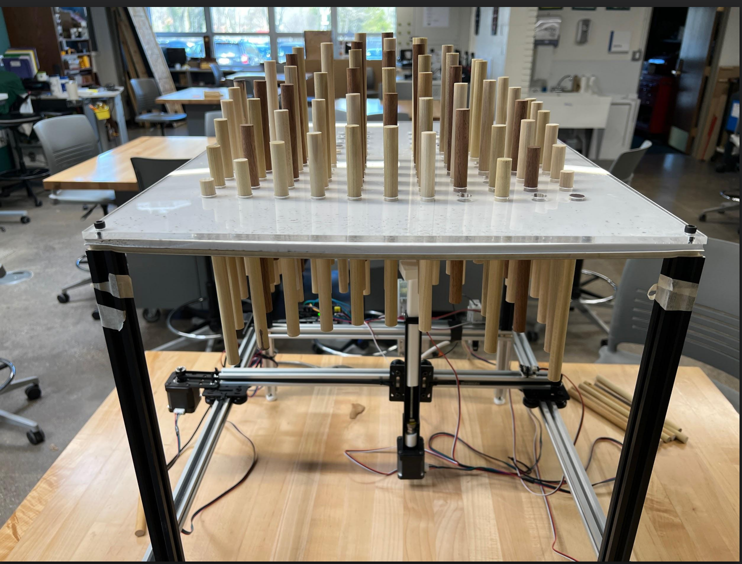
I've had countless opportunities to get my hands on actual flight hardware at our test facility within Zucrow Labs. In the photo to the left, I'd just finished trimming carbon fiber after completing an ablative layup of our hotfire engine. I've also had experience operating ground support equipment through system tests, valve checkouts, and full vehicle cold flows + hotfires. I've learned to read P&IDs, and effectively communicate with a team in high-stakes test conditions. Involvement with testing and operations has allowed me to learn a little bit about almost every system in our vehicle as I work to resolve unpredictable challenges that arise. These have ranged from troubleshooting an avionics wiring harness to diagnosing a leaky valve to repairing our hotfire mount—and almost everything in between.

Manufacturing

I have created both CAD and CAM for a variety of parts and models. I am comfortable with CAD in both Fusion 360 and Siemens NX (with Teamcenter), and CAM in Fusion 360. I have created CAM for 3- and 5- axis CNC machines and lathes.
Shown to the right is a partially machined piece of a model stand that I designed and manufactured to be gifted to team sponsors. This part required 5-axis machining to manufacture its unique geometry. My manufacturing experience regularly informs my design decisions across areas of engineering, as I naturally consider manufacturability. Additive manufacturing of our flight chamber also provided me with experience in the unique design considerations behind an additively manufactured part.

Engineering Projects

Vertically Actuated Multivariable Modeling System

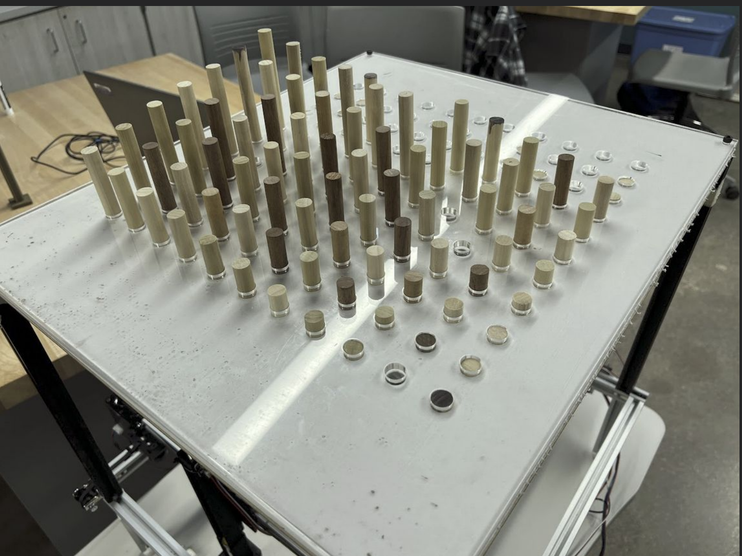


Overview

Vertically Actuated Multivariable Modeling System (VAMMS) is a device designed to model 3-dimensional equations in physical space by vertically actuating a grid of points. I led a team of 3 to create VAMMS after noticing the lack of resources to visualize 3D mathematical surfaces and the struggles students experience in doing so. VAMMS was created in six months entirely from scratch.

Hardware

VAMMS is based on a single vertical actuator translated on an X-Y gantry which actuates 121 individual points. Each axis is driven by a NEMA-17 stepper motor, and includes a limit switch for calibration. The vertical actuator is based on a custom lead screw design and 3D printed frame. The pins are secured by a laser cut triple layer grip-plate, which provides friction while still allowing movement.

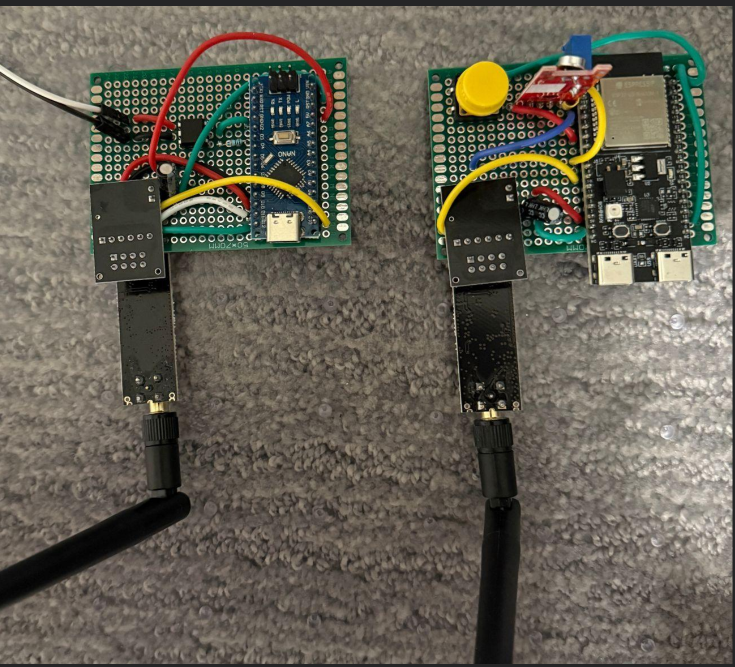


Software + Control

VAMMS is run by a repurposed 3D printer mainboard fed GCODE commands from a Python program via the serial port. The board runs modified Marlin firmware, and connects power, motors, and limit switches. The Python program accepts and parses input, evaluates the function, scales Z values to fill vertical space, generates GCODE commands, and handles the serial connection to the board.

Engineering Projects

Sound-Activated Wireless Camera Trigger



I created a sound-activated wireless camera trigger using an ESP32 and Arduino Nano to enable safe and reliable photography of rocket tests (such as cold flows and hotfires). The trigger unit contains a microphone which, upon detecting the volume spike of a test, sends a trigger command via RF to the receiver unit connected to a mirrorless camera. This is a cost effective solution that does not rely on integration into test auto-sequences or a DAQ, simplifying setup and eliminating potential interference with critical control systems. Data obtained from high quality photography of tests has proven critical in diagnosing issues.

Accessible Toy Adaptation

With Purdue EPICS (Engineering Projects in Community Service), I worked to adapt toys for children with disabilities in collaboration with a local speech-language pathologist. This typically involved reverse-engineering the toy to attach leads connected to a universal female 3.5mm jack. Teachers can then connect various types of adaptive switches to this connector, allowing students with a variety of special needs to interact with the toy and work toward milestones. The adaptation process typically consisted of reverse-engineering the toy, soldering connector leads, and making physical modifications to physically accommodate the cable safely. This required a careful approach to balancing speed with safety, which was critical to delivering the maximum benefit.