Project Portfolio

Matthew Gencher

This is a collection of engineering projects I have worked on through course work, design teams, extracurriculars and past co-ops. I hope they demonstrate the wide variety of skills I have learned and refined.

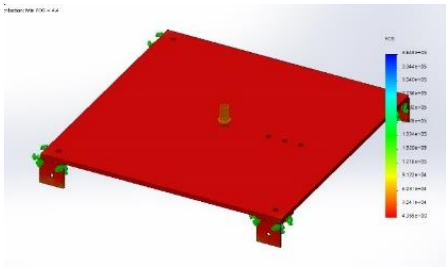
Levithan of the Sky - (2023)

Waterloo Rocketry designs, manufactures, and tests hybrid sounding rockets for launch every year at the Spaceport America Cup. At the 2023 we launched the Leviathan of the Sky, a 30k SRAD Hybrid Rocket. Some numbers for this rocket are:

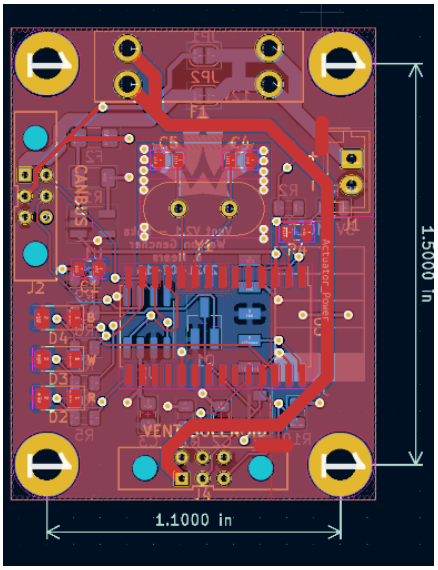
- Dry Mass: 83.9 lbs (38 kg)
- Wet Mass: 126.8 lbs (57.5 kg)
- Specific Impulse: 216s
- Apogee: 31,476 ft
- Thrust: 2350 lbf (10.5kN)
- Propellants: Nitrous Oxide (N_2O) & Hydroxyl-Terminated Polybutadiene (HTPB)

Tank Stand - (2019)

Part of the testing procedure for the rocket is to conduct static fires to validate and get a thrust profile of the engine. To run these tests, the proper infrastructure is required. I designed a tank stand to hold the oxidizer tank vertically during these tests. The stand had to be tall enough to accommodate the 6ft tank as while as required plumbing, strong enough to support the 100lb tank, and stable enough withstand winds up to 50km/h winds due to testing occurring outdoors. The stand was designed in SolidWorks, including FEA (finite element analysis) being done to ensure that the required factors of safety were met.



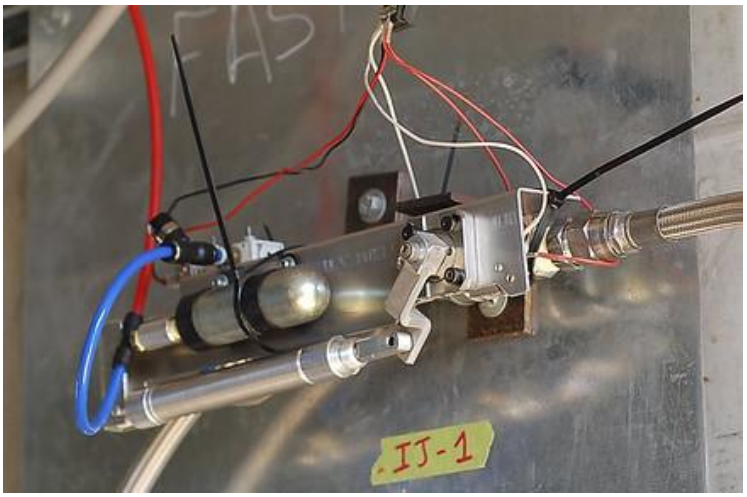
Actuator Board - (2020)



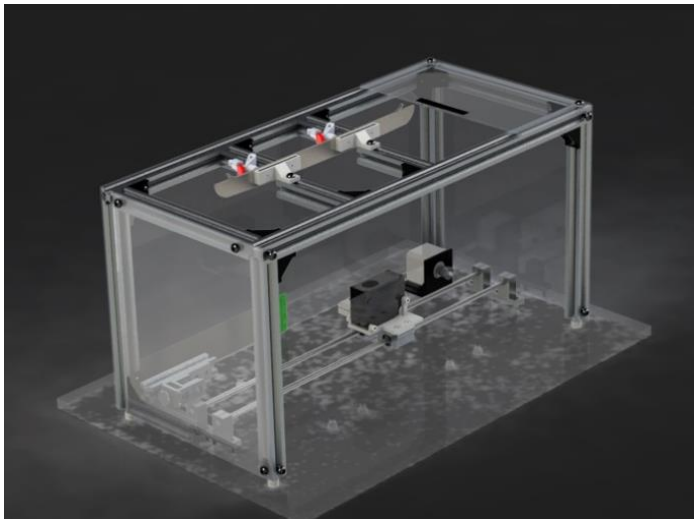
Another project I led was the design of the actuator circuit board. Originally meant for use with the injector valve, this board is now used in multiple parts of the rocket including the injector valve, vent valve, and fill disconnect. Using a PIC microcontroller as the brains, the board is connected to RocketCAN, the CAN Bus which interconnects the entire rocket, and tells the associated valve, or actuator, when to actuate by powering a transistor. Additionally, the board accommodates voltage sensing in order to track the associated batteries for the valves, as well as two limit switches so the valve position is known. This board was designed using KiCAD, printed by a third party, then populated by the team.

FAST [Injector Valve] – (2021)

FAST stands for Fast Actuation Solenoid Nitrous Transfer. The goal of this project was to reduce the weight of the injector valve of the rocket, as well as to decrease the time it takes to reach maximum flow rate of nitrous oxide. The previous injector valve used a heavy motor to open a mechanical valve. FAST instead uses a solenoid valve to allow a pneumatic cylinder to turn a ball valve. This project required calculating the air pressure required, the volume of air needed, as well as the length of the arm to provide enough torque to open the valve. This upgrade saved approximately 3.5lbs, on a rocket weighing 85lbs dry, which is a 4% weight savings.



Fourth Year Design Project - (2023)

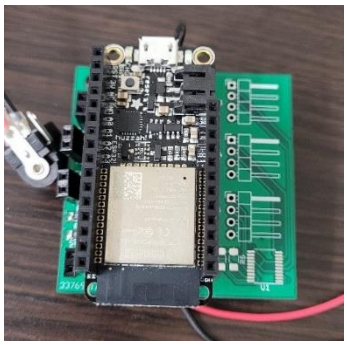


At the culmination of my degree, we were tasked with a fourth-year design, or capstone, project. The intention of the project is to identify a problem and create a mechatronic system to solve it. The problem my group chose to solve is that the tools used to measure the profile of a hockey skate are analog, and the results are prone to human interpretation. We aimed to create an automated digital solution which could measure and characterize a skate blade. My role on this project was to design the electrical system, as well as to write the code for communication between the measurement device and user's computer.

Electrical System

The electrical system uses an ESP32 board as the brains, which came packaged on a Feather breakout board. A custom PCB was designed for the feather to sit on. The PCB contains circuitry for a h-bridge motor controller, limit switches, as well as an analog input for our sensor. The schematic and PCB layout were designed in KiCAD.

Bluetooth Firmware



To communicate between the board and the user's computer BLE (Bluetooth Low Energy) was used. The ESP32 acted as a Bluetooth server, the code being programmed in C++ using the Arduino built in BLE library. The user's computer acted as the Bluetooth server with the code being written in JavaScript as that is what the UI was written in as well.

COLUMBIAD
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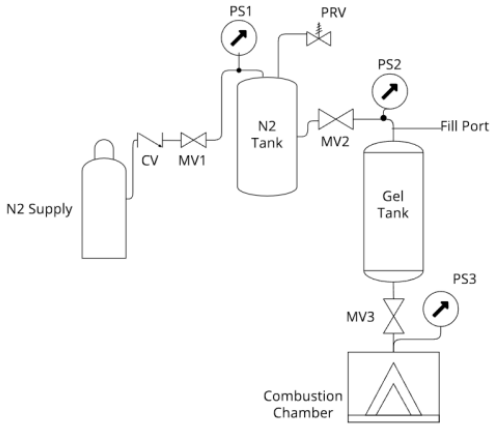
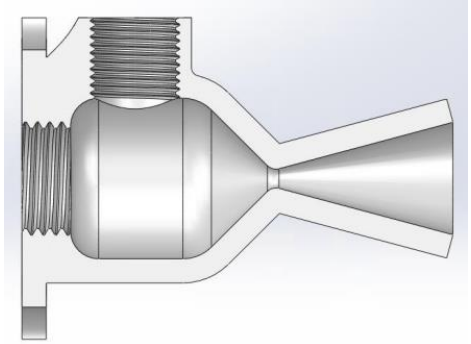
Nano-Thermite CubeSat Propulsion - (2022)

At Columbiad we were exploring the use of nano-thermites suspended in a gel as a fuel for in space satellite propulsion. The two projects I worked on was the overall system design, including doing calculations on the size of the pressurant tank in order to obtain the desired mass flow rate of fuel into the combustion chamber.

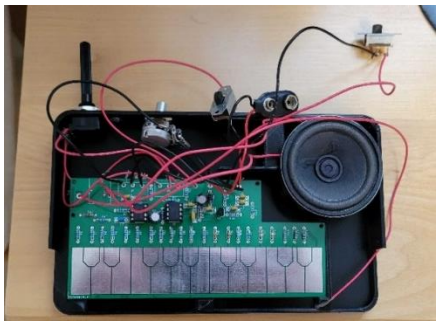




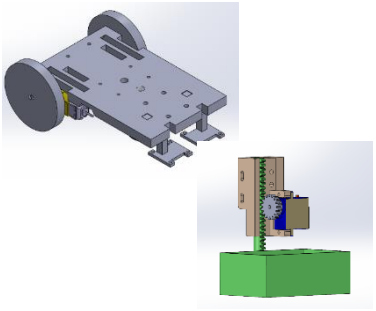
The other project I worked on was design of the combustion chamber and integrated nozzle. This component was 3D printed out of an Inconel alloy, so the design had to be optimized to withstand the pressures generated by combustion as well as be geometrically possible to print. In addition due to the use of a novel fuel, a novel ignition method had to be devoloped. I did a considerable amount of research and wrote an internal literature review on the ignition of nano-thermites through different methods including the use of lasers, and high-voltage generated plasma.

And More…

Curtiss-Wright - Helicopter Landing Gear Simulations

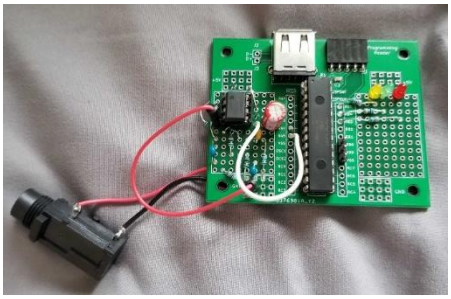


Custom Printed Stylophone PCB

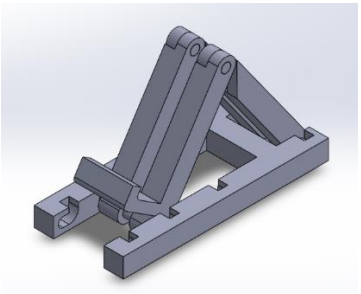


Autonomous Search and Rescue Robot – Mechanical Design

Mastercam CNC Machined Shield

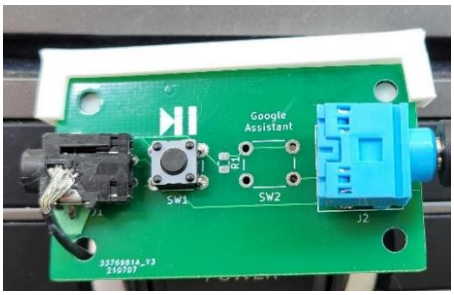


Automatic Guitar Tuner

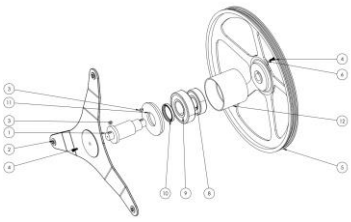


3D Printed Adjustable Phone Stand

3D Printed Watch Stand with Integrated Charger



Music Control PCB



Washing Machine Shaft, Bearing and Seal Design