

Engineering Portfolio

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Introduction

I design, build, and test rockets, mechanisms, and experimental hardware. My work has focused on recovery systems, avionics packaging, compact mechanisms, composites, and iterative prototyping. I primarily use Onshape, OpenRocket, and RASAero, and I hold a National Association of Rocketry Level 1 certification.

Except for the IREC dual-deployment system, all of the work in this portfolio was completed while I was in high school, largely self-directed and without formal engineering instruction or material support from my school. I lived in New York City throughout high school, so access to suitable launch and full-scale test sites was a significant practical constraint; high-power flight testing required long-distance travel.



Upper-stage nose cone on the launch rail at the Friends of Amateur Rocketry site.



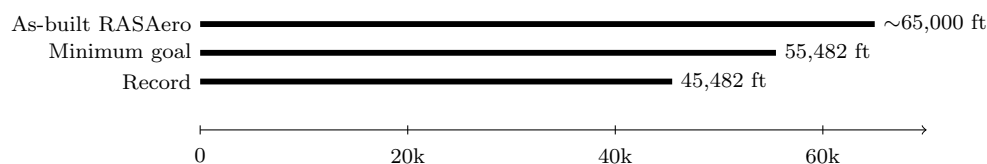
Regional and local context for the FAR launch site in California's Mojave Desert.

1 Two-Stage High-Power Rocket

North Brooklyn Aerospace, 2024–2026. High-school project; co-founder.

Goal

Design and build a rocket capable of exceeding the 45,482 ft AGL high-school altitude record set by Brazoswood High School's *Horizon 1* in 2022 by at least 10,000 ft. The final RASAero model reflected the as-built vehicle.



Constraints and design decisions

- **54 mm minimum diameter:** The L1000 booster and K455 sustainer were the most powerful motors practically available to us in the required form factor. Keeping the airframe at the 54 mm motor diameter minimized frontal area and drag, at the cost of extremely limited space for avionics, recovery hardware, wiring, and structural attachments.
- **Two stages:** Staging let us carry substantially more total motor impulse using the motors available to the project without increasing airframe diameter.
- **Stability:** Stability margin and fin geometry were reviewed throughout the design. The goal was sufficient stability through supersonic flight without making the rocket so overstable that crosswinds would strongly drive windcocking.
- **Materials:** Fiberglass provided a strong, relatively lightweight airframe that could be drilled, sanded, and structurally bonded with epoxy. PA6 nylon was selected for the fins for toughness and comparatively inexpensive CNC fabrication.

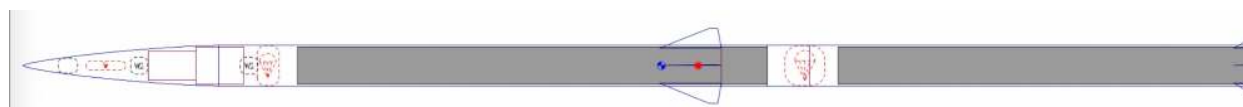
My work

I designed and 3D-printed the avionics and dual-deployment housings and internal mounts, iterating packing layouts so the electronics remained secure while preserving ambient-air access, arming/service access, and e-match connections inside the 54 mm airframe.

I used OpenRocket for vehicle design and RASAero for higher-speed flight estimates. Recovery used a drogue at apogee and a main at approximately 2,500 ft AGL to limit drift. I selected high-strength shock cords and **tuned black-powder charges through full-section ground tests** until separation was repeatable; open-air tests refined e-match placement and ignition reliability.



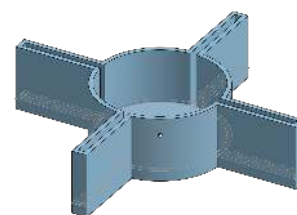
Vehicle on launch rail at FAR.



Earlier OpenRocket vehicle model.

Fabrication and outcome

I fabricated and assembled vehicle hardware: cutting carbon fiber, drilling fiberglass, preparing shear pins, installing rail guides, finishing surfaces, and vacuum-degassing structural epoxy. I CADed and printed the fin-alignment jig and coordinated CNC fabrication of the PA6 nylon fins through JLCPCB.



CAD fin-alignment jig.

Based in NYC, we transported the vehicle across the country to FAR for its February 7, 2026 launch. The booster reached roughly 15,000 ft; the sustainer did not ignite. Our leading hypothesis is that the upper-stage avionics unit broke up after supersonic separation, preventing ignition; the exact failure remains unconfirmed.

2 IREC Dual-Deployment System

Harvard Undergraduate Aerospace Collective, fall 2026–present. Work in progress.

Goal

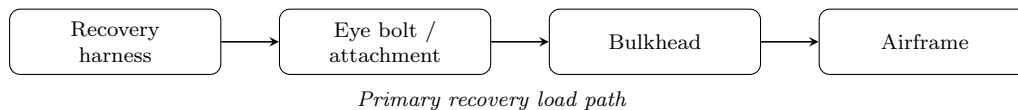
Design the mechanical dual-deployment system for HUAC’s 10,000 ft IREC rocket and payload. Recovery has to bring the vehicle down safely without subjecting a potentially fragile payload to unnecessary shock, while also limiting drift so the rocket can be located and recovered efficiently.

Requirements and design decisions

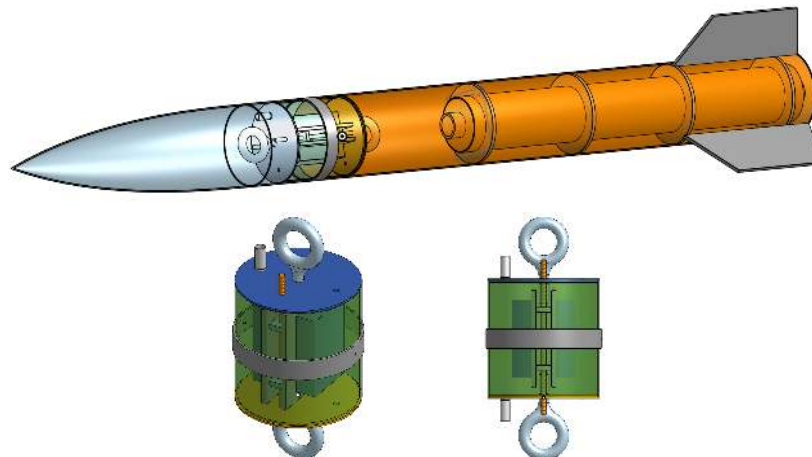
- **Two-stage recovery:** A drogue at apogee limits descent speed without the drift of descending under the main parachute for the entire flight; the main deploys lower in the descent to reach a safe landing speed.
- **Continuous load path:** Deployment loads must pass from the shock cord through eye bolts, bulkheads, joints, and the fiberglass airframe without concentrating load at a weak interface.
- **Serviceability:** Charge wells, wiring, arming access, shear pins, fasteners, and recovery hardware have to remain accessible after installation so the system can be inspected and reset between tests and flights.
- **Material placement:** Aluminum is used for compact hardware carrying concentrated loads or located near ejection charges; fiberglass carries loads through the airframe; wood provides lightweight structural plates; printed parts handle alignment and complex packaging where they are not the primary tensile load path.
- **Remote arming:** The mechanical layout has to accommodate remotely actuated arming hardware and status access without obstructing the recovery system or weakening its structural interfaces.

My work

I am **designing the complete mechanical recovery assembly in CAD** inside the 6 in airframe, using experience from dual-deployment systems I previously built for a modified Zephyr and the two-stage rocket. I am **selecting and packaging recovery hardware**—eye bolts, bulkheads, shock-cord attachments, shear pins, charge wells, and fasteners—and deciding which interfaces should be bonded and which need to remain removable. I am also **calculating black-powder separation requirements** from enclosed volume and separation load; full-section ground tests will validate the final charge size.



A major design priority is making the system straightforward to manufacture and service. My earlier dual-deployment assemblies worked, but tight packaging made assembly and access unnecessarily difficult. The current IREC layout keeps charge wells, electrical connections, arming hardware, and structural fasteners reachable while preserving the direct recovery load path shown above.



Current 10,000 ft vehicle layout and two views of the dual-deployment assembly.

3 Active Airbrake for TARC

North Brooklyn Aerospace. High-school project; mechanism designed, built, and iterated independently.

Goal

For the 2025 American Rocketry Challenge, the qualification target was 790 ft while carrying two raw hen eggs, with a 41–44 second flight duration and safe recovery. Motor variation, air density, wind, and manufacturing tolerances can all shift apogee, so I developed an active airbrake to correct the predicted altitude during coast.

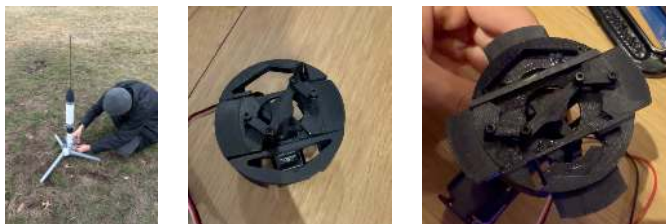
Why this mechanism

I first considered an autorotating propeller with variable blade angle to control descent rate, but fitting the mechanism and controlling blade angle inside the competition rocket added substantially more mechanical complexity than the altitude-correction problem required. I instead developed a sliding-plate airbrake after seeing a conceptually similar MIT mechanism. A compact servo rotates a drive bar that pushes two brake plates linearly outward along constrained tracks; a second mechanism is stacked below on the same axle. Mechanically coupling all four brakes to one servo forces equal commanded motion and reduces the chance that small alignment differences between independently hinged surfaces would create asymmetric drag. Stacking the mechanisms also made four brakes fit within the fuselage diameter.

Iteration and testing

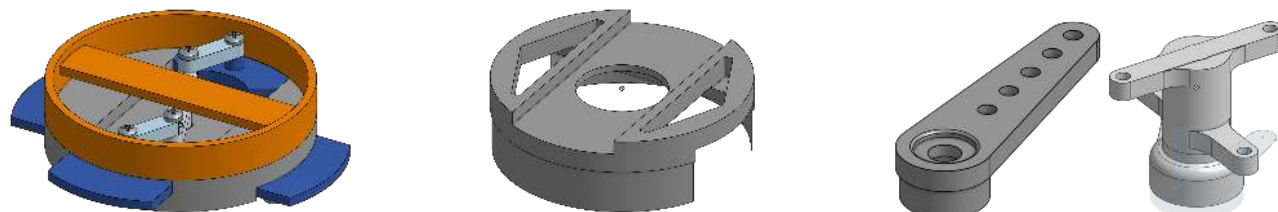
I produced roughly 30 prototypes on my own 3D printer, varying materials, lubrication, power setup, and submillimeter clearances. The final version used ASA because it remained tough while working well with the sliding interfaces and lubricants. The most important geometry change was a small retaining lip above each brake, combined with revisions around the track, which kept the plate captured instead of allowing it to lift or cock during motion.

Variable tested	What I observed	Design response
Material	PLA, PETG, ASA, and variants behaved differently in the sliding mechanism	Selected ASA for toughness and reliable sliding behavior
Clearance	Submillimeter geometry and nozzle wear changed the fit of the sliding plates	Tuned track clearances empirically across printed iterations
Retention	Plates could lift or cock instead of remaining captured in the track	Added a retaining lip and revised surrounding track geometry
Lubrication	Oil-, water-based, and graphite lubricants changed friction behavior	Evaluated lubrication experimentally alongside geometry changes



Full TARC rocket, followed by the finished airbrake closed and deployed.

I tested the mechanism empirically with a PWM controller, focusing on repeatability, friction, and actuation behavior. The intended control logic used the rocket's post-burnout velocity and altitude to project the remaining coast to apogee; the difference between projected and target altitude then set the servo command and deployed brake area.



Airbrake CAD: early interstage mechanism, early casing, and central-shaft components.

Outcome

The final mechanism actuated reliably in bench testing after roughly 30 printed iterations. The competition flight was disqualified after windcocking and an incorrect field-scale reading led to excessive ballast, so that flight did not provide a useful test of the active apogee-control system.

4 Build and Test Systems

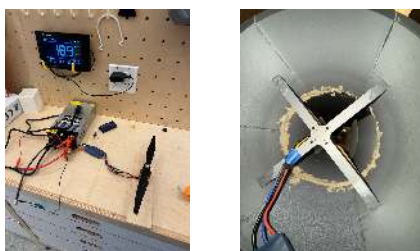
Independent high-school projects completed outside formal coursework.

Subsonic wind tunnel

Goal. The project began as a physics-class presentation on drag; I decided to build a functioning wind tunnel that could demonstrate the concept directly and potentially generate aerodynamic data for my machine-learning research.

Design choices and constraints. I used an open-circuit layout because it was far smaller and simpler to fabricate than a return-flow tunnel while still providing a usable test section for demonstrations and data collection. The clear test section was approximately 9 in $\times$ 9 in $\times$ 15 in. Plywood was used for large simple structural surfaces, acrylic for visibility through the test section, and 3D printing for the complex transition into the fan section. Mesh at the inlet acted as a simple flow-conditioning screen, breaking up large-scale inlet disturbances before air entered the test section.

A conventional small fan did not provide the airflow I wanted, so I selected a 12-inch RC-aircraft propeller and brushless motor. I designed the electrical chain from mains AC through a DC power supply and electronic speed controller to the three-phase brushless motor, along with the fan mount and tunnel integration.



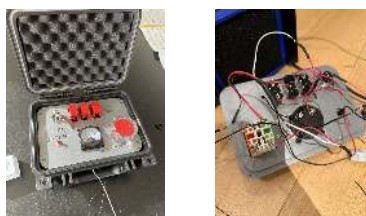
Powertrain bench test and installed fan mount with power wiring.

Outcome. The tunnel operated successfully. During a later run, the propeller had not been tightened sufficiently, loosened from the motor, and fragmented inside the tunnel, destroying the propeller and damaging electronics. The next design would use positive propeller retention and better containment around the rotating assembly.

Rocket launch controller

Goal. Build a reusable field controller that could display supply voltage, make continuity faults easy to diagnose, and require an intentional sequence before ignition.

Design choices. I built the controller around a removable key, three staged arming switches, indicator lights, a hold-down control, and a separate launch button. The deliberately multi-step arming sequence reduces the chance of an accidental firing command and makes the controller state easy to see. The continuity path limits test current so continuity can be checked without supplying firing current to the igniter; the launch path bypasses that limitation to deliver the required ignition current. I selected the launch-lead wire gauge to carry igniter current over the required cable run without excessive voltage drop.



Completed controller and internal wiring during assembly.

Outcome. I measured the components, CADed and iterated the panel, soldered the wiring, and tested the circuit before integration. The controller worked on its first complete system test and was subsequently used for launches. The voltage display, indicator lights, and accessible case made field diagnosis of failed ignitions substantially easier.

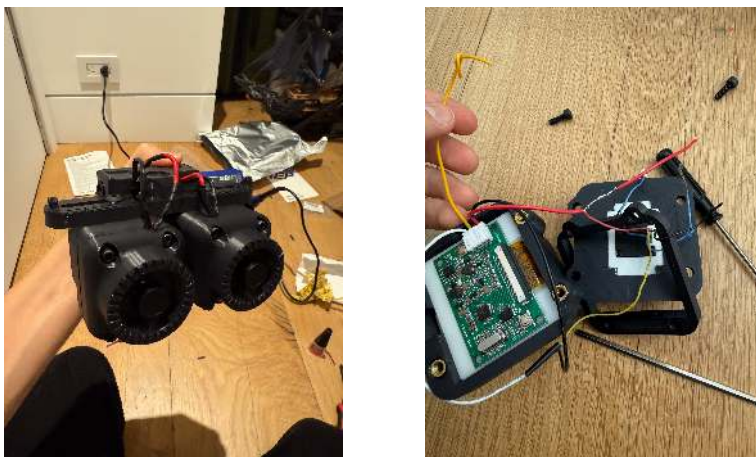
5 Additional Hardware

The work on this page was completed during high school.

Digital infrared night-vision goggles

Goal. Build usable binocular digital night vision at far lower cost than commercial night-vision systems.

Design choices and constraints. I selected compact RunCam FPV cameras because they were inexpensive, had useful low-light performance, and provided a field of view close to normal vision. Analog video allowed the cameras to connect directly to the displays without software or a digital video interface. I initially CADED a complete housing, then adapted an existing open-source housing whose overall form factor was more compact and practical than my first design. I redesigned the camera mount for the RunCam and printed it in TPU to isolate vibration and stabilize the image while moving; the main structure was printed in ASA. Screws adjust the biconvex-lens position, and the rear-mounted battery connects through a removable power connector.



Assembled goggles and the internal camera, display, and wiring.

Outcome. The completed goggles produced a usable binocular low-light/infrared image and made infrared illumination visible to the cameras.

Other work

I independently used a NASA aerodynamic dataset and machine learning to estimate static-pressure distributions over a wingtip; the resulting paper was published in the *Journal of Student Research—High School Edition*. I also built a four-legged robot in a Columbia SHAPE project.