Statement of Work

Student-Led Observations of Sinusoidal Hydrodynamics (SLOSH)

NASA Student Launch 2025 for Middle and High School

Madison West High School

30 Ash Street, Madison, WI 53726

September 10, 2024

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General Information

Educators and high-power Rocketry Mentors

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HPR mentor
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Team Leader

Everett Gihring
Team Leader and Integration Coordinator

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Safety Officer

Ayelet Blum
Safety Officer

ablum@madison.k12.wi.us
608-692-1330

Supporting NAR/TRA Sections

NAR Section #558 WOOSH

Tripoli Wisconsin

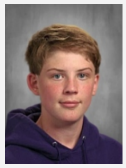
Quad Cities Rocket Club (QCRC)

Student Participants

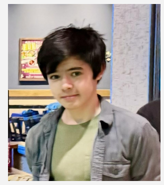
A total of 16 students were chosen to participate in the project. The table of members and their proposed duties are shown below. The finalized list of team members will be provided by CDR due date.

Vehicle: Responsible for vehicle design, flight safety parameters, altitude target, propulsion, and launch operations.

Costa Molle
Recovery engineer

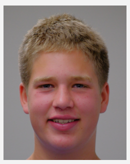


Garrison Bogen
Construction Engineer

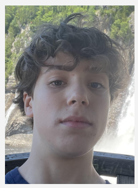


Henry Nguyen-Shreve
Airframe Specialist

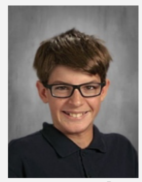
Jack Rogge
Lead Vehicle Engineer



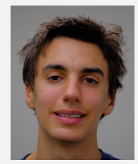
Mark Ginder-Vogel
Vehicle Modeling



Oliver Gartler
Vehicle Safety Engineer



Summit Todd
Vehicle Design Specialist

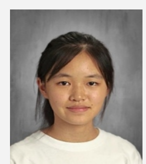


Zachary Richmond
Recovery Specialist

Payload: Responsible for payload design, payload preflight preparations, and activation and postflight payload data analysis.

Cameron Luedtke
Imaging Specialist

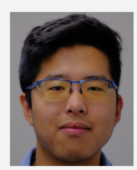
Ethan Lee
Software Engineer



Jeane Pan
Data Specialist

Mei Dryer
Payload Technician

Sarita Desai
Design Lead



Zijun He
Data Specialist Lead/ Hardware Engineer

Integration Lead: Responsible for overseeing the merging of the sections to ensure a successful plan.

Safety: Responsible for following safety procedures and updating safety documentation.

 **Everett Gihring**	 **Ayelet** Blum

Proposal Work Documentation

Week of August 5

SL application essays and selection, initial preparation, 7 hours

Week of August 12

Reading of call for proposals, proposal document prep, 5 hours

Additional individual material (resumes, etc...), 2 hours

Week of August 19

Payload brainstorming session, 8/23, 7 pm - 9 pm, 2 hours

Writing, 3 hours

Week of August 26

Payload design, simulations, 5 hours

Week of Sept 2

Writing workshop, 9/2, 11 am - 3 pm, 4 hours

Club workshop, rocket simulation work, 9/6, 5 pm - 7 pm, 2 hours

Additional vehicle design simulation work, 2 hours

Writing workshop, 9/8, 10 am - 3 pm, 5 hours

Week of Sept 9

Final editing/writing, 9/9-9/10, 2 hours.

Rocket club workshop, outreach, and budget plan, 9/13, 1 hour

Proposal PDF generation and submission, 9/11, 1 hour

Design Review Presentations Availability

The team will be available to meet for design review presentations at the following dates and times:

Monday 8 am - 9 am
Wednesday 8 am - 9 am
Friday 4 pm - 5 pm

The letter on the following page was received from administrators noting permission to meet at these and other times.

MADISON METROPOLITAN SCHOOL DISTRICT

Madison West High School | 30 Ash St. | Madison, Wisconsin 53726 | west.mmsd.org

Pheng Lee, Katie Medema, Lori Schacht DeThorne, Sean Storch - *Assistant Principals*
Dan Kigeya, *Principal*

September 7, 2024

To Whom it may concern,

Madison West Rocket Club is submitting a proposal for the 2024-2025 NASA Student Launch. As such, if selected, members of the Madison West team are required to attend video conference presentations with NASA representatives to defend their project. This letter confirms administrative support and acceptance of this requirement, and agrees to excuse team members from school to attend these events.

Team Educator:

Christine Hager Signed: Christine L Hager Date: 9/9/24

School Administrator:

Principal Dan Kigeya Signed: D Kig Date: 09/9/24

Facilities and Equipment

Facilities

Planning, discussion, and writing will occur at UW Madison, Dept. of Atmospheric and Oceanic Sciences, Room #811, located at 1225 W Dayton St., Madison, Wisconsin, 53706, on the weekends. Construction of the rocket will occur at a workshop at 3555 University Ave, Madison, Wisconsin, 53705, on the weekends or as necessary. The team has 24/7 access to this facility. The workshop has four connected rooms: one room dedicated to machinery, another designated for electronics manufacturing/staging area, a third room used for discussion and design, and finally a storage room.

The payload and vehicle will be constructed at a workshop at 3555 University Ave, Madison, Wisconsin, 53705. This will occur on the weekends or as necessary throughout the week. We have 24/7 access to this facility, so the team can use it anytime. The workshop has four rooms: one for machinery and construction, another for electronics manufacturing and assembly, a third housing computers and being equipped for meetings and discussions, and a storage room for parts and supplies.

Team organizational meetings will take place at lunchtime every Monday in Room #3051 of Madison West High School, 30 Ash Street, Madison, Wisconsin, 53726.

Launching of low-powered scale model rockets will occur on the weekends from November through April. NFPA code 1122 and NAR Model Rocket Safety Code will be followed during these launches. Mentors will supervise all launches.

Launching of high-power rockets will occur at the Richard Bong Recreational Area located in Southeast Wisconsin at 26313 Burlington Rd, Kansasville, Wisconsin, 53189. We will attend launches only with the appropriate Power Rocket Altitude waivers from the FAA before high-power launches, and we carry NAR launch site insurance. high-power launches will coincide with the high-power launch of WOOSH, Section 558 of the NAR, and Tripoli Wisconsin. Additional high-power launches will be conducted at TRA QCRS (Tripoli Quad Cities) launches near Princeton, IL. Mentors will supervise all launches.

Hours

Workshop hours are set based on team member availability and project needs. The suggested schedule for this year is below.

Day	Start	End	Activity	Location
Monday	12:01 PM	12:51 PM	Organizational Meeting	Madison West HS Rm. #3315
Friday	05:00 PM	09:00 PM	Rocketry Workshop	Workshop, 3555 University Ave.
Saturday	08:00 AM	06:00 PM	Rocketry Launches	Bong / Princeton / Duerst Farm / Johnson Creek
Sunday	10:00 AM	04:00 PM	Writing Session	1225 W Dayton St., Rm #811
Sunday	08:00 AM	06:00 PM	Outreach Fundraising	Various Locations

Table 1: Facility Hours

Personnel

We have three engineers working with students in a workshop regularly:

Mr. Brent Lillesand: Mechanical engineer, high-power construction, and flight tests.

Mr. Max Jetzer: Mechanical engineer, high-power construction, and flight tests.

Mr. Easton Bednarek: Part fabrication, high-power construction, and flight tests.

In a classroom setting, the following educators work with students regularly:

Dr. Ankur Desai: Professor at the UW Dept. of Atmospheric Oceanic Space Sciences.

Ms. Christine Hager: Microbiologist and biology teacher, 14 years of SL experience.

Equipment

The team has full access to a fully equipped workshop, suitable for machining, electronics development, design meetings, and discussions. The workshop has three working rooms, as well as an adjacent storage room:

1. **Machinery room:** This room contains heavy machinery, such as a band saw, table router, belt sander, and drill press. Hand-held power tools, such as corded and cordless drills, electric sanders, and Dremel rotary tools are also available in this room. Additionally, this room has a wide collection of hand tools, including hacksaws, X-acto knives, box cutters, various clamps, screwdrivers, crescent wrenches, hammers, pliers, clippers, and vices of several sizes. All gluing and assembly of vehicles and payloads is also done in this room. All of the heavy machinery in this room is connected to a centrifugal dust collection system, which collects sawdust and fumes from the machines and filters it before returning the air to the room. Finally, this room contains several industrial-strength air filters to remove fumes from machines and adhesives from the air and maintain a safe environment.
2. **Electronics room:** This room is equipped for the assembly of electronics and general soldering tasks. We have several soldering stations with temperature control, hot-air guns, crimpers, wire strippers, fluorescent-lit magnifying lamps, and several helping-hand type grips to help assembly. This room also contains a fume extraction system, which helps prevent inhalation of soldering fumes. The fume extraction system connects with the machinery room's dust collection and air filtration systems.
3. **Computer and meeting room:** In this room, we have several computers available for Computer-Aided Design (CAD) work, simulation, and other various software needs. We use Onshape, a cloud-based CAD software, for designing parts and payloads, and we use OpenRocket and RockSim to simulate our rockets' flights. This room also has a large central table and chairs for meetings, and most of this

room's walls are covered with whiteboards to facilitate discussion and problem-solving.

Supplies

During the active season, the club maintains a reasonable stock of common supplies and parts for rocket construction.

- **Rocket parts**: We have a section of the workshop dedicated to storing miscellaneous rocket parts, such as body tubes, nose cones, fins, motor tubes, motors, and many more which we have used to put together rockets.
- **Adhesives:** We stock several types of adhesives, including short and long-cure epoxies (West System and System3 brand) and thickening agents, super glue, and wood glue. We also maintain a good supply of tapes, including electrical, masking, painter's, and duct tape.
- **Electronic components:** We maintain a steady supply of common electronic components, such as wires, solder, header pins, and batteries. In the event of depletion, these supplies can be acquired from several online vendors, including superstores such as Mouser, DigiKey, and Newark. More specialized components, such as specific boards or modules, can be purchased from smaller hobby-oriented stores such as Adafruit, SparkFun, and Parallax.
- **Miscellaneous supplies:** Items such as notebooks, pens, rulers, rubber gloves, and other miscellaneous supplies can be purchased from local department stores.

Safety

Written Safety Plan

The following section addresses the risks and potential problems that could endanger the successful completion of our project. We have performed risk assessments and proposed mitigations listed beneath each risk.

Risk Assessment and Proposed Mitigation

Facility Risks

- **Workshop inaccessible:** We have signed a rental agreement for our workshop space, and should it become temporarily inaccessible, we will work with our landlord to resolve the issue in a timely manner. Rocket construction can also be temporarily moved to Mr. Lillesand's house.
- **Classrooms unavailable:** The classrooms are provided by the Engineering Dept., with several choices available should the primary room become inaccessible. We can also utilize other options if necessary, such as reserving a meeting room in a local library or temporarily meeting in a club member's house.
- **Launch site unavailable/inclement weather:** We routinely schedule redundant launch windows to ensure that we will have enough opportunities to carry out all necessary flights. We are currently working with three rocketry organizations (NAR Section WOOSH, TRA WI, and TRA QCRS) to maximize our launch opportunities.

Project Risks

- **Project behind schedule:** Project progress is constantly compared to the list of required milestones, and working hours are extended as necessary to meet all milestones. All deadlines are considered difficult to reach.
- **Key team member unavailable:** No task is assigned to a single team member; all tasks will be carried out by a pair or a small group of equally knowledgeable students. Students are not allowed to limit their participation in the project to a single area of expertise.

- **Unsolvable technical problem:** A thorough feasibility review is conducted before the Statement of Work is submitted. Alternative solutions will be sought.
- **Unresolvable personal disagreements:** Should the students involved fail to reach an acceptable compromise, the educators will protect the progress of the project, regardless of the individual interests of the parties in the dispute. All students were informed of this rule before their admission to the program.
- **Part unavailability:** All purchasing is conducted as soon as practically possible. We are also working with several vendors, trying to maintain part availability redundancy as much as possible. In the event that a part is not available, the next best alternative will be used.
- **Budget overrun:** The initial fundraising goal is set at 140% of estimated project expense.

Vehicle Risks

- **Repeated test flight failure**: Rocket design review, performance prediction experiment evaluation, static stability check, and static ejection tests will be carried out before each test flight. A due consideration will be given to weather conditions to maximize the probability of safe flight and successful recovery. All flight data will be analyzed to identify problems before the next flight.
- **Vehicle lost/irreparably damaged during test flight:** A sufficient time reserve will be built into the project schedule to allow for complete vehicle replacement. All team members will participate in additional workshop hours. The airborne vehicle will be tracked using three different methods: CAT (Cloud Aided Telemetry), onboard RF telemetry, and sonic beacon. A GPS device will also be used to locate the rocket after launch.

Payload risks

- **Water damage:** Scale models of the payload design will be thoroughly tested before insertion in the vehicle to prevent damage to the payload, vehicle, or data collection.
- **Rocket over/instability:** Payload design will be repeatedly reviewed by the vehicle team to prevent the payload causing stability issues. Payload will test movement of a level that will not cause instability.

Personal risks

- **Physical injury:** The use of Personal Protective Equipment is mandated during all construction tasks and preparation of the rocket for a flight or static test. Adult supervision is provided at all times. The use of headphones and personal electronics during rocketry activities and workshop hours is strictly prohibited.
- **Toxicity:** MSDS documentation is available for all chemicals used in the project and dangerous chemicals are avoided as much as possible. Adult supervision is provided at all times, and PPE use is mandated.

NAR/TRA Personnel

Mr. Lillesand (L3 certified, NAR and TRA member, LEUP holder) is the mentor for the team and designated owner of the rocket for liability purposes. Mr. Lillesand will accompany the team to Huntsville, AL.

All hazardous materials will be purchased, handled, used, and stored by Mr. Lillesand or project educators (Ms. Hager). Mr. Lillesand will be the only person purchasing and handling energetics. The use of hazardous chemicals in the construction of the rocket will be carefully supervised by NAR mentors and project educators.

In the construction of our vehicle, only proven, reliable materials, made by established manufacturers, will be used, under the supervision of the mentor and educators. We will comply with all NAR standards regarding the materials and construction methods. Reliable, verified methods of recovery will be exercised during the retrieval of our vehicle. Motors will be used that fall within the NAR HPR Level 2 power limits, as well as the restrictions outlined by the SL program.

Additionally, all HPR flights will be conducted only at public launches covered by an HPR waiver (mostly the WOOSH/NAR Section #556 10,000ft MSL waiver for Richard Bong Recreation Area launch site and 15,000ft MSL waiver for Princeton, IL, TRA QCRS site). We will be assisted by members of the hosting section (WOOSH, TRA WI or TRA QCRS) and will follow all instructions issued by their range personnel and our mentors.

All LMR flights will be conducted at the launches, with the FAA notification phoned in at least 24 hours prior to the launch. NAR and NFPA Safety Codes for model rockets and high-power rockets will be observed at all launches.

Team Member Safety Briefing

Mentors, educators, and experienced rocketry team members will take time to teach new members the basics of rocket safety. All team members will be taught about the hazards of rocketry and how to respond to them; for example, ground fires, errant trajectories, and environmental hazards. Students will attend mandatory meetings and pay attention to pertinent emails prior participation in any of our launches to ensure their safety. A mandatory safety briefing will be held prior to each launch. During the launch, adult supervisors will make sure the launch area is clear and that all students are observing the launch. The NAR mentor will ensure that any electronics included in the vehicle are disarmed until all essential pre-launch preparations are finished. All hazardous and flammable materials, such as ejection charges and motors, will be assembled and installed by our NAR-certified mentor, complying with NAR regulations. Each launch will be announced and preceded by a countdown (in accordance with NAR safety codes).

Safety Documentation Procedures

In all working documents, all sections describing the use of dangerous chemicals will be highlighted. Proper working procedure for such substances will be consistently applied, including the required PPE (Personal Protective Equipment), such as using protective goggles and gloves while working with chemicals such as epoxy. MSDS sheets will be on hand at all times to refer to for safety and emergency procedures. All work done on the building of the vehicle will be closely supervised by adult mentors, who will make sure that students use proper protection and technique when handling dangerous materials and tools necessary for rocket construction.

Federal, State, and Local Law Compliance

All team members will act with care and responsibility to ensure the safety of the launch operations per federal, state, and local laws. This will primarily be accomplished by attending NAR and TRA launches to launch rockets, and following their rules and regulations regarding how we construct, prepare, and fly our rockets. For operations outside of scheduled launches, team members will follow laws concerning the handling of motors and other energetics.

The team understands and will reference the following federal, state, and local laws as necessary to ensure proper compliance:

- **Use of Airspace:** Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C
- **Handling, Exchange, and Commerce of Low Explosives:** Code of Federal Regulation 27 Part 55: Commerce in Explosives
- **Fire Prevention:** NFPA 1127 Code for high-power Rocketry

These publications are readily available to the team to be referenced at any time.

Energetics Purchase, Storage, Transport, and Use

NAR/TRA mentor Mr.Lillesand holds a Level 3 HPR certification and a Low Explosives User Permit (LEUP). In most cases, the motors and electrical matches are purchased from the on-site vendor, Mr. Tim Lehr of Wildman Rocketry, and used on the same day. Mr. Lillesand will be the only person to purchase and handle energetics (motors, ejection charges, and igniters). Mr. Lillesand will be responsible for depositing unused propellant. Only NAR/TRA certified motors will be used.

Written Safety Statement

All team members, educators, and mentors understand and will abide by the following written safety statement:

Range Safety Inspection

Range safety inspections of each rocket shall be carried out before the rocket is flown. The team shall comply with the determination of the safety inspection and follow any instructions received from the RSO regarding the safety of their rocket.

RSO Ruling Compliance

The Range Safety Officer(RSO) has ultimate authority on all rocket safety issues. The RSO has the right to deny the launch of any rockets for safety reasons, and team members will accept and comply with this decision if it is reached.

Mentor Approval Compliance

The team mentor, that is, Mr. Brent Lillesand, is ultimately responsible for the safe flight and recovery of the team's rocket. The team will not fly a rocket until the mentor has reviewed the design, examined the build, and is satisfied The rocket meets established rocketry design and safety guidelines.

Team Compliance with Safety Requirements

Should the team fail to comply with the safety requirements, they will not be permitted to launch their rocket.

Technical Design

Vehicle

Our rocket will be a single stage, J-Class vehicle that will deliver our payload to the projected altitude of ~4,300 ft. Our project is to measure the amount of slosh in multiple tanks of water inside the rocket. Each tank has a different baffle to prevent slosh. We are measuring which baffle works the best at preventing slosh and therefore keeping the rocket stable.

The rocket will be constructed from fiberglass tubing and will have four ⅛” G10 fiberglass fins. The rocket will be robust enough to endure 35+g of acceleration and high-power rocket flight and deployment stresses. We will also be using the standard dual deployment method.

General Vehicle Dimensions

Our proposed motor choice is an AeroTech J800, 54x316mm, with a total impulse of 1264Ns. The vehicle has no issues launching from an 8 or 12-foot rail in simulations.

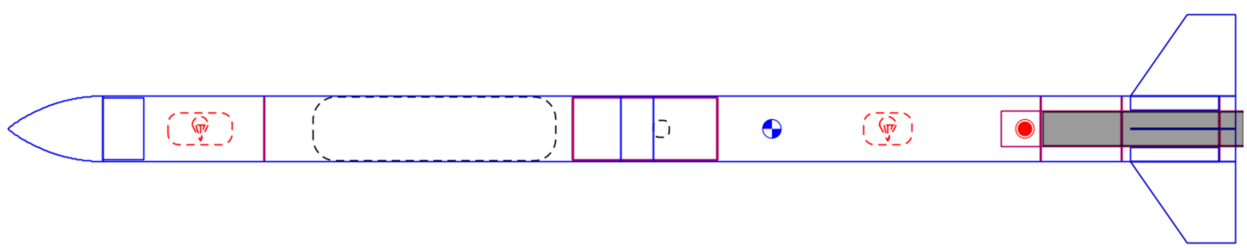


Figure 1: Two dimensional schematic of the entire rocket

Rocket Length	76.4 in
Outer/Inner Diameter	4.02/3.9 in (Wall thickness: 0.06 in)
Liftoff Mass	11.2lb
Stability Margin (*calibers*)	4.05 cal

Table 2: General Vehicle Dimensions

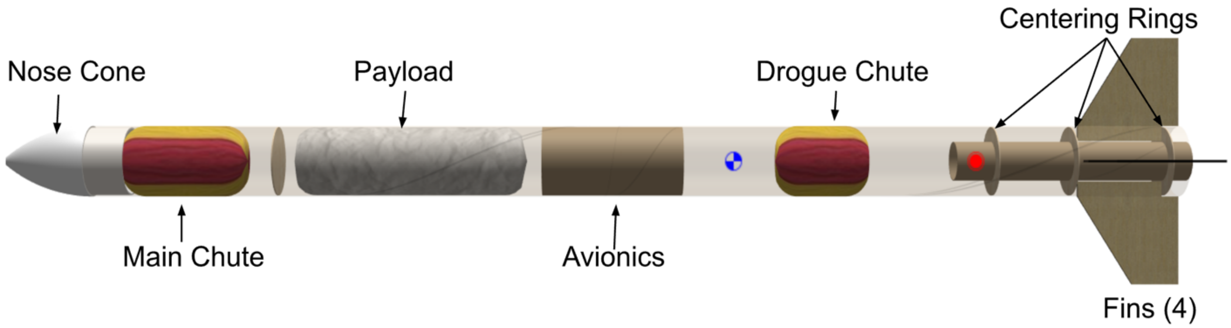


Figure 2: Individual segments breakdown

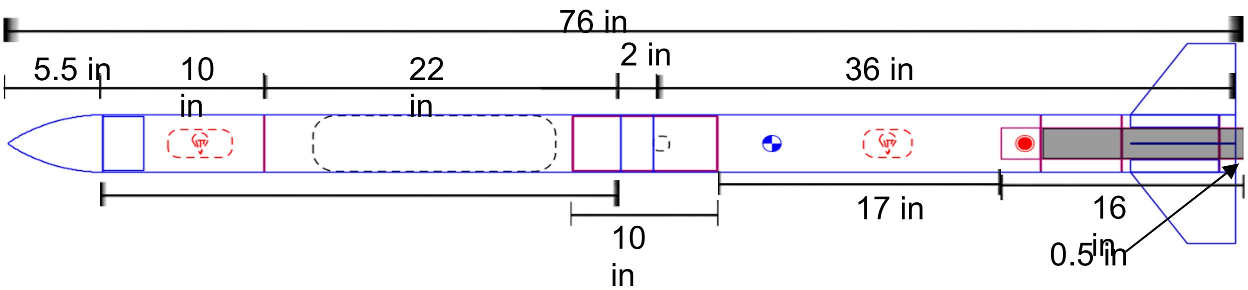


Figure 3: Dimensions of the different rocket sections

The vehicle will contain three separable sections that separate at two different times, described in more detail below. All sections will be tethered together with ⅜" kevlar cord attached to I-bolts on each end.

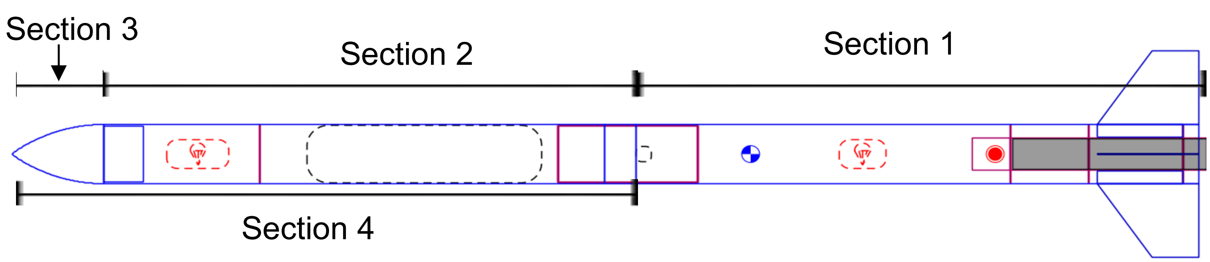


Figure 4: Section Breakdown

Section 1, the "booster section" will contain the booster and space for the drogue chute, as well as the fins (with fin tabs). At apogee, section 1 will separate from section 4. There are bulkheads at each end of the avionics bay, and the booster section tube will slide off the aft end of the avionics bay.

Section 2, the “Sustainer Section”, contains the payload, avionics bay, and space for the main chute. It will separate from section 3 at a specified altitude (700 ft).

Section 3, the nose cone, will separate from section two as specified above so that the main chute can release.

Material Selection

Our primary rocket material is fiberglass. The benefits of using fiberglass include:

- Strength - Fiberglass is very durable and has a temperature resistance far above necessary qualifications. Due to the glass fibers embedded in the resin matrix, fiberglass has a very high tensile strength and can withstand the stresses of launches without cracking.
- Surface Finish - Fiberglass has a smooth surface finish that will allow for an easier and better-looking painting job.
- Moldability - Fiberglass can be easily and precisely machined.

Rocket Part	Material
Nosecone	3D printed PLA plastic
Body Tube	Fiberglass tubing - 4” diameter
Anchors	1/4” in stainless steel U-bolts
Centering Rings	1/8” g10 fiberglass
Fins	3/32” in F10 Fiberglass
Parachutes	Ripstop Nylon
Couplers	Fiberglass 4” coupler tubing
Motor mount	Fiberglass 54mm tubing
Tie Rods	Steel

Table 3: Materials

Construction Methods

Work will be done under the supervision and advice of mentor Mr. Max Jetzer and mentor Mr. Ankur Desai to make sure that the rocket is built correctly. We plan to use West System epoxy with appropriate fillers for rocket assembly. The rocket will be all-fiberglass construction, including bulkheads and centering rings. The fins will be through-the-wall mounted, secured by root, inner and outer filets. The motor will be retained using a positive motor retainer (Aeropack type). The rocket construction will be done in the workshop, which is fully equipped for high-power rocketry projects. Mr. Easton Bednarek is our advisor and production manager for 3D printed parts.

Performance Projections

Projected Altitude

Our rocket's projected altitude is 4,300 feet. We chose this altitude so we would have sufficient time to gather data from our payload during ascent.

Altitude Profile

Below is a simulated graph of the vehicle's altitude versus flight time under power of an AeroTech J800 motor. The vehicle will accelerate until motor burnout at ~2.09 seconds after launch. The rocket will coast until it reaches an apogee of 4,307 feet at ~15.06 seconds after launch. At this time, our drogue parachute will deploy. The rocket will descend until the main parachute deploys, at an altitude of 700 feet, 55.1 seconds after launch. In the case of this preliminary simulation, and based on prior flight experience, the average coefficient of drag (C_d) was set to 0.8. The total flight duration is expected to be 82.7 seconds, with a drift under a 15 mph of 1487.2 ft.

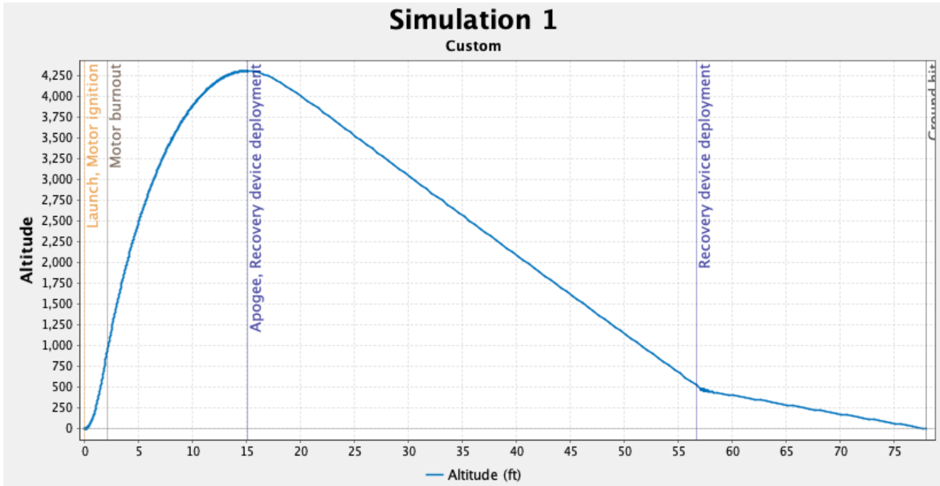


Figure 5: Altitude (ft) vs time (s)

Our simulation under no wind reported a very small, 7 foot (0.1%) overshoot of our targeted altitude. This is likely due to the fact that our simulation is under perfect conditions. All simulations are preliminary, and are not an indication of final vehicle performance. We will use the same motor in our final test flight, as we will for the flight in Huntsville, to ensure estimates and requirements are fulfilled.

Wind Speed vs Altitude

The vehicle's apogee versus the wind speed was simulated and is displayed in the table below. If the vehicle were to launch in 20 mph winds, the maximum allowed for launch by the NAR, there would be a 3.23% reduction in altitude at apogee from a launch with no wind.

Wind Speed	Apogee (ft)	Δ Apogee
0 mph	4345	0.00%
5 mph	4335	-0.23%
10 mph	4306	-0.91%
15 mph	4261	-1.97%
20 mph	4209	-3.23%

Table 4: Vehicle Apogee (ft) vs Wind Speed (mph)

Thrust Profile

The graph below shows the thrust profile for the AeroTech J800 motor. The motor reaches its maximum thrust after 0.05 seconds and burns at a quickly decreasing thrust for 0.15 seconds, then at a slowly decreasing rate for ~1.4 seconds. The thrust then quickly decreases for 0.49 seconds, until the motor burns out 2.09 seconds after ignition.

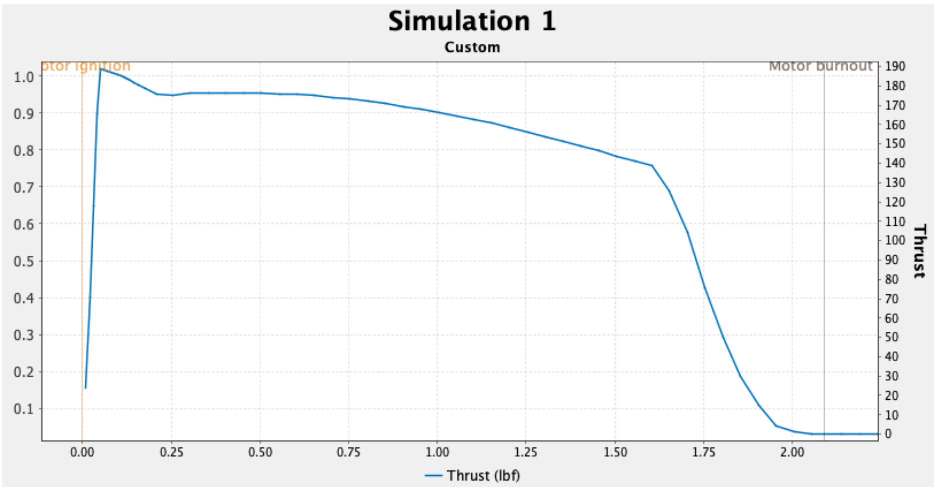


Figure 6: Motor Thrust (lbf) vs Time (s)

Velocity Profile

As shown in the following graph, the rocket quickly accelerates to a maximum velocity of 719 fps (490 mph) shortly before motor burnout, ~1.8 seconds after launch. The vehicle remains subsonic for the duration of its flight.

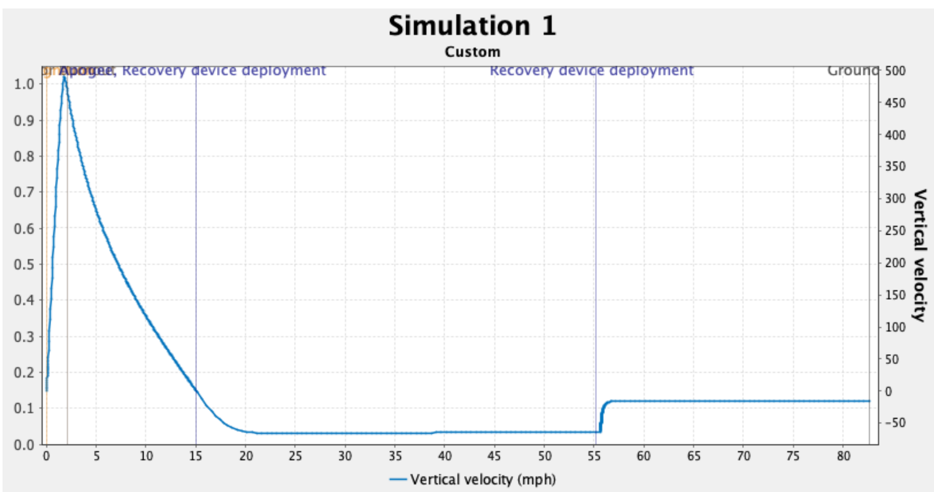


Figure 7: Vehicle Vertical Velocity (mph) vs Time (s)

Acceleration Profile

The graph below shows the acceleration profile of the flight. The rocket will reach a maximum acceleration of 15.8g (508.34 ft/s^2). The vehicle and payload will be designed to endure the acceleration stresses during the flight.

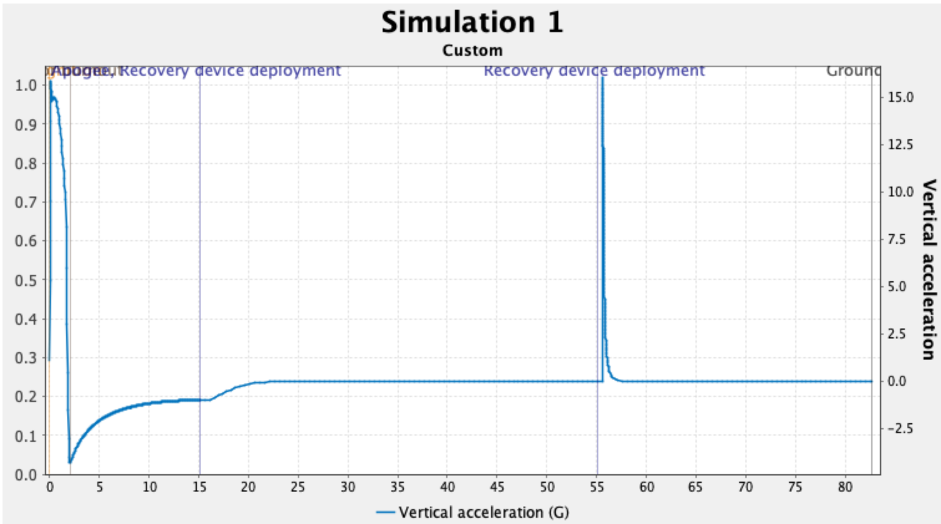


Figure 8: Vehicle Acceleration (g) vs Time (s)

Vehicle Flight Sequence

The chart below shows the flight sequence of the rocket. We will construct a standard dual-deployment vehicle using a primary computer for ejection charges, as well as a backup in case of failure. The drogue parachute will be deployed at apogee, and the main deployed at 700 ft. The payload will not separate from the rocket at any point during the flight, and the vehicle itself will be recovered in 3 tethered sections.

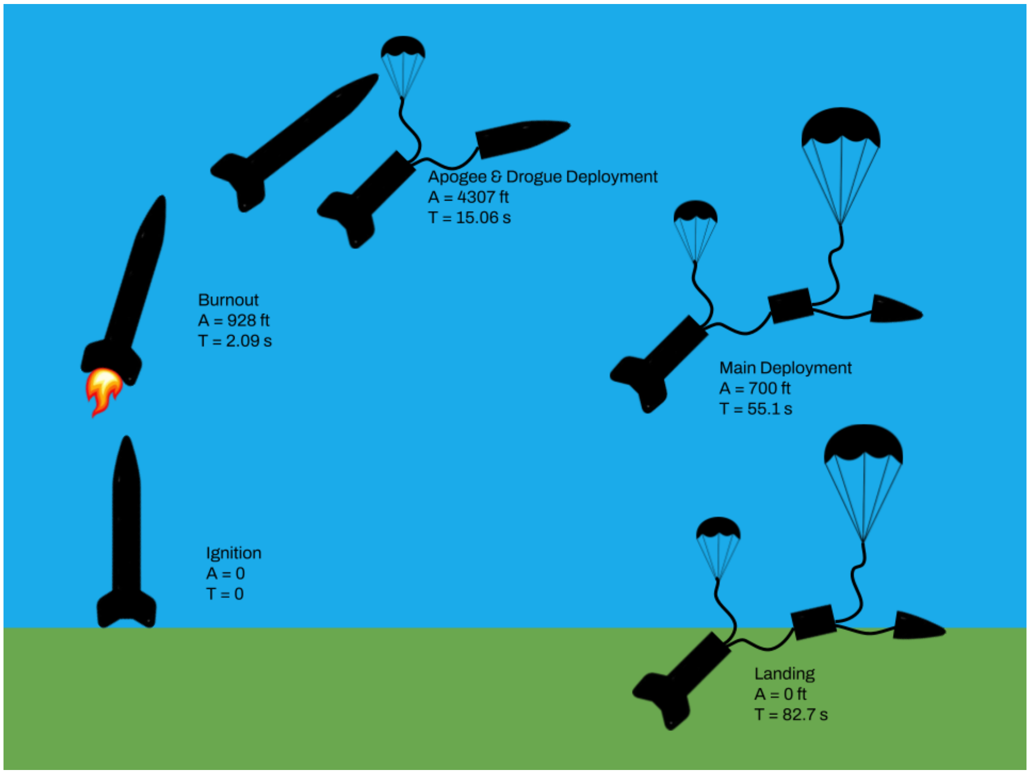


Figure 9: Mission Profile Chart

#	Event	Time (s)	Altitude (ft)	Trigger
1	Ignition	0	0	Launch Controller
2	Burnout	2.09	928	--
3	Apogee	15.06	4307	--
4	Drogue Deployment	15.06	4307	Flight Computer
5	Main Deployment	55.1	700	Flight Computer
6	Landing	82.7	0	--

Table 5: Mission Sequence of Events

Recovery System Design

We plan to use a dual-separation, dual-deployment recovery technique. The recovery system will be powered by two PerfectFlite Stratologger dual deployment altimeters, along with two batteries, to ensure system redundancy. The altimeters, as well as telemetry electronics, will be housed in an electronics bay located toward the center of the vehicle. Separation and parachute deployment will be accomplished using black powder charges. Our drogue parachute will deploy once the flight computer has determined the vehicle has reached its apogee, based on barometric pressure data. The main parachute will deploy once the barometer senses an altitude of 700 feet. Both the drogue and main parachutes will be made of ripstop nylon. The main parachute bay is located at the top of the rocket. The first separation event will occur at the nose cone, where the drogue parachute bay is located below the electronics bay. All parts of the recovery system will adhere to NAR and TRA regulations and guidelines, and students will not be handling or manufacturing the black powder charges. Because of the negative acceleration of the rocket caused by both the main and drogue parachute, the rocket will slow down to an impact velocity of approximately 19.3 feet per second and have an overall descent time of 67.6 seconds.

Planned Motor

We plan to use an AeroTech J800 motor in our rocket design. This will enable us to reach our desired altitude and fulfill rocket requirements. We were considering using a K class motor but settled for a lower impulse motor because the J800 will still allow us to reach the target altitude.

Projected Payload

Motivation

The sloshing of fuel inside large rockets can cause unwanted trajectories, due to destabilization, and can even cause damage to the rocket. Slosh baffles greatly reduce the amount of slosh in fuel tanks. Prior research has already been conducted on the use of separational barriers within tanker trucks and rockets to mitigate the instability of the vehicles in motion. However, slosh baffles have conventionally been tested using a ground-based apparatus, which may fail to account for in-flight instability and turbulence. Therefore, our goal is to offer a student-led effort to analyze the effects of various separational barriers in mitigating the amount of sloshing occuring within a rocket and therefore decreasing the effects of sloshing on the trajectory of the rocket and the rocket itself.

Objective

Our project's objective is to test different slosh baffles and determine which is best at preventing slosh to keep the rocket stable and on its planned trajectory. We will test two different baffle designs: one with panels lining the sides of the tank and another with rings around the walls of the tank.

Hypothesis

We hypothesize that a baffle in a tank of liquid mounted in the rocket will significantly reduce the amount of slosh. The hydrodynamics of the tank with the baffle will cause the amplitude of the slosh to be less than it would be without a baffle. We know this because the baffle will create a barrier that decreases the peak height the water can reach. The frequency of the slosh will remain unchanged; however, the decay will increase in speed, because the baffles will dampen the vibration from the rocket motor.

We also hypothesize that a panel-based baffle design will work 10% better than a ring-shaped baffle design at reducing the amount of slosh in a fuel tank filled with water. The panel based design will reduce the amplitude of the slosh more than the ring shaped design because the panels have a greater surface area and will therefore limit the distance the water can travel. Decay and frequency will remain the same between the two designs.

Payload Design and Experimental Setup

Our payload will consist of three 3D-printed tanks, each half full of water. The tanks are 5 inches tall and will be stacked in the payload section of the rocket. Each tank will have a different baffle design. We will test two different baffle designs, compared to one control design. One of the baffle designs will be flexible, 3D printed panels glued to the side of the tank. The other design will be rigid 3D printed plastic rings placed around the diameter of the tank (as seen below in figure 10). The third control tank will have the same amount of water and sensors as the other two, but no baffle.

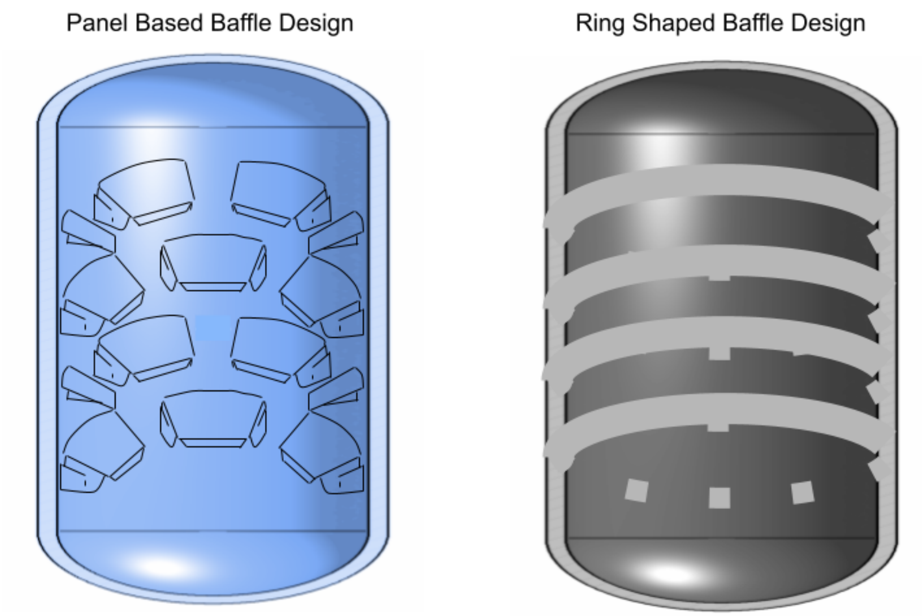


Figure 10: A sketch of the proposed baffle designs

We will use liquid sensors and RunCam cameras to measure the amount of slosh. We will split the sensor array in half, depending on the direction of the slosh. We will use infrared liquid sensors to find the highest sensors triggered on both sides. To get the displacement amplitude of the liquid, we will subtract the heights of different sides.

Payload Assembly

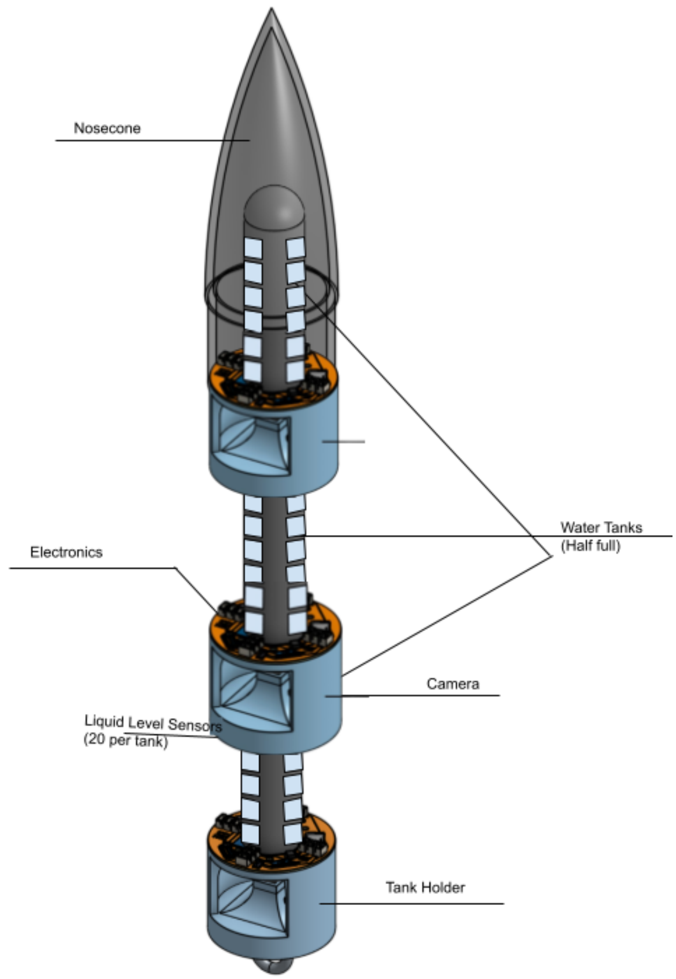


Figure 11: 3D model of the payload units

Experimental Sequence

The experimental sequence is as follows:

1. We will fill the three fluid tanks with each the same amount of water, about half full.
2. We will load the tanks into the payload.
3. We will turn on the electronics on the payload and load it to the rocket prior to launch.
4. We will launch the rocket.
5. We will retrieve the data from the sensors after recovery.
6. We will analyze the data using the data analysis techniques described below.

Data Analysis

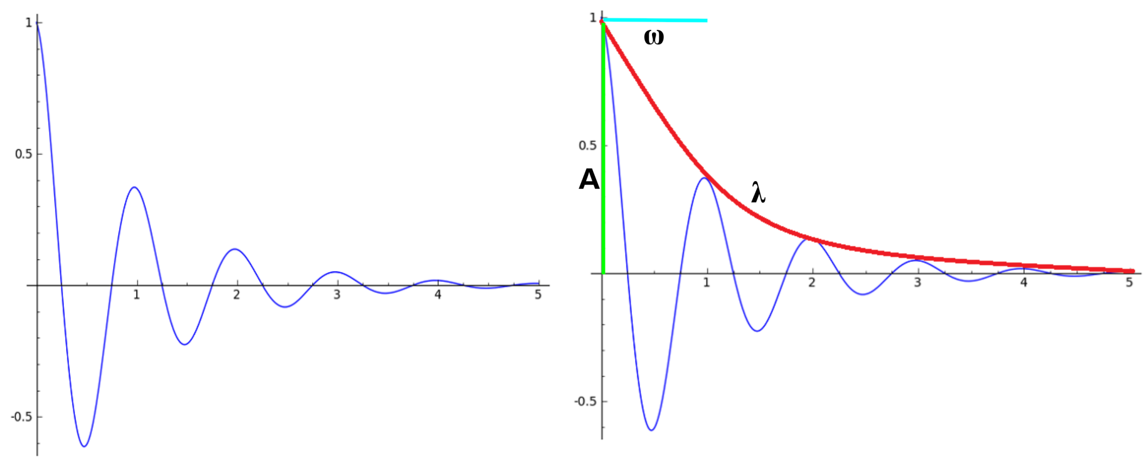
Based on the oscillatory nature of sloshing water and the dampening of water movement over time, the "sloshing" of a fluid, in this case water, can typically be modeled as a damped sine wave, where the amplitude of the curve decreases as time trends to infinity. Based on "StatisticsHowTo" and our mentor Ankur Desai, we can write a general equation for an exponentially damped sinusoid as:

$$y(t) = Ae^{-\lambda t} \cdot \left(cos(\omega t + \Phi) + sin(\omega t + \Phi)\right)$$

Equation 1: General equation for an exponentially damped sinusoid

Where:

- **t** is the time
- **A** is the maximum amplitude
- **λ** is the damping/decay constant
- **Φ** is the phase angle
- **ω** is the angular frequency



Figures 12 & 13: Example of Damped Sine Curve, Extracted Parameters

Data Collection

Within our payload, we “split” the payload in half vertically, with one side designated as the “Right” Side and the other side designated as the “Left” Side. We will use a series of cameras to record multiple angles of the payload. This recording will be stored as an “.mp4” file on an onboard SD card. In the event of water damage, our camera has a shut-off protection, and we have a Serial Flash Memory (SFM) that operates as temporary storage. This SFM has been conformal-coated to increase water resistance and decrease the possibility of risk. Then, we will be able to find the highest point of sloshing on the “Right Side” of the payload and the highest point on the “Left Side”. Once both points have been found, we will calculate the difference value by subtracting the max height of the “right” side from the height of the “left” side (H_{Right}-H_{Left}). We will then repeat the exact same steps in 0.01 second increments and concatenate them into a plot of “Time” versus “Amplitude”.

In the event the cameras do not operate, we have prepared infrared liquid sensors to find the highest sensor triggered on the Right Side and the highest sensor triggered on the Left Side. The data acquired by each infrared liquid sensor will be stored as a “.csv” file on an SD card and, as a contingency plan, to the FRAM. After we recover the rocket, we will begin the extraction of the “.csv” files onto a computer. Once we have extracted both sensors and their corresponding heights within the payload, we will repeat the steps above as if we were using a camera, subtracting the “Right” Point from the “Left” Point and concatenating them together into a damped sine curve with the exact same labels.

Data Fitting and Parameter Extraction

Once the data has been collected, we will perform 2 fits using Python: the 1st fit using curve_fit, a scipy package designed to give exact values for **A, $\boldsymbol{\lambda}$, $\boldsymbol{\Phi}$, $\boldsymbol{\omega}$**. It will perform the fitting using a non-linear least squares method to fit the data. We will repeat this process 100 times, in order to obtain an error given by curve_fit.

Using sample sloshing data:

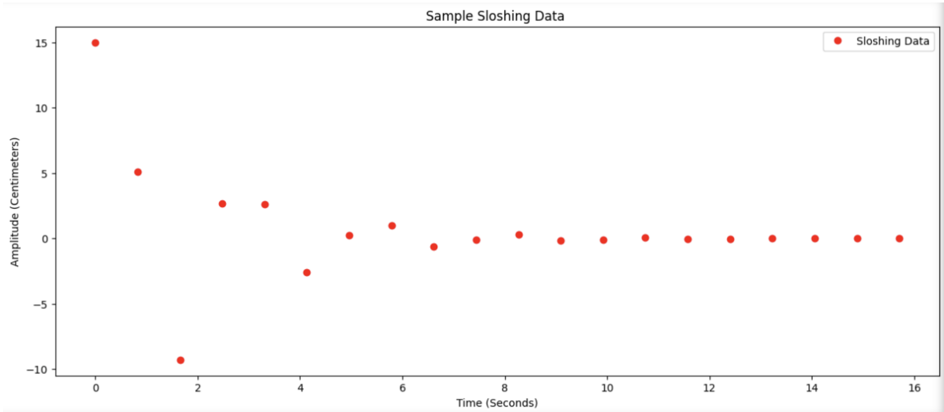


Figure 14: Sample Damped Sine Curve Data (noise = ±0.1).

We developed an algorithm using curve_fit to obtain the parameters from the graphs:

```
Amplitude: 14.999999956706446
Frequency: 2.4000000013016356
Phase: -7.851282131206185e-10
Decay Constant: 0.4999999989117736
```

Figure 15: Extrapolated curve_fit Parameters for A (Max Amplitude), λ (Decay Constant) , Φ (Phase), ω (Angular Frequency)

We can also replot the curve for accuracy:

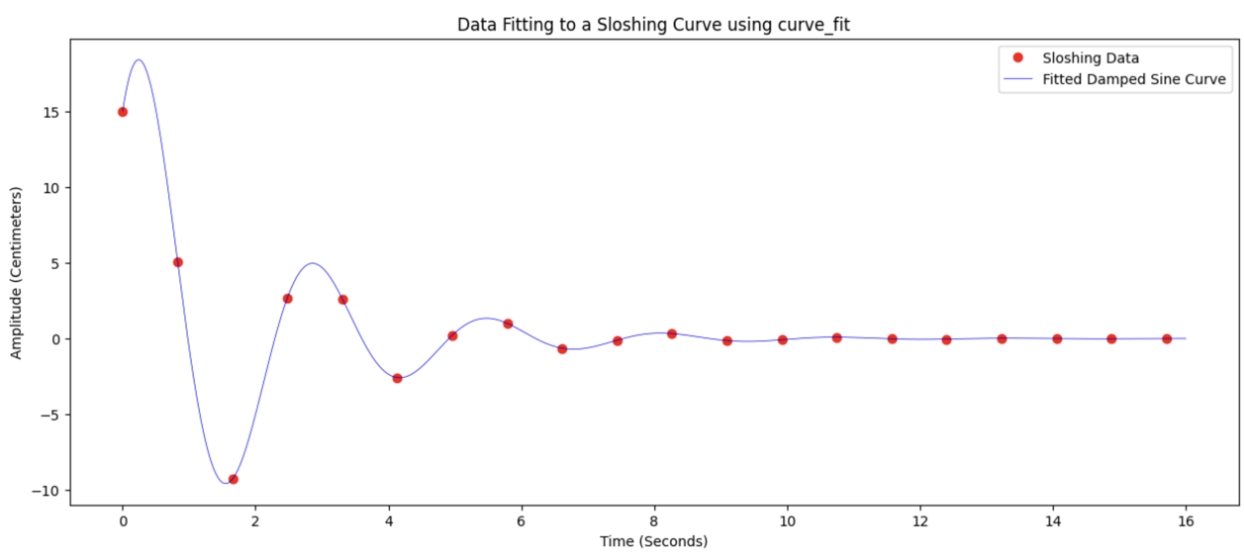


Figure 16: Fitted Damped Sine Curve using curve_fit

Once the curve_fit has been completed, we will verify its accuracy using our second fitting method: emcee – a python module that implements a sampling algorithm for a "Markov-Chain-Monte-Carlo" (MCMC) and is designed to give heuristic values for **A, λ, Φ, ω** – using the exact same equation. This MCMC will be run with 10,000 steps, 50,000 steps, and finally 100,000 steps to verify its accuracy. We set the burn-in phase as 3,000 steps to ensure a full removal of the burn-in and will analyze the trace plots if there is a need to adjust how many steps are removed. Finally –once extracting the Angular Frequency, Max Amplitude, and Decay Constant– We can evaluate the effect of the separation barriers on the mitigation of fluid movement within the baffles by directly comparing our controls with our payloads that contain a baffle.

Using sample sloshing data:

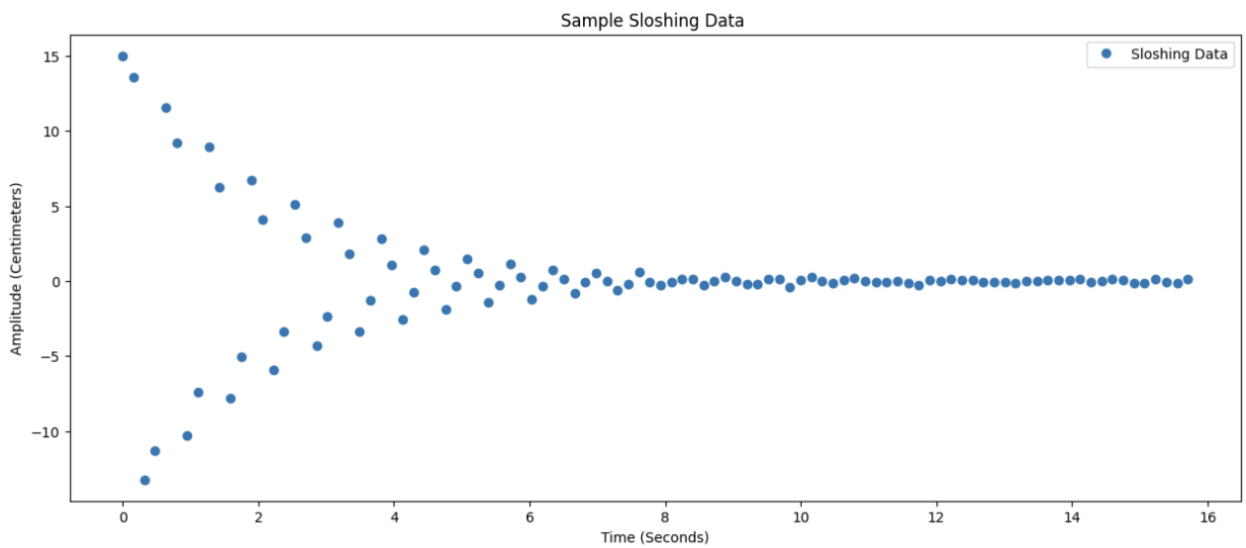


Figure 17: Sample Damped Sine Curve Data (noise = ±0.1)

We can run the Markov-Chain-Monte-Carlo, which will give us Trace Plots and Corner Plots:

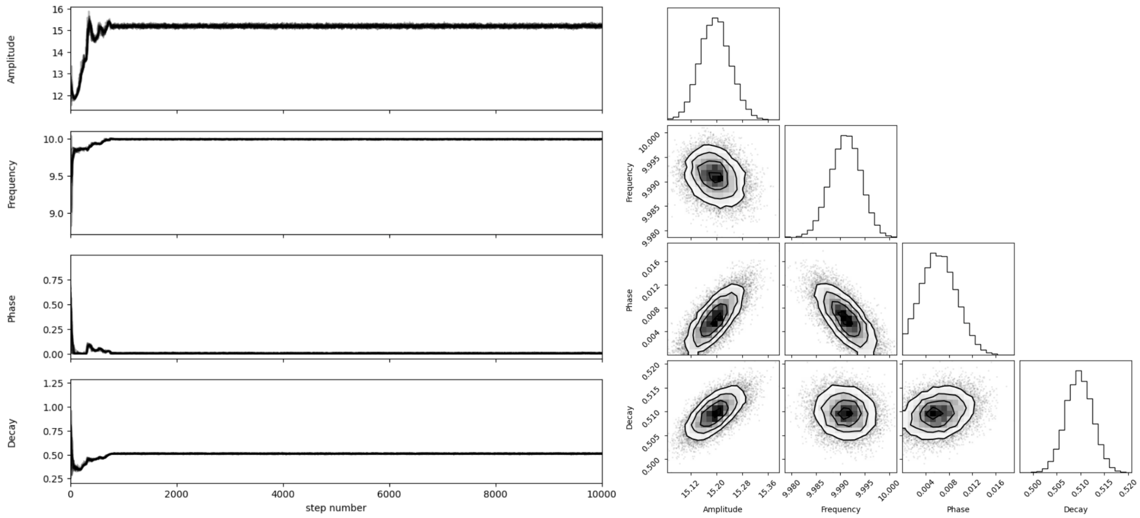


Figure 18 & 19: Trace Plots, Corner Plots

Trace Plots

These are used as important diagnostic tools for a Markov-Chain-Monte-Carlo and assess the quality of the sampling process. They help in multiple ways. For example, Trace Plots can be used to analyze whether or not convergence has been achieved and can help identify if there is a need to change the burn-in period. In addition, it can help detect auto-correlations and any outliers in our data.

Corner Plots

These are another tool we use to understand our data analysis when using MCMC. They have many uses and applications in terms of data analysis. For example, they help us understand the covariance and correlations between all parameters within our fit. They also indirectly offer evidence of whether or not convergence has been achieved and help us identify whether there is a need to adjust our burn in period, much like a Trace Plot. Corner plots can also help visualize the shape of our posterior distributions for each parameter and their relationships. The visualization can help us to understand how the parameters vary together and may reveal additional features, such as multimodal distributions or skewness within our values. It also affects our error bars in our values.

Once we have obtained our supplementary charts (Trace Plots and Corner Plots), our next step is to extract the parameters:

$$\text{Amplitude} = 15.1954062^{0.0475230}_{-0.0460629} \quad \text{Phase} = 0.0061988^{0.0031288}_{-0.0029495}$$

$$\text{Frequency} = 9.9910856^{0.0030478}_{-0.0032404} \quad \text{Decay} = 0.5096700^{0.0028391}_{-0.0028039}$$

Figure 20 & 21: Extrapolated MCMC Parameters for A (Max Amplitude), λ (Decay Constant) , Φ (Phase), ω (Angular Frequency)

Finally, we can plot our fitted damped sine curve against our sample sloshing data and compare the parameters from curve_fit against the values obtained from the MCMC.

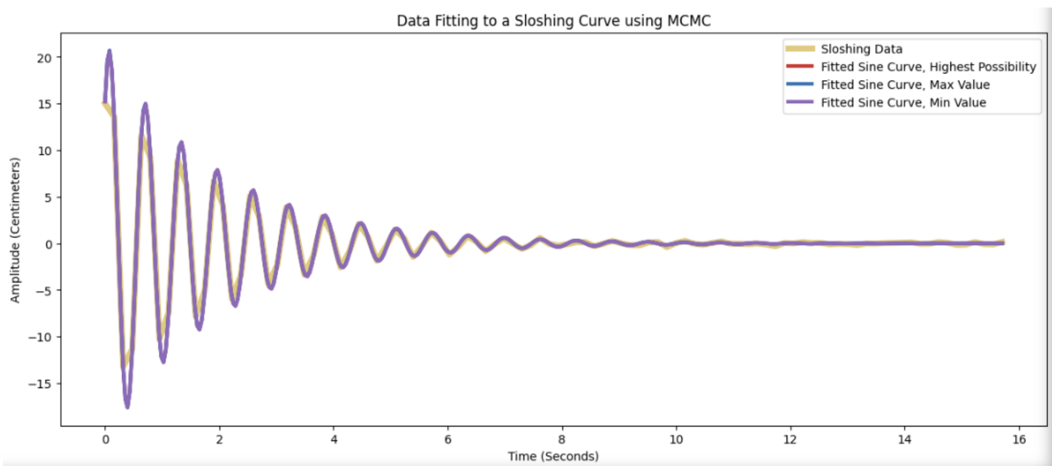


Figure 22: Fitted Damped Sine Curve with additional curves to account for MCMC Error (Note: Error is so small that the max and min graphs are essentially indistinguishable)

We will then compare the parameters from curve_fit against the values obtained from the MCMC in order to ensure accuracy across methodologies. In the event of large differences in values, we will use the Markov-Chain-Monte-Carlo Fittings, due to this methodology being a more robust fit.

Statistical Evaluation

In order to evaluate the error of the fittings as compared to the actual data acquired, we will use a Chi-Square Test and a Root Mean Square Error Test: two statistical methods to analyze how accurate curve_fit and the MCMC fittings were to our data. This data will output a numerical value that can help us understand how certain our values are.

Pros and Cons of curve_fit:

Pros of curve_fit	**Cons of curve_fit**
Easy to use due to simple and intuitive API	**Could incorrectly converge(Local Minima)**: Due to the use of the Levenberg-Marquardt algorithm, it could end up in a local minimum, rather than the true solution.
Flexibility: Allows a large number of fittings because it allows a person to select their own custom function.	**Sensitive to initial guess**: For complex models, the choice of the initial guess for the parameters can greatly affect the outcome
Parameter Estimation: curve_fit returns estimates of the best-fit parameters using a Non-Linear Least Squares	**Weak to Noisy Data:** Noisy data leads to large distortions and incorrect estimations.
Easily Integrated: Works smoothly with any other SciPy Functions.	**Assumes a Gaussian Error Distribution:** Least Squares Methods assumes that errors follow a Gaussian distribution. Our noise may not follow a gaussian distribution, so we may make additional changes to the code.
Excellent Extrapolation: Operates incredibly well with a low number of data points	**Doesn't Handle Multi-Dimensional Data:** curve_fit is primarily designed for 1D curve fitting. For multi-dimensional data fitting, additional modifications may be required.

Table 6: Nonexhaustive list of the Pros and Cons of curve_fit

Pros and Cons of a Markov_Chain_Monte_Carlo:

Pros of MCMC	**Cons of MCMC**
Versatility: MCMCs can be used to fit from simple, to complex distributions and data.	**Convergence Issue:** MCMC algorithms may need multiple diagnostic tests in order to check for convergence.

Flexibility: Can be used in many different ways with many different equations and algorithms (Metropolis-Hastings, Gibbs Sampling).	**Computational Cost:** MCMCs may need to run for very long periods of time, especially when running high dimensional problems
Robustness: Often effective even when the distribution is not smooth or when dealing with multiple eigenvalues.	**Tuning Parameters:** Adjusting the number of steps used may lead to different end values.
Holistic Exploration: Unlike curve_fit, which may end of in a local minima and give incorrect values, MCMC will explore the entire parameter space, ensuring a better representation/fit of the data.	**Sensitivity to Initial Values:** The MCMC will eventually converge to the targeted distribution values. However, the chain may take a while to forget, leading to longer burn-in phases and more steps.

Table 7: Nonexhaustive list of the Pros and Cons of a Markov-Chain-Monte-Carlo

General Requirements

Vehicle Requirements

All vehicle requirements are in detail addressed in the Project Requirements section, with Vehicle Requirements starting on page 59. The vehicle itself is described in the Technical Design section, starting on page 21.

Recovery Requirements

All recovery system requirements are in detail addressed in Project Requirements section, with Recovery System Requirements starting on page 72. The detailed description of the recovery system starts on page 29.

Payload Requirements

All payload requirements are in detail addressed in Project Requirements section, with Payload Requirements starting on page 75. The detailed description of the proposed payload starts on page 29.

Safety Requirements

All safety requirements are in detail addressed in the Safety Requirements sections, with Safety requirements starting on page 76. Detailed safety plan is included and starts on page 15.

Technical Challenges and Solutions

Major Technical Challenges and Solutions for Vehicle

The vehicle must be recovered within a 2,500ft diameter circle with the center being the launch point. With the rocket reaching an apogee of 3,500-5,500 feet above ground level, recovery within this circle may pose a challenge, particularly if the vehicle is caught in a thermal current on its way down. To combat this potential challenge, a multi-staged recovery device is used to minimize the time the vehicle is moving through the air with a full parachute deployed. With this device, distance to recover the rocket is minimized, while maintaining a safe, graceful landing.

The proposed payload consists of a slosh baffle, which will likely affect the center of gravity of the vehicle as the liquid inside moves around. To assure the safety of the rocket and a straight trajectory after launch, our team will rigorously test the payload to ensure there is an appropriate amount of liquid within that will not drastically change the vehicle's center of gravity.

Major Technical Challenges and Solutions for Payload

The proposed payload includes the usage of a liquid. Therefore, the payload container must be waterproofed, to avoid any leakage during vehicle transport and flight. The payload will be designed accordingly, to ensure the safety of the vehicle.

Data collection is crucial to the payload's purpose, but storage for recording that data is limited onboard the vehicle. The payload will include sensors that collect data, and there should be adequate storage onboard for that data. However, if there are issues with data storage, it is possible to add additional hard drives proximate to the payload within the rocket (on the top or bottom).

The payload must be able to fit snugly in the midsection of the rocket; however, the liquid needs enough room to slosh during flight, in order to collect data. The payload, therefore, will be designed in a manner as compact as possible, to leave the maximum amount of room for the liquid.

STEM Engagement

STEM Engagement Overview

Our club attends a multitude of outreach events throughout each year. These events vary from local elementary classroom activities to large public events, including, but not limited to, the Physics Open House at UW Madison and the Wisconsin Science Festival. The team will return to these events this year, as well, at the request of the event organizers.

After steadily building our reputation through outreaches for nearly a decade, the name Madison West Rocket Club is well recognized, and many schools request our participation in their STEM related events. This year, the team expects to reach approximately 2,000 people. All supplies and materials for outreach events are supplied by the club. Minimum cost outreach designs, such as paper pneumatic rockets or surplus items from the workshop, are used to ensure that a large number of children can participate in outreach opportunities and witness a meaningful demonstration of rocketry forces.

The team's fundraising efforts, dubbed Raking for Rockets, allow the club to keep in contact with local communities, while earning funds for our projects. Last year, the club raked over 120 yards, earning about 50% of our annual budget, while also connecting with the local community and spreading awareness of the club. Several times during the Raking for Rockets program, our raking teams helped people who otherwise could not carry out this necessary autumn task because of their advanced age, frail health, or the high prices charged by professional landscaping companies.

In addition to the programs outlined above, new members for the club are recruited continuously at Madison West High School. This is done through a number of methods, including participation in club fairs at West High School, personal referrals, and friendly encouragement. Programs such as the Spare Parts Airborne program during the summer allow curious members to try out rocketry and attempt an L1 certification flight in the process. These programs not only help with bolstering membership but also bring exposure to rocketry and STEM fields to those who are either too busy or shy to seek out opportunities on their own.

STEM Engagement Plan

The table below shows our planned STEM engagement activities for this year. The programs primarily target elementary and middle schools. We will likely add several events to the plan as the year progresses and we receive requests from new schools and venues.

Date	Event / Location	Activities	Expected Attendance
September 3rd	Club Fair / West High	Telling other West High students and incoming members about the club.	~150 High School Freshmen
October 19th	Outreach / 2300 S. Park St. #100; UW Space Place	• Share info about MWRC • Launch pneumatic paper rockets with kids	~150 kids, 30 adults
November 9th	Outreach / 700 N. Madison St. Waunakee (Prairie Elementary)	*Same activities*	~ 65 Elementary Schoolers
March 8th	Outreach / 718 Gilmore Street (Wingra School)	*Same activities*	~ 65 Elementary Schoolers
March 9th	Outreach / 1802 Regent Street (Randall Elementary)	*Same activities*	~ 65 Elementary Schoolers
March 14th	Outreach / 5930 Old Sauk Road (Crestwood	*Same activities*	~ 65 Elementary Schoolers

	Elementary)		
March 19th	Outreach / 6602 Inner Drive (John Muir Elementary)	*Same activities*	~ 65 kids
March 20th	Outreach / 1170 N Bird St. Sun Prairie (Ch. Bird Elementary)	*Same activities*	~ 65 Elementary Schoolers
April 4th	Club Fair / West High	Telling other West High students about the club	~ 200 High Schoolers
April 6th	Outreach / Chamberlain Hall (Physics Fair)	• Share info about MWRC • Launch pneumatic paper rockets with kids	~ 150 kids, 30 adults
April 23rd	Outreach / 2601 Prairie Road (Huegel Elementary)	*Same activities*	~ 65 Elementary Schoolers
April 24th	Outreach / 1105 Shorewood Blvd (Shorewood Elementary)	*Same activities*	~ 65 Elementary Schoolers

Table 8: Stem engagement schedule

Additional indirect engagement will occur through our social media and websites: https://www.instagram.com/westrocketry and https://madison-west-rocketry.github.io/SL/, which we will use to reach multiple audiences.

Project Plan

Development Timeline

Timeline Key

	Workshop
	Organizational meeting
	SLI writing sessions
	NASA SL Events dates and due dates
	School
	Fundraising and Outreach

Timeline

August 2024	
Saturday 17	SLI writing session
Saturday 24	SLI writing session
September 2024	
Monday 2	SLI writing session
Tuesday 3	SLI writing session
Friday 6	Workshop
Sunday 8	SLI writing session
Wednesday 11	Proposal due
October 2024	
Thursday 3	Awarded proposals announced
Friday 4	Workshop
Monday 7	Kickoff and PDR Q&A

Saturday 5	Fundraising
Sunday 6	SLI writing session
Friday 11	Workshop
Saturday 12	Organizational meeting
Sunday 13	SLI writing meeting
Thursday 17	Science fair
Friday 18	Workshop
Saturday 19	Outreach
Sunday 20	SLI writing session
Friday 25	Workshop
Saturday 26	SLI writing session
Monday 28	PDR report, presentational slides, and flysheet submitted
November 2024	
Monday 4-Tuesday 26	PDR video teleconferences
Friday 8	Workshop
Saturday 9	SLI writing session
Monday 11	Organizational meeting
Wednesday 13	Outreach
Friday 15	Workshop
Saturday 16	SLI writing session
Monday 18	Organizational meeting
Friday 22	Workshop
Saturday 23	SLI writing session
Monday 25	Organizational meeting
Wednesday 27- Friday 29	No school

Friday 29	Gateway Registration Deadline
Saturday 30	SLI writing session
December 2024	
Sunday 1	Fundraising
Monday 2	Organizational meeting
Friday 6	Workshop
Saturday 7	SLI writing session
Monday 9	Organizational meeting
Friday 13	Workshop
Saturday 14	SLI writing session
Monday 16	Organizational meeting
Friday 20	Workshop
Saturday 21	SLI writing session
Monday 23- Tuesday 31	No school
January 2025	
Wednesday 8	Subscale Flight Deadline
Wednesday 8	CDR due
Monday 13	Organizational meeting
Wednesday 15	CDR Teleconferences
Friday 17	Workshop
Saturday 18	SLI writing session
Monday 20	Organizational meeting
Friday 24	Workshop
Saturday 25	SLI writing session
Monday 27	Organizational meeting
Friday 31	Workshop

February 2025	
Saturday 1	SLI writing session
Monday 3	Organizational meeting
Friday 7	Workshop
Saturday 8	SLI writing session
Monday 10	Team photos due
Tuesday 11	FRR Q&A
Tuesday 2/11- Monday 3/17	Work on FRR
Friday 14	Workshop
Saturday 15	SLI writing session
Monday 17	Organizational meeting
Friday 21	Workshop
Saturday 22	SLI writing session
Monday 24	Organizational meeting
Friday 28	Workshop
March 2025	
Saturday 1	SLI writing session
Monday 3	Organizational meeting
Friday 7	Wingra Science Night
Saturday 8	SLI writing session
Monday 10	Organizational meeting
Friday 14	Workshop
Saturday 15	SLI writing session
Monday 17	FRR due
Wednesday 19	Outreach
Thursday 20	Outreach

Friday 21	Workshop
Saturday 22	SLI writing session
Monday 24	FRR teleconferences
Friday 28	Workshop
Saturday 29	SLI writing session
Monday 31	Organizational meeting
April 2025	
Monday 7	Organizational meeting
Friday 11	Workshop
Monday 14	Payload Demonstration Flight
Thursday 17	Launch week Q&A
Friday 18	Workshop
Wednesday 30	Team arrives in Huntsville, AL
May 2025	
Thursday 1- Friday 2 Saturday 3 Sunday 4 Monday 19	All-day Launch Week Events Launch day Backup Launch Day. PLAR submitted

Table 9: SL Project Schedule

GANTT Chart

The GANTT Chart below outlines the different overlaps of deadlines and activities, in order to better understand the time needed to complete each component of the NASA SL project.

Figure 23: GANTT chart for NASA SL 2025

Budget

Funding Plan

Madison West Rocket Club has multiple avenues to earn enough funding to sustain a significant effort within the NASA Student Launch. We typically rake during the fall season and raise funds to continue the Rocket Design and development process without any interruptions. In addition, we have received sponsorships from people and companies, and we are exploring additional funding opportunities and grants we can use to cover any additional costs. Finally, it is the policy of our team to provide necessary economic help to all SL students who cannot afford the travel expenses associated with the program with full and partial travel scholarships. The monetary amounts and the names of recipients of scholarships are not disclosed. Based on our previous proposals and experiences, this is our projected financial breakdown:

Project Expenses

Full-Scale Vehicle:

Item:	Cost:
Fin Material (G10 Fiberglass)	$60.00
Tubing & Nosecone Material (G10 Fiberglass)	$200.00
Nosecone, Bulkheads, Rings	$50.00 (Many resources available at our workshop from previous projects)
Paint and Primer	$100
Altimeter/Stratalogger	$0 - Already have enough at the workshop.
Motor Retention	$40.00
Parachutes, Shock Cords, Nomex	$200.00
Epoxy, Filler	$50.00
GPS Tracker, Beacon	$150.00
Payload Sensors and Fabrication	$300.00
Misc. Tools: Tools, Batteries, Wires, Hardware	$250.00
Total	$1,400.00

Table 10: Full-scale vehicle budgeting

Scale Model:

Item:	Cost:
Tubing (G10 Fiberglass)	$100.00
Parachutes and Shock Cord	$50.00
Fin material (G10 Fiberglass)	$50.00
Total	$200.00

Table 11: Scale Model Budgeting

Motors and Propellant:

Item:	Cost:
Scale Model Motor:	$150.00
Full Scale Test Flight Motor	$750.00 (5 test flights, $150.00 Each)
Propellant (AeroTech)	$680.00
Total:	$1,580.00

Table 12: Motor Budgeting

Travel Expenses:

The following tables show the estimated expenses from traveling to Huntsville, Alabama. Prices were calculated from past knowledge and publicly available online prices as of 9/8/2024. The total travel cost is currently estimated at $8746.00 with a per capita cost of $460.32. This budget does not include items that are purchased at the discretion of the individual such as food, souvenirs, or other individual expenses.

Flights:

Cost Per Person	Number of People:	Total Cost
$309.00	19	$5,871.00

Lodging:

Hotel	Cost Room Per Night:	Number of Rooms:	Number of Nights:	Hotel Cost Total:

Embassy Suites	$127	5 Rooms	5 Nights	$3,175.00

Ground Support:

Item:	Cost per Day	Days	Cost:
Rental SUV to haul rocket from WI	$150	6	$900.00
Two rental minivans to transport students in AL	$200	6	$1,200.00

Table 13: Transport budgeting

Cost Summary:

Item:	Cost:
Full Scale Vehicle:	$1,400.00
Scale Model:	$200.00
Motors and Propellant:	$1,580.00
Workshop Rental:	$0.00
Workshop Insurance:	$700.00
Teleconferencing Fee(s):*	$0.00
Outreach Costs:	$500.00
Flight Expenses:	$5,871.00
Hotel Expenses:	$3,175.00
Ground support:	$2,100
Total Cost:	$15,526.00

Table 14: Total budgeting

*Teleconferencing venues and equipment have already been provided by UW-Madison's Atmospheric and Oceanic Sciences Department.

Total expected revenue funding[1]:

Item:	Cost:
Raking	$7,000.00
Donations	$2,500.00
Completion of Rockets For Schools Requirements	$1,500.00
Travel Funds[2]	$9,046.00
Total Expenses:	$20,046.00

Table 15: Total expected revenue funding

1 Funding reflects total expected club revenue, which is split between expenses for SL and other team competitions (e.g., ARC or R4S)
2 Students pay the travel expenses associated with SL launch. Any student who needs support to cover expenses will be provided funds through our fundraising.

Project Sustainability

This area will highlight the sustainability of our project, our connections with our community, our methodology for recruiting and retaining Rocket Club Members, and finally, our STEM Engagement Activities.

Community Support

Due to Rocket Club's twenty-one years of experience, the club has had many opportunities to forge partnerships and collaborations within our Madison community, this section will highlight the connections created within UW-Madison and our local community.

From UW-Madison:

The longevity of Rocket Club has allowed our club to develop multiple connections with professors and faculty at many different departments. The UW researchers have helped in many aspects of previous Student Launch projects and have been helpful in designing and refining our experiments. Furthermore, they have opened up more opportunities for the club members to pursue their interests, via internships and collaborative opportunities. For example, the club has assisted Professor Wendt in displaying a NSF-funded, fully functional plasma thruster at the Milwaukee Plasma Expo. In addition, one of our club members has gone on to obtain a fellowship with the help of our professors.

The list of professors and experts who help and have recently helped significantly in club endeavors are listed below in alphabetical order:

- Alyssa Jankowski - Dept. of Astronomy
- Professor Anderson - Dept. of Mechanical Engineering
- Dr. Barker - Dept. of Botany
- Professor Bonazza - Dept. of Mechanical Engineering.
- Professor Desai - Dept. of Atmospheric Oceanic Space Sciences
- Professor Eloranta - Dept. of Atmospheric Oceanic Space Sciences
- Professor Fernandez - Dept. of Botany
- Professor Gilroy - Dept. of Botany
- Professor Masson - Dept. of Genetics
- Professor McCammon - Dept. of Physics
- Professor Pawley - Dept. of Zoology
- Professor Bednarek - Dept. of Biochemistry
- Professor Wendt - Dept. Electrical and Computer Engineering

Through educator affiliation with UW-Madison, our research meetings and teleconferences will continue to be held in classrooms belonging to the Department of

Atmospheric and Oceanic Space Sciences (AOS) and the Space Sciences and Engineering Center (SSEC). This provides us with state-of-the-art classrooms, including projection technology and document cameras that we can use during our meetings. We are also participating in UW Outreach Activities, such as the Physics Open House, Super Science Saturdays, and most notably the Wisconsin Science Festival, where we can reach over 9,000 people annually. Additionally, UW-Madison provides us with teleconferencing venues and equipment, saving us over $2,600.00 in teleconferencing expenses annually.

From the Local Community:

Twenty-one years of existence has allowed the club to build a reputation among the community as a reliable educational entity. Event organizers often request our presence at STEM-related events to talk about rocketry and provide hands-on activities. Children are especially eager to construct and launch their own pneumatic rockets. The enthusiasm of the children and the reputation of the club among event organizers make it much easier for the team to reach a large number of people during public outreaches. Many of the new members in our club cite our presence at an outreach as the main reason they decided to join the rocket club.

On top of support during outreaches, the team raises funds by raking leaves in local neighborhoods during the fall. We find this is an excellent way to earn the support of the community and increase our visibility. Leaf raking requests have steadily grown over the years, and people regularly donate over $100 per yard to show their appreciation and support for the club.

More than three committed mentors aid the program throughout all project stages of our well established rocketry program. They patiently teach and guide the club in the planning, processing, writing, building, organization, and launching of our project. Our mentors dedicate much time and effort throughout the year, and we greatly value their compassion and support. Parents also support the club through their assistance in fundraisers, meetings, outreach projects, and launches. They provide food and transportation during the cold winter events and launches, take on administrative roles, such as fundraising and logistics, and, perhaps most importantly, provide encouragement and support. Finally, we have an established our social media presence, and at peak times, our postings reach over 2,500 people.

NASA Student Launch Project Requirements

General Requirements

1. 1 Students on the team will do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor). Students will do 100% of work on the project, write the documentation and presentations and present the project during teleconferences. Mr. Brent Lillesand is the Level 2 mentor for the team, and he will handle all motor and ejection charge assembly. Educator mentors Desai, Jetzer, Bednarek, and Madison West teacher/club advisor Hager provide mentoring, supervision, and safety.

1.2. The team will provide and maintain a project plan to include, but not limited to the following items: project milestones, budget and community support, checklists, personnel assigned, educational engagement events, and risks and mitigations. A project plan has been written and will be maintained and updated as the project progresses.

1.3. Team members who will travel to the Huntsville Launch shall have fully completed registration in the NASA Gateway system before the roster deadline. Team members shall include:

1.3.1. Students actively engaged in the project throughout the entire year. All team members are identified in the Student Participants section near the beginning of this document.

1.3.2. One mentor (see requirement 1.13). Mr. Brent Lillesand is the mentor for the team.

1.3.3. No more than two adult educators. Ms. Christine Hager and Dr. Ankur Desai are the two adult educators for our team.

1.4. . Teams shall engage a minimum of 250 participants in Educational Direct Engagement STEM activities. These activities can be conducted in-person or virtually. To satisfy this requirement, all events shall occur between project acceptance and the FRR addendum due date. A template of the STEM Engagement Activity Report can be found on pages 86 – 89. Our education engagement plan includes 2,000 students from local elementary and middle schools and members of the general public. At least 500 of those are middle school students. Educational engagement forms will be completed and submitted within two weeks of each event's completion.

1.5. The team will establish a social media presence to inform the public about team activities. A social media presence will be created and updated throughout the duration of the project. The team is a part of Madison West Rocket Club, which already has an established media presence: https://www.instagram.com/westrocketry and https://madison-west-rocketry.github.io/SL/

1.6. Teams will email all deliverables to the NASA project management team by the deadline specified in the handbook for each milestone. In the event that a deliverable is too large to attach to an email, inclusion of a link to download the file will be sufficient. All deliverables will be emailed on time to NASA project management with either an attachment or a download link, following the project timeline and as noted on the Gannt chart.

1.7 Teams who do not satisfactorily complete each milestone review (PDR, CDR, FRR) shall be provided action items needed to be completed following their review and shall be required to address action items in a delta review session. After the delta session, the NASA management panel shall meet to

determine the teams' status in the program and the team shall be notified shortly thereafter. Action items will be reviewed and addressed after each milestone review.

1.8. All deliverables must be in PDF format. All deliverables will be in PDF format.

1.9. In every report, teams will provide a table of contents including major sections and their respective sub-sections. The aforementioned format of each report will be followed.

1.10. In every report, the team will include the page number at the bottom of the page. Page numbers will be included at the bottom of each page in all reports (right bottom corner of each page).

1.11. The team will provide any computer equipment necessary to perform a video teleconference with the review panel. This includes, but is not limited to, a computer system, video camera, speaker telephone, and a broadband Internet connection. Cellular phones can be used for speakerphone capability only as a last resort. We will be using fully equipped teleconference rooms in the Atmospheric and Oceanic Sciences building at UW-Madison. The cellular phone will be on hand as a backup only.

1.12. All teams will be required to use the launch pads provided by Student Launch's launch service provider. No custom pads will be permitted on the launch field. Launch services will have 8 ft. 1010 rails [2.4 m 1010 rails], and 12 ft. 1515 rails [3.7 m 1515 rails] available for use. The launch rails will be canted 5 to 10 degrees away from the crowd on launch day. The exact cant will depend on launch day wind conditions. We will use the launch pads provided by Student Launch's launch service provider. We will need an 8ft, 1010 rail for this project.

1.13. Each team must identify a "mentor." A mentor is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year, and may or may not be affiliated with the school, institution, or organization. The mentor must maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged) a minimum of two flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to launch this week. One travel stipend will be provided per mento regardless of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team and mentor attends launch week in April. SL25 Statement of Work Madison West High School Madison West Rocketry Club Page 6. Mr. Brent Lillesand is the mentor for the team. He is Level 3 certified and satisfies all requirements listed above. He will accompany the team to the Huntsville launch.

1.14 Teams will track and report the number of hours spent working on each milestone. A Google spreadsheet is being used to track hours spent by each member and will be combined for reporting on total hours spent.

Vehicle Requirements

2.1. The vehicle shall deliver the payload to an apogee altitude between 3,500 and 5,500 feet above ground level (AGL). Teams flying below 3,000 feet or above 6,000 feet on their competition launch will not be eligible for the Altitude Award. The current simulation predicts that the rocket will reach 4,307 ft. The coefficient of drag is set to $C_d = 0.8$. We have obtained this value from our previous experiments using a similar constant diameter J-class delivery vehicle. The performance predictions will be updated as data from scale model flight and half-impulse flight become available. If necessary, the rocket will be ballasted to prevent it from exceeding target altitude.

2.2. Teams shall declare their target altitude goal at the CDR milestone. The declared target altitude shall be used to determine the team's altitude score The target altitude goal will be finalized at the CDR milestone.

2.3. The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications. The vehicle is designed as reusable and can be launched several times a day. The maximum flight preparation time is 2 hours.

2.4 The launch vehicle shall have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main vehicle using its own parachute. The vehicle consists of three tethered sections (nose cone, compartment housing both the payload and main parachute, and the booster section).

- **2.4.1. Coupler/airframe shoulders which are located at in-flight separation points shall be at least two airframe diameters in length. (One body diameter of surface contact with each airframe section.)** All coupler and airframe shoulders located at in flight separation points will be one body diameter in length at minimum. This requirement is satisfied in the current vehicle design.
- **2.4.2. Coupler/airframe shoulders which are located at non-in-flight separation points shall be at least 1.5 airframe diameters in length. (0.75 body diameter of surface contact with each airframe section.)** This requirement of separation points at least 1.5 airframe diameters in length is satisfied in the current vehicle design.
- **2.4.3. Nosecone shoulders which are located at in-flight separation points shall be at least ½ body diameter in length.** All nosecone shoulders located at in-flight separation points will be at least 1⁄2 body diameter in length. This requirement is satisfied in the current vehicle design.

2.5.The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours of the time the Federal Aviation Administration flight waiver opens. The maximum preparation time for the rocket is 2 hours. The team will practice the vehicle preparation in order to assure their ability to ready the vehicle for launch within allocated time.

2.6 The launch vehicle and payload shall be capable of remaining in launch-ready configuration on the pad for a minimum of 3 hours without losing the functionality of any critical on-board components, although the capability to withstand longer delays is highly encouraged. Our payload and launch design consider and plan for a more than three-hour window.

2.7. The launch vehicle will be capable of being launched by a standard 12-volt direct current firing system. The firing system will be provided by the NASA-designated launch services provider. The vehicle is using an AeroTech motor, which is compatible with 12V igniters. Electrical current of 3A is sufficient to fire the igniter. The vehicle can be launched from the standard 12V launch system.

2.8. The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the launch services provider). No external circuitry other than the standard 12V launch system is required to launch the vehicle.

2.9. The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR) Only motors satisfying this performance target are used in design, testing, and operation of the vehicle. Currently, AeroTech J800 54mm motor is the primary propulsion choice.

2.9.1. Final motor choice shall be declared by the Preliminary Design Review (PDR) milestone. We will finalize our propulsion choice by Critical Design Review (CDR).

2.9.2. Any motor change after PDR shall be approved by the NASA management team or NASA Range Safety Officer (RSO). Changes for the sole purpose of altitude adjustment shall not be approved. The only exception is teams switching to their secondary motor choice, provided the primary motor choice is unavailable due to a motor shortage. We will comply with all instructions from NASA should this situation arise.

2.10. The launch vehicle shall be limited to a single motor propulsion system. The launch vehicle is a single stage rocket.

2.11. The total impulse provided by a Middle and/or High School launch vehicle will not exceed 2,560 Newton-seconds (K-class). None of the three motor alternatives considered for this project exceed the 2560Ns impulse limit. The primary motor choice has a total impulse of 1280Ns.

2.12. Pressure vessels on the vehicle will be approved by the RSO and will meet the following criteria:

2.12.1. The minimum factor of safety (Burst or Ultimate pressure versus Max Expected Operating Pressure) will be 4:1 with supporting design documentation included in all milestone reviews. Not applicable.

2.12.2. Each pressure vessel will include a pressure relief valve that sees the full pressure of the valve that is capable of withstanding the maximum pressure and flow rate of the tank. Not applicable.

2.12.3. Full pedigree of the tank will be described, including the application for which the tank was designed, and the history of the tank, including the number of pressure cycles put on the tank, by whom, and when. Not applicable.

2.13. The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail. The vehicle stability margin is predicted as 4.05 calibers at liftoff.

2.14. The launch vehicle shall have a minimum thrust to weight ratio of 5.0 : 1.0. Our current thrust to weight ratio is 25.8.

2.15. Any structural protuberance on the rocket shall be located aft of the burnout center of gravity. Camera housings will be exempted, provided the team can show that the housing(s) causes minimal aerodynamic effect on the rocket's stability. No protuberances are part of this design.

2.16. The launch vehicle will accelerate to a minimum velocity of 52 fps [15.8 m/s] at rail exit. The predicted rail exit velocity is 57.2fps (17.43m/s).

2.17. All teams shall successfully launch and recover a subscale model of their rocket. Success of the subscale is at the sole discretion of the NASA review panel. The subscale flight may be conducted at any time between proposal award and the CDR submission deadline. Subscale flight data shall be reported in the CDR report and presentation at the CDR milestone. Subscales are required to use a minimum motor impulse class of E (Mid Power motor). We are planning to launch the subscale model prior to the Critical Design Review due date. This is a standard step in our project development cycle.

> **2.17.1. The subscale model should resemble and perform as similarly as possible to the full-scale model; however, the full-scale model will not be used as the subscale model.** The subscale model will be a half-scale model of the full-scale vehicle. The stability margin will be the same, and the same deployment scheme will be used.

2.17.2. The subscale model shall carry an altimeter capable of recording the model's apogee altitude. The subscale model will be equipped by the same altimeter brand as the full-scale vehicle (PerfectFlite StratoLogger CF).

2.17.3. The subscale rocket shall be a newly constructed rocket, designed and built specifically for this year's project. We will design and build the subscale rocket specifically for this year's project.

2.17.4. Proof of a successful flight shall be supplied in the CDR report.. We will provide altimeter data as proof of a successful flight. This data will be supplied in the CDR report.

2.17.4.1. Altimeter flight profile graph(s) OR a quality video showing successful launch and recovery events as deemed by the NASA management panel are acceptable methods of proof. Altimeter flight profile graph(s) that are not complete (liftoff through landing) will not be accepted. We will ensure complete graphs of the flight profile will be recorded. As a backup, we will record the flight to the best of our ability.

2.17.4.2. Quality pictures of the as landed configuration of all sections of the launch vehicle shall be included in the CDR report. This includes, but is not limited to: nosecone, recovery system, airframe, and booster. Photos of these components will be included in the CDR report.

2.17.5 The subscale rocket shall not exceed 75% of the dimensions (length and diameter) of your designed full-scale rocket. For example, if your full-scale rocket is a 4" diameter 100" length rocket, your subscale shall not exceed 3" diameter and 75" in length. Dimensions will be limited to 75% of design-scale.

2.18. All teams will complete demonstration flights as outlined below.

2.18.1. Vehicle Demonstration Flight—All teams shall successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown shall be the same rocket to be flown as

their competition launch. The purpose of the Vehicle Demonstration Flight is to validate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly (drogue chute at apogee, main chute at the intended lower altitude, functioning tracking devices, etc.) The following criteria shall be met during the full-scale demonstration flight:

2.18.1.1. The vehicle and recovery system shall have functioned as designed. Noted.

2.18.1.2. The full-scale rocket shall be a newly constructed rocket, designed and built specifically for this year's project. We are building a new rocket.

2.18.1.3. The payload does not have to be flown during the full-scale Vehicle Demonstration Flight. The following requirements still apply:

2.18.1.3.1. If the payload is not flown, mass simulators shall be used to simulate the payload mass. We intend to fly the payload as constructed in the demonstration flight.

2.18.1.3.2. The mass simulators shall be located in the same approximate location on the rocket as the missing payload mass. N/A

2.18.1.4. If the payload changes the external surfaces of the rocket (such as camera housings or external probes) or manages the total energy of the vehicle, those systems will be active during the full-scale Vehicle Demonstration Flight. N/A

2.18.1.5. Teams shall fly the competition launch motor for the Vehicle Demonstration Flight. The team may request a waiver for the use of an alternative motor in advance if the home launch field cannot support the full impulse of the competition launch motor or in other extenuating circumstances. We will most likely fly the launch motor to be used at competition.

2.18.1.6. The vehicle will be flown in its fully ballasted configuration during the full-scale test flight. Fully ballasted refers to the maximum amount of ballast that will be flown during the competition launch flight. Additional ballast shall not be added without a re-flight of the full-scale launch vehicle. Vehicle will be fully ballasted.

2.18.1.7. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components shall not be modified without the concurrence of the NASA management team or Range Safety Officer (RSO). No modification without approval will be made post-demonstration flight.

2.18.1.8. Proof of a successful flight shall be supplied in the FRR report.

> **2.18.1.8.1. Altimeter flight profile data output with accompanying altitude and velocity versus time plots is required to meet this requirement. Altimeter flight profile graph(s) that are not complete (liftoff through landing) shall not be accepted.** Altimeter profile will be collected for full launch.
>
> **2.18.1.8.2. Quality pictures of the as landed configuration of all sections of the launch vehicle shall be included in the FRR report. This includes, but is not limited to: nosecone, recovery system, airframe, and booster.** Photos will be taken of the indicated sections.
>
> **2.18.1.8.3. Raw altimeter data in .csv or .xlsx format.** Altimeter data will be in .csv format.

2.18.1.9. Vehicle Demonstration flights shall be completed by the FRR submission deadline. No exceptions will be made. If the Student Launch office determines that a Vehicle. Demonstration Re-flight is necessary, then an extension may be granted. THIS

EXTENSION IS ONLY VALID FOR RE-FLIGHTS, NOT FIRST TIME FLIGHTS. Teams completing a required re-flight shall submit an FRR Addendum by the FRR Addendum deadline. Deadlines are noted on our project plan and timeline.

2.18.2. Payload Demonstration Flight—All teams shall successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload Demonstration Flight deadline. The rocket flown shall be the same rocket to be flown as their competition launch. The purpose 56 2025 Student Launch Handbook & Request for Proposal Middle/High School General and Proposal Requirements of the Payload Demonstration Flight is to prove the launch vehicle's ability to safely retain the constructed payload during flight and to show that all aspects of the payload perform as designed. A successful flight is defined as a launch in which the rocket experiences stable ascent and the payload is fully retained until it is deployed (if applicable) as designed. The following criteria shall be met during the Payload Demonstration Flight:

2.18.2.1. The payload shall be fully retained until the intended point of deployment (if applicable), all retention mechanisms shall function as designed, and the retention mechanism shall not sustain damage requiring repair. All mechanisms will be retained.

2.18.2.2. The payload flown shall be the final, active version. Final payload design will be flown.

2.18.2.3. If the above criteria are met during the original Vehicle Demonstration Flight, occurring prior to the FRR deadline and the information is included in the FRR package, the additional flight and FRR Addendum are not required. Our intention is to fly payload at demo flight.

2.18.2.4. Payload Demonstration Flights shall be completed by the FRR Addendum deadline. NO EXTENSIONS WILL BE GRANTED. Deadlines noted.

2.19 An FRR Addendum shall be required for any team completing a Payload Demonstration Flight or NASArequired Vehicle Demonstration Re-flight after the submission of the FRR Report.

2.19.1. Teams required to complete a Vehicle Demonstration Re-Flight and failing to submit the FRR Addendum by the deadline shall not be permitted to fly a final competition launch. Noted.

2.19.2. Teams who complete a Payload Demonstration Flight which is not fully successful may petition the NASA RSO for permission to fly the payload during launch week. Permission shall not be granted if the RSO or the Review Panel have any safety concerns. Noted.

2.20 The team's name and Launch Day contact information shall be in or on the rocket airframe, as well as in or on any section of the vehicle that separates during flight and is not tethered to the main airframe. This information shall be included in a manner that allows the information to be retrieved without the need to open or separate the vehicle. We will include launch information on the airframe.

2.21. All Lithium Polymer batteries shall be sufficiently protected from impact with the ground and will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other payload hardware. Any Li-Poly batteries will be colored and protected.

2.22. Vehicle Prohibitions

2.22.1. The launch vehicle shall not utilize forward firing motors. Noted.

2.22.2. The launch vehicle shall not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.) No expelling sponges are used.

2.22.3. The launch vehicle shall not utilize hybrid motors. No hybrid motors planned.

2.22.4. The launch vehicle shall not utilize a cluster of motors. No cluster motors planned.

2.22.5. The launch vehicle shall not utilize friction fitting for motors. No friction fitting for motors.

2.22.6. The launch vehicle shall not exceed Mach 1 at any point during flight. Max speed is below Mach 1.

2.22.7. Vehicle ballast shall not exceed 10% of the total unballasted weight of the rocket, as it would sit on the pad (i.e., a rocket with an unballasted weight of 40 lbs. on the pad may contain a maximum of 4 lbs. of ballast). Ballast will be kept below 10% of unballasted weight.

2.22.8. Transmissions from on-board transmitters, which are active at any point prior to landing, shall not exceed 250 mW of power (per transmitter.) Transmitter power will be < 250 mW.

2.22.9. Transmitters shall not create excessive interference. Teams shall utilize unique frequencies, handshake/passcode systems, or other means to mitigate interference caused to or received from other teams. Interference will be considered in design.

2.23.10. Excessive and/or dense metal shall not be utilized in the construction of the vehicle. Use of lightweight metal will be permitted but limited to the amount necessary to ensure structural integrity of the airframe under the expected operating stresses. No dense metal material will be used.

Recovery System Requirements

3.1. The full-scale launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee, and a main parachute is deployed at a lower altitude. Tumble or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue stage descent is reasonable, as deemed by the RSO. Our recovery system includes drogue and main.

3.1.1. The main parachute shall be deployed no lower than 500 feet. Main parachute will deploy above 500 ft.

3.1.2. The apogee event shall contain a delay of no more than 2 seconds. Apogee delay will be limited to 2 seconds.

3.1.3. Motor ejection is not a permissible form of primary or secondary deployment. No motor ejection will occur.

3.3. Each independent section of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf at landing. Max KE noted.

3.4. The recovery system shall contain redundant, commercially available barometric altimeters that are specifically designed for initiation of rocketry recovery events. The term "altimeters" includes both simple altimeters and more sophisticated flight computers. The vehicle will carry two identical barometric altimeters, each capable of serving the role of official scoring altimeter. The team will designate and visually identify one of the altimeters as the official scoring altimeter, before the actual flight.

3.5. Each altimeter shall have a dedicated power supply, and all recovery electronics shall be powered by commercially available batteries. Power supplies will be separate for each.

3.6. Each altimeter shall be armed by a dedicated mechanical arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad. Independent external switches are standard requirement for all Madison West sounding rocket projects. This performance target will be satisfied and documented.

3.7. Each arming switch shall be capable of being locked in the ON position for launch (i.e., cannot be disarmed due to flight forces). We use switches operated by a key. None of the switches can be moved after the key has been removed. None of the switches is momentary.

3.8. The recovery system, GPS and altimeters, and electrical circuits shall be completely independent of any payload electrical circuits. Independent circuits will be used for each.

3.9. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment. Removable shear pins will be used at all separation points. The shear pins will be tested during static ejection tests to assure that they will hold but not interfere with the separation of the corresponding compartment.

3.10. Bent eye bolts shall not be permitted in the recovery subsystem. No bent eye bolts.

3.11. The recovery area shall be limited to a 2,500 ft. radius from the launch pads. The rocket will remain within the confines of the launch area, even under 20mph wind-speed conditions.

3.12. Descent time of the launch vehicle shall be limited to 90 seconds (apogee to touch down). Descent time is designed to be < 90 s.

3.13. An electronic tracking device shall be installed in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.

> **3.13.1. Any rocket section or payload component, which lands untethered to the launch vehicle, shall contain an active electronic tracking device.** All tracking devices will be fully operational during official flight in Huntsville and, if possible, for all full-scale vehicle test launches.
> **3.13.2. The electronic tracking device(s) shall be fully functional during the official competition launch.** Noted.

3.14. The recovery system electronics shall not be adversely affected by any other on-board electronic devices during flight (from launch until landing).

> **3.14.1. The recovery system altimeters shall be physically located in a separate compartment within the vehicle from any other radio frequency**

transmitting device and/or magnetic wave producing device. Recovery altimeter location is separated.

3.14.2. The recovery system electronics shall be shielded from all on-board transmitting devices to avoid inadvertent excitation of the recovery system electronics. 58 2025 Student Launch Handbook & Request for Proposal Middle/High School General and Proposal Requirements There will be no interference between recovery deployment circuitry and payload or tracking circuitry. Shielding will be used as necessary.

3.14.3. The recovery system electronics shall be shielded from all on-board devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system. There are no magnetic wave generators onboard.

3.14.4. The recovery system electronics shall be shielded from any other on-board devices which may adversely affect the proper operation of the recovery system electronics. The recovery system altimeters are housed in a dedicated electronics bay, separate from all other electronics.

Payload Experiment Requirements

All payload designs shall be approved by NASA. NASA reserves the authority to require a team to modify or change a payload, as deemed necessary by the Review Panel, even after a proposal has been awarded. We look forward to feedback on our payload.

4.1. High School/Middle School Division— Teams may design their own science or engineering experiment or may choose to complete the College/University Division mission stated below. Data from the science or engineering experiment will be collected, analyzed, and reported by the team following the scientific method. Our payload is developed and described in the technical design section to study the role of baffles in reduced liquid slosh in launches.

4.2. USLI Payload Mission Objective: College/University Division— N/A

4.3. STEMCRaFT Mission Requirements. N/A

4.4. General Payload Requirements:

4.4.1. Black powder and/or similar energetics are only permitted for deployment of in-flight recovery systems. Energetics will not be permitted for any surface operations. No energetics are used in the payload.

4.4.2. Teams shall abide by all FAA and NAR rules and regulations. Noted.

4.4.3. Any payload experiment element that is jettisoned during the recovery phase shall receive real-time RSO permission prior to initiating the jettison event, unless exempted from the requirement by the RSO or NASA. No jettison of material is proposed.

4.4.4. Unmanned aircraft system (UAS) payloads, if designed to be deployed during descent, shall be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given permission to release the USA. Payload does not have UAS.

4.4.5. Teams flying UASs shall abide by all applicable FAA regulations, including the FAA's Special Rule for Model Aircraft (Public Law 112-95 Section 336; see https://www.faa.gov/uas/faqs). N/A

4.4.6. Any UAS weighing more than .55 lbs. shall be registered with the FAA and the registration number marked on the vehicle. N/A

Safety Requirements

5.1. Each team shall use a launch and safety checklist. The final checklists shall be included in the FRR report and used during the Launch Readiness Review (LRR) and any Launch Day operations. We will use a launch and safety checklist for each launch. The checklists will be checked and improved during each test launch. All checklists will be included in our Flight Readiness Review.

5.2. Each team shall identify a student safety officer who will be responsible for all items in Section 5.3. Ayelet Blum is the team's safety officer.

5.3. The role and responsibilities of the safety officer shall include, but are not limited to:

5.3.1. Monitor team activities with an emphasis on safety during:

5.3.1.1. Design of vehicle and payload

5.3.1.2. Construction of vehicle and payload components

5.3.1.3. Assembly of vehicle and payload

5.3.1.4. Ground testing of vehicle and payload

5.3.1.5. Subscale launch test(s)

5.3.1.6. Full-scale launch test(s)

5.3.1.7. Competition Launch

5.3.1.8. Recovery activities

5.3.1.9. STEM Engagement Activities

All items are acknowledged and part of our standard set of procedures.

All items are acknowledged and part of our standard set of procedures.

5.3.2. Implement procedures developed by the team for construction, assembly, launch, and recovery activities. All items are acknowledged and part of our standard set of procedures

5.3.3. Manage and maintain current revisions of the team's hazard analyses, failure modes analysis, procedures, and SDS/chemical inventory data. All items are acknowledged and part of our standard set of procedures

5.3.4. Assist in the writing and development of the team's hazard analyses, failure modes analysis, and procedures. All items are acknowledged and part of our standard set of procedures

5.4. During test flights, teams shall abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch does not give explicit or implicit authority for teams to fly those vehicle configurations and/or payloads at other club launches. Teams shall communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch. The team's intentions are communicated to the host organization prior to each launch. The team will abide by the launch rules set by the host organization.

5.5. Teams shall abide by all rules set forth by the FAA. All FAA rules are strictly followed during all our activities.

Final Flight Requirements

Teams shall conduct the final flight in Huntsville during Launch Week (NASA Launch Complex) or at a local launch field (Commercial Spaceport Launch Site) by the applicable deadlines as outlined in the Timeline for NASA Student Launch. We intend to participate in Huntsville during Launch Week.

6.1. NASA Launch Complex

6.1.1. Teams are not permitted to show up at the NASA Launch Complex outside of launch day without permission from the NASA management team. We will attend on launch day.

6.1.2. Teams shall complete and pass the Launch Readiness Review conducted during Launch Week. Noted.

6.1.3. The team mentor shall be present and oversee rocket preparation and launch activities. The team members will attend all activities.

6.1.4. The scoring altimeter shall be presented to the NASA scoring official upon recovery. The scoring altimeter shall be one of the altimeters used for recovery events. We will present the scoring altimeter upon recovery.

6.1.5. Teams may launch only once. Any launch attempt resulting in the rocket exiting the launch pad, regardless of the success of the flight, will

be considered a launch. Additional flights beyond the initial launch, will not be scored and will not be considered for awards. Noted.

6.2. Commercial Spaceport Launch Site N/A

Supplementary Information

Team Member Resumes

See following pages

Resume for Ayelet Blum

Academic Education:
- Edith C. Baker School (2014)
- Van Hise Elementary School (2015-2020)
- Velma Hamilton Middle School (2020-2023)
- Madison West High School (2023-present)

Languages:
English (Fluent), Hebrew (Fluent), Spanish (4 years)

Activities:
- Madison West Rocket Club (2023-present)
    - Rockets For Schools (2023-2024)
- Science Olympiad (2021-present)
    - National Team (2023, 2024)
    - MIT Invitational Team (2024)
- Madison West HOSA-Future Health Professionals (2023-present)
    - Hosa Bowl State and International Team (2023)
- Madison West Mock Trial (2023-present)
- Environmental Club
- Ornithology Club
- Jazz West
- UW-Madison Research Assistant - Boekhoff-Falk Lab
- Taekwondo (2021-present)

Awards and Achievements:
- 10th place Agricultural Sciences - Science Olympiad Nationals 2024
- 39 Science Olympiad Medals
- 2nd Place Hosa Bowl State 2024
- Honor Roll (2023-)

Honor and AP Classes:
- Algebra Honors
- Algebra 2/Trigonometry Honors
- English I Honors
- Biology Honors
- US History Honors

Service Work:
- Assemblywoman Renuka Mayadev's campaign (field manager)
- Angel’s Wish Cat Center
- Environmental Club Cleanup
- Sequoya Library
- Rocket Club Outreaches

Resume for Mark Ginder-Vogel

Academic Education:
- Franklin Elementary School (2014-2017)
- Randall Elementary School (2017-2020)
- Velma Hamilton Middle School (2020-2023)
- Madison West High School (2023-Present)

Languages:
English (Fluent), Spanish (3 years)

Activities:
- Madison West Rocket Club (2023-Present)
- Madison West Mountain Bike Team (2020-Present)
- Madison West Swim Team (2023-present)
- Madison West Ultimate Frisbee Team (2023-present)
- Rockets for Schools (2023-2024)
- Shorewood Hills Pool Lifeguard (2024)
- Madison West Athletics Media Assistant (2023-present)

Awards and Achievements:
- Honor Roll (2023)
- 5th Place Rockets 4 Schools 2024

Honors and AP Classes:
- Algebra 1 Honors (2021-22)
- Geometry Honors (2022-23)
- US History Honors (2023-24)
- English 1 Honors (2023-24)
- Biology Honors (2023-24)
- Algebra 2/Trigonometry Honors (2023-24)

Service Work:
- Blackhawk Ski Club Snowboard Lesson Instructor (2020-present)
- Blackhawk Ski Club Park Crew (2022-present)
- CORP Mountain Bike Trail Building/Maintenance (2021-present)
- West High Swim & Dive Photography (2023-present)
- Rocket Club Outreaches

Interests:
Engineering, Aerospace, Rocketry, Photo/Videography, Snowboarding, Mountain Biking, Water Polo

Resume for Sarita Desai

Academic Education:

- Franklin Elementary School (2014-2017)
- Randall Elementary School (2017-2020)
- Velma Hamilton Middle School (2020-2023)
- Madison West High School (2023-present)

Languages:

English (Fluent), Hebrew (7 years), Spanish (2 years), German (2 years)

Activities:

- Rocket Club (2023-present)
- Jazz West (2023-present)
- Mountain Biking (2022-present)
- Recorder Lessons (2015-2019)
- Saxophone Lessons (2020-present)
- Hebrew School

Awards and Achievements:

- Honor Roll (2023)
- 5th Place Rockets 4 Schools 2024

Honors and AP Classes

- Algebra Honors
- Geometry Honors
- Algebra 2/Trigonometry Honors
- English Honors
- Biology Honors
- US History Honors

Service Work

- Assemblywoman Renuka Mayadev Canvassing

Interests:

Reading, Biking, Skiing, Hiking, Mountain Biking

Resume for Zijun He

Academic Education:
- Shorewood Hills Elementary School (2013-2019)
- Velma Hamilton Middle School (2019-2022)
- Madison West High School (2022-present)

Languages:
English (Fluent), Chinese (Fluent), Spanish (3 years)

Activities:
- Rocket Club (2022-present)
- Science Olympiad (2019-present)
- Student Senate (2022-present)
- West High School Tutor (2022-present)
- Research with the UW-Madison Department of Astronomy (2024-present)
- Academic and Career Planning Manager (2022-present)
- Anti-Racist Communication Team (2023-present)

Awards and Achievements:
- 63 Science Olympiad Medals, including 10 state medals and 1 nationals medal.
- 2024 AGU Presenter, Presented on 3D General Circulation Models
- 2024 Hubert Mack Thaxton Fellowship Recipient, Data Analysis of Exoplanets using MCMC

Honors and AP Classes:
- Algebra 2/Trigonometry Honors
- English 1 Honors and English 2 Honors
- Biology Honors
- US History Honors
- Chemistry Honors
- AP World History: Modern
- AP Calculus AB
- AP Computer Science Principles

Service Work
- Rocket Club and Science Olympiad Outreaches
- Student Senate Secretary and Volunteer
- Voter Registration Volunteer
- MSCR Program Leader
- Madison Children's Museum Volunteer

Interests:
Reading, Research, Studying, Tennis, Learning

Resume for Garrison Bogen

Academic Education:
- Van Hise Elementary School (2014-2019)
- Velma Hamilton Middle School (2020-2022)
- Madison West High School (2022-present)

Languages:
English (Fluent) Spanish (2 years)

Activities:
- Madison West Rocket Club (2023-present)
    - Rockets For Schools (2023-2024)
- Madison West Soccer Team (2024)
- Club Soccer (2015-present)
- Referee (2022-present)
- Tournament Field Marshall (2022-Present)
- Boy Scout (2019-2022)

Awards and Achievements:
- 5th place in Rockets 4 Schools 2023
- Honor Roll 2023

Honors and AP Classes:
- Geometry Honors
- U.S. History Honors
- Algebra Honors

Service Work:
- Rocket Club Volunteer and Outreach
- Thanksgiving volunteer at First Congregational UCC Madison
- Highway Cleanup Volunteer

Interests:
Computers, Soccer, Learning, Solving problems

Resume for Zachary Richmond

Academic Education:
- Shorewood Elementary School (2014-2019)
- Hamilton Middle School (2020-2022)
- Madison West High School (2023-Present)

Languages:
English (Fluent)   Spanish (3 years)

Activities:
- Madison West Soccer (2023)
- Madison West Tennis (2024-Present)
- Madison West Rocket Club (2023-Present)
- Hebrew School (2016-2020)
- Piano Lessons (2018-2023)

Awards and Achievements:
- Honor Roll (2023)
- 5th place in Rockets for Schools (AEROSIS team, 2024)

Honors and AP Classes:
- US History Honors
- Biology Honors
- English 1 Honors
- AP Calculus AB
- AP Computer Science Principles

Service Work:
- Rocket Club volunteer, fundraising, and outreach
- Summer Future Problem Solving program assistant

Interests:
Programming, Math, Reading, Table Tennis, Board Games, Tennis, Learning

Resume for Ethan Lee

Academic Education:
- Shorewood Elementary School (2014-2020)
- Hamilton Middle School (2020-2023)
- Madison West High School (2023-present)

Languages:
English (Fluent) Spanish (3 years)

Activities:
- Madison West Rocket Club (2023-present)
    - Rockets for Schools (2023-2024)
- Madison West Mountain Biking Club (2024-present)
- West Madison Polar Caps (2017-2023)
- Madison West Track and Field (2023-2024)

Awards and Achievements:
- Honor Roll (2023-2024 school year)
- 5th place in Rockets for Schools (AEROSIS team, 2024)

Honors Classes:
- Algebra Honors (2021-2022)
- Geometry Honors (2022-2023)
- Algebra 2/Trig Honors (2023-2024)
- Biology Honors (2023-2024)
- English 1 Honors (2023-2024)
- AP Computer Science Principles (2023-2024)

Service Work:
- Rocket Club Outreaches (2023-present)

Interests:
Computer science, Graphics programming, Data science, Information science, Electrical engineering, Music

Resume for Everett Gihring

Academic Education:
- Glen Springs Elementary School (2013-2016)
- Thoreau Elementary School (2016-2019)
- Cherokee Middle School (2019-2022)
- Madison West High School (2022-present)

Languages:
English (Fluent), French (4 years)

Activities:
- Rocket Club (2023-present)
- Madison West Mountain Biking Club (2020-present)
- Boy Scouts of America, Senior Patrol Leader and Life Rank (2019-Present)

Awards and Achievements:
- 2nd Place, Rockets for Schools 2023
- 3rd Place, Rockets for Schools 2024
- Honor Roll (2023)
- Honor Roll (2024)

Honors and AP Classes
- Algebra 2 Honors
- AP Precalculus
- AP Computer Science A
- US History Honors
- Biology Honors
- Chemistry Honors
- English 1 Honors
- English 2 Honors

Service Work
- Various service projects through Boy Scouts, over 20 hours of service logged

Interests:
Biking, Coding, Reading, Electronics, Amateur Rocketry

Resume for Cameron Luedtke

Academic Education:
- Franklin Elementary School (2014-2017)
- Randall Elementary School (2017-2020)
- Velma Hamilton Middle School (2020-2023)
- Madison West High School (2023-Present)

Languages:
English (Fluent), Spanish (3 years)

Activities:
- Madison West Rocket Club (2023-Present)
- American Rocketry Challenge (2024)
- Madison West Mountain Bike Team (2020-Present)
- Piano (2017-Present)
- Concert band (2023-Present)

Awards and Achievements:
- Honor Roll (2023)
- 3rd Place American Rocketry Challenge 2024

Honors and AP Classes:
- Algebra 1 Honors (2022-23)
- Geometry Honors (2023-24)
- US History Honors (2023-24)
- Biology Honors (2023-24)
- English 1 Honors (2023-24)

Service Work:
- Rocket Club Elementary School Outreach events
- Rocket Club Raking
- Church silent auction
- CORPs (Capital Off Road Pathfinders) Trail building work

Interests:
Engineering, Aerospace, Rocketry, Photo/Videography, Snowboarding, Mountain Biking, Piano, Guitar, Art

Resume for Henry Nguyen-Shreve

Academic Education:

- Marin Elementary School (2014-2019)
- Randall Elementary School (2019-2020)
- Hamilton Middle School (2020-2023)
- Madison West High School (2023-present)

Languages:
English (Fluent), Spanish (3 years)

Activities:

- Madison West Rocket Club (2023-Present)
- Madison West Model UN (2023-Present)
- Madison West Track (2023)
- Rockets For Schools (2024)
- Taigu Restaurant staff (2023-2024)
- Piano (9 years)
- Neighborhood lawn care (2021-2024)

Awards and Achievements:

- Honor Roll (2023)
- Third place Rockets for Schools (2024)
- Madison City Spelling Bee finalist (2021)
- WMTA piano award winner (3x)

Honors and AP Classes:

- Algebra 1 Honors (2022-23)
- Geometry Honors (2023-24)
- US History Honors (2023-24)
- Biology Honors (2023-24)
- English 1 Honors (2023-24)

Service Work:

- MWRC Outreach events
- MWRC Raking
- Arboretum Volunteer program
- Property upkeep Martha's Vineyard, MA

Interests:
Engineering, Aerospace, Rocketry, Photo/Videography, Basketball, Boating, Gardening

Resume for Constantine Molle

Academic Education:
- Midvale Elementary (2014-2020)
- Lincoln Elementary (2017-2020)
- Cherokee Middle (2020-2022)
- Spring Harbour Middle (2022-2023)
- West High (2023-present)

Languages:
English (Fluent), Spanish (Fluent), Bulgarian (Fluent), French (1 year)

Activities:
- Madison West Rocket Club (2023-present)
- Tennis (2023-present)
- Cross-Country Skiing (2020-present)
- Student Senate (2024-present)

Awards and Achievements:
- Rockets For Schools 3rd place
- Cross-Country Ski racing awards
- 8th Grade Gold Honor Roll student

Honors, AP’s, and Interesting classes:
- English 1 Honors
- Biology Honors
- Trigonometry Honors
- US History (In Spanish)

Service and Work:
- Worked as a lifeguard over the summer of 2024
- 14 Volunteer hours from MWRC outreaches
- Madison West Rocket Club fundraising rakings
- Carpenter’s assistant over the summer of 2023

Resume for Jeane Pan

Academic Education:
- Kangcheng Elementary School (2013-2019)
- Guangzhou No.2 Middle School (2019-2022)
- Guangzhou No.2 High School (2022-2023)
- Madison West High School (2023-present)

Languages:
Chinese (Fluent), English (Fluent)

Activities:
- Member, Rocket Club (September 2023 - Present)
- Member, Science Olympiad (September 2023 - Present)
- President, Music Diversity Club (March 2024 - Present)

Awards and Achievements:
- 3rd place in 2024 WYROC
- 10 science olympiad medals

Honors and AP Classes:
- Chemistry Honors
- English 1 Honors
- AP Precalculus
- AP Environmental Science
- AP Chinese

Service Work:
- Internship, Guangzhou Institutes of Biomedicine and Health, CAS
- Volunteer, Chinese School
- Rocket club outreaches

Interests:
Physics, Biology, Chemistry

Resume for Mei Dryer

Academic Education:
- Franklin Elementary School (2014-2017)
- Randall Elementary School (2017-2020
- Hamilton Middle School (2020-2023)
- Madison West High School (2023-present)

Languages:
English (Fluent), Korean (Fluent), Spanish (3 years)

Activities:
- Rocket Club (2023-present)
- Jazz West (2023-present)
- Environmental Club (2023-present)
- DECA (2023-present)
- West High School Tutor (2023-2024)
- Girls JV2 Tennis (2024-present)
- Piano (2016-present)
- Cello (2018-present)
- Wisconsin Youth Symphony Orchestra (2020-present)

Awards and Achievements:
- Silver Key in Photography in the Scholastic Art & Writing Awards
- Gold Key in Poetry in the Scholastic Art & Writing Awards
- Honorable Mention in the Bolz Young Artist Competition on Piano
- Nominated for Exemplary Performer Recognition in Solo & Ensemble

Honors Classes:
- English Honors 1
- Algebra Honors
- Geometry Honors
- Algebra 2 Honors
- US History Honors
- Biology Honors

Service Work:
- 30+ volunteer hours at Angel's Wish Cat Center
- 20+ volunteer hours at Sequoya Library
- WYSO Connections Mentoring
- Concerts on the Square Volunteer
- Assemblywoman Renuka Mayadev's campaign
- Rocket Club Outreaches

Interests:
Piano, cello, music, reading, rocketry, photography, poetry, traveling, art, taekwondo

Resume for Oliver Gartler

Academic Education:
- Franklin Elementary School (2012-2014)
- EAGLE School (2014-2021)
- Madison West High School (2021-present)

Languages:
English (Fluent) French (Fluent)

Activities:
- Madison West Rocket Club (2021-present)
    - TARC (2021-2022, 2023-2024)
    - Rockets For Schools (2021-2023)
- Research Internship (Machine Learning) (2024)
- Madison West Alpine Ski Team (Captain) (2022-present)
- Madison West Tennis Team (2022-present)
- Madison West MTB Team (2023-present)
- French 2 TA (2023-present)

Awards and Achievements:
- Honor Roll 2022, 2024
- 1st Place Rockets For Schools 2022
- 2nd Place Rockets For Schools 2023
- TARC National Qualifier 2022
- 35 ACT 2024
- NHS Chapter Member
- 1st Place Team WHSARA Skiing 2022, 2023

AP Classes (No space to add honors):
- AP Computer Science Principles (4 on exam)
- AP Computer Science A (4 on exam)
- AP French Language and Culture (3 on exam)
- AP World History (4 on exam)
- AP Calculus AB (5 on exam)
- AP Chemistry (4 on exam)
- AP US History (4 on exam)

Service Work:
- Assistant Teacher at West High School
- Yard Work for Dudgeon Monroe Neighborhood
- Madison West Rocket Club Outreach Events

Interests
Fishing, Skiing, Boating, Computers, Engineering, Motorbikes

Resume for Jack Rogge

Academic Education:
- Wingra Elementary School (2012-2014)
- Wingra Middle School (2014-2021)
- Madison West High School (2021-present)

Languages:
English (Fluent) Spanish (Advanced)

Activities:
- Madison West Rocket Club (2021-present)
  - TARC (2021-2022, 2023-2024)
  - Rockets For Schools (2021-2023)
- Madison West Alpine Ski Team (2022-2023)
- Madison West Cross Country Team (2022-present)
- Madison West Track and Field Team (Captain) (2022-present)
- Madison West DECA

Awards and Achievements:
- Honor Roll 2022-2024
- 1st Place Rockets For Schools 2022
- 2nd Place Rockets For Schools 2023
- TARC National Qualifier 2022
- 35 ACT 2024
- NHS Chapter Member

AP Classes (No space to add honors):
- AP Computer Science Principles (5 on exam)
- AP Language and Composition (4 on exam)
- AP Chemistry (4 on exam)
- AP US History (5 on exam)

Service Work:
- DECA Volunteer
- Hoofers Sailing Club youth volunteer
- Madison West Rocket Club Outreach Events

Interests:
Sailing, Skiing, Running, Computers, Engineering, Guitar

Resume for Summit Todd

Academic Education:

- Midvale Elementary School (2014-2017)
- Abraham Lincoln Elementary School (2017-2020)
- Velma Hamilton Middle School (2020-2023)
- Madison West High School (2023-Present)

Languages:
English (Native), Spanish (2 Years)

Activities:

- Madison West Rocketry Club (2023-Present)
- Madison West Tri-M Music Honors Society (2023-Present)
- Rockets for Schools (2023-2024)
- Piano (2018-Present)
- Cross Country (2023-Present)
- Track and Field (2024-Present)
- Jazz West (2023-Present)

Awards and Achievements:

- Placon Sustainability Award (2023)
- Honor Roll (2023)
- Tri-M Officer (2024)

Honors Classes:

- Geometry Honors (2022)
- US History Honors (2023)
- English 1 Honors (2023)
- Biology Honors (2023)
- AP Precalculus (2023) (5 on exam)
- AP Computer Science Principles (2023) (4 on exam)

Service Work:

- Madison West Tutoring (2024-Present)
- All City Swim Shorewood Hills (2024)
- Westmorland Neighborhood Association (2024)

Interests: Engineering, Running, Rocketry, Mathematics, Chemistry

NAR Model Rocketry Safety Code

Materials. I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.

Motors. I will use only certified, commercially made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

Ignition System. I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the “off” position when released.

Misfires. If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

Launch Safety. I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance. When conducting a simultaneous launch of more than ten rockets, I will observe a safe distance of 1.5 times the maximum expected altitude of any launched rocket.

Launcher. I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

Size. My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse.

Flight Safety. I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

Launch Site. I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

Recovery System. I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

Recovery Safety. I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

NAR Launch Site Dimensions

Installed Total Impulse (N-sec)	Installed Total Impulse (N-sec)	Minimum Site Dimensions (ft.)
0.00-1.25	1/4A, 1/2A	50
1.26–2.50	A	100
2.51–5.00	B	200
5.01–10.00	C	400
10.01–20.00	D	500
20.01–40.00	E	1000
40.01–80.00	F	1000
80.01–160.00	G	1000
160.01–320.00	Two Gs	1500

NAR high-power Rocketry Safety Code

Certification. I will only fly high-power rockets or possess high-power rocket motors that are within the scope of my user certification and required licensing.

Materials. I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.

Motors. I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.

Ignition System. I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the “off” position when released. The function of on-board energetics and firing circuits will be inhibited except when my rocket is in the launching position.

Misfires. If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

Launch Safety. I will use a 5-second countdown before launch. I will ensure that a means is available to warn participants and spectators in the event of a problem. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table. When arming on-board energetics and firing circuits, I will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable. When conducting a simultaneous launch of more than one high-power rocket, I will observe the additional requirements of NFPA 1127.

Launcher. I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour, I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 and clear that area of all combustible material if the rocket motor being launched uses titanium sponge in the propellant.

Size. My rocket will not contain any combination of motors that total more than 40,960 N-sec (9,208 poundseconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high-power rocket motor(s) intended to be ignited at launch.

Flight Safety. I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

Launch Site. I will launch my rocket outdoors, in an open area where trees, power lines, occupied buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1,500 feet, whichever is greater, or 1,000 feet for rockets with a combined total impulse of less than 160 N-sec, a total liftoff weight of less than 1,500 grams, and a maximum expected altitude of less than 610 meters (2000 feet).

Launcher Location. My launcher will be 1,500 feet from any occupied building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

Recovery System. I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

Recovery Safety. I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

NAR Minimum Distance Table

Installed Total Impulse (Newton-Seconds)	Equivalent high-power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	MInimum Personnel Distance (Complex Rocket) (ft.)
0 - 320.00	H or smaller	50	100	200
320.01-640.00	I	50	100	200
640.01-1280.00	J	50	100	200
1280.01-2560.00	K	75	200	300
2560.01-5,120.00	L	100	300	500
5120.01-10,240.00	M	125	500	1000
10,240.00-20,480.00	N	125	1000	1500
20,480.01-40,960.00	O	125	1500	2000

List of Applicable Outside Resources

Electrical Data Sheets / User Manuals

PerfectFlite Stratologger CF
Eggfinder mini GPS tracker
C&K Keylock Switches

Coding Resources

Arduino Language Reference
Python Coding Standards
Python Coding Library
Python Beginner Resources
Typography Standards
Visual Studio Code Manual

West Rocketry Resources

Club Website
Instagram
Linktree

Safety Laws

FAR CFR 14 Chapter F Part 101 Subpart C
CFR 27 Part 55: Explosives In Commerce
NFPA 1127

Other Info

Fin Flutter Calculations

List of Applicable Safety Data Sheets

Propulsion and Deployment

Ammonium Perchlorate
Aerotech Reloadable Motors
Aerotech Igniters
Firewire Initiators
Pyrodex Pellets
Black Powder
Nomex (thermal protector)

Glues

Elmer's White Glue
Two Ton Epoxy Resin
Two Ton Epoxy Hardener
Bob Smith Cyanoacrylate Glue
Super-glue Accelerator
Super-glue Debonder

Soldering

Flux
Solder
Solder Braid

Painting and Finish

Automotive Primer
Automotive Spray Paint
Clear Coat

Construction Supplies

Kevlar
Fiberglass Cloth
Fiberglass Resin
Fiberglass Hardener
Self-expanding Foam (Marine grade)

Solvents

Ethyl Alcohol 70%
Distilled Water
Isopropyl alcohol

Payload Materials

Aluminum

Acrylic

Polycarbonate