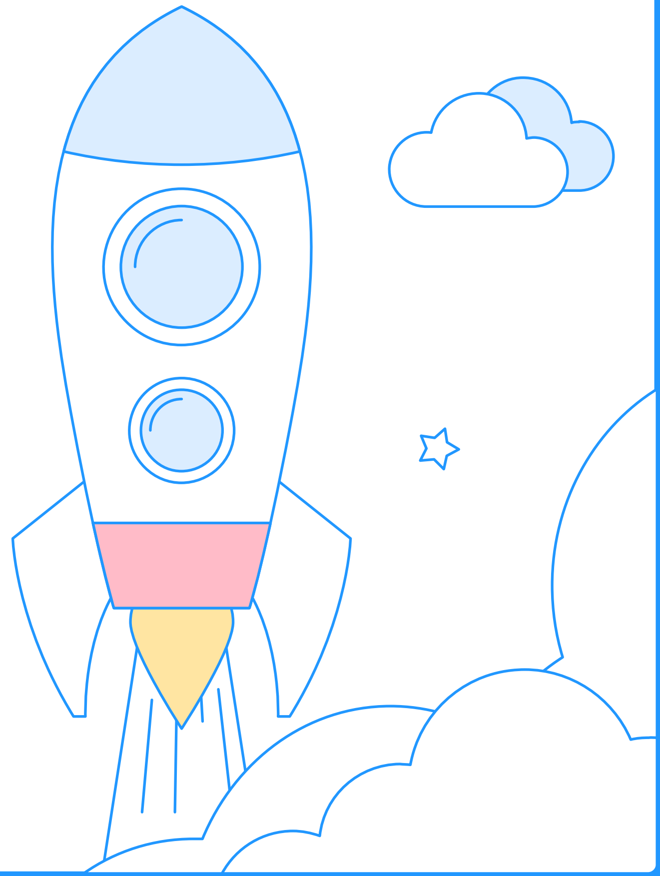
SLOSH

Madison West Rocket Club

MADISON WEST ROCKETRY

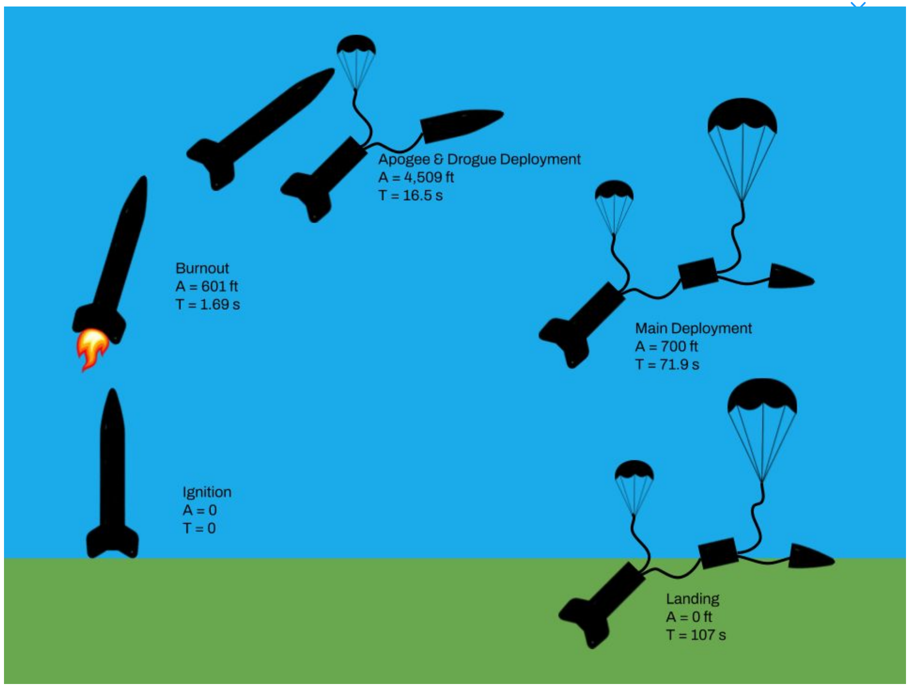
STUDENT LAUNCH 2025

Part I: Vehicle

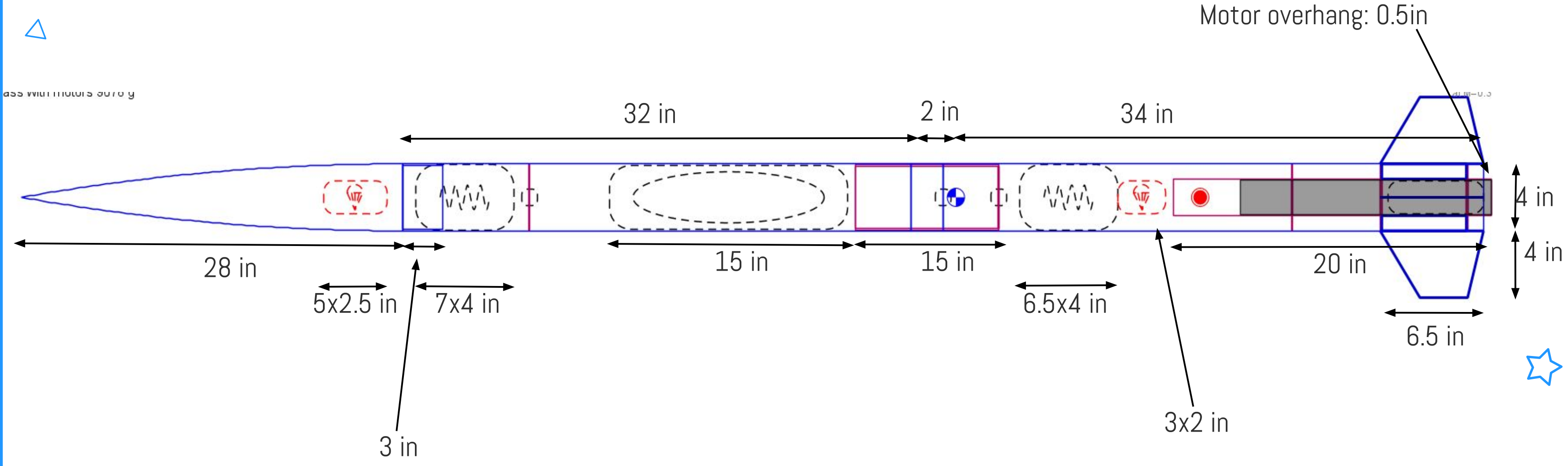


Mission Profile Chart

#	Event	Time (s)	Altitude (ft)	Trigger
1	Ignition	0	0	Launch Controller
2	Burnout	1.69	601	--
3	Apogee	16.5	4,509	--
4	Drogue Deployment	16.5	4,509	Flight Computer
5	Main Deployment	71.9	700	Flight Computer
6	Landing	107	0	--



Vehicle Dimensions



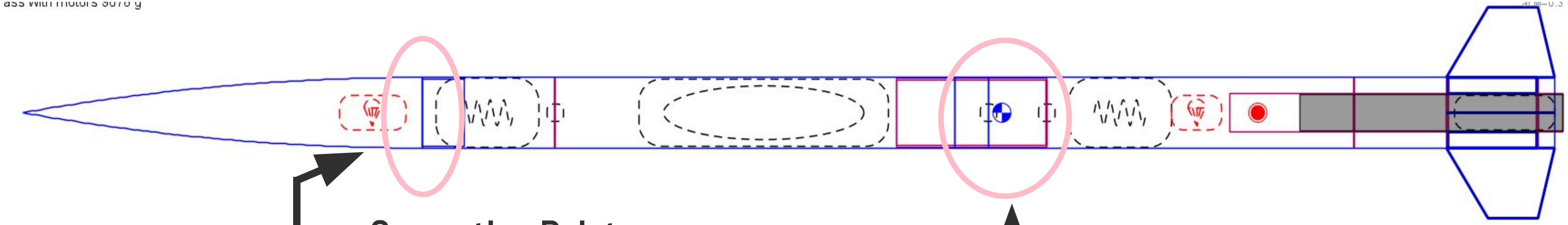
Vehicle Materials and Justification

Material	Part	Justification
PLA plastic	Payload	In order to design the payload in a successful manner, we will be designing it using a CAD program and 3D printing it
Nylon	Drogue Chute, Main Chute	Nylon is inexpensive, commonly available, and easy to work with, while being durable.
Fiberglass	Body Tube, Fins, Nosecones, Centering Rings, Couplers, Motor Mount	Fiberglass is durable and temperature resistant, has a smooth finish for a better paint job, and is easy to precisely machine.
Steel	Tie Rods, U-bolts	Steel is very strong and inexpensive.

Rocket Statistic Values

Parameter	Value
Stability Margin	3.77 calibers
Center of Gravity	59.022 in (from top)
Center of Pressure	74.175 in (from top)
Thrust-Weight Ratio	12.3
Rail Exit Velocity	88 ft/s

Visuals of Separation Points



Separation Points

- Between booster and sustainer section
  - Releases drogue chute
- Nosecone
  - Releases main chute

Motor Selection

Primary: AeroTech K-1103 (Total Impulse: 1,810 Ns)

Alternatives:

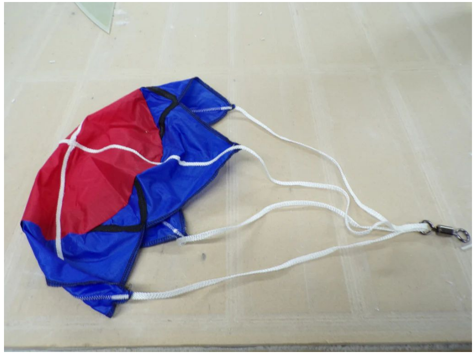
- AeroTech K-805 (Total Impulse: 1,762 Ns)
- Loki Research K-960 (Total Impulse 1,946.5 Ns)

Justification

- Enough thrust to reach target altitude
- Provides enough flight time for payload study
- Fulfills vehicle requirements
- Fits budget

Recovery System

- **Drogue Parachute**
    - Deployed at apogee
    - Recon Recovery 20" diameter parachute
    - Ripstop nylon
- **Main Parachute**
    - Deployed at 700 feet
    - 66" diameter toroidal parachute
    - Ripstop nylon
- **Shock Cord**
    - 38' of 10mm Tubular Kevlar
- **Mounting Hardware**
    - ¼" U-bolts wherever possible
    - ¼" Welded eye bolt for nose cone
- **Deployment Altimeter**
    - Perfectflite Stratologger Barometric Dual-Deployment Altimeter



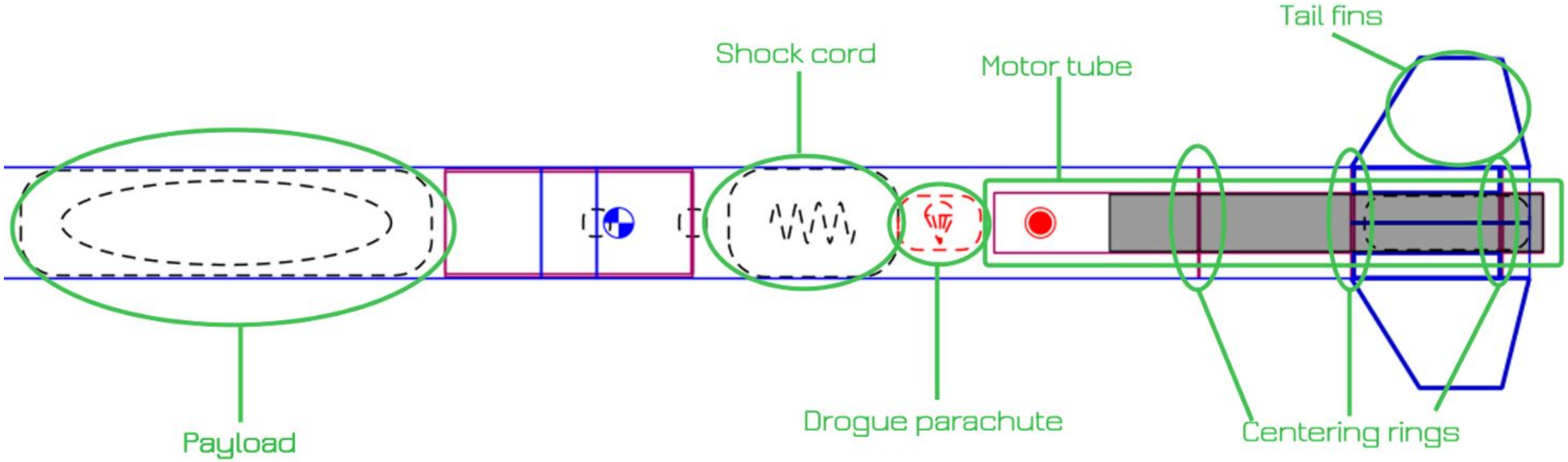
Recon Recovery 20"-Diameter Parachute

10mm Tubular Kevlar

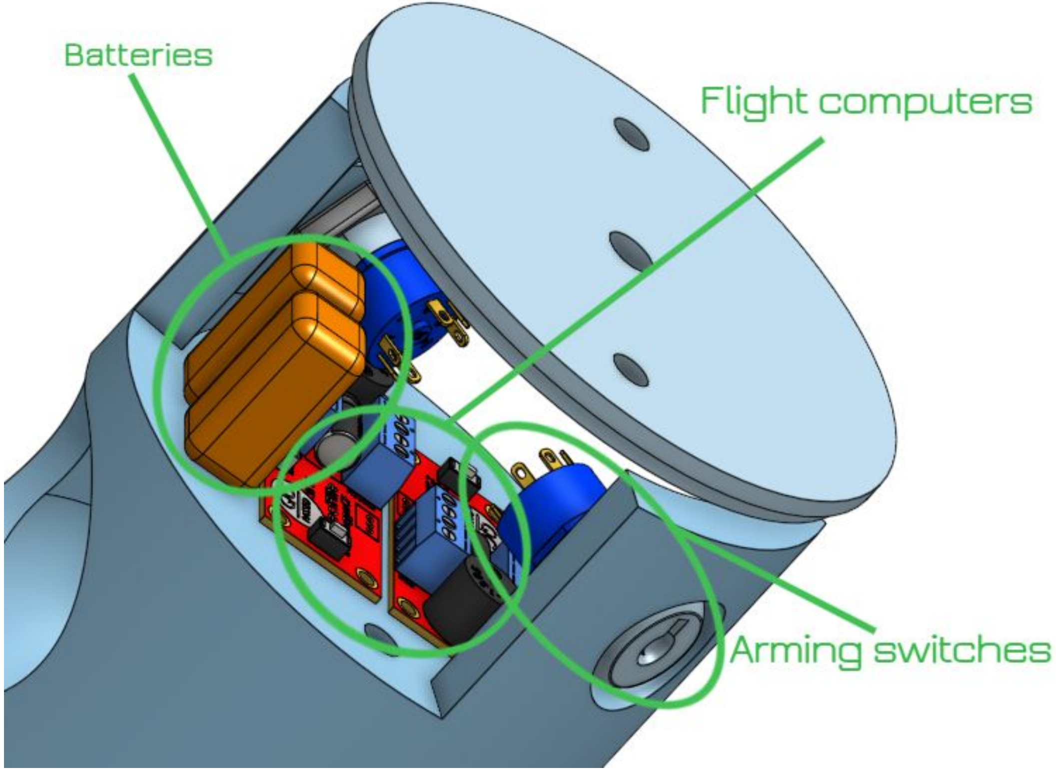
PerfectFlite StratoLogger

System Visuals - Full Vehicle

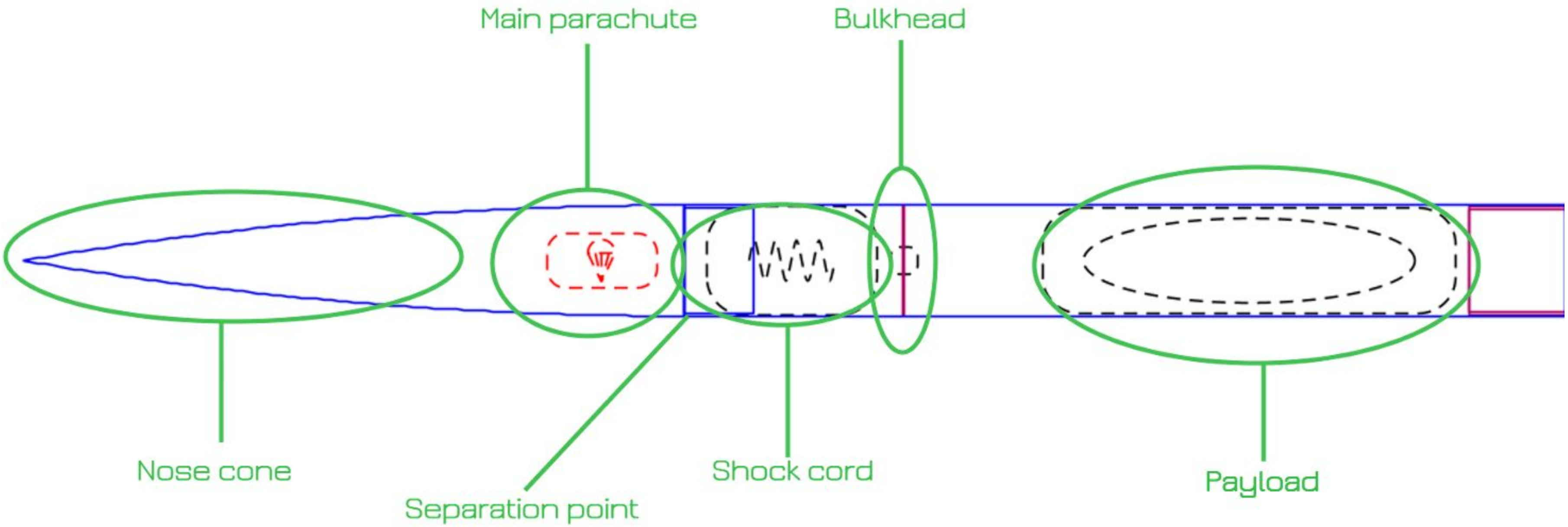
System Visuals - Booster



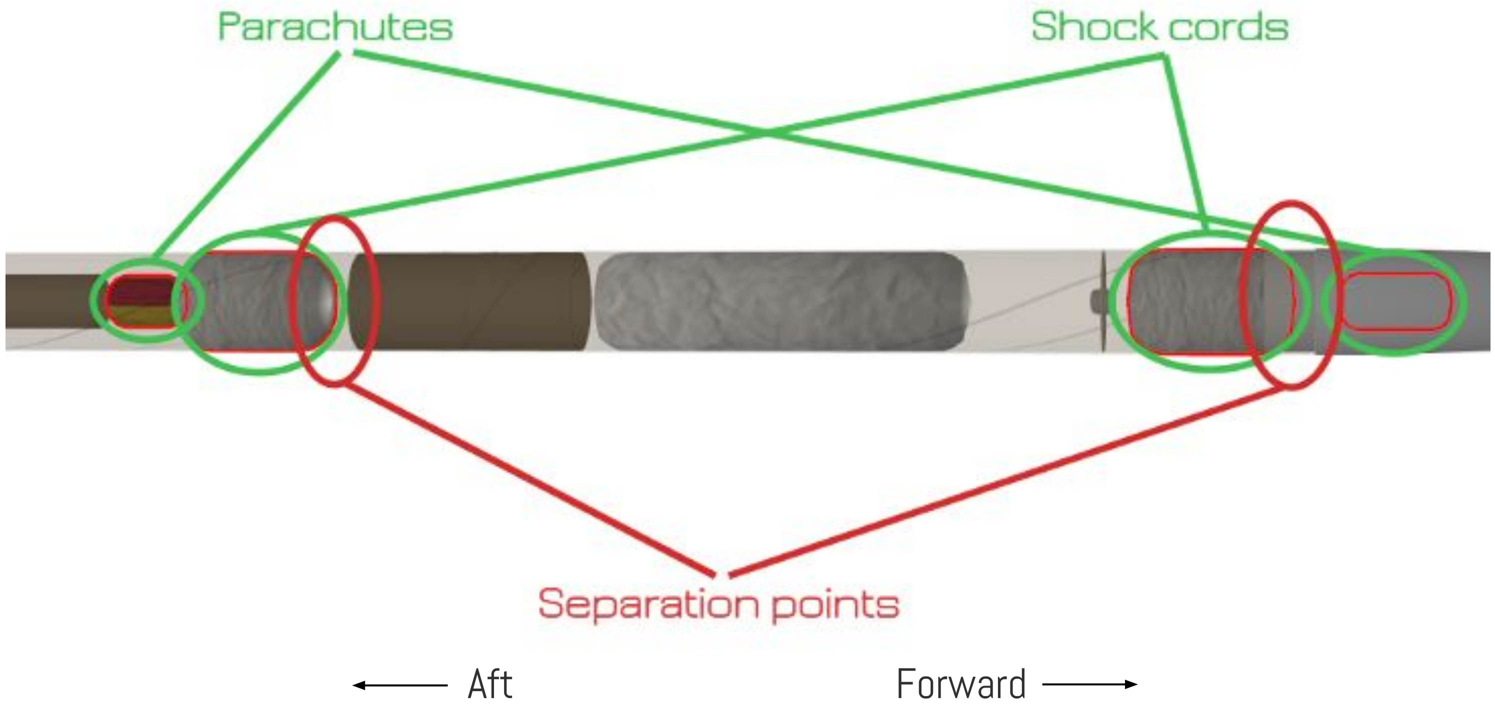
System Visuals- Electronics Bay



System Visuals - Upper Section & Nosecone



System Visuals - Recovery



Parachute Data

Parachute	Diameter	Descent Rate	Deployment Altitude	Weight (lbs)	Drag Coefficient
Main	66in	18 ft/sec	700ft	0.236 lbs	2
Drogue	20in	68 ft/sec	Apogee (~4,509ft)	0.117 lbs	1.5

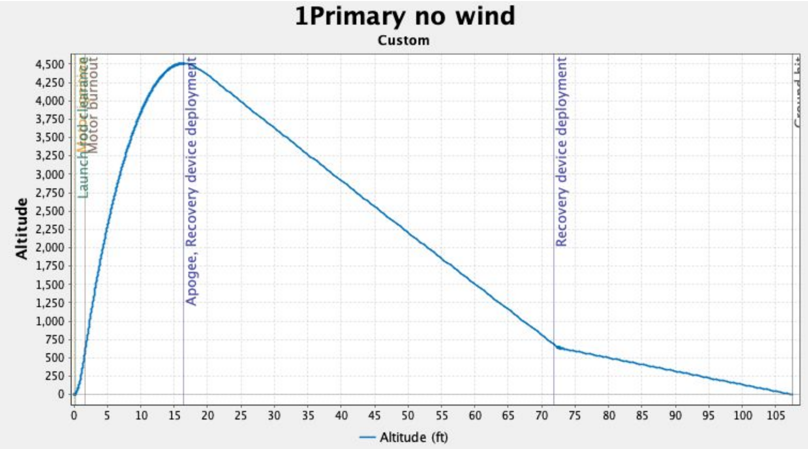
Mission Performance Predictions

The vehicle is robust enough to withstand the expected loads.

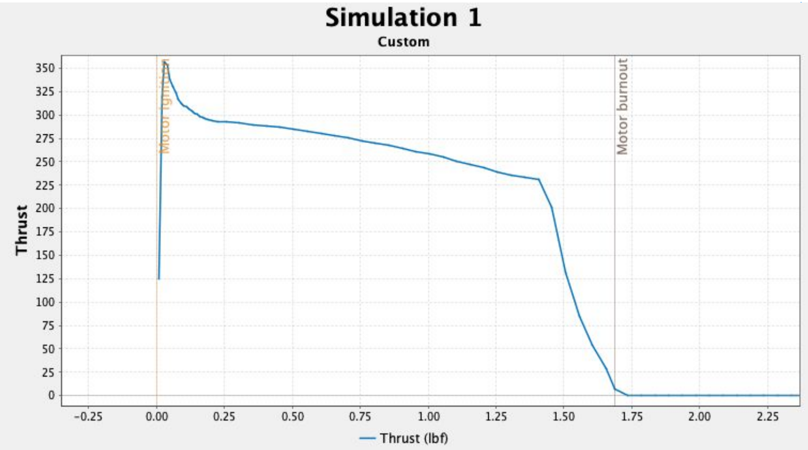
Descent Time: 90.5 seconds

Wind Speed	Apogee (ft)	Δ Apogee (ft)
0 mph	4,509′	0′ (0%)
5 mph	4,502′	-7′ (-0.2%)
10 mph	4,485′	-25′ (-0.6%)
15 mph	4,457′	-53′ (-1.2%)
20 mph	4,420′	-90′ (-2.0%)

Mission Performance Simulations

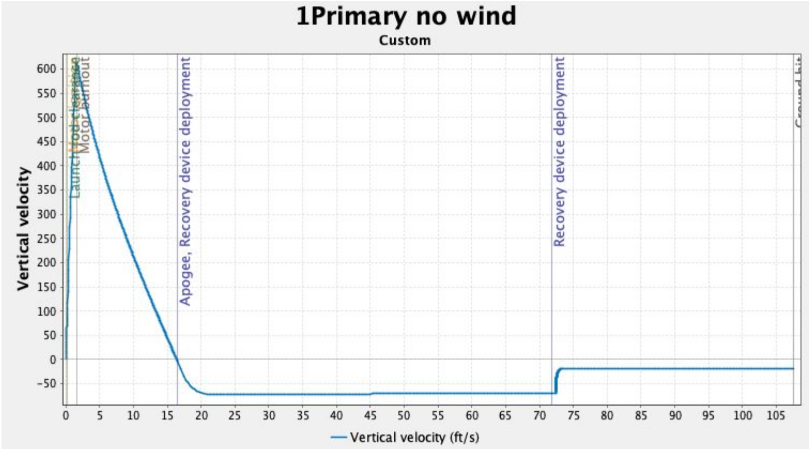


Altitude Profile

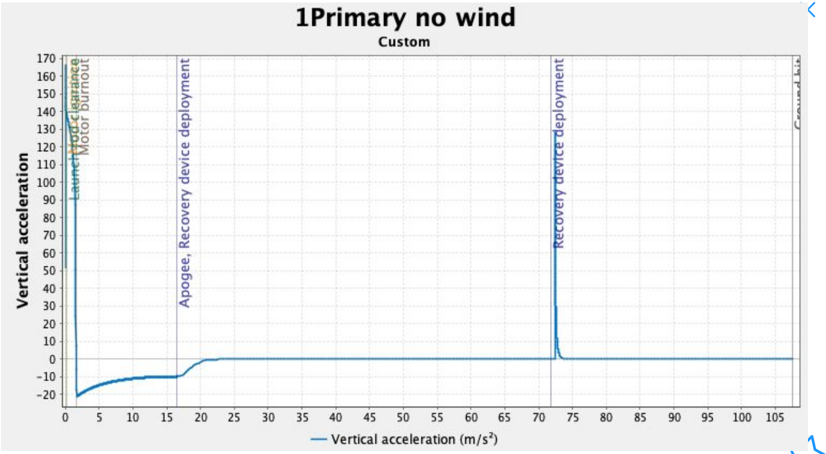


Thrust Profile

Mission Performance Simulations



Velocity Profile

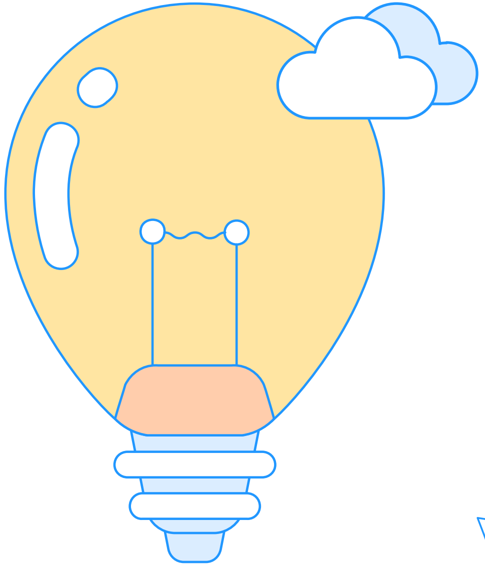


Acceleration Profile

Kinetic Energy at Impact

Booster Section	Sustainer Tube	Nose Cone
29.7 ft · lbf	36.73 ft · lbf	6.07 ft · lbf

Alternatives



Nose Cone Alternative

3D-printed nose cone .

- Lots of versatility, based off of our stability margins and design plans.
- Much weaker and much heavier.
- We would only be able to 3D-print a 1:1 nose cone length to rocket diameter (4").

We also have a backup nose cone that is very similar to our primary nose cone in case the primary is damaged or is otherwise rendered unusable.

Recovery System Alternatives

Main parachute alternative

- Fruity Chutes 66" toroidal main parachute
- ¼" U-bolt located in top bulkhead
- Rated for deployment up to 100 ft/s with a 20lb rocket

Drogue parachute alternative

- 32" toroidal drogue chute
- ¼" U-bolt located at bottom of e-bay

Shock cord alternative

- 10mm nylon webbing
- Less fire resistant

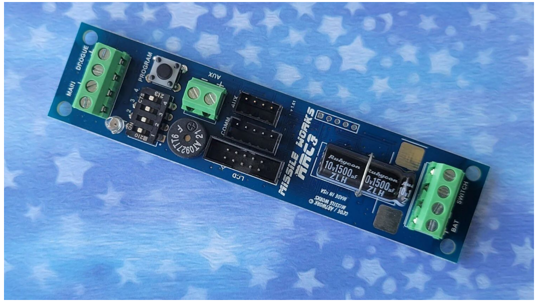
Fruity Chutes 66" Toroidal Parachute

10mm Nylon Webbing

Recovery System Alternatives

Deployment altimeter alternative

- **Missile Works RRC3 Deployment Altimeter**
- Used in tandem with PerfectFlite StratoLogger
- Dissimilar Redundancy



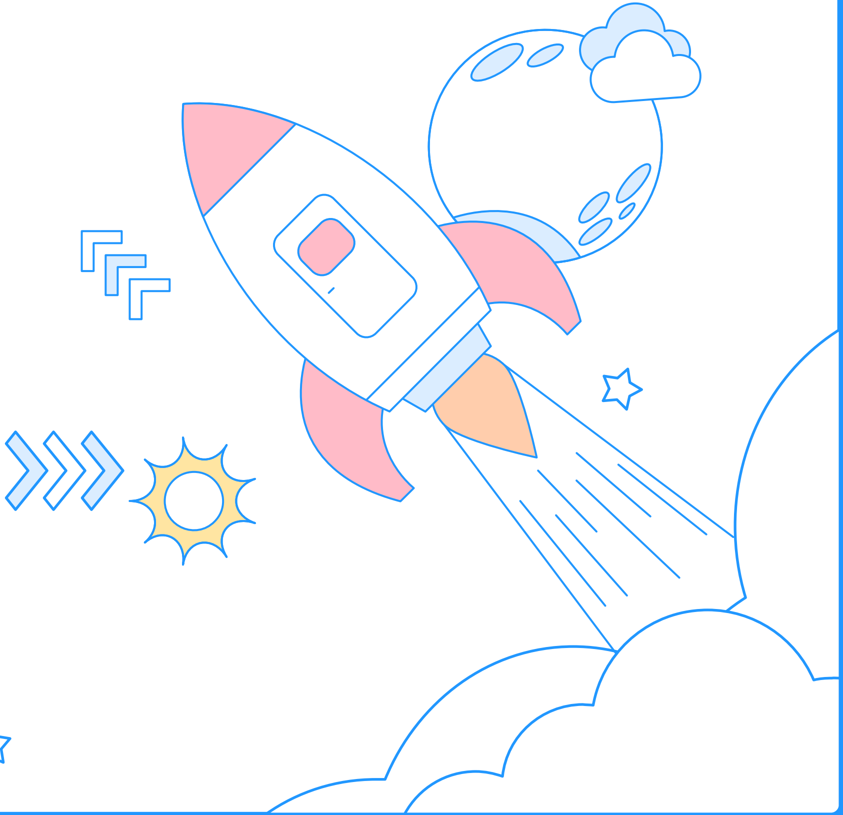
Missile Works RRC3 Deployment Altimeter

Charge igniters alternative

- **WildMan Rocketry WM01 Ejection Lighters**
- Low-current
- Designed for charge deployment
- Comes with a well for floating charge configurations

WildMan Rocketry WM01 Ejection Lighters

Part II: Payload



Preliminary Payload Design

Four systems of our preliminary payload design are as follows:

– **Tanks**
Hold our liquid and baffles

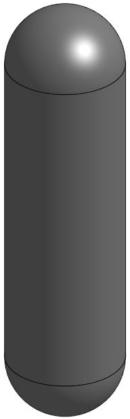
– **Camera Capture System**
Gather visual data from inside the tanks

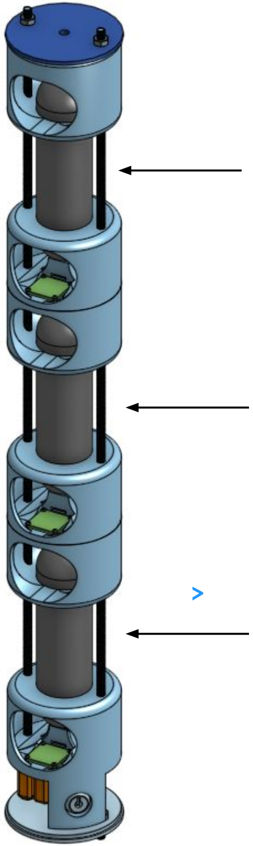
– **Electronic Sensor System**
Measure data from inside the tanks

– **Data Management System**
Collect and store the data from the sensor system

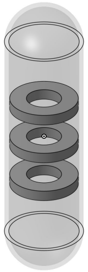
Tanks

- Three liquid tanks, placed vertically adjacent to each other and parallel to the rocket's long axis.
- Tanks will be placed vertically to allow space for the electronic sensor system.
- Each tank is two separate pieces that are screwed together at the base of the tank.
- Clear windows at both ends will allow viewing of the interior
- Two tanks will be fitted with a different baffle design.
- One tank will be a control and will not contain baffles.





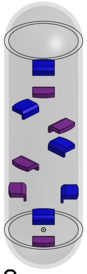
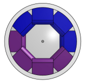
Baffle Designs




Primary Design

Ring

- 2-3 rings will be epoxied or screwed to the outside of the tank
- Two concentric circles will be 3D printed
- Easy to produce and install
- Best design in terms of construction and strength
- Allows a substantial amount of water to travel throughout the tank, while maintaining stability

Alternative Design 1

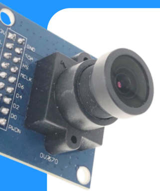
Panels

- Panels will be epoxied to the insides of the tank
- A slot in two sides of the panels allows flexibility to reduce pressure from the water
- Easy to install
- More fragile and difficult to produce
- Parts are easily replaceable

Alternative Design 2

Balls

- Hollow plastic spheres will have medium-sized holes punched into them, or they will be 3D printed
- Proven design and easy to manufacture
- Difficult to measure slosh
- Reduces the fuel capacity of the tanks



Camera System

Primary Design

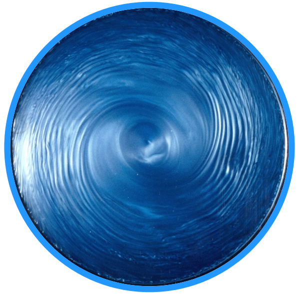
End-Mounted Cameras (ruler)

- Two cameras per tank will be positioned at either end
- The cameras will observe two rulers on the tank's inner walls to measure the water movement
- The tank will be lit with an LED
- The water will be dyed a dark color to make it more visible
- We will be using RunCam Split 4s to save footage to SD cards
- The small form factor will allow them to fit between the tanks with minimal extra space

Alternative Design 1

Rheoscopic Fluid

- Rheoscopic fluid
- Allows visualization of movement of water
- Cameras record through clear tank
- View internal currents



Alternative Design 2

Distortion Grid

- A grid pattern will be on either side of the tanks with cameras in the same spot
- The water will be transparent
- The cameras record the distortion, which can be analyzed post-flight
- Requires advanced image processing and analysis techniques
- Provides a good idea of how the water is moving under the surface

Electronic Sensor System

Primary Design

Capacitive Non-Contact Sensors

- Non contact water sensors
- Exposed contacts inside the tank
- Capacitive sensors detect large movements of water
- Contacts able to detect small movements of water
- Combination can confidently detect the sloshing of water inside the tank

Alternative Design 1

Laser Rangefinders

- Liquid contains a particulate detectable by the rangefinders
- Mounted in groups of 4 on top and bottom of tanks pointing towards the center
- Allows detection of the water during any phase of flight

Alternative Design 2

Photoelectric Level Sensors

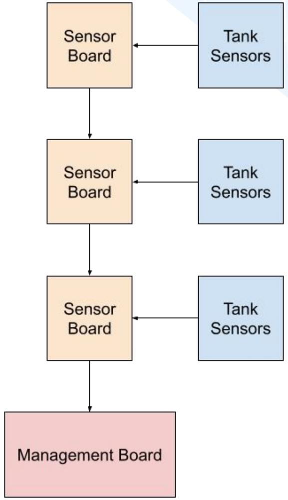
- Embedded in sides of tank
- Light emitters and detectors
- Work in high temperatures and pressures
- Too big to fit in payload

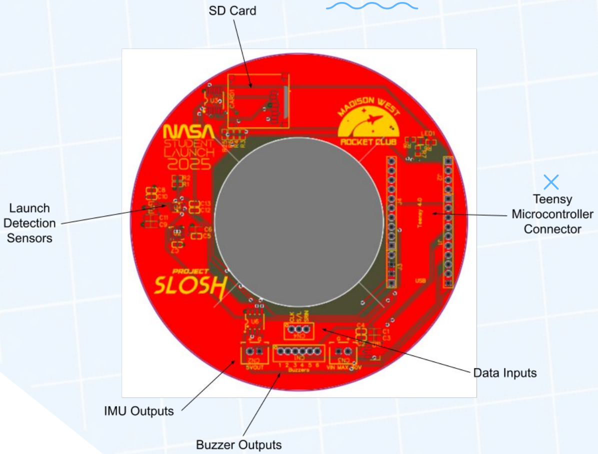
Data Management System

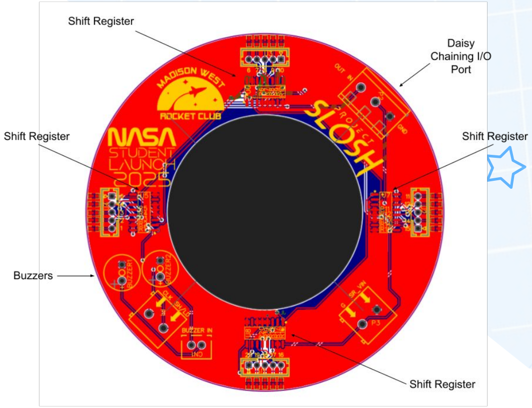
Primary Design

Daisy-Chained System

- Shift register-based sensor boards are daisy chained down to a management board
- Management board contains:
    - Processor
    - Launch detection sensors
    - FRAM non-volatile soldered storage
    - SD card slot
- Pros:
    - Minimal wiring between layers
    - One processor to program
- Cons:
    - All tanks rely on one processor







Data Management System

Alternative Design 1

Distributed Management

- Each tank has a dedicated management board
- Management board contains the same components as the primary design, plus shift registers to condense data
- Pros:
    - No wiring between layers
    - Lower processor speed required
- Cons:
    - High cost
    - Multiple copies of code needed

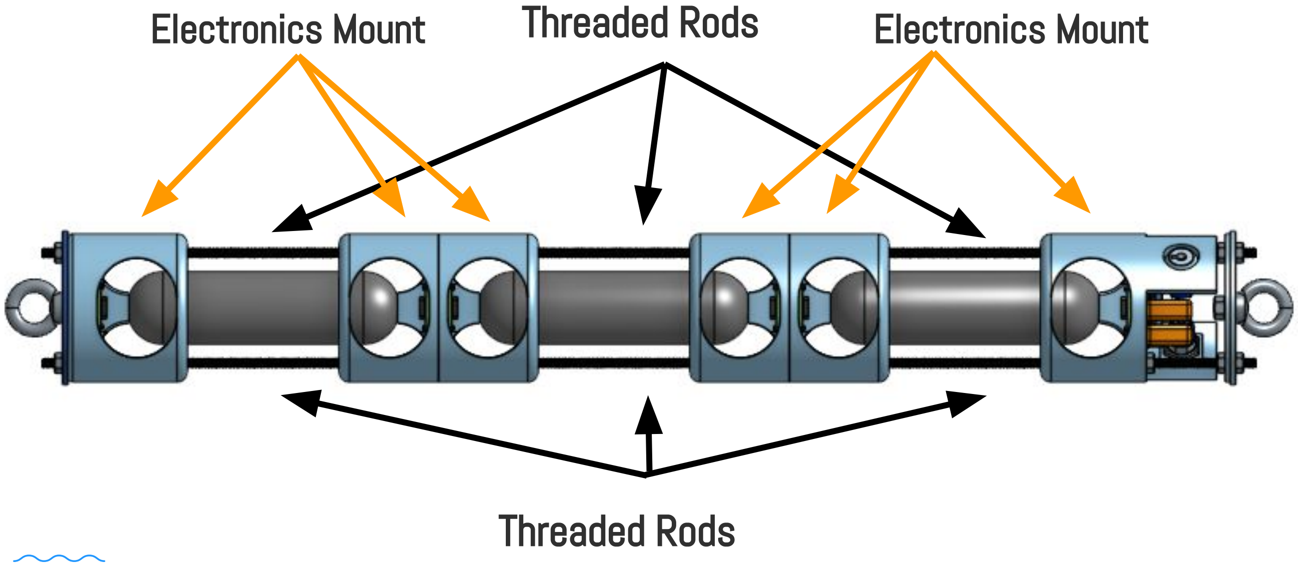
Alternative Design 2

Hardware Serial Logging

- Each tank has a dedicated management board
- Management board contains:
    - A series of 555 timers for timing
    - A serial flash memory chip to store data
    - Breakouts for SPI communication pins
- Pros:
    - No potential code or firmware errors
- Cons:
    - Complexity
    - Extensive hardware iteration

Payload retention design

For payload and e-bay retention, we will have threaded rods passing through the length of the payload and secured to two bulkheads. This stabilizes the payload and ensures we can retain the payload inside the rocket.



Team Derived Requirements Compliance Plan

All rocket designs must abide to these requirements and will be reviewed at each milestone using simulations and excessive testing. If requirement are not met, changes to the design will be made or alternatives will be considered so that the design meets requirements.

Vehicle

- Stability

Recovery

- Events timing

Payload

- Decrease in slosh
    - Tanks with baffles vs control tank
- Water retention
- Data collection