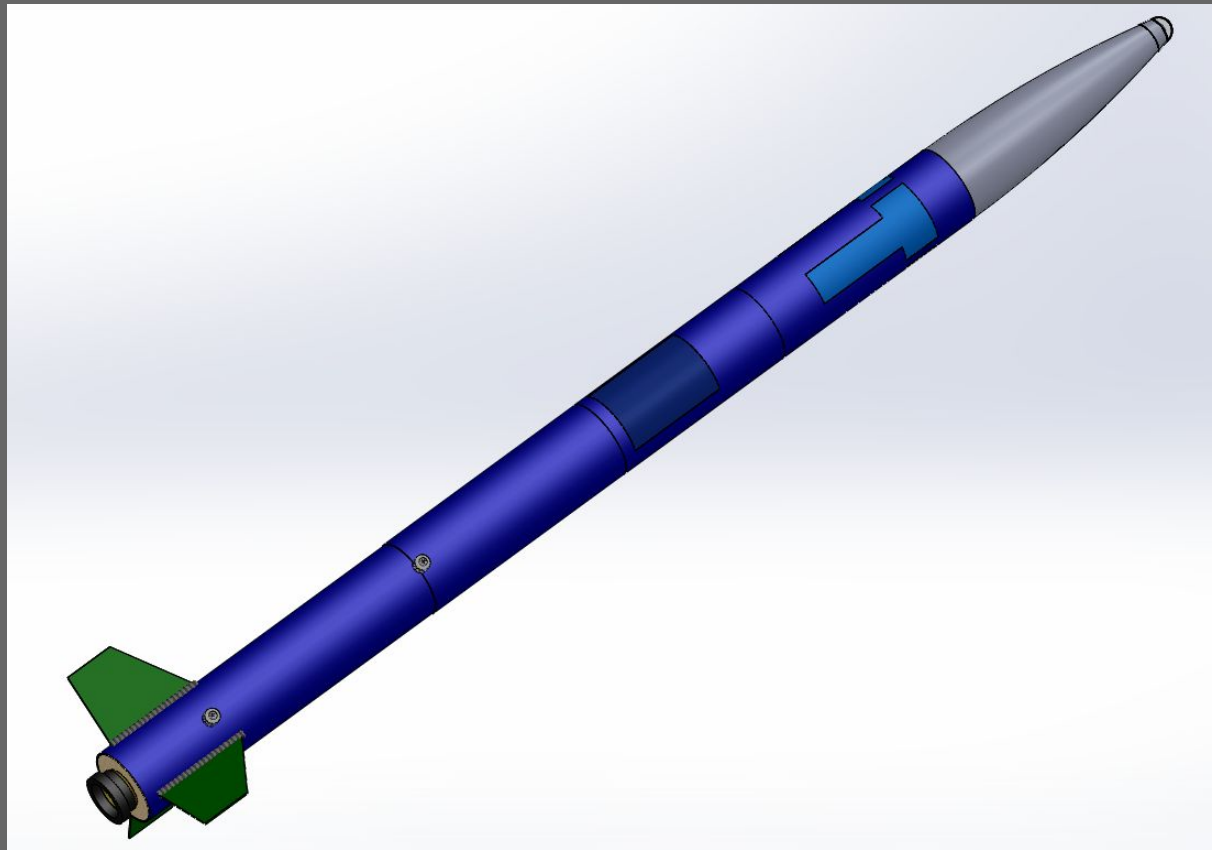

STAR

Airframe



Vehicle Summary

AirFrame

- Overall length: 8’ 7”
- Total Weight: 32.06 lbs
  - Expected Weight Range: 30-34 lbs
- Diameter: 6”
- Nose cone length (ogive): 24”
- Payload section length: 18”
- Avionics section length: 15”
- Recovery section length: 18”
- Booster section length: 2’ 3”
- Motor type: Aerotech L1150 motor
- CG: 59.85” from nose cone tip
- CP: 76.56” from nose cone tip
- Stability margin: 2.78 calibers
- Thrust to weight ratio: 8.064
- Launch rod size: 12’ 1515 rail
- Rail exit velocity: 78.7 ft/s

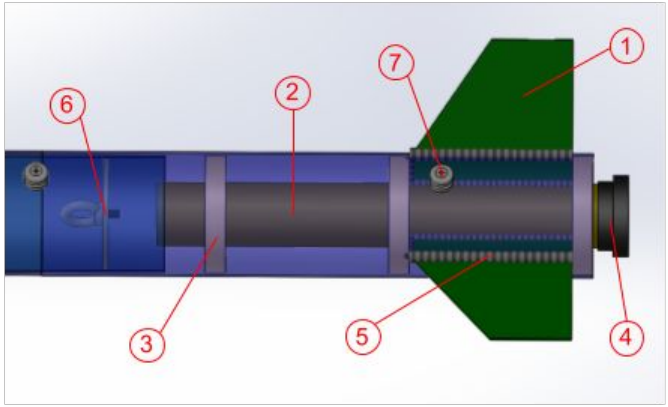
Materials

Airframe

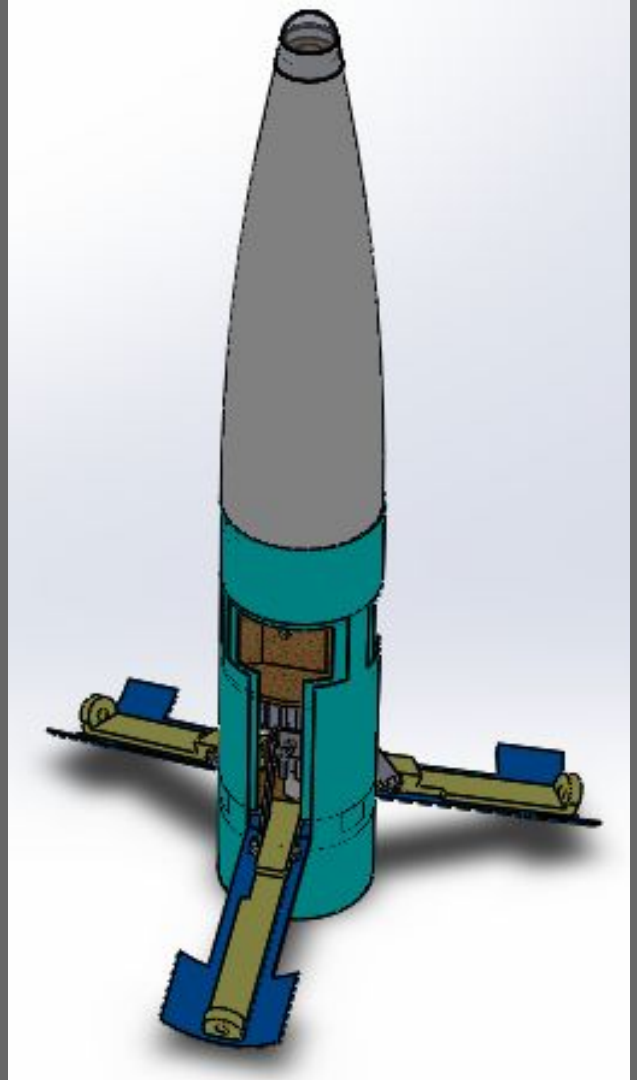
- Main body
  - Blue Tube
- Nose cone
  - Dome shaped tip is Polyethylene terephthalate glycol-modified (PET-G)
    - To facilitate camera viewing through the nose cone, as required by our payload experiment.
  - Lower portion fiberglass
- Fins
  - G-10 Fiberglass with carbon fiber/glue reinforcement
- Motor Mount Tube
  - Kraft Phenolic
  - Plywood centering rings/bulkheads
- Glue
  - West System 105/205 Epoxy Resin/JB Weld

Booster Section

1. G-10 Fiberglass Fins
2. Kraft Phenolic Motor Mount
3. Plywood Centering Rings
4. 75mm Motor Retainer
5. Carbon Fiber Fillets
6. Plywood Bulkhead
7. 1515 Rail Buttons



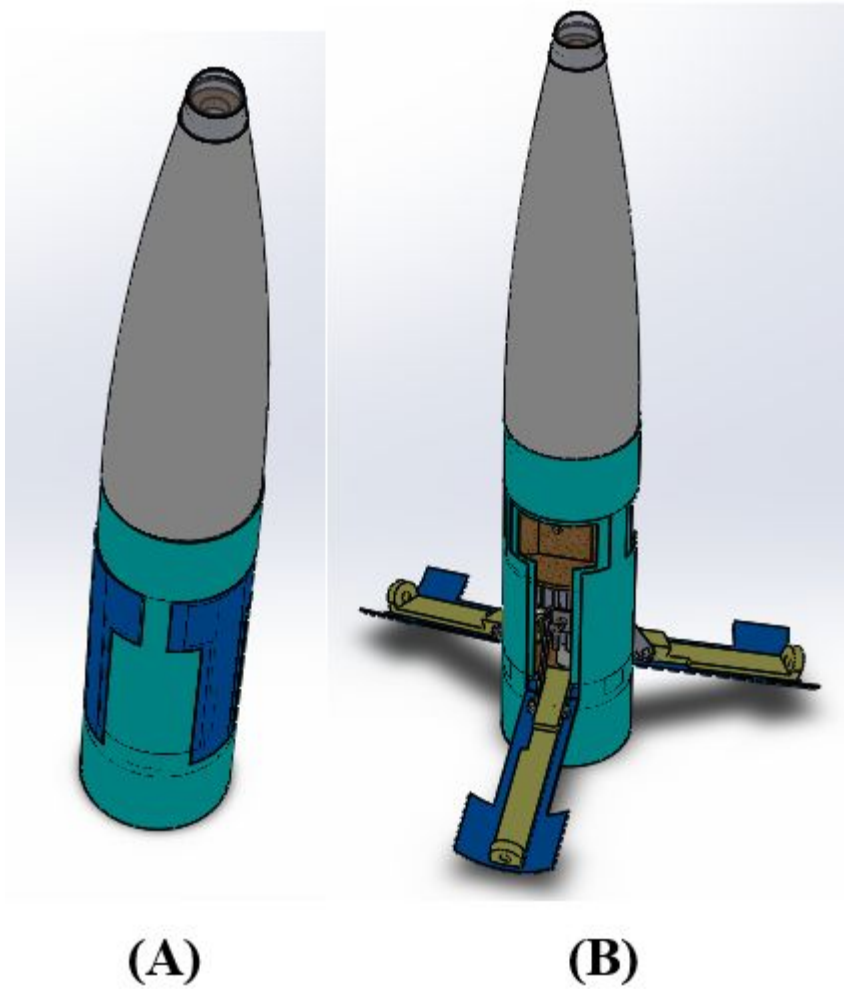
Payload



Payload

Target Detection and Upright Landing

- Detect and differentiate ground targets with camera mounted in nose cone
- Deploy landing legs
  - Deploy three parachutes

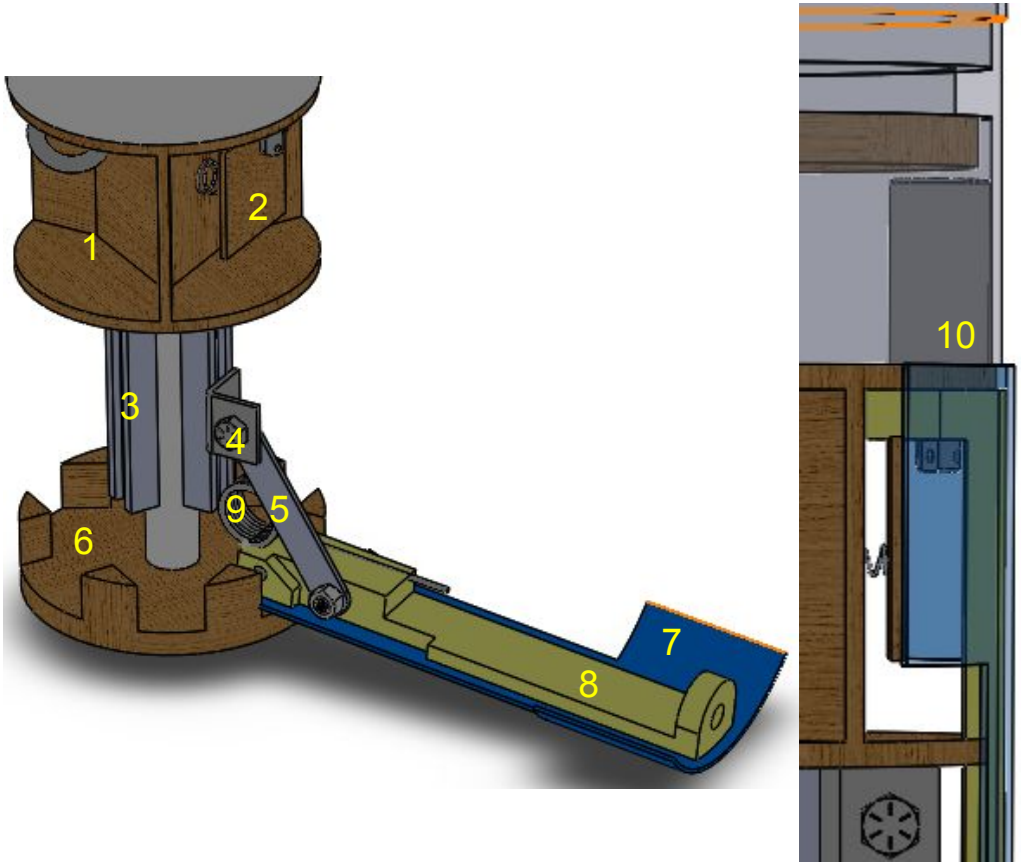


(A) (B)

Payload

Landing Leg Assembly

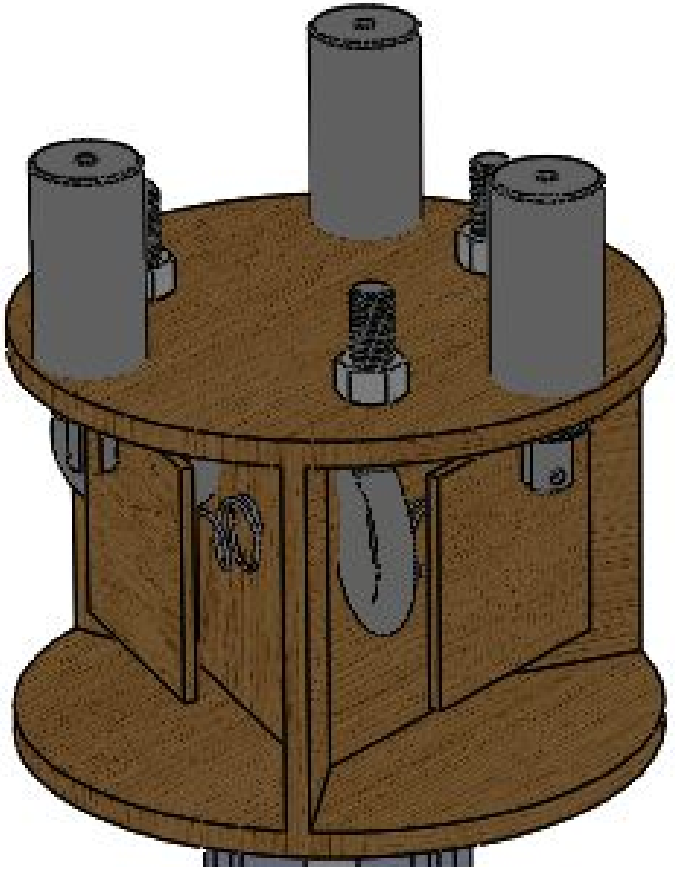
1) Parachute container
2) Parachute spring board
3) Rail
4) Rail carriage
5) Support leg
6) Lower bulkhead
7) Landing leg
8) Landing leg frame
9) Torsion spring
10) Solenoid actuator



Payload

Payload Recovery System

- Parachute containers mounted to upper payload tube
  - Redundant deployment
    - Spring board
    - Nylon cord



Payload

Target Detection Procedure:

The algorithm will follow these steps for each image taken:

- Search the image captured for the three targets (regions of color in the image) by sampling pixels at regular intervals.
- If any targets are found, save the image to the file system, along with a timestamp and the positions of the detected targets. If no targets are found, don't save anything to the file system.

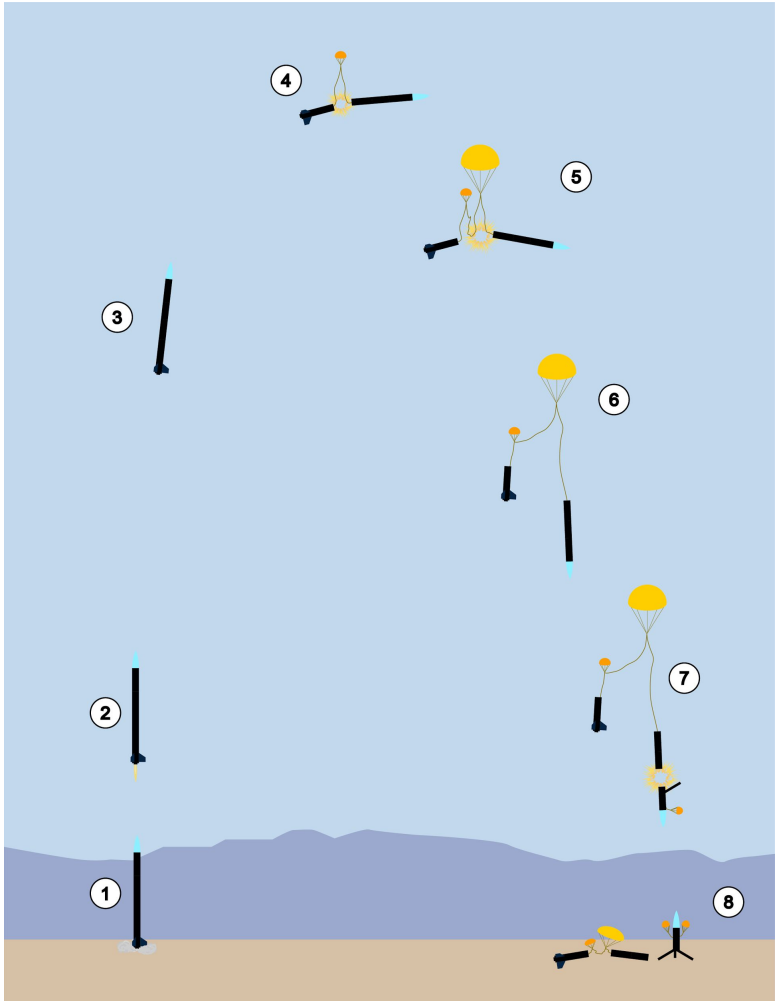
Some exceptions do apply - under conditions that would cause undue glare, such as the camera being pointed at the sun (see top left image), the algorithm will skip so as not to generate a false positive.

Photos from subscale launch:

The camera experienced glare often,

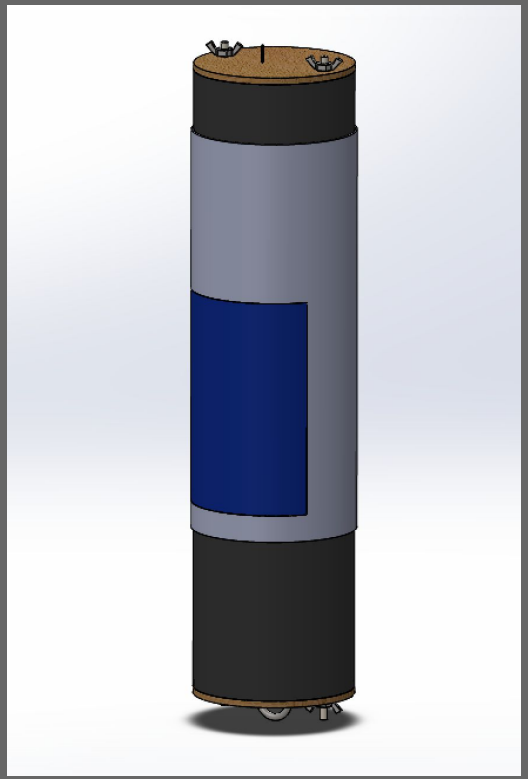
But was still able to pick out small features on the ground

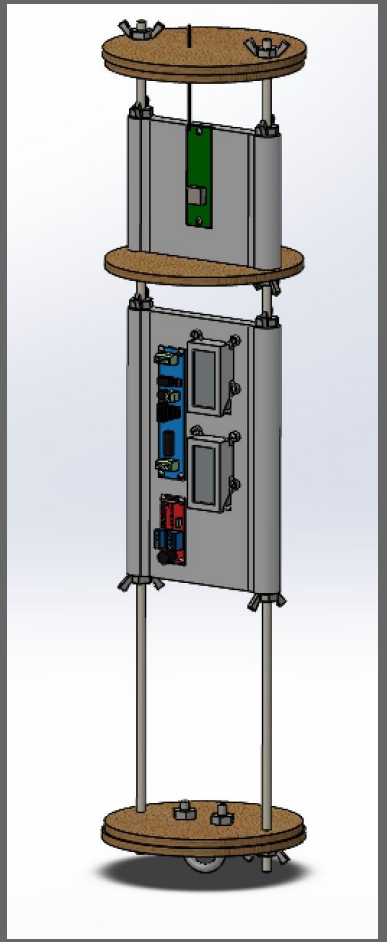
Payload/Recovery



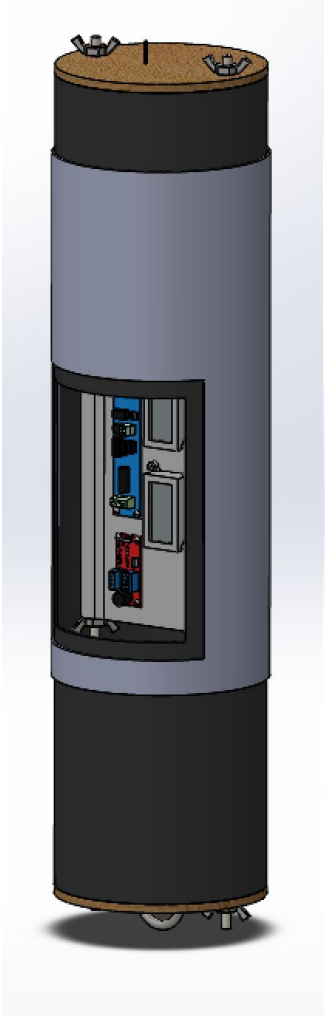
PHASE	EVENT
1	Ignition.
2	Powered flight.
3	Coasting.
4	Drogue parachute deployed at apogee (projected at 5,322 ft. AGL)
5	Main parachute deployed at an altitude of 1,000 ft. AGL.
6	Camera in the nosecone of the rocket begins target spotting.
7	Payload section deploys itself from rocket and deploys its legs and three parachutes.
8	All sections of the rocket land with a KE under 75 ft-lbf.

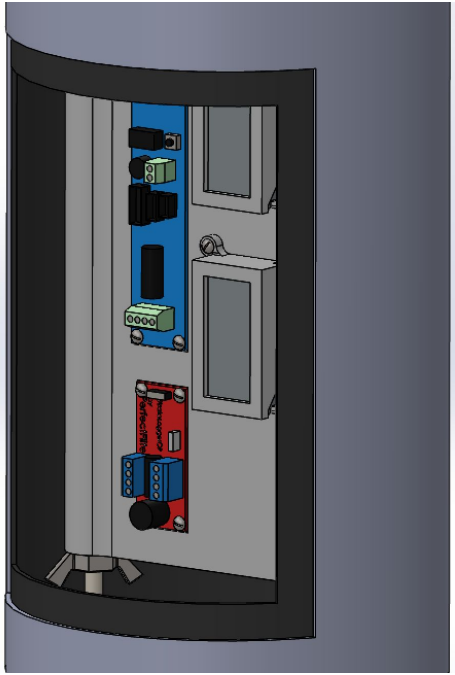
Recovery





Recovery





Avionics Bay

External Design

- removable door
- covered by an O-ring

Internal Design

- 3D printed sled
- two rod system

Calculating Parachute Sizes

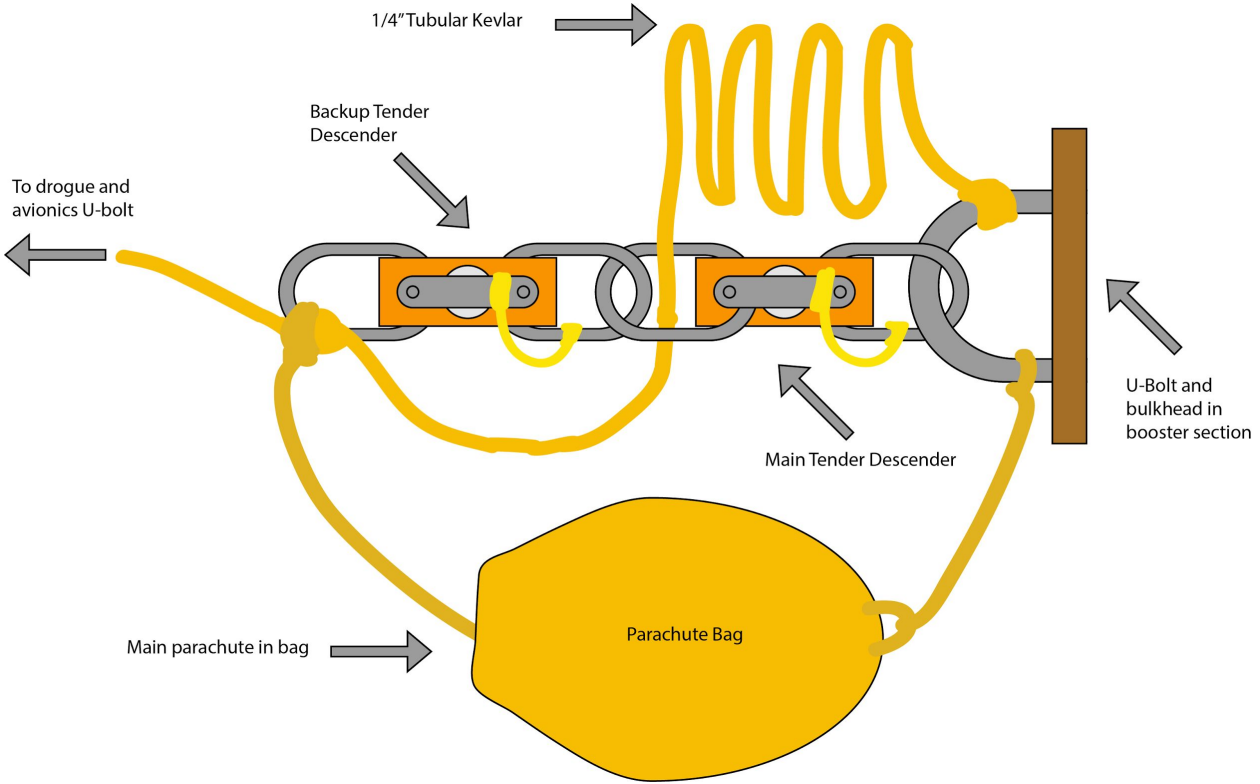
- *Drogue Parachute*
  - Optimally velocity 50 mph (or 73 ft/s)
  - **1x 24” diameter elliptical parachute with C_d = 1.5**
- *Main Parachute*
  - Payload will detach before rocket lands
  - **1x 72” diameter toroidal parachute with C_d = 2.2**
- *Payload Parachute*
  - 3 parachutes for stabilization
  - **3x 36” diameter elliptical parachute with C_d = 2.2**

$$V_{Terminal} = \sqrt{\frac{(2m_{total}g)}{\rho C_1 A_1}}$$

$$m_{total(w/o\ payload)}g = \frac{1}{2}\rho v_{max}^2 C_1 A_1 + \frac{1}{2}\rho v_{max}^2 C_2 A_2$$

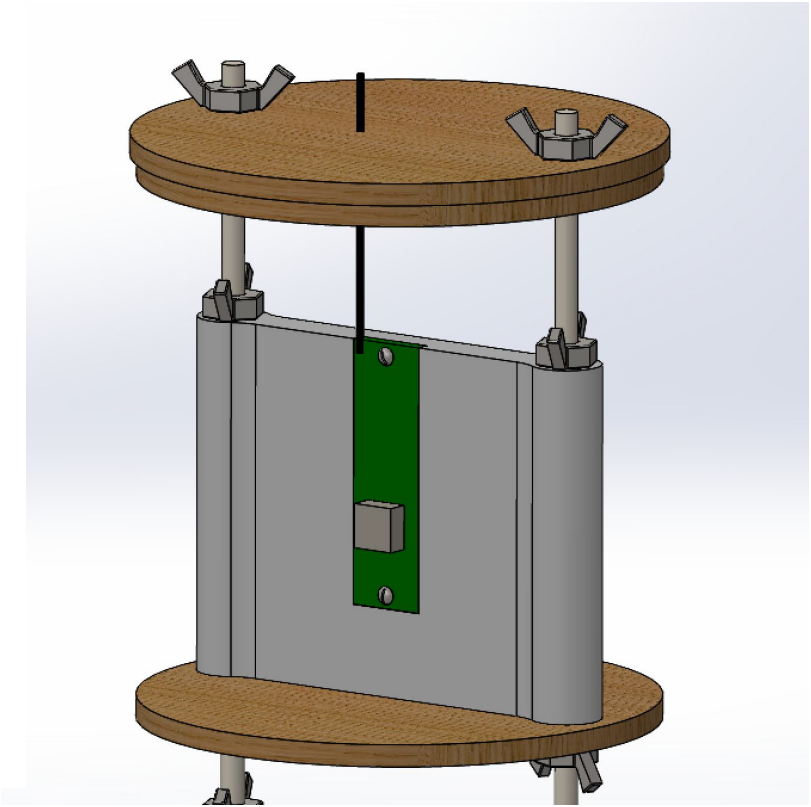
Tender Descender System

- Connected in series
- ¼” tubular kevlar
- Detachable wires
- Quicklinks



GPS

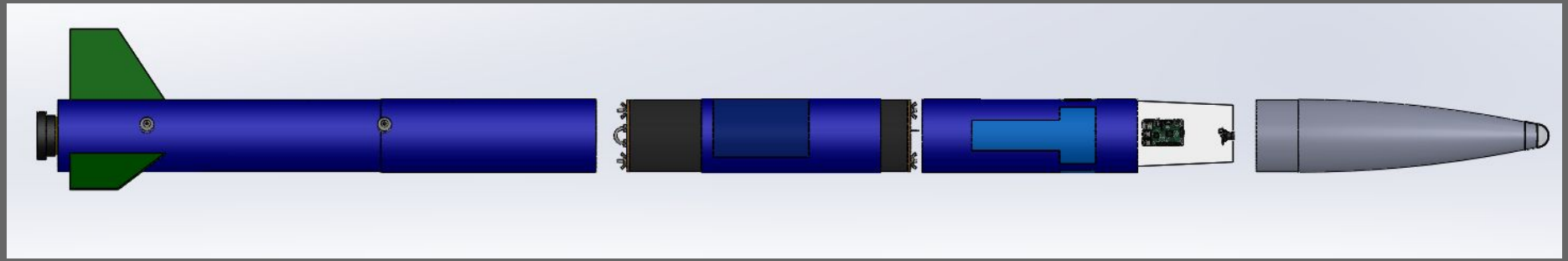
- Operating at 923.000 MHz
- Mounted on same rods as altimeter sled
- Separated from altimeters with bulkhead
- Used for booster and avionics section



Calculating Final KE at landing

Section	Scenario	Kinetic Energy (ft-lbf)
Avionics Bay	Payload Detaches	12.42
Booster	Payload Detaches	34.91
Payload	Payload detaches and 3 parachutes deploy	23.97
*Avionics and Payload (attached)	Payload does NOT detach	64.64
*Booster	Payload does NOT detach	55.67
*Payload	Payload detaches and 1 parachute deploys	71.92

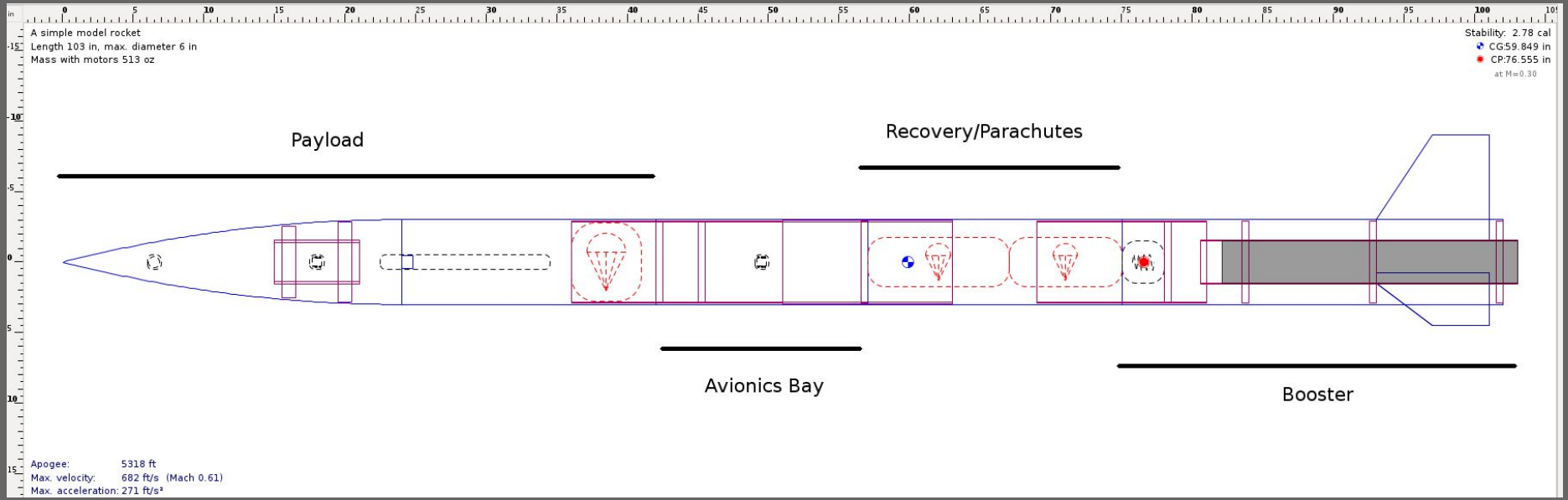
Vehicle Interfaces



Vehicle Interfaces

- Blue Tube couplers between booster - av-bay, and av-bay - payload.
- 3.5” shoulder at av-bay - payload interface; shear pinned
- 3.5” shoulder at payload - nose cone interface; screwed together
- Shock cord between booster and av-bay

Flight Simulations



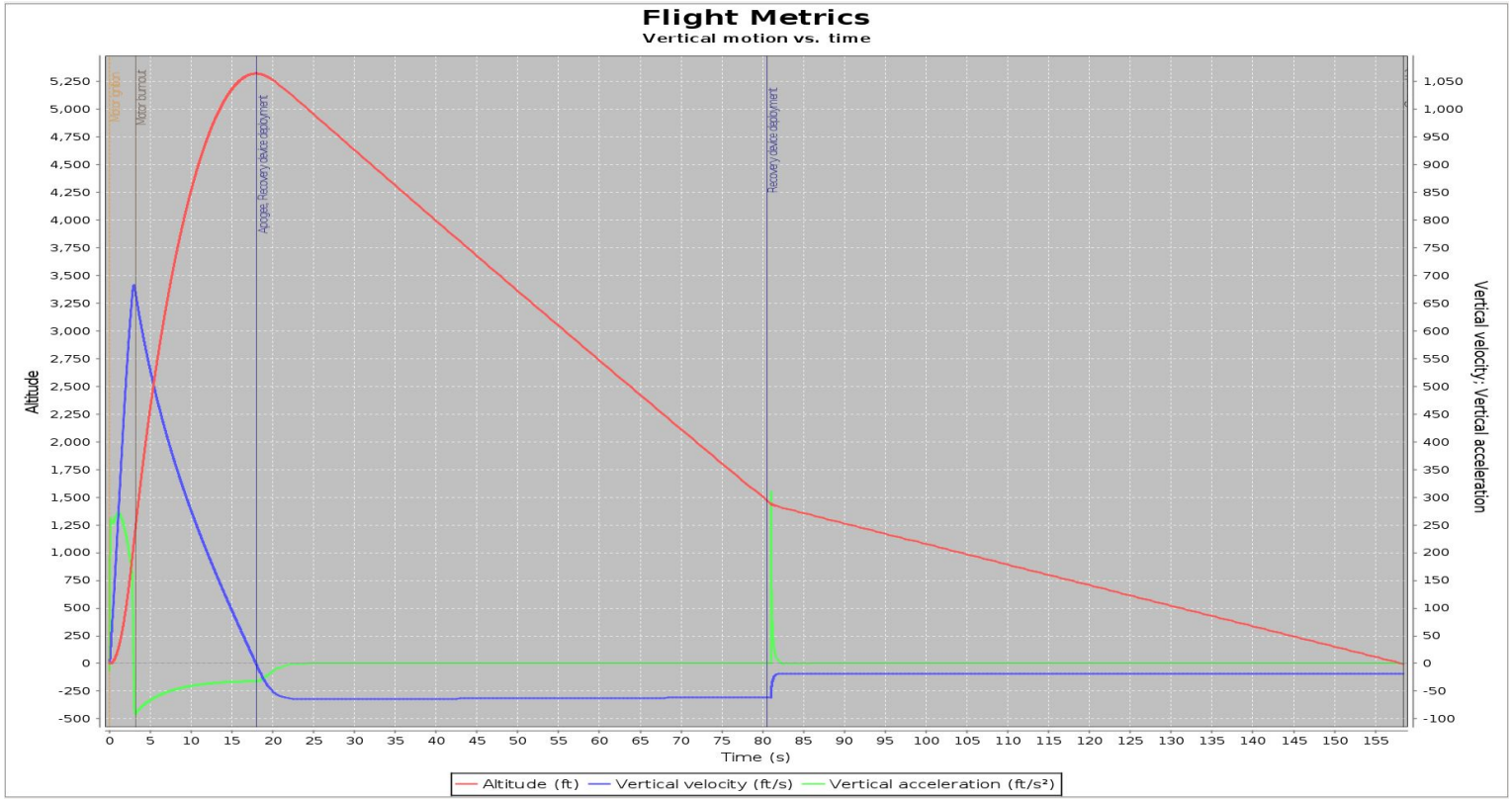
Simulation Results (Zero Wind)

Flight Simulations

Apogee	5322 ft
Velocity off Launch Rail	78.7 ft/s
Velocity at Parachute Deployment	61.2 ft/s
Maximum Velocity	683 ft/s (Mach 0.61)
Maximum Acceleration	271 ft/s^2 (8.42 G's)
Ground Hit Velocity	18.3 ft/s
Time to Apogee	18 s
Total Flight Time	158 s

Simulated Flight Profile

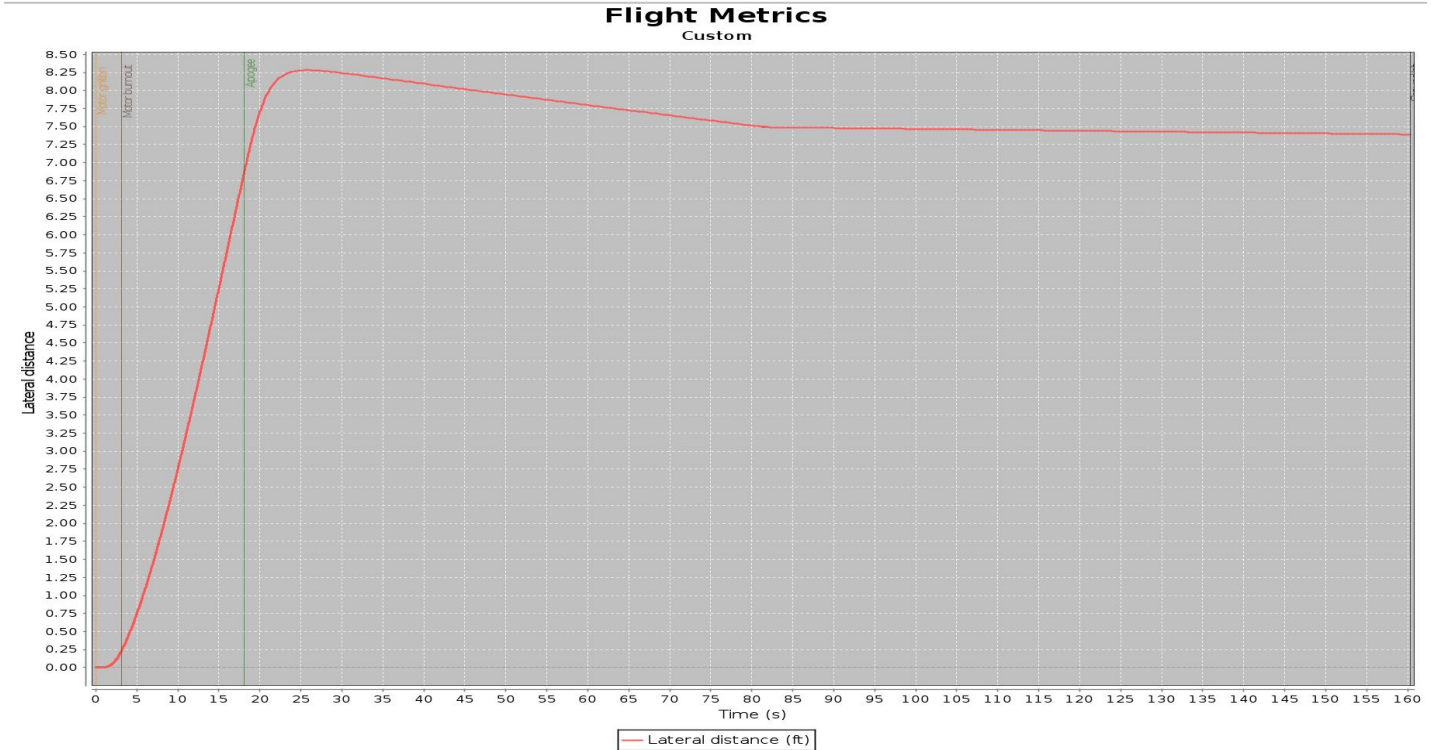
Flight Simulations



Drift Simulation (Zero Wind)

Flight Simulations

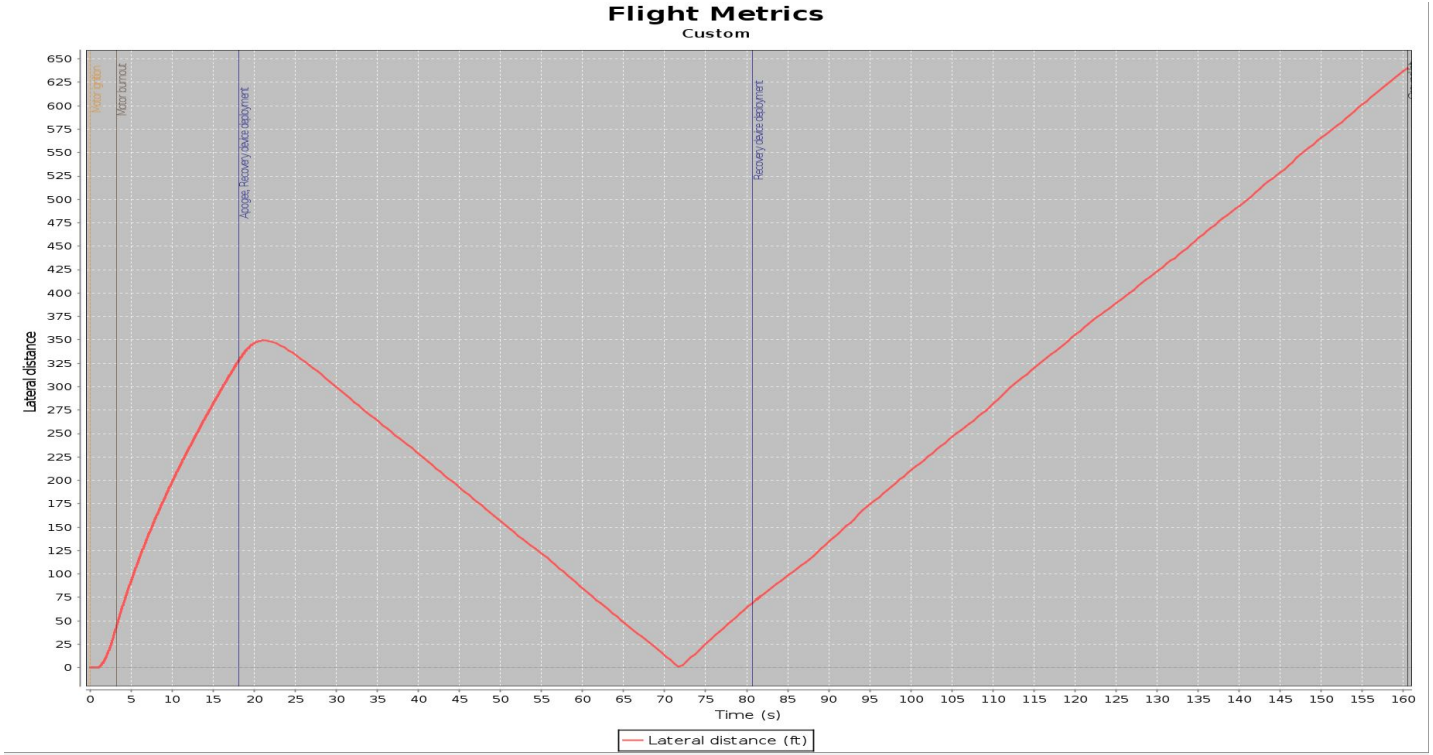
- Maximum Drift: ~7.50 ft



Drift Simulation (5 mph Wind)

Flight Simulations

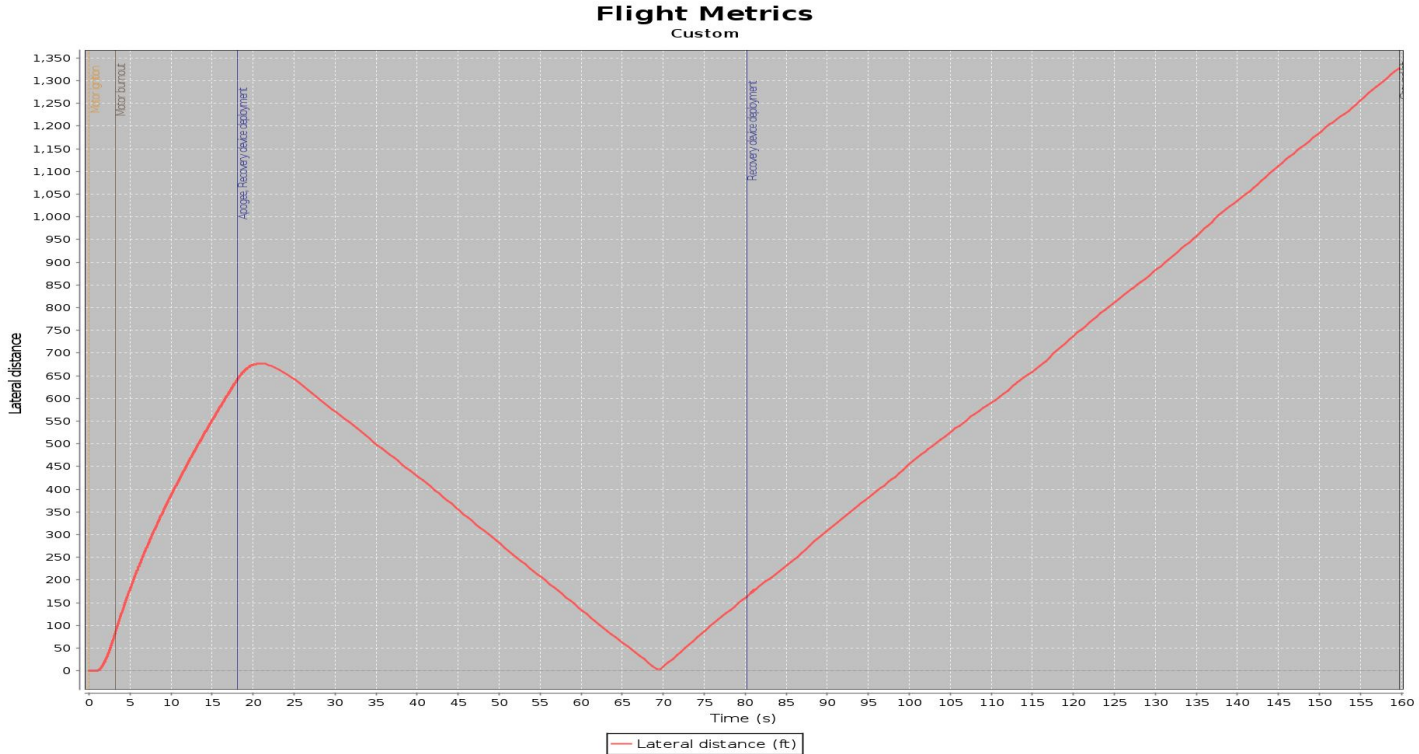
- Maximum Drift: ~640 ft



Drift Simulation (10 mph Wind)

Flight Simulations

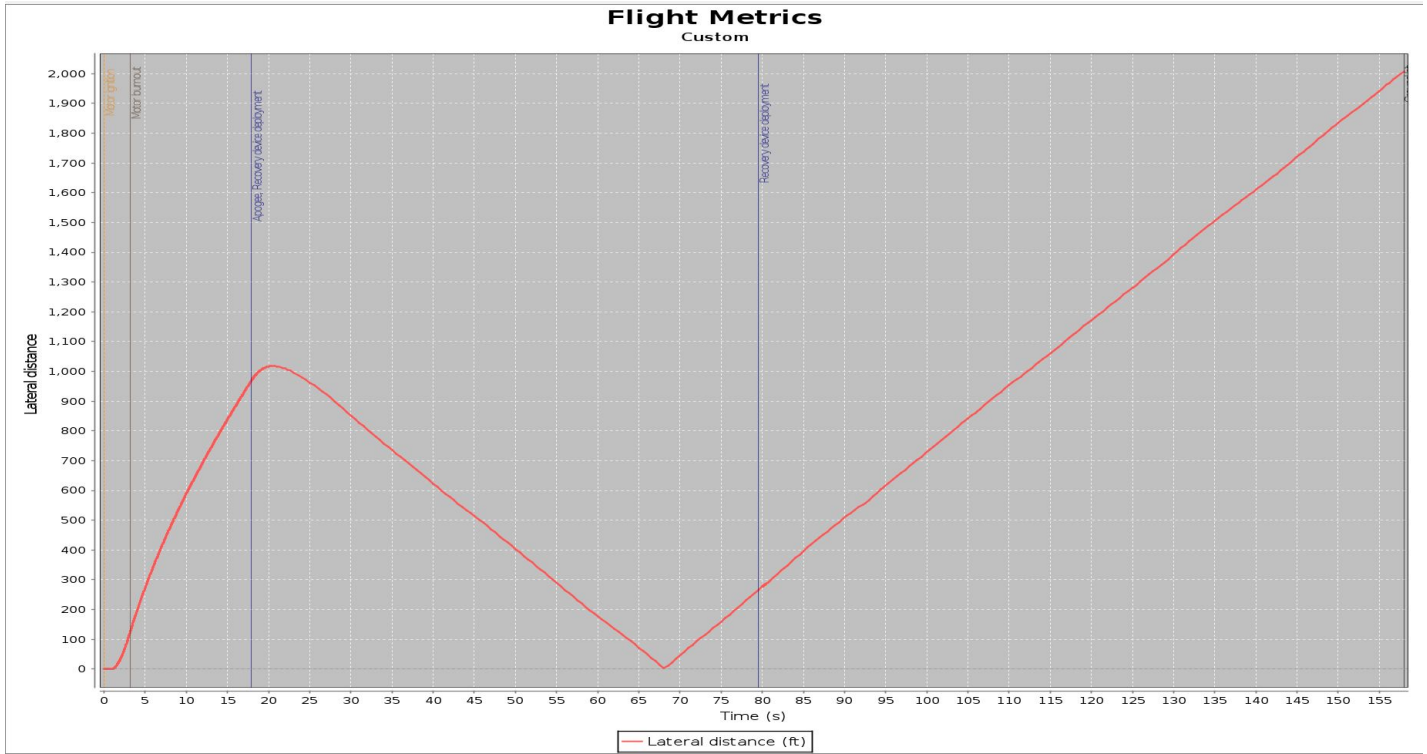
- Maximum Drift: ~1330 ft



Drift Simulation (15 mph Wind)

Flight Simulations

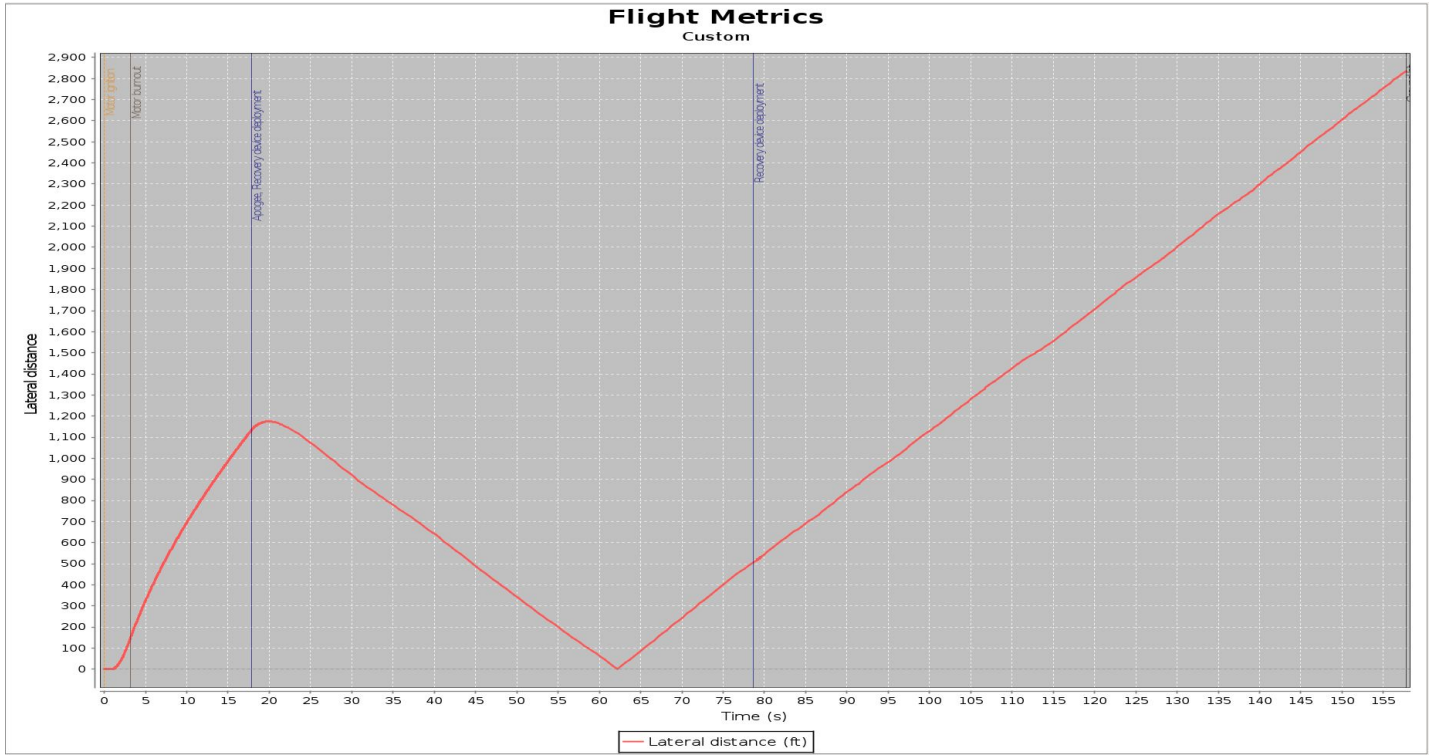
- Maximum Drift: ~2000 ft



Drift Simulation (20 mph Wind)

Flight Simulations

- Maximum Drift: ~2800 ft



Subscale Flight

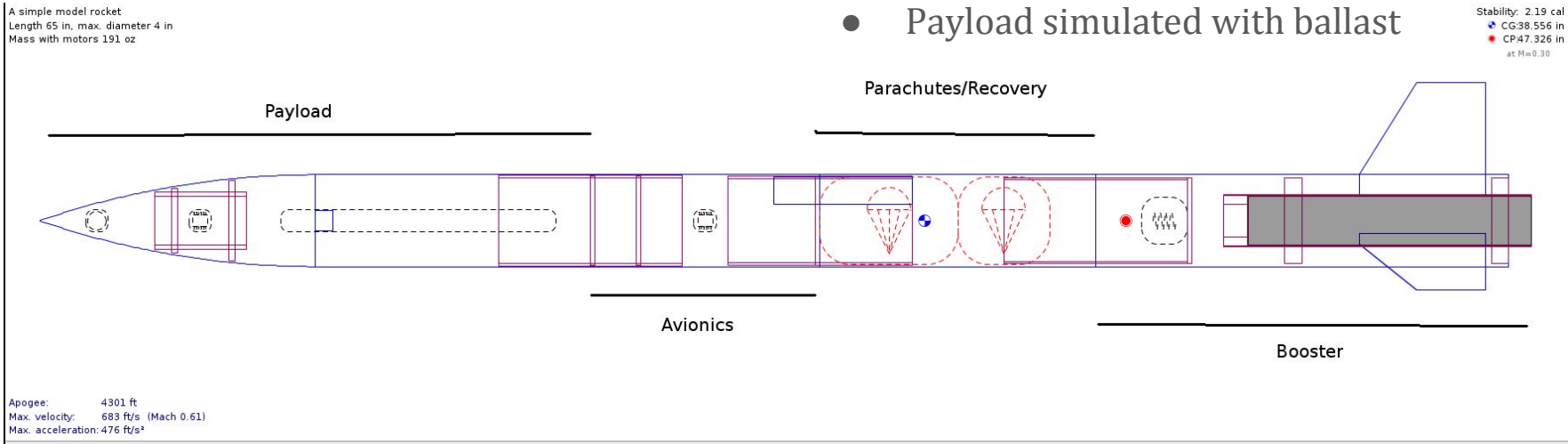
Vehicle Summary

- Scaling: ⅔ length and diameter
- Length: 5’ 5”
- Weight: 11.614 lbs
- Diameter: 4”
- Motor: Aerotech J800

Subscale Flight

- CG: 37.845” from nose cone tip
- CP: 47.326” from nose cone tip
- Stability margin: 2.37 calibers

- Recovery system tested
- Camera hardware tested
- Payload simulated with ballast

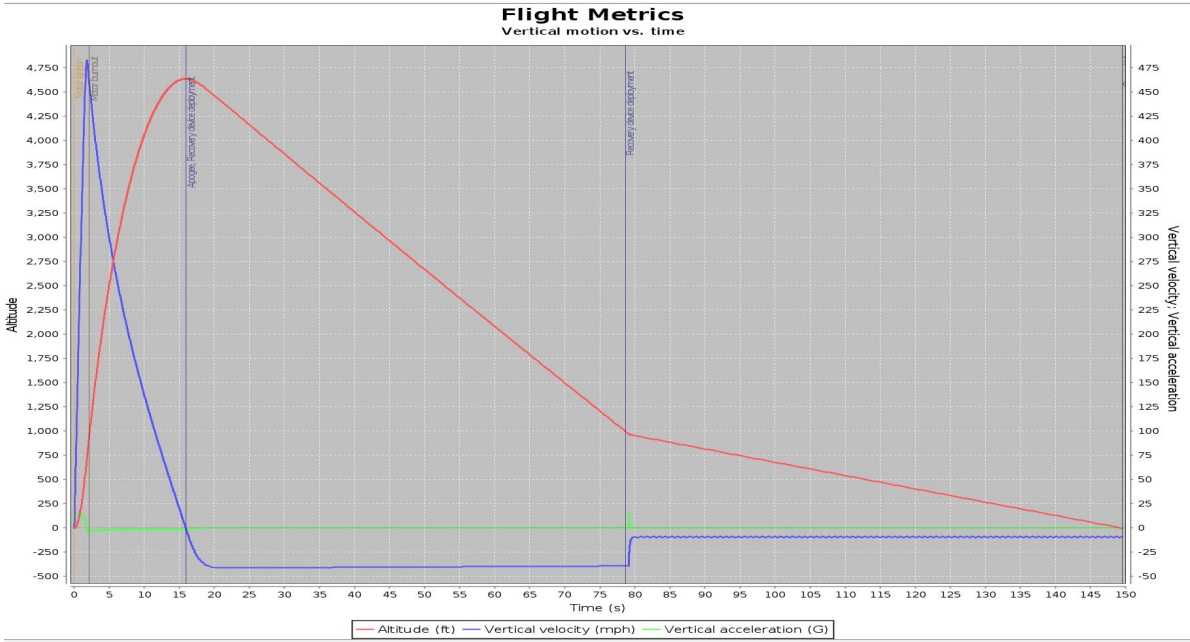


Launch Conditions/Flight Results

Subscale Flight

- December 4th, 2016
  - 3:55 P.M. PST
- Temperature: 56 deg F
- Air Pressure: 30.2 inHg
- Wind: 0 mph

- Simulated Apogee: 4633 ft
  - Actual Apogee: 4574 ft
- Velocity off Rail: 89.9 ft/s
- Maximum Velocity: Mach 0.63
- Maximum Acceleration: 15.3 G's



Impact on Final Design

Subscale Flight

- Nose cone tip design/manufacture
  - Better 3D mold
  - Different epoxy
  - Scratch resistant cover/spray
  - Reduce transparent area to decrease glare
- Motor Mount Construction
  - Step-by-step process ensures alignment of fins
  - Ensures all steps are carried out
  - Nothing is missed

Safety

Safety

General

Safety Officer: Grant Posner

Mentor: David Raimondi

- President of Livermore Unit of NAR (LUNAR)
  - Advises team
  - Owns project
  - Handles motor hardware

Safety

Personnel Hazards: Greatest Risks

- Construction injuries

- Launch safety: energetic devices
  - Subscale tests
  - Full-scale tests/launches

Environmental Risk

1. Minimize any environmental issues during the design phase.
2. Be aware of applicable laws and regulations.
3. Identify and rate all risks.
4. Have containment and remediation plans.

Project Plan/ Outreach

Test Plans and Procedures

Project Plan

- Payload Tests
  - Camera/Target Identification
    - Received data from subscale flight
  - Drop Test/Upright Landing
  - Parachute Deployment Test
- Epoxy Strength Test
- Testing variables will ensure durability of design

Status of Requirement Verification

Project Plan

- All design requirements fulfilled
  - Subscale vehicle and recovery test completed
  - Full-scale vehicle, payload, and recovery test scheduled for Feb. 4th, 2017 (alt. Launch on Feb. 18th)
- Redundant verification when possible

Project Plan

Outreach Plan

- Habitat for Humanity STEM Outreach Day
- KIPP Public Charter School
  - In contact with 7th grade teacher and program coordinator
- Currently signing up for more outreach programs
  - Expanding Your Horizons, UC Berkeley Engineers Week, etc.

Questions?

Thank You