NUMAV

AIAA Northeastern

Team Officials

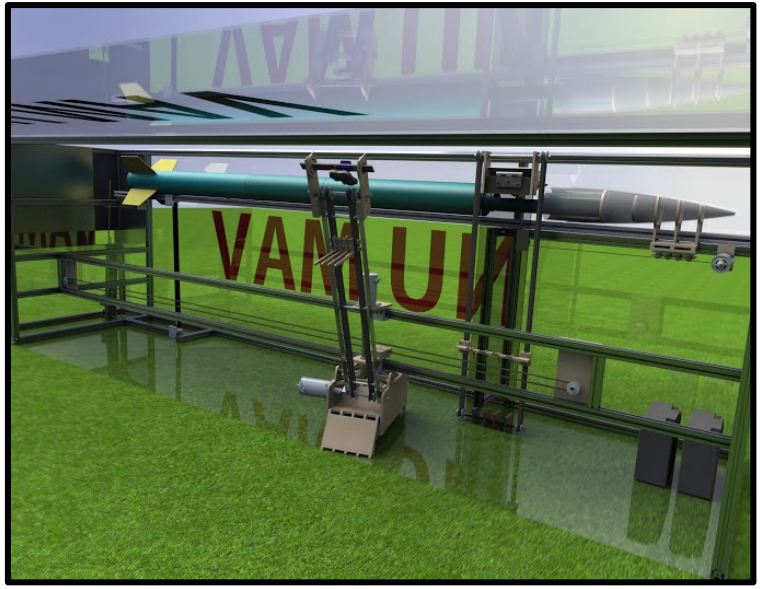
- Andrew Buggee, President, Northeastern AIAA Chapter
- John Hume, Safety Officer
- Dr. Andrew Gouldstone, Faculty Advisor
- Rob DeHate, Team Mentor

Team Roster

William Benoit
Eleanor Blair
Shaina Blitt
Harry Brodsky
Andrew Buggee
Joseph Conahan
Alex D’Amato
Alanna Ferri
Joe Flaherty
Kaely Gallagher
Corey Hoard
John Hume
Evan Kuritzkes
Jon Malsan
Jen Morin
Caroline Mueller

Mission

1. Locate and capture a payload
2. Load the payload into the rocket
3. Position and launch rocket
4. Reach target altitude of 3,000 feet
5. Safely deploy the payload at 1,000 feet
6. Recover all rocket components



Launch Vehicle

Launch Vehicle Summary

Length: 87.2 inches

Diameter: 4.0 inches

Mass (excluding motor): 4500 grams

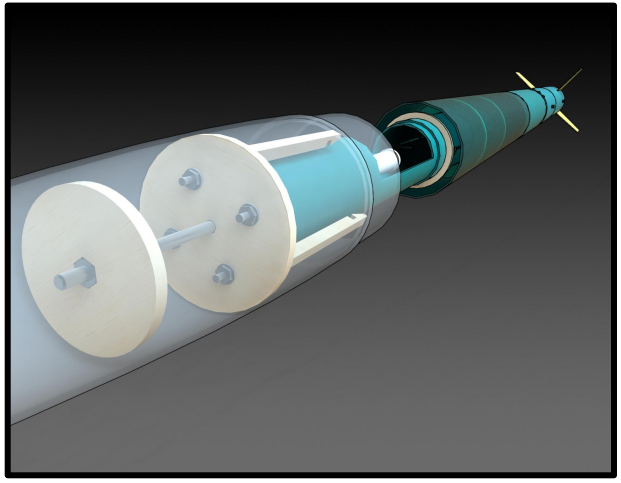
Motor: See “Proposed Motor Change”

Thrust-to-weight ratio: 6.5

Static margin of stability: 2.77

Rail exit velocity: 34.9 ft/s

Expected apogee: 3076 ft

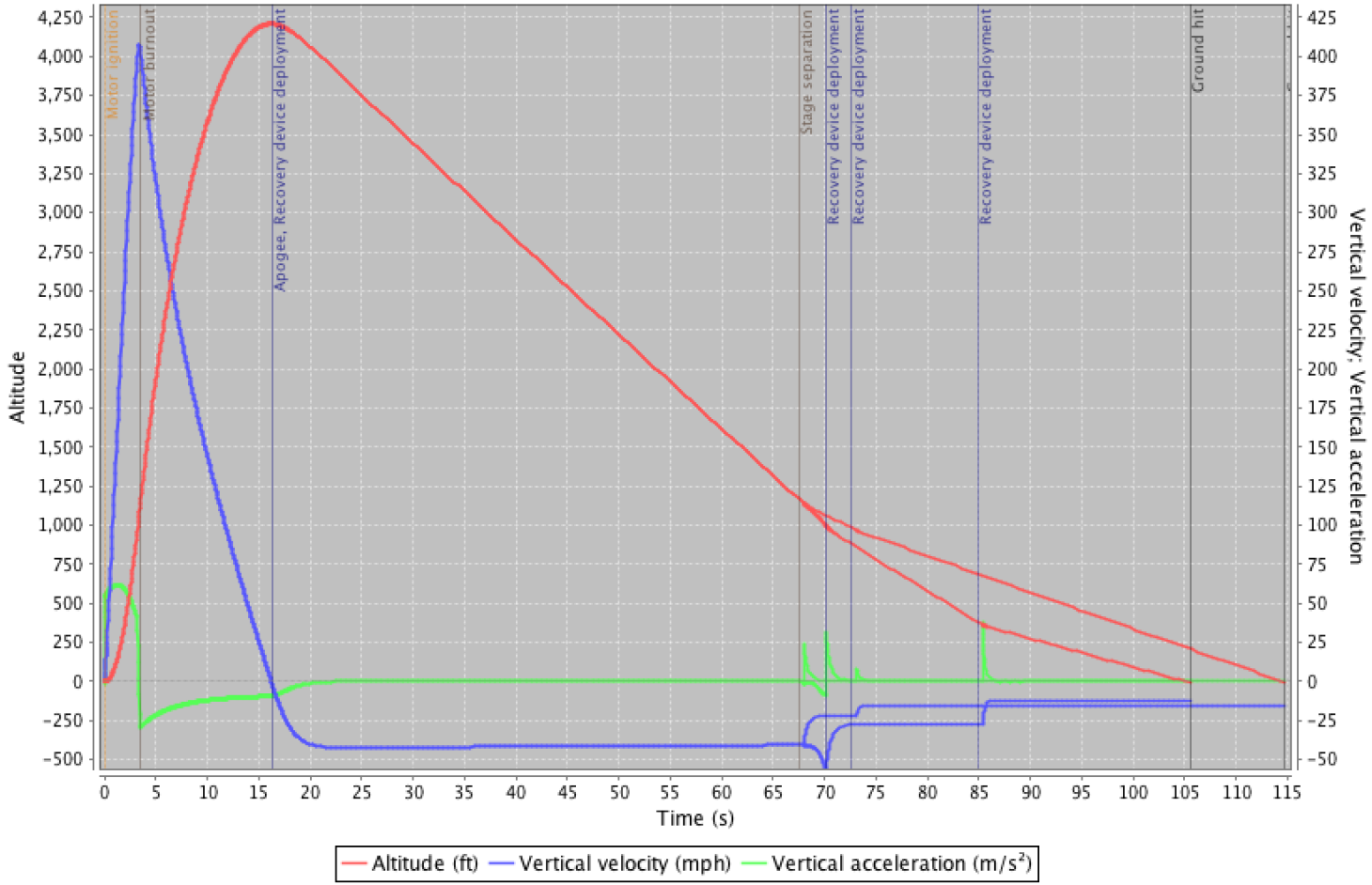


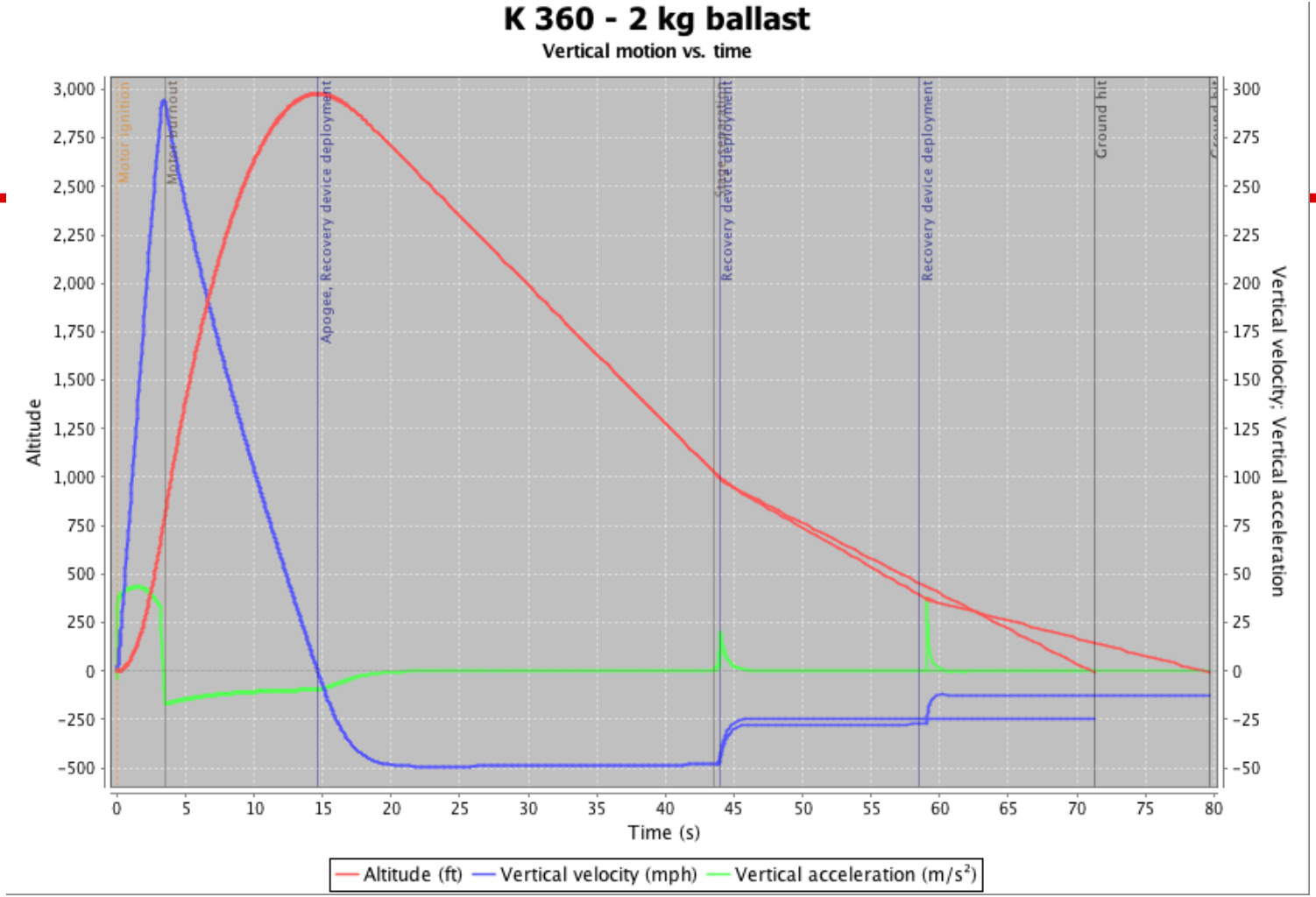
Proposed Motor Change

- **K360 to J380**
  - K360 predicted Apogee: 4140 ft
  - Would need additional ~4 lbs ballast to reach 3000 feet
    - Safety Concerns:
    - Anticipated 25-33% mass increase from PDR
      - USLI Manual PDR Mass statement “Rule of Thumb”
      - Mass on full scale is LESS than PDR simulation mass
    - Dangerous failure modes, increased risk of recovery harness failing
    - Would require extensive modifications of current recovery system design and AGSE system to ensure safety during the launch
  - Team believes it would be safer to use J380-SS on launch day
    - Would only need to add less than .5 lbs ballast to reach 3000 feet

K 360 - 0g ballast

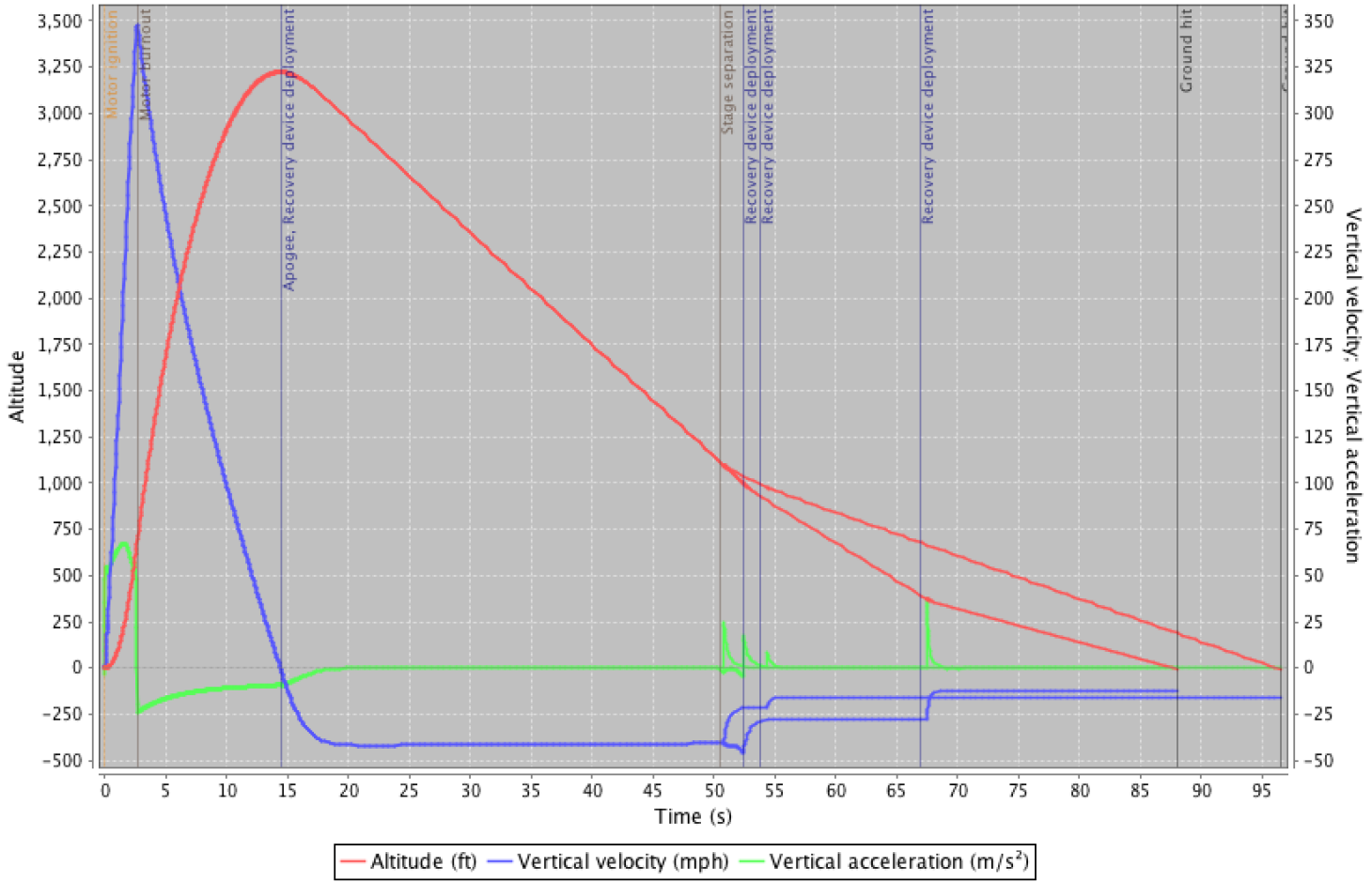
Vertical motion vs. time




K 360 - 2 kg ballast
Vertical motion vs. time
Motor ignition
Motor burnout
Apogee, Recovery device deployment
Recovery device deployment
Recovery device deployment
Ground hit
Altitude
Vertical velocity; Vertical acceleration
Time (s)
Altitude (ft)
Vertical velocity (mph)
Vertical acceleration (m/s²)

J 380 - 0g ballast

Vertical motion vs. time

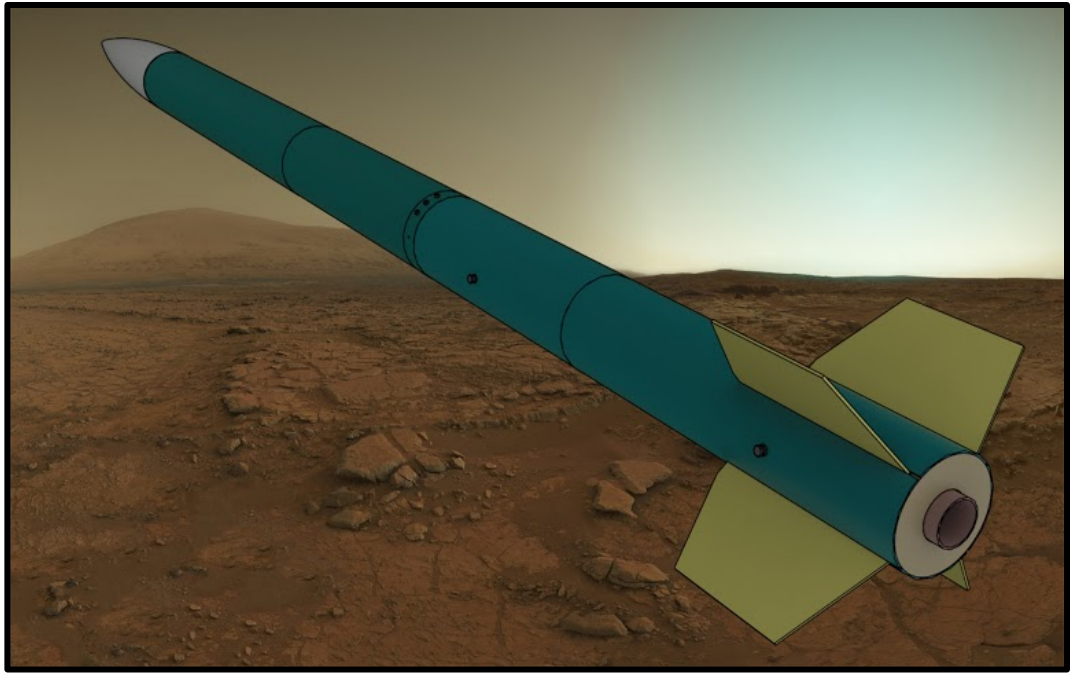


Kinetic Energy

	Weight added (lb)	Velocity (ft/s)		Weight (lb)		Kinetic Energy (ft-lbs)	
		Motor section	Payload section	Motor section	Payload section	Motor section	Payload section
Old Motor K360	3.5	39	28	12.83	3.47	155	35.68
New Motor J380	0.2	12	28	9.73	3.47	21.27	35.68

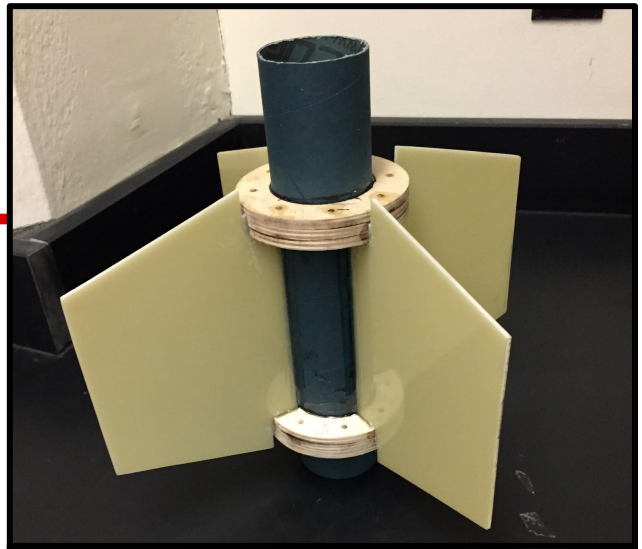
Air Frame

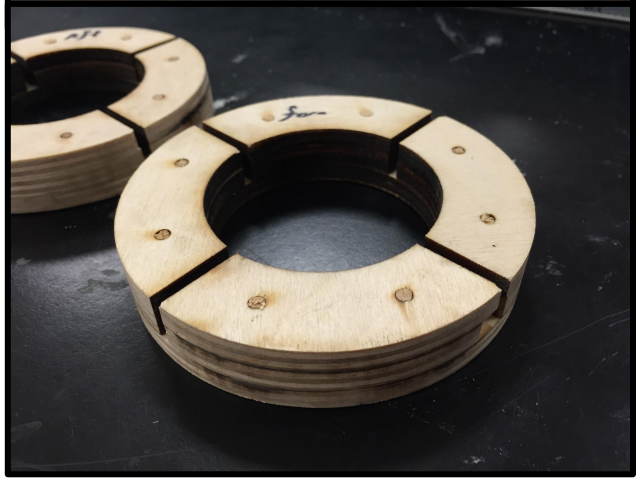
- Blue Tube
- Motor section:
  - 15.5 inches
- Payload section:
  - 38.5 inches
- Parachute section:
  - 31.5 inches



Motor Section

- **Length:** 15.5 inches blue tube
- **Diameter:** 4 inches
- **Centering rings:**
  - 3 layers of ¼ inch plywood
  - Laser cut alignment slots
- **Fins:**
  - G10 garolite composite
  - Root chord- 7.25 inches
  - Tip chord- 4.75 inches
  - Height- 4 inches

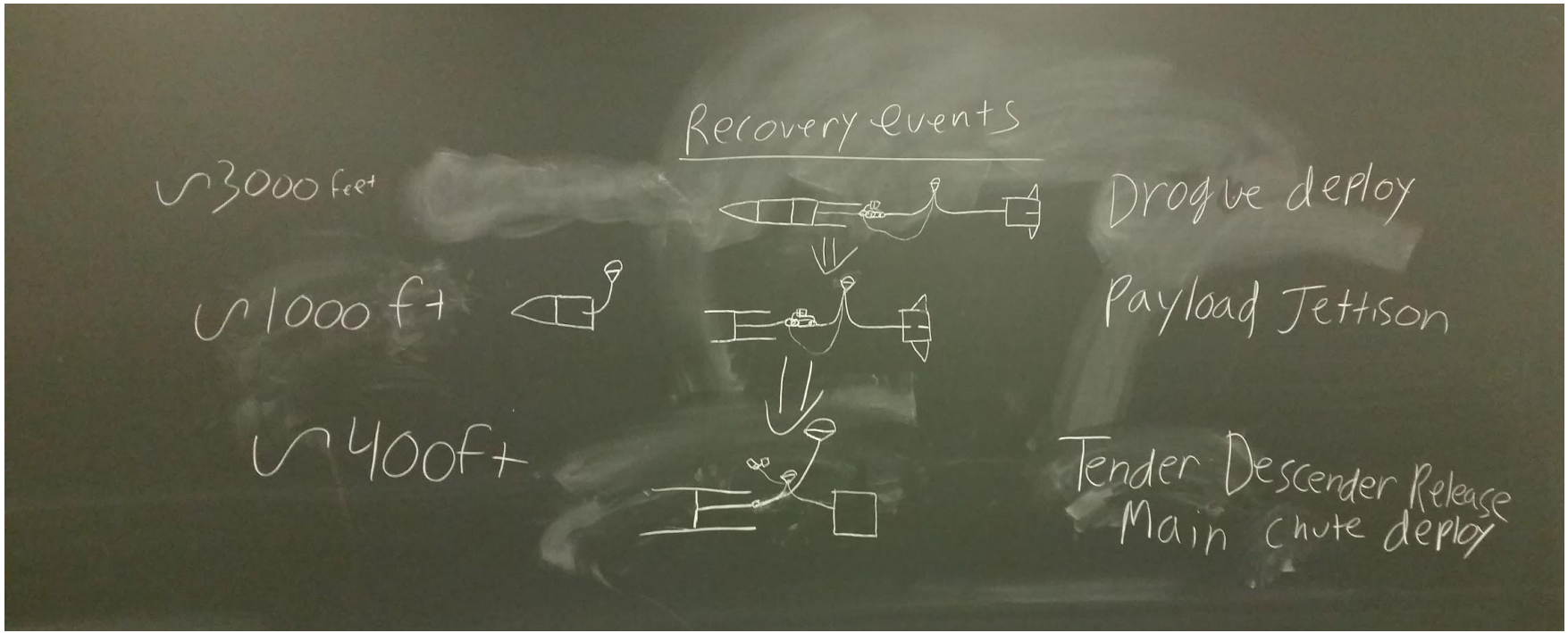




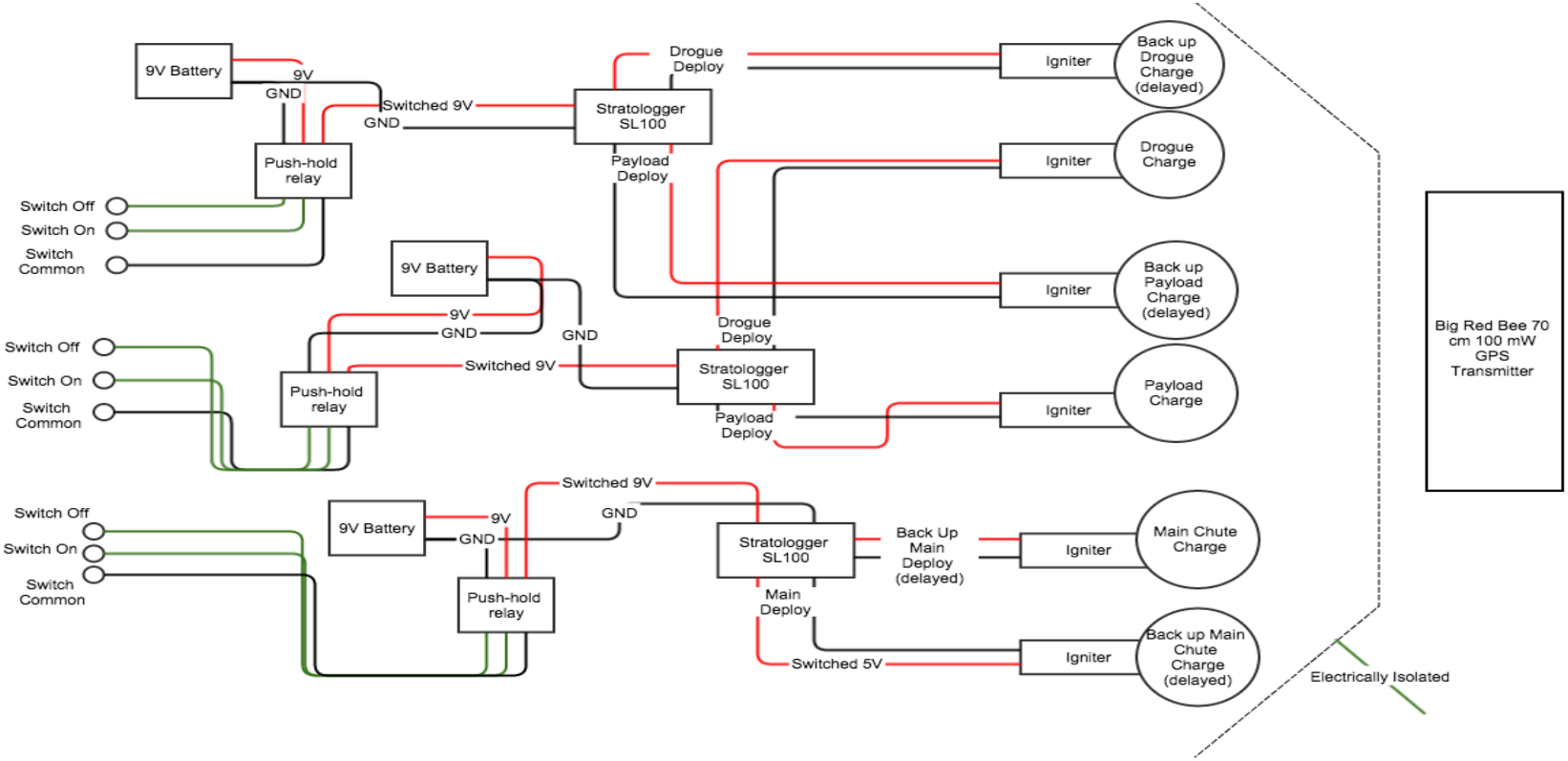
Recovery System Overview

- **3 PerfectFlite StratoLogger altimeters**
- **Drogue Parachute:**
  - 12 in diameter
  - Deployed at apogee ~3000 ft
- **Main Parachute:**
  - 36 in diameter
  - Deployed by Tender Descender at 400 ft
- **Payload Parachute:**
  - 18 in diameter
  - Ejected and deployed at 1000 ft
- **2 BigRedBee GPS trackers (Payload Section and Avionics Bay)**

Recovery System Order of Events



Recovery System Wiring



Drogue Parachute

- 12 inch Ripstop nylon
  - Fruity Chutes
  - Deployed by StratoLogger altimeter at apogee ~3000 ft
  - Descent rate: 60.3 ft/s

Main Parachute

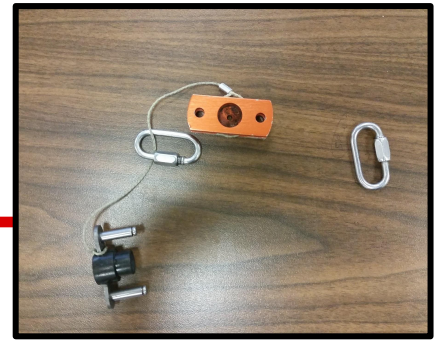
- 36 inch Ripstop nylon
  - Fruity Chutes
  - Deployed at 400 feet with Tender Descender
  - Descent Rate 13.1 ft/s

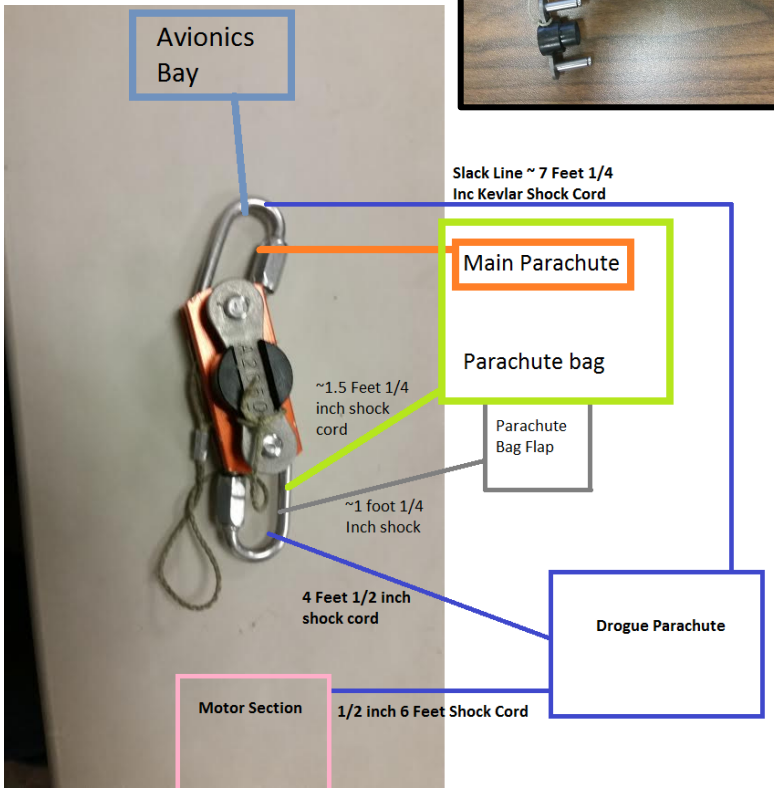
Payload Parachute

- 18 inch Ripstop nylon
  - Fruity Chutes
  - Deployed at 1000 feet
  - Descent Rate 26.5 ft/s

Tender Descender

- Dual Deployment from single section
  - Deployed at apogee with drogue and parachute bag
  - Ejection charge fires at 400 feet, freeing main parachute





Avionics Electromagnetic Isolation

<u>Inside</u> Faraday cage:

- 3 PerfectFlite StratoLogger altimeters
  - Main, back-up, Tender Descender
- 3 9V batteries
- 3 sets of 3 brass Push-Hold switch relays

<u>Outside</u> Faraday cage:

- BigRedBee GPS Tracker (with 20 mile range)
  - Powered by own battery

Predicted Lateral Drift & Altitude

Open Rocket analysis with Weather Cocking

Wind Speed (mph)	Lateral drift (ft)		Altitude (ft)
	Motor section	Payload section	
0	750	715	3,140
5	510	553	3,080
10	138	300	3,011
15	60	120	2,986
20	60	140	2,996

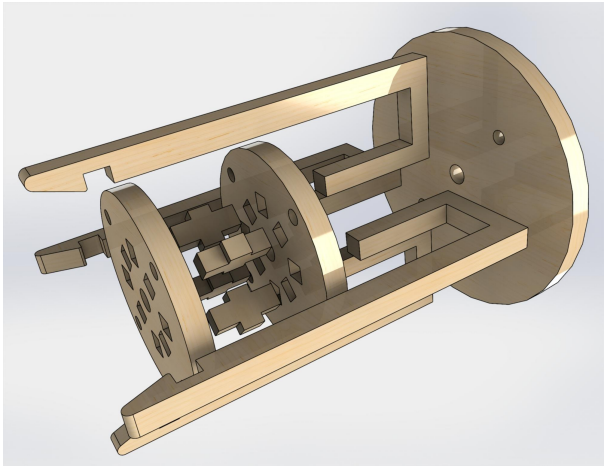
No Weather Cocking Approximation

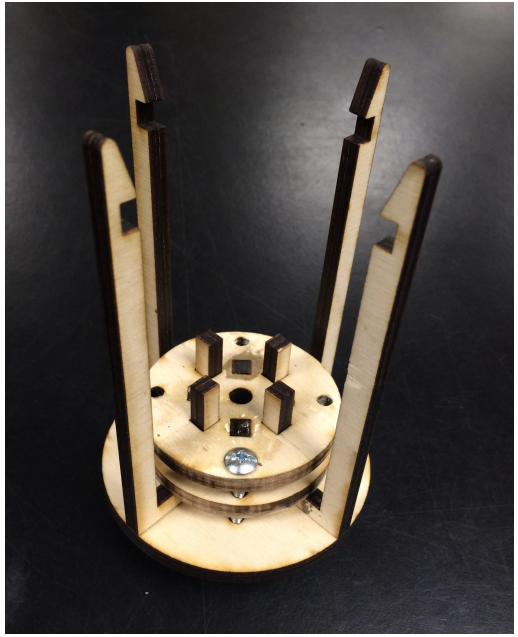
Wind Speed (mph)	Lateral drift (ft)		Altitude (ft)
	Motor section	Payload section	
0	0	0	3,000
5	540	520	3,000
10	1080	1040	3,000
15	1620	1560	3,000
20	2160	2080	3,000

Snap Features

Original Design

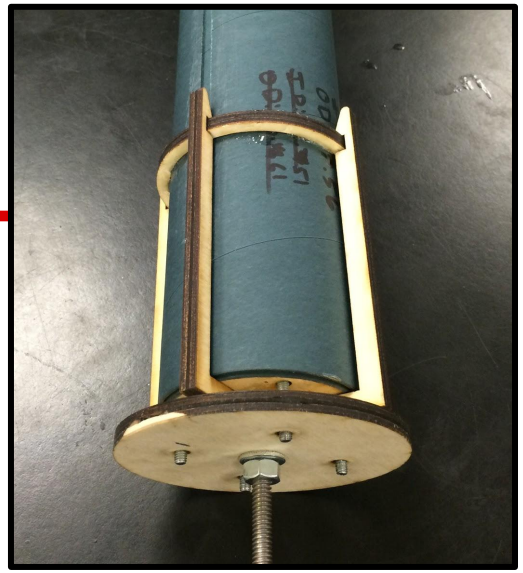
Revised Design

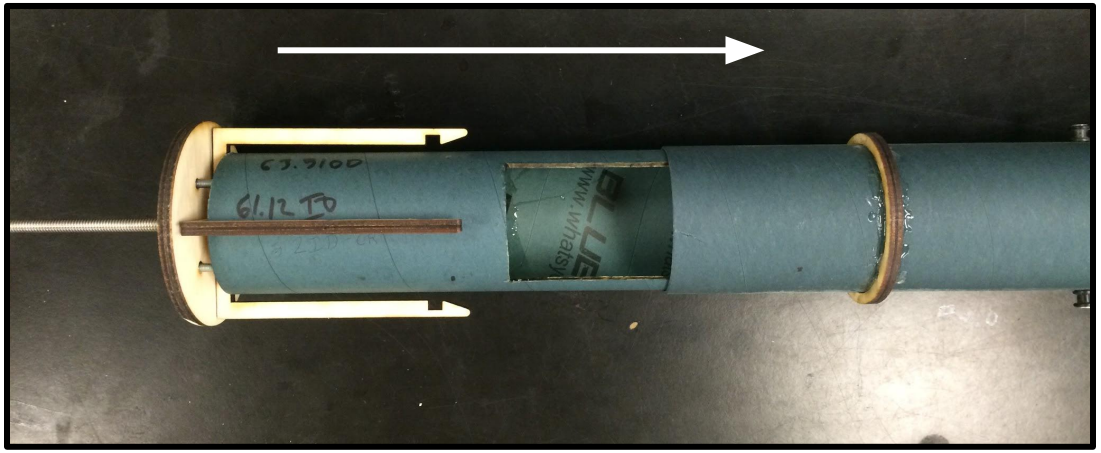


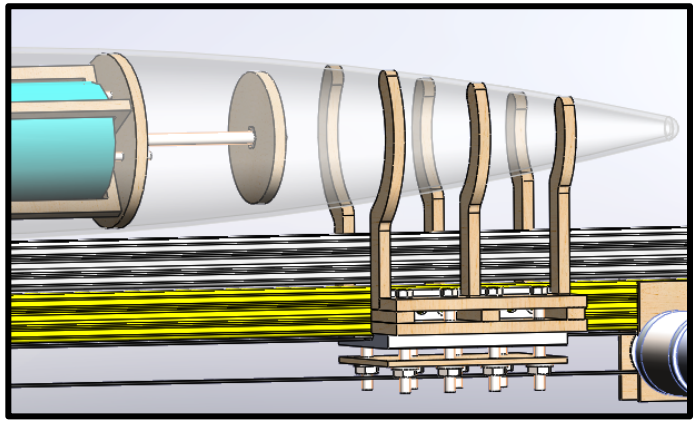


Payload Section

- Bulkhead in nose cone screws onto bolt
- Nose cone is pushed via timing belt
- Snap features engage centering ring to close rocket







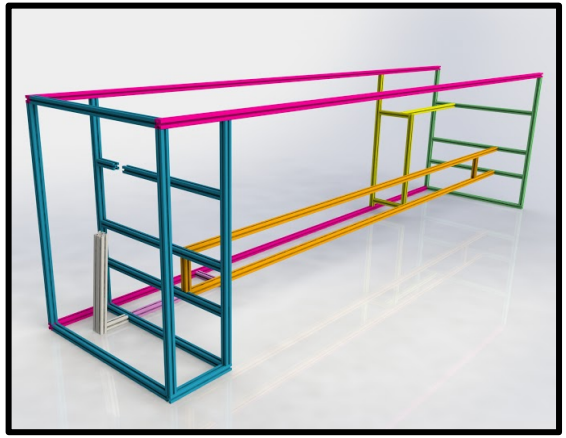
Full-scale Flight Test

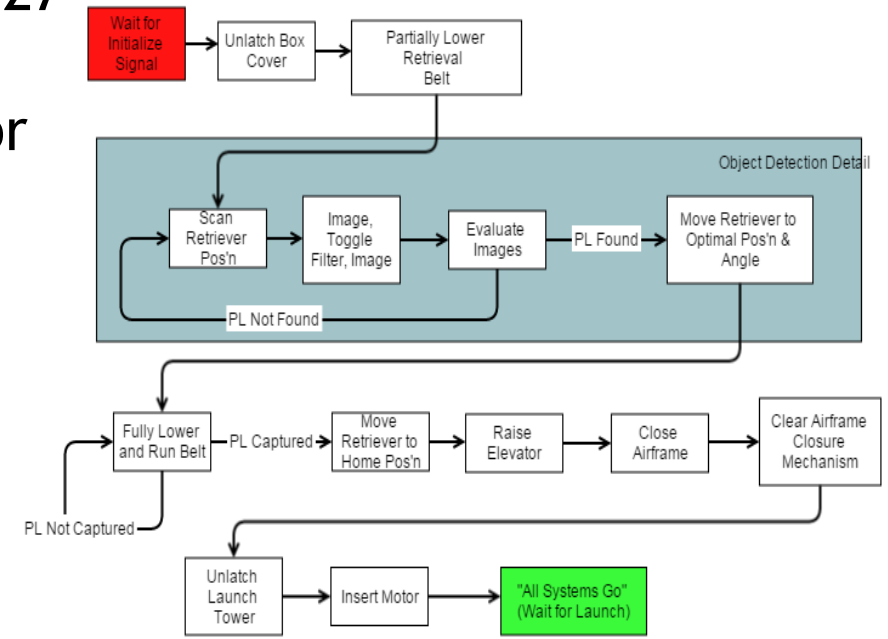
- Launched March 8th in Amesbury, MA
- **Successes:**
  - Rocket successfully recovered
  - Rocket intact
  - Payload jettisoned at ~ 1000 ft
- **Problem Areas:**
  - Overshot target altitude
  - Parachute deployment issues led to difficult recovery

AGSE

AGSE System Summary

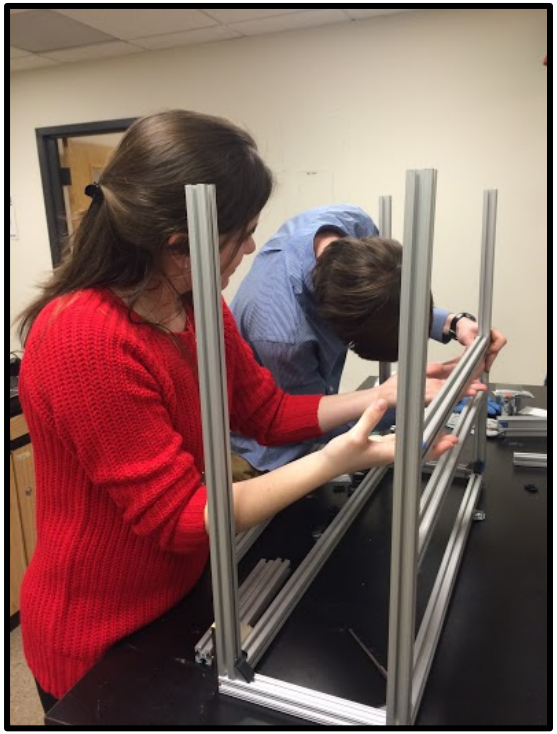
- Sealed Dimensions: 112”x 33”x 27”
- Structure built with 80/20 1010
- Laser-cut craft plywood used for precision custom components





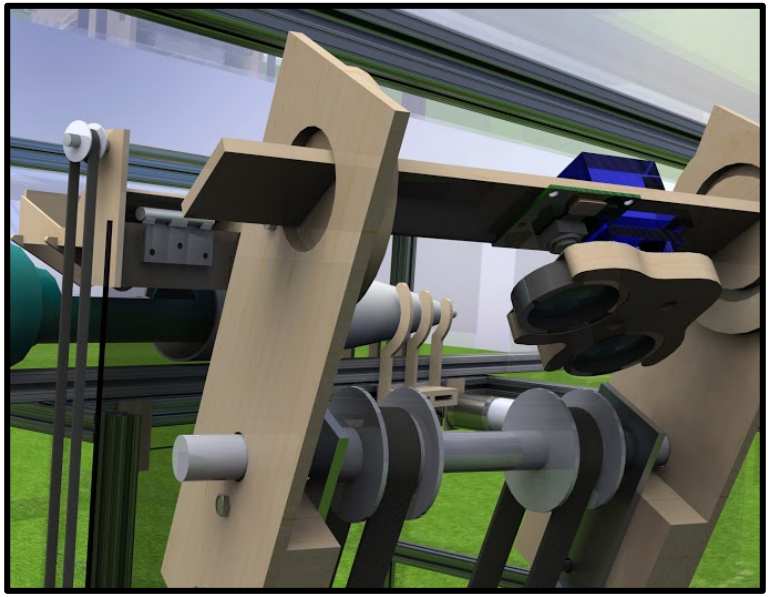
Construction Practices

- 80/20 cut lengths generated from CAD weldment cut list
- 80/20 structure built in modules for rapid on-site assembly
- Lasercut plywood components have screw clearance hole



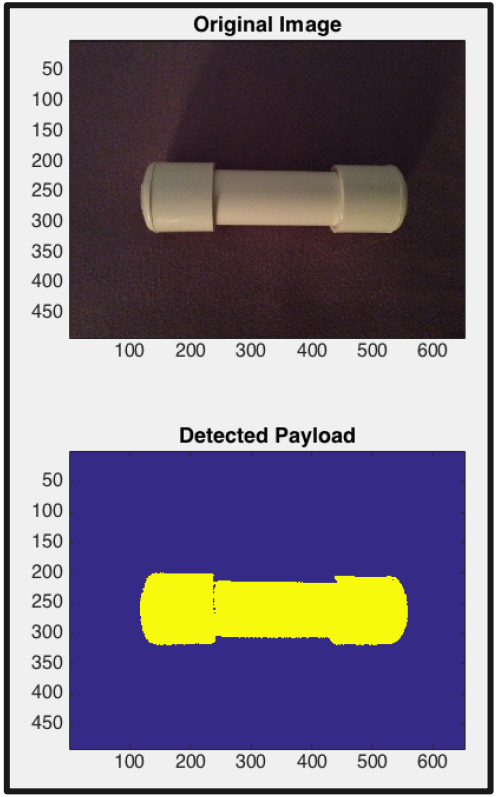
Camera Tracking

- Captures visible and infrared images
- Feeds images to Raspberry Pi
- Images are classified to determine if payload is present
- If payload is found location is determined
- If payload is not found, system moves horizontally and repeats



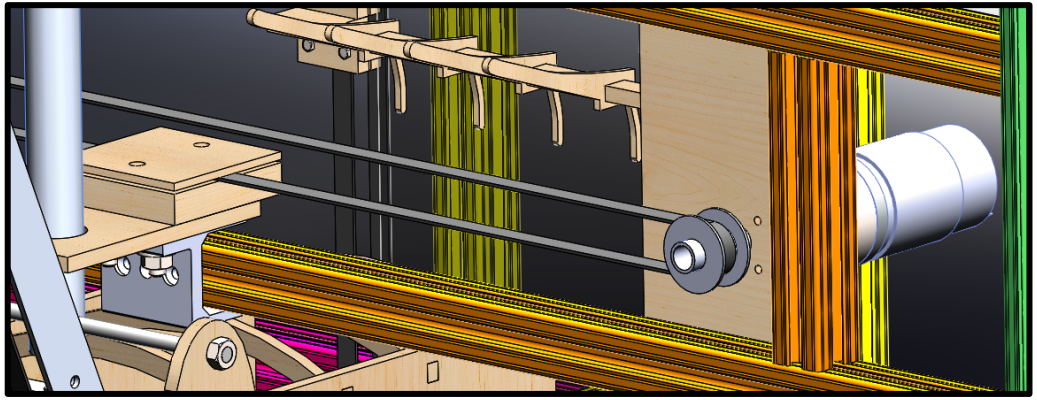
Proof of Concept

- Current Python implementation showing strong payload recognition on Raspberry Pi
- Only visible image used in image to the right
- Inclusion of infrared image will increase accuracy
- More training data from real system will increase accuracy



Horizontal Scanning System

- Timing belt drives mobile belt module across AGSE's length
- Stepper motor drives pulleys
- Scanning continues until payload is found

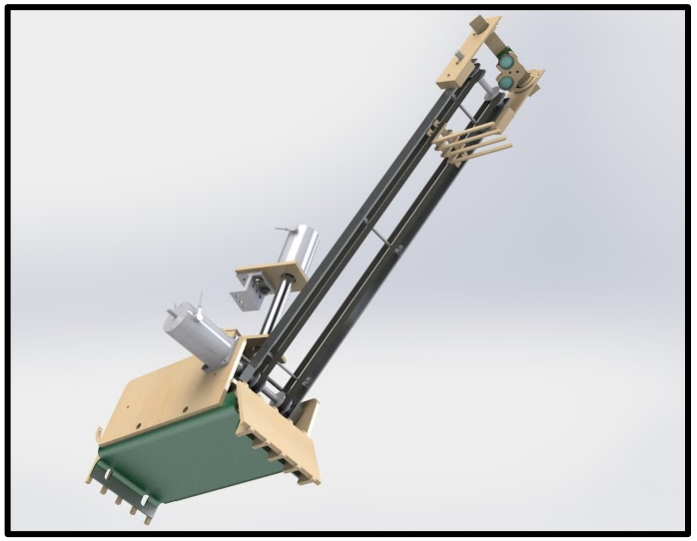


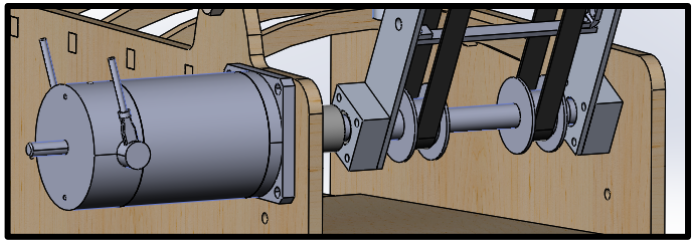
Stepper Motor Resistors

- High power resistors are imperative to run the stepper motors
  - TE Connectivity HSA25 Aluminum Housed Power Resistors
- Safety Concerns:
  - Resistors run at 24 Watts
  - Reaches at least 70 degrees Celsius: resistors boiled ethanol
  - Surrounded by sensitive components
- We propose adding fans (one for each resistor) in order to cool the resistors to a safe temperature

Mobile Belt Module

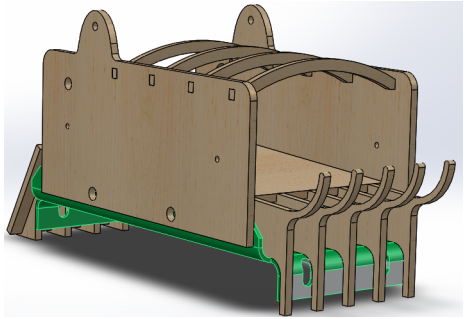
- Belt module strafes and pivots to align with payload
- One way bearings couple conveyor structure and drive shaft
  - One motor lowers conveyor and turn pulleys

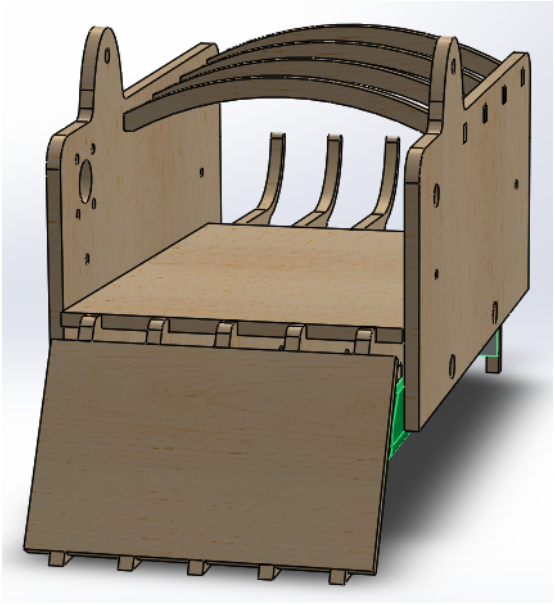




Payload Ramp

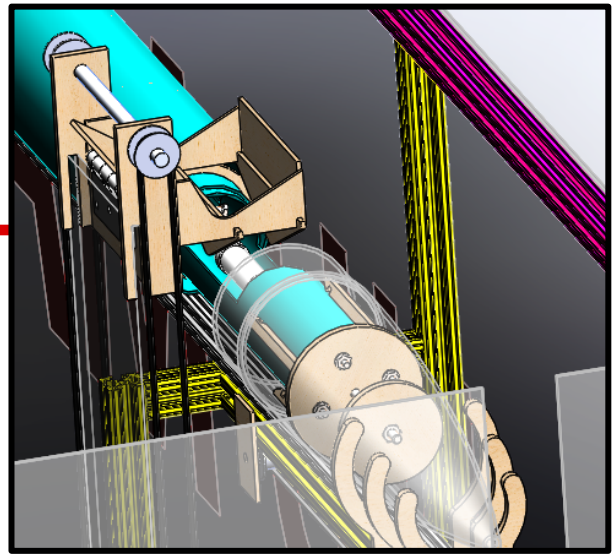
- Plywood structure built on McMaster Ball Transfer Conveyor Plate
- Plywood structure bears load of shaft
- Plywood wall has motor mount holes
- Cradle in rear of ramp holds payload during travel to elevator

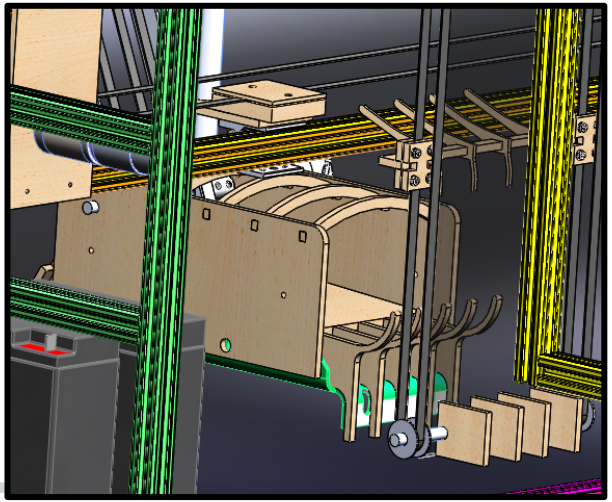




Elevator System

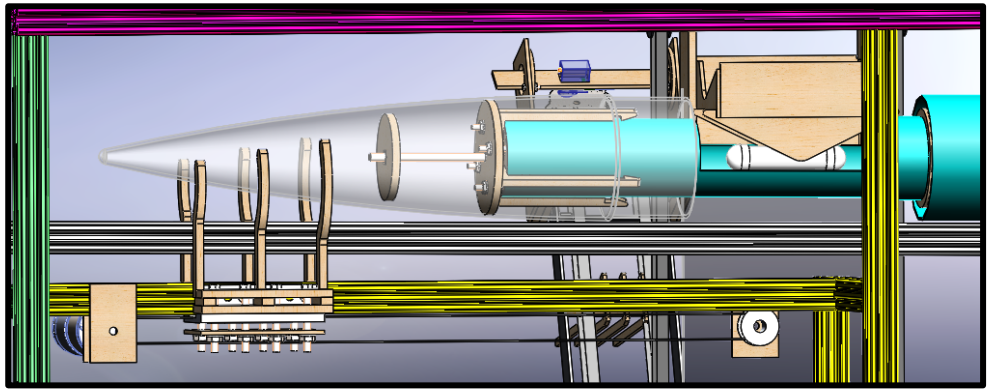
- Payload ramp slides in front of elevator
- Elevator hooks slide in between cradle hooks to receive payload
- During elevation payload rests on backboard
- Ramp guides payload into rocket

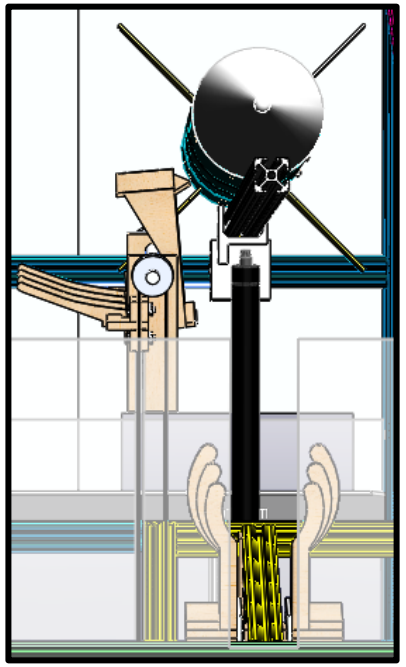




Nosecone Closure System

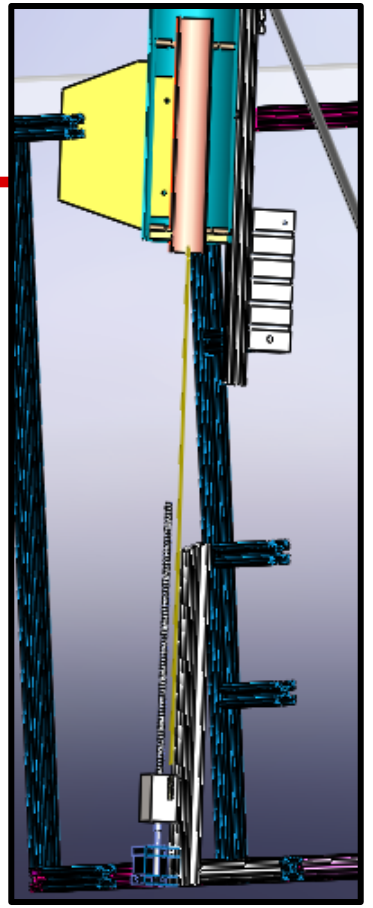
- Belt driven arm pushes rocket shut
- Snap features inside payload bay form seal
- Payload ramp pivots on hinge to allow rocket to erect



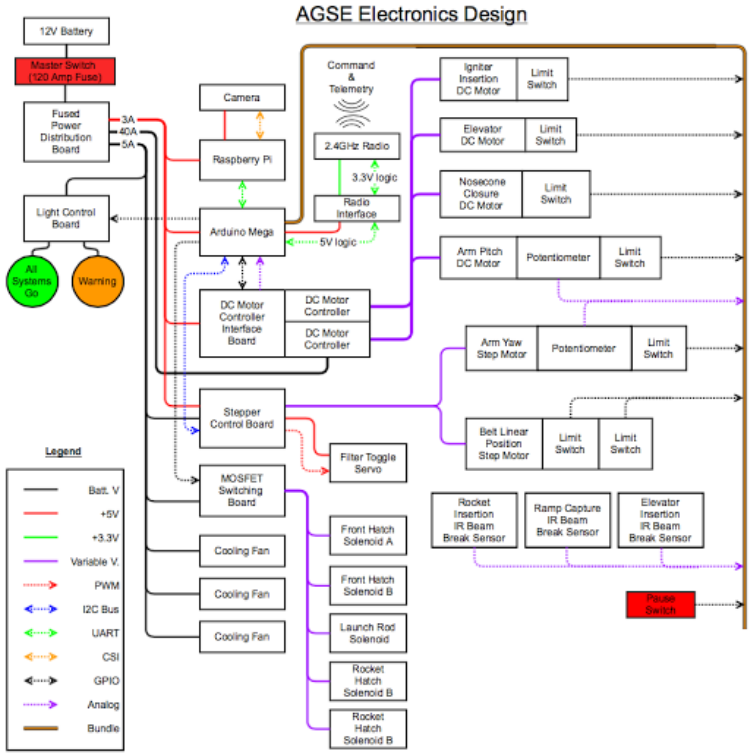


Rocket Rotation and Ignition

- Rocket erection driven by gas spring
- Mechanical stop at correct launch angle
- Ignitor driven by power screw



AGSE Electronics



AGSE Test Plan

- Payload Tracking
  - Optimize vision system code through speed tests
  - Test with variables such as shadows, bright spots
- Insertion tests
  - Repetitively test payload ramps for failure frequency
  - Ensure payload rolls straight on ramps, under rakes

The End

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