NC STATE UNIVERSITY HIGH POWERED ROCKETRY CLUB

2015-2016 FLIGHT READINESS REVIEW

Tacho Lycos

FRR Overview

1. Launch Vehicle
   - Layout
   - Recovery
   - Performance
2. Full Scale Launch
   - Predictions
   - Results
3. AGSE Design
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   - Construction
4. AGSE Subsystems
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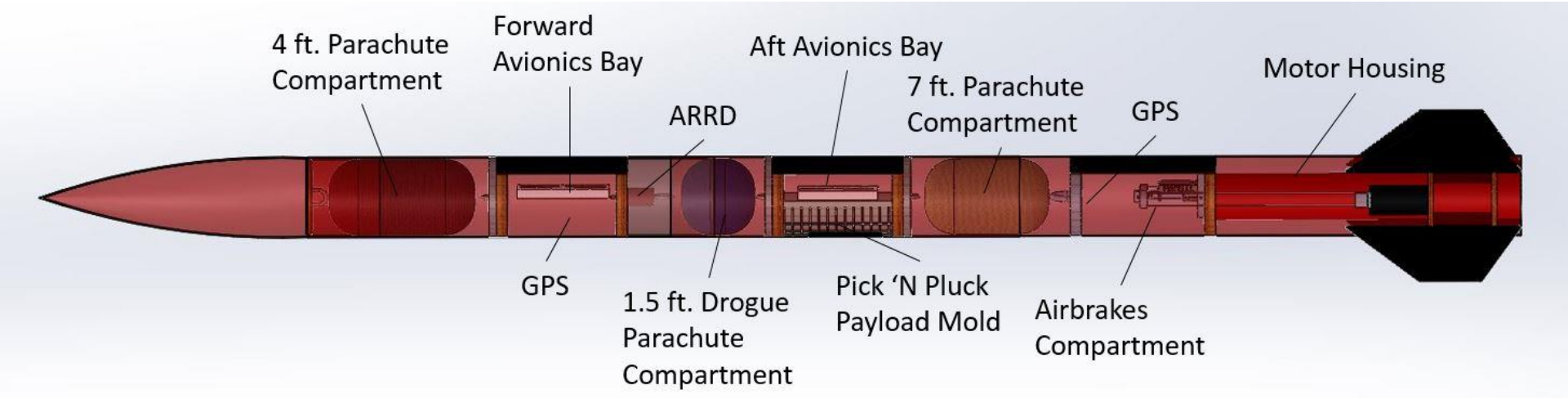
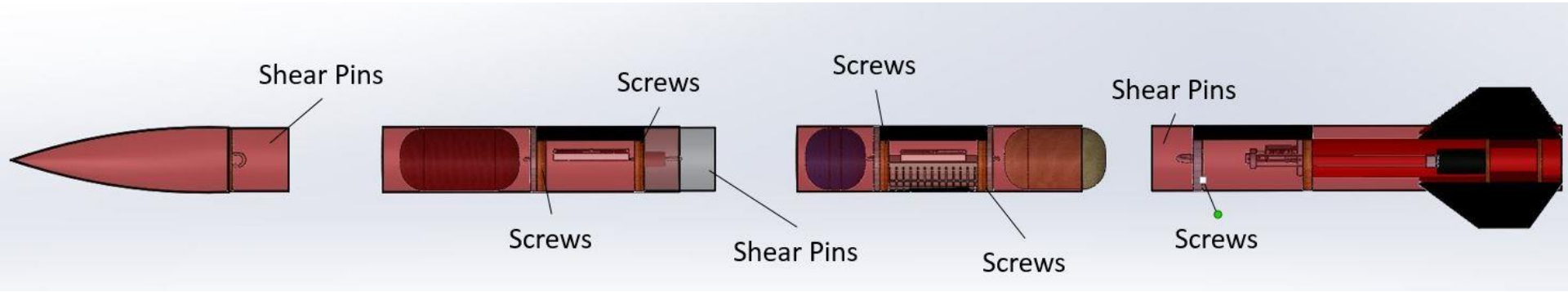
   - Rocket Raising System
   - Igniter Inserter
5. Requirements Verification
6. Conclusion

Vehicle Design - Layout

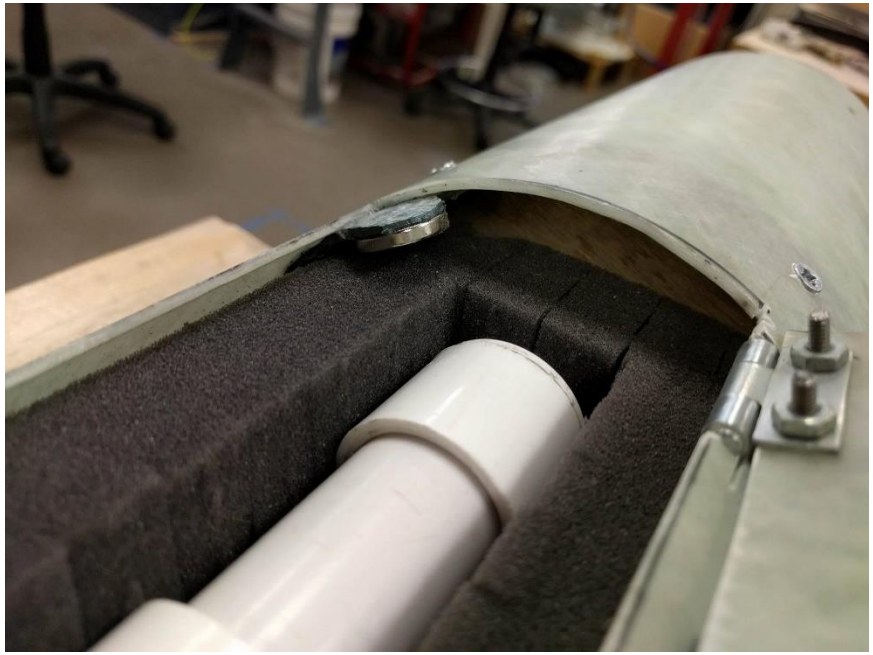


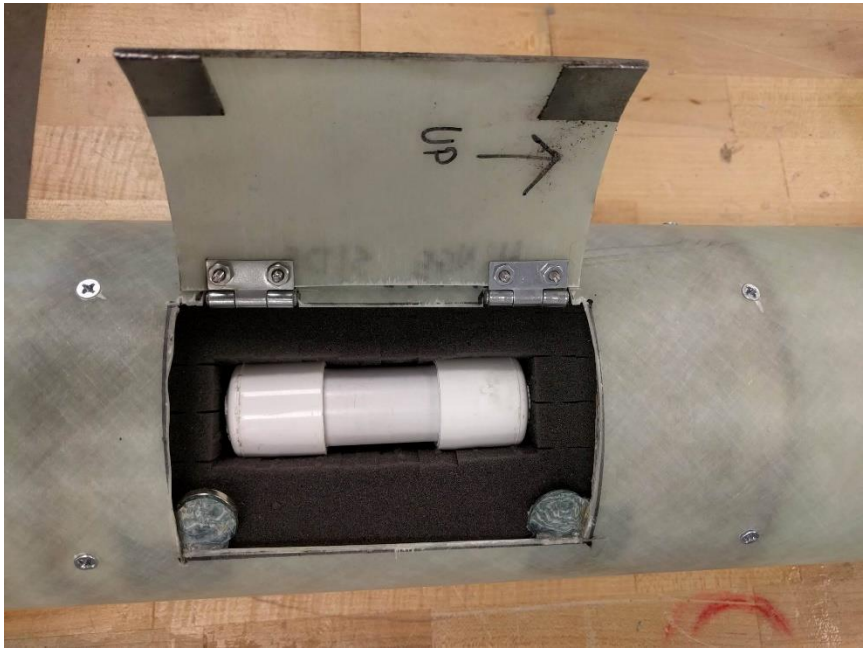


Vehicle Design - Weight

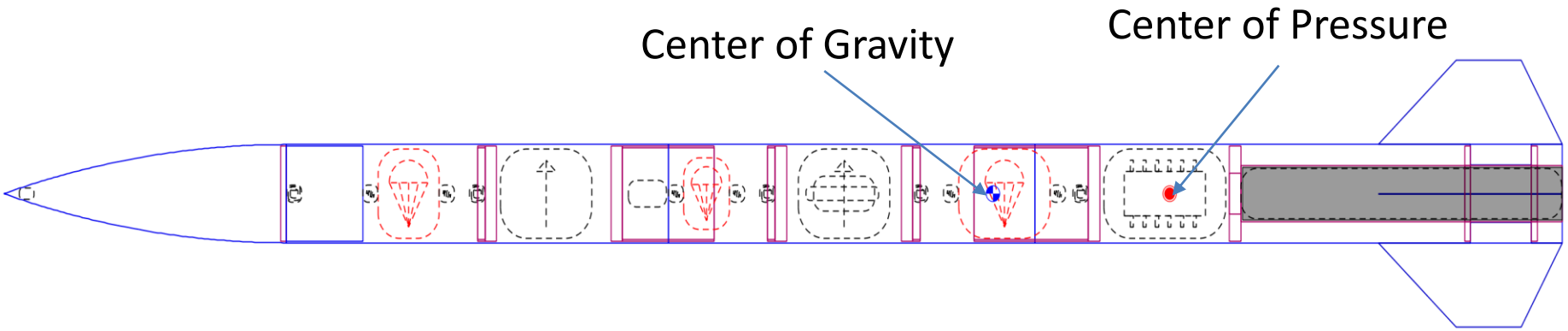
Component	Pounds
Nosecone	3.0
Forward Airframe	5.2
Aft Airframe	4.9
Fin Section	8.8
Motor	8.1
Parachutes	3.1
Total	33.7

Payload Integration



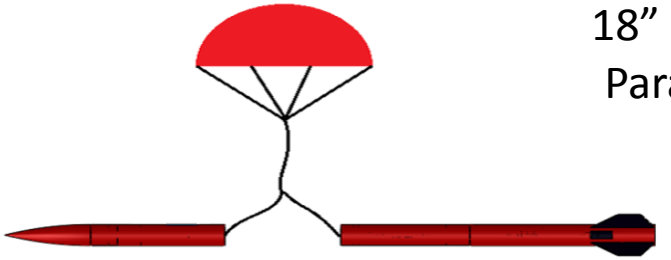


Flight Stability



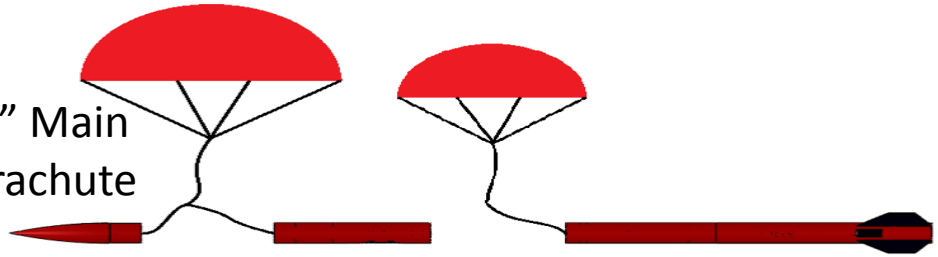
- Center of Pressure (inches from nose): 76.3
- Center of Gravity (inches from nose): 64.5
- Static Stability Margin: 2.15
- Verified using OpenRocket, Barrowman's Equations, and Fluent CFD which were +-0.1 from actual

Vehicle Recovery– Event Sequence



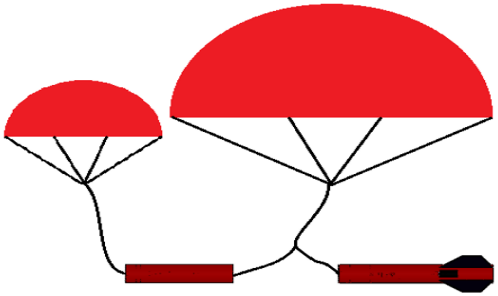
18” Drogue Parachute

Apogee



48” Main Parachute

1000 ft



84” Main Parachute

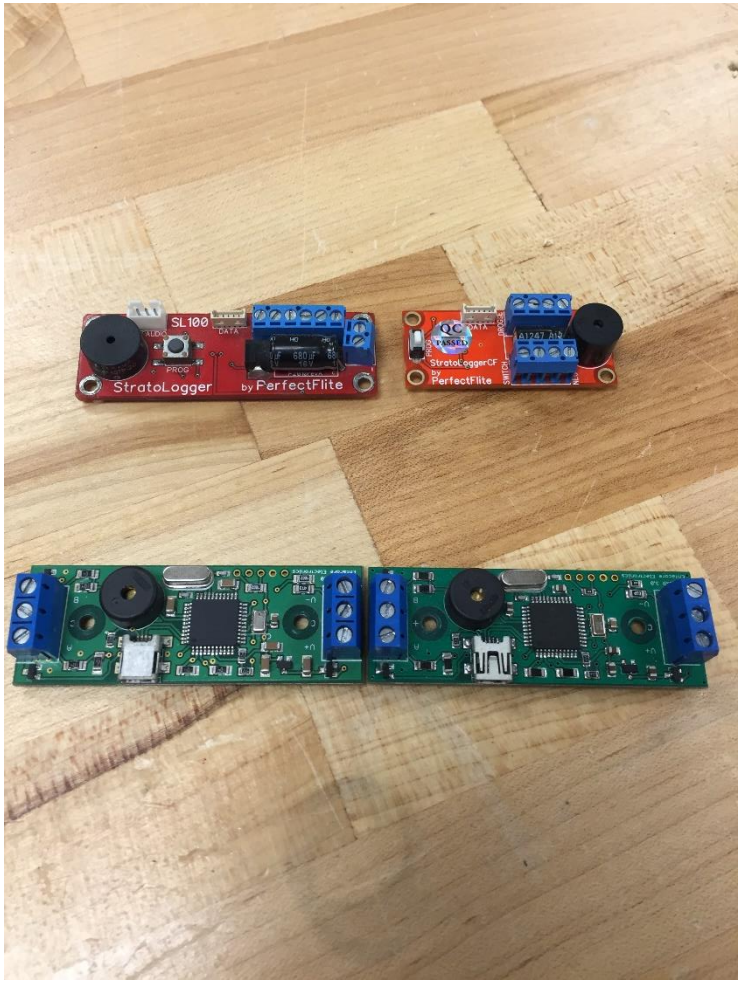
700 ft

Vehicle Recovery - Parachutes

- 92.9 feet per second on the drogue parachute, slowing the entire rocket after apogee
- 75.6 feet per second for the drogue, slowing only the lower airframe
- 20.2 feet per second for the 48” main, slowing the nosecone and upper airframe section
- 14.6 feet per second for the 84” and drogue, slowing the middle airframe section and fin section

Vehicle Recovery - Avionics

- Two avionics compartments:
  - Stratologger SL100, Stratologger CF, two Entacore AIM 3.0 altimeters, 9V batteries, 3D printed ABS sled, and GPS
  - Forward avionics: ARRD 1100’, nosecone from upper airframe 1000’
  - Aft avionics: Drogue charge at apogee, Aft and fin section at 700’



Vehicle Recovery System - Tests

Ejection Tests

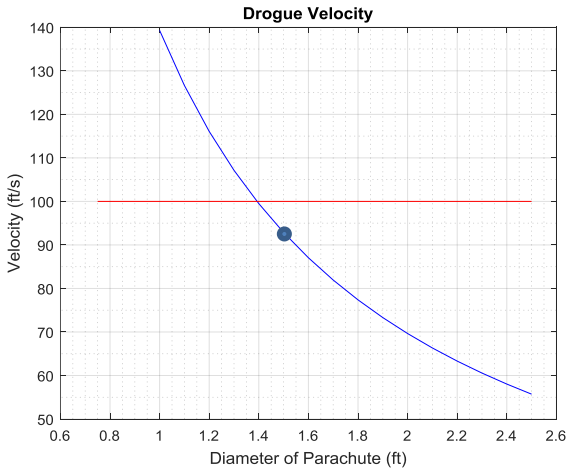
- Drogue Chute 2.1 g charge
- Main Chute 3.3 g charge in nose
- Main Chute 2.2 g charge in fin section

ARRD performance tests

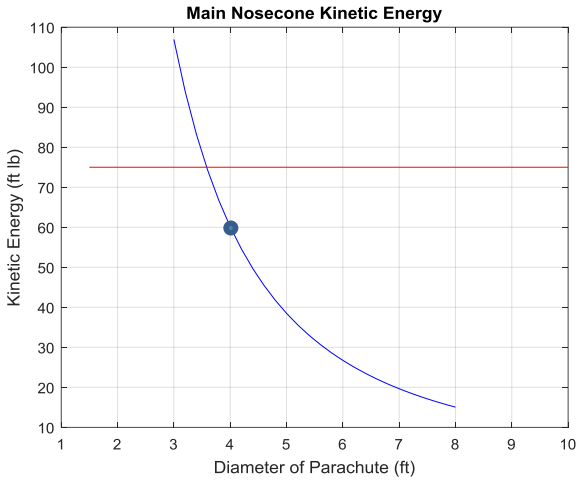
- Complete release of eye-bolt on all tests
- Successful at 0.1 grams black powder

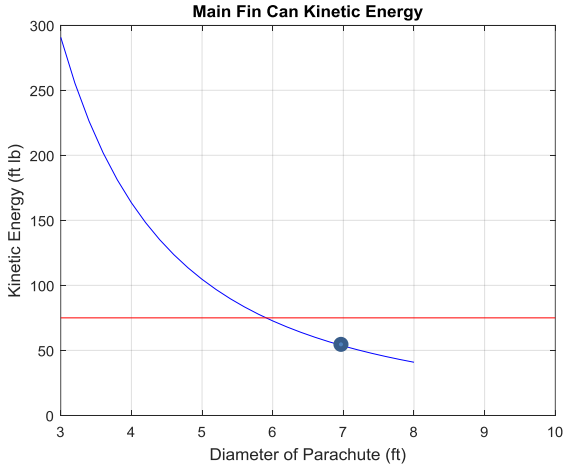
Mission Performance – Kinetic Energy

Vehicle Under Drogue Velocity



Main Nosecone Kinetic Energy





Main Fin Section Kinetic Energy

Vehicle Recovery - Wind Drift

Lateral Drift Due to Wind, 5° Launch Angle Into the Wind

Wind Speed (Miles per Hour)	Distance From Launch Site (Upper Airframe)	Distance From Launch Site (Lower Airframe)
0	460	461
5	369	395
10	1198	1251
15	2027	2108
20	2856	2965

Lateral Drift Due to Wind, 5° Launch Angle with the Wind

Wind Speed (Miles per Hour)	Distance From Launch Site (Upper Airframe)	Distance From Launch Site (Lower Airframe)
0	460	461
5	1289	1317
10	2118	2174
15	2947	3030
20	3776	3886

Vehicle Performance - Wind

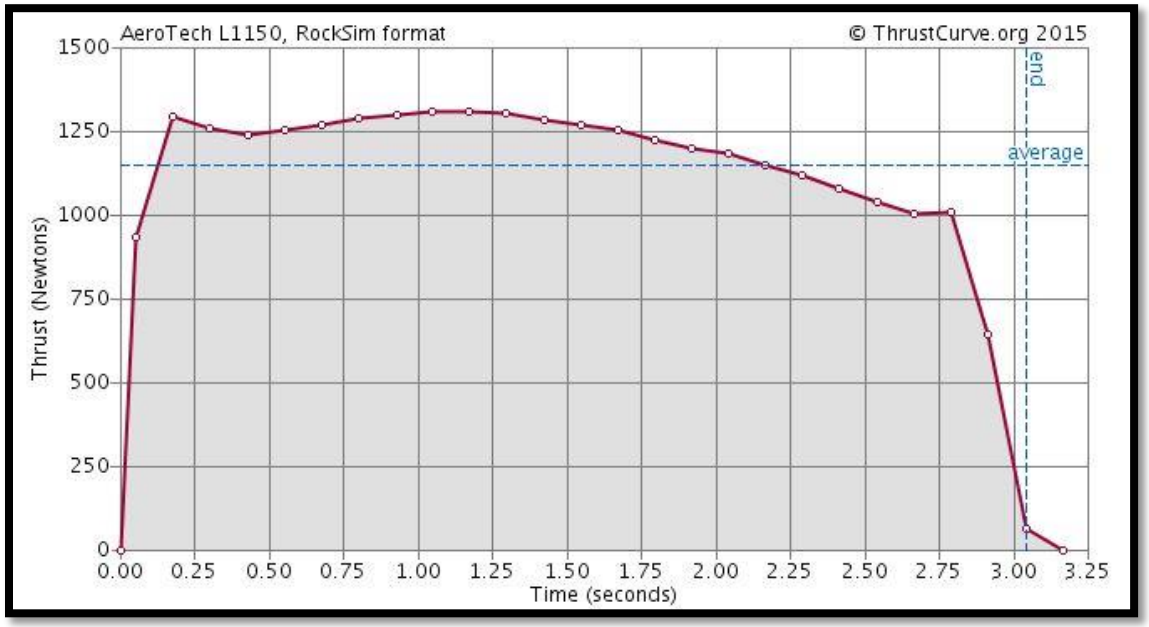
Altitude Variance Due to Wind, 5° Launch Angle

Wind Speed (Miles per Hour)	Apogee of Rocket(feet)
0	5519
5	5463
10	5415
15	5357
20	5305

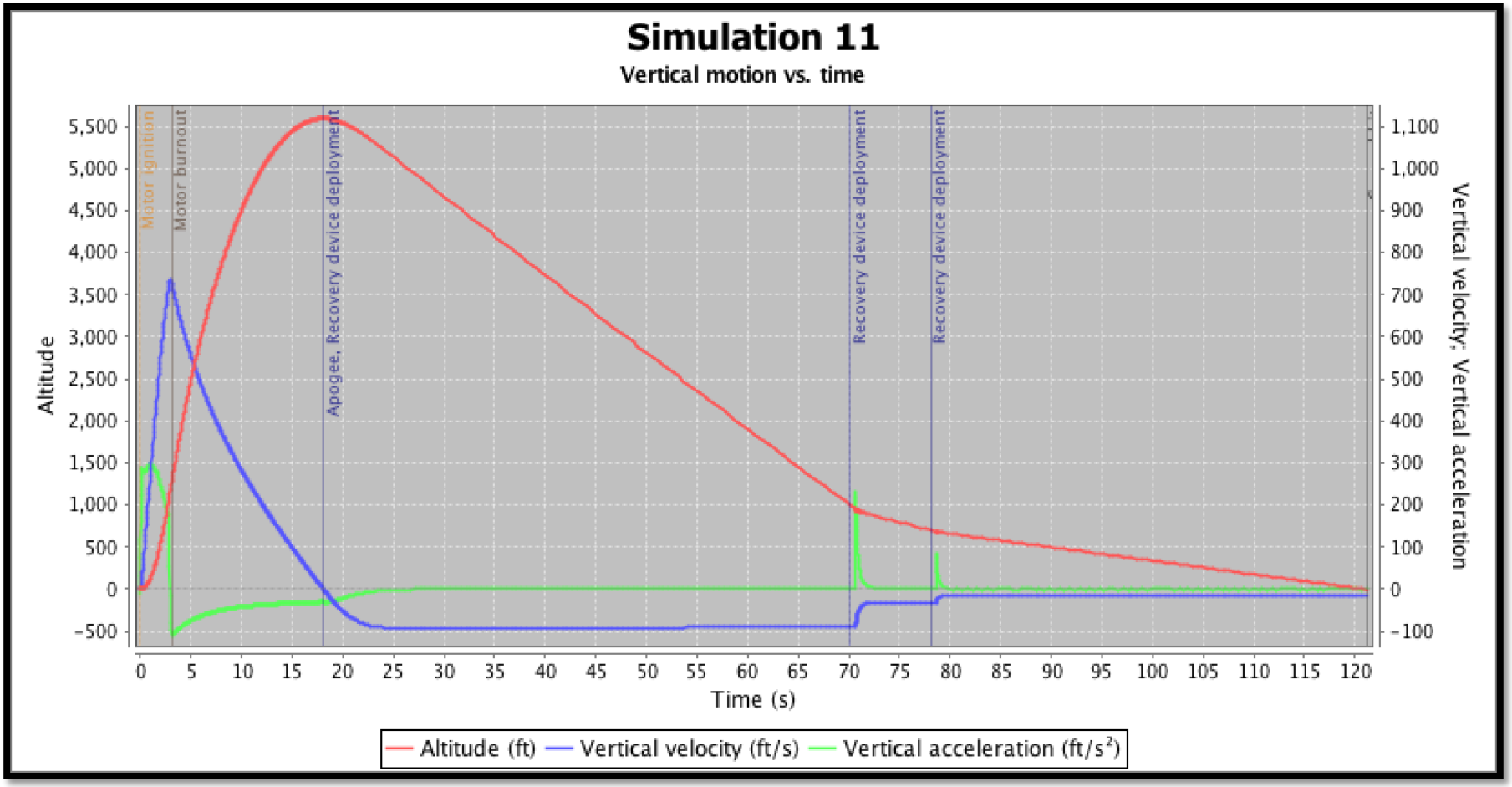
Vehicle Design – Motor Selection

AeroTech L1150-R

- Weight: 8.10 pounds
- Length: 20.9 inches
- Maximum: 294 pounds
- Total impulse: 784 lb-s
- Burn time: 3.0 seconds
- Thrust-to-weight ratio: 8.047:1

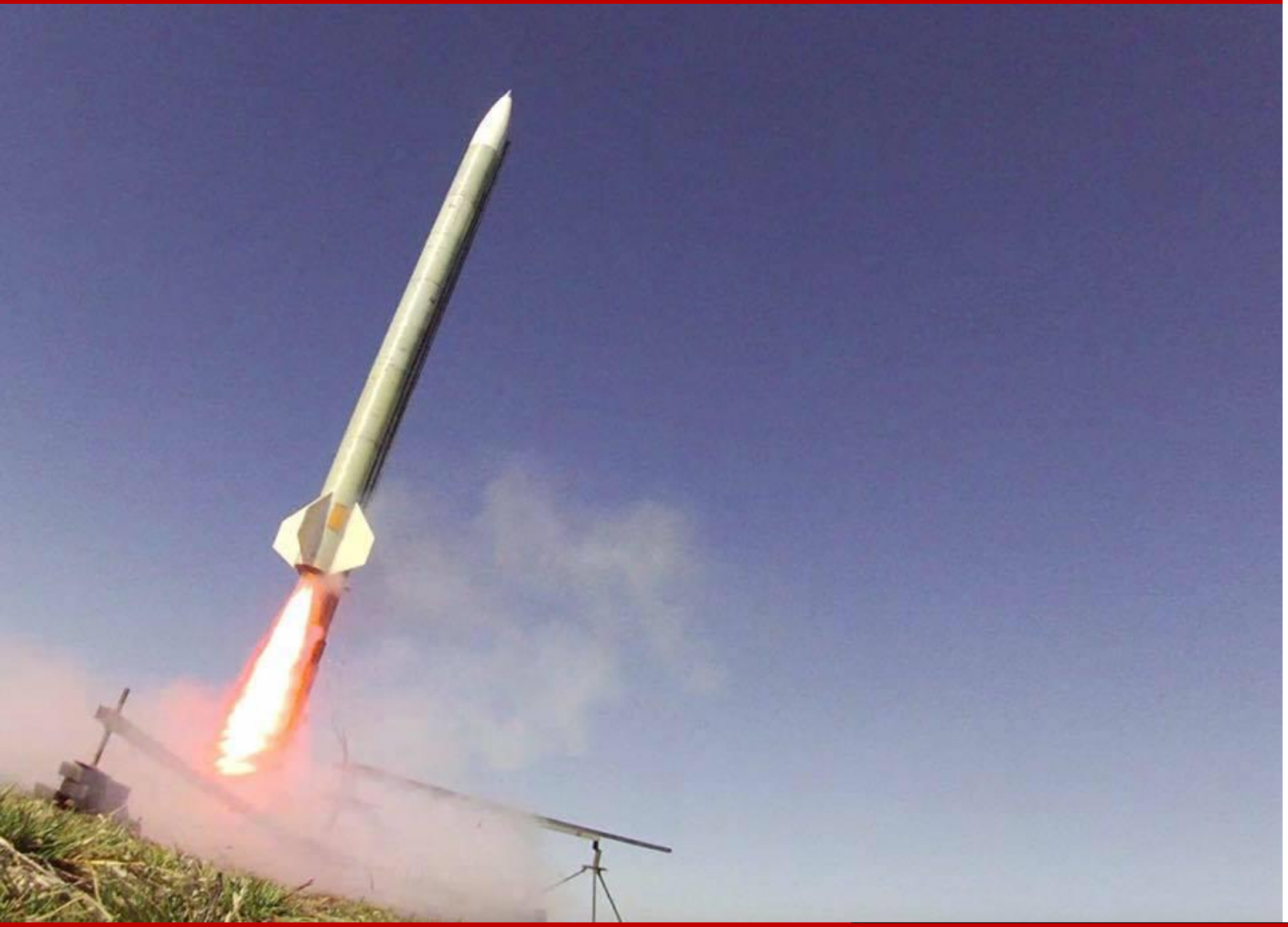


Vehicle Performance– Flight Profile

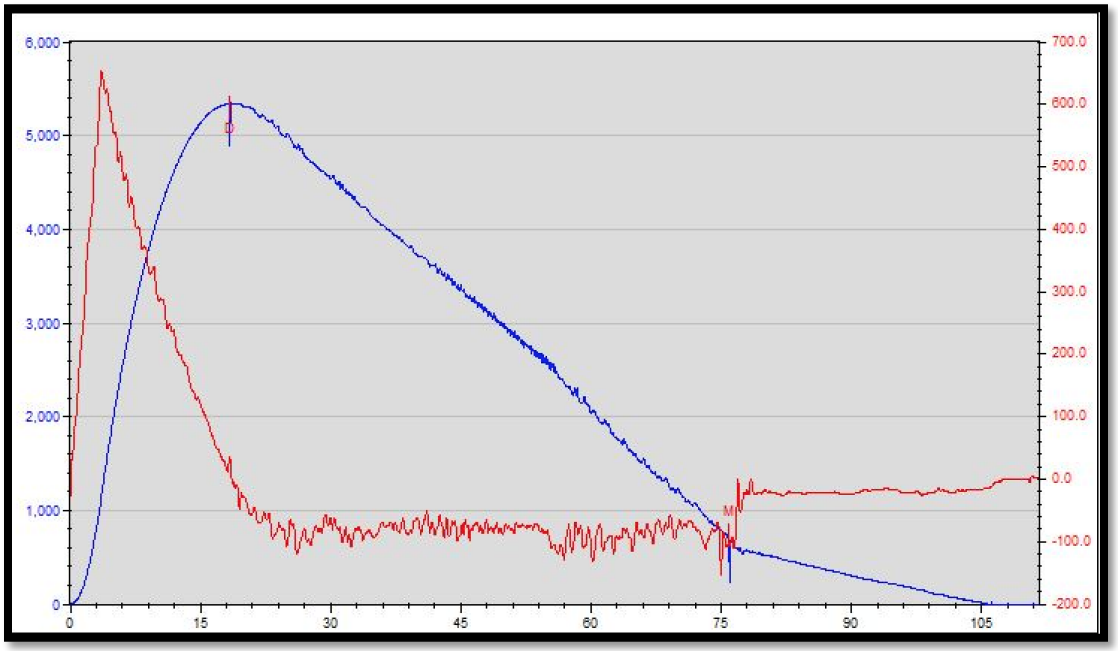


OpenRocket Simulation using AeroTech L1150

Full Scale Launch

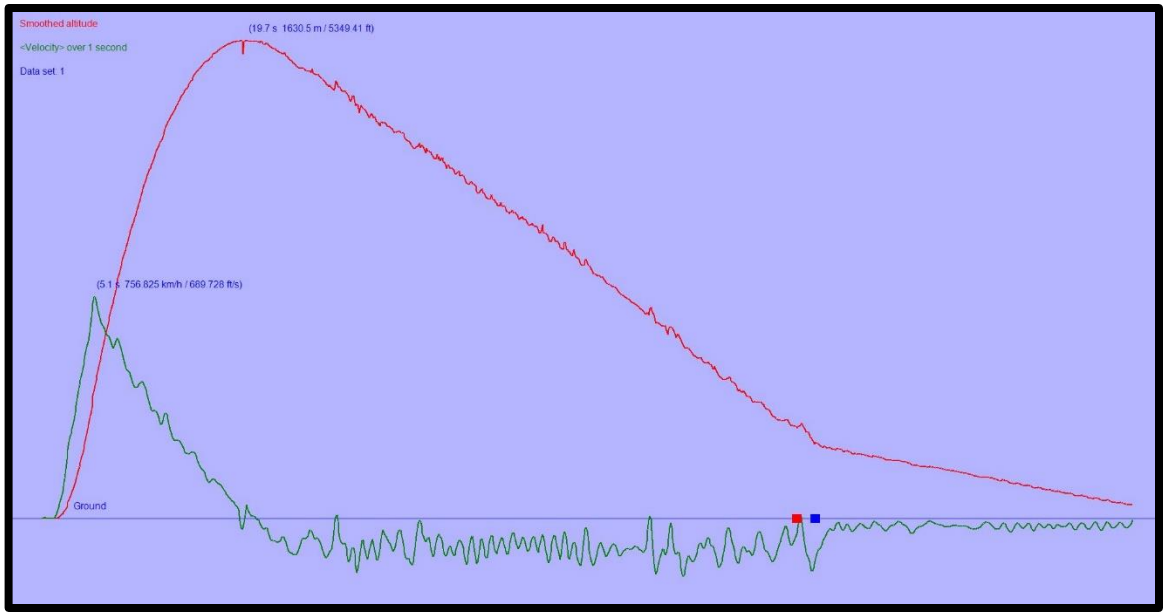


Stratologger CF Data



- Apogee: 5344 ft
- Time: 105 sec
- Max Velocity: 678 ft/s
- Apogee Delay: 1 sec
- Main Chute Deployment: 700 ft

Entacore Data



- Apogee: 5349 ft
- Time: 105 sec
- Max Velocity: 689 ft/s
- ARRD Deployment: 1100 ft
- Main Chute Deployment: 1000 ft

Entacore AIM 3.0 Data

AGSE DESIGN

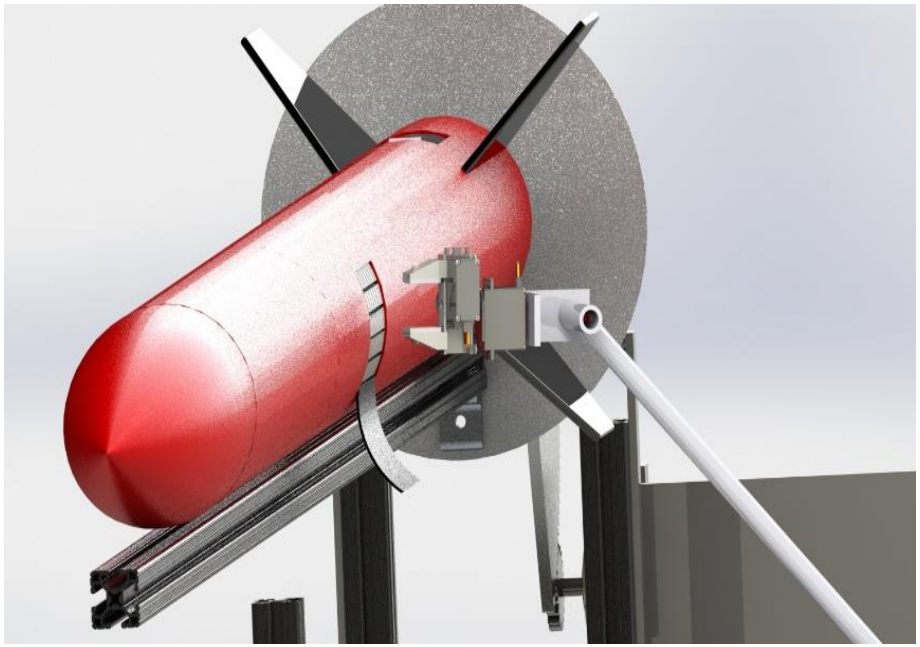
AGSE DESIGN - WEIGHT

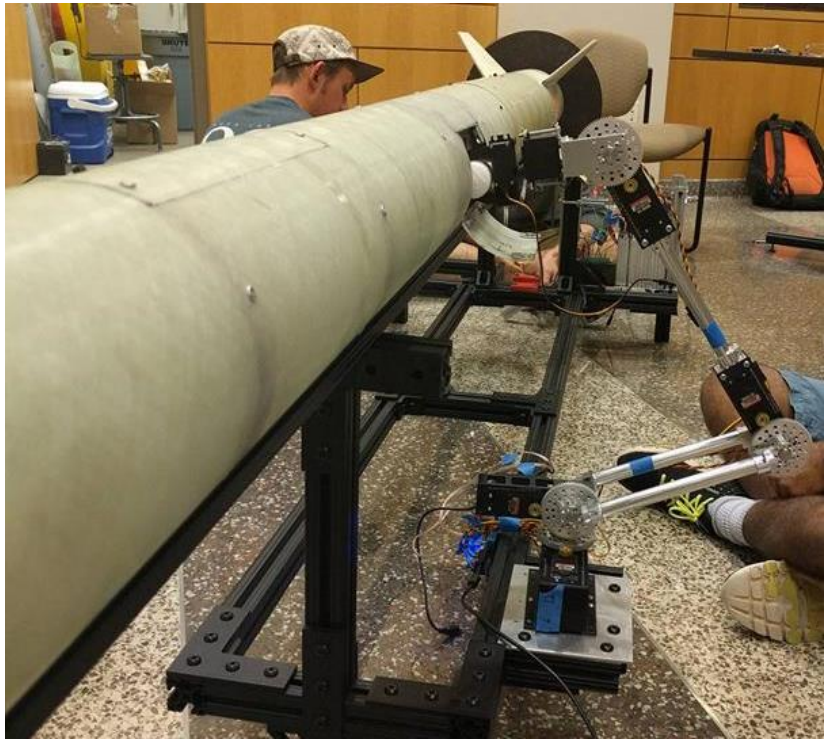
Component	Pounds
Robotic Arm Subassembly	4.2
Igniter Insertion Subassembly	5.9
Rocket Erection Subassembly	13.0
Launch Rail	8.8
Supporting Frame and Electronics Box	49.7
Blast Plate	3.9
Total	85.5

AGSE DESIGN - SIZE

Component	Inches
Length	132
Width	31.5
Height	26
Total Volume	62.56 ft^3

AGSE DESIGN





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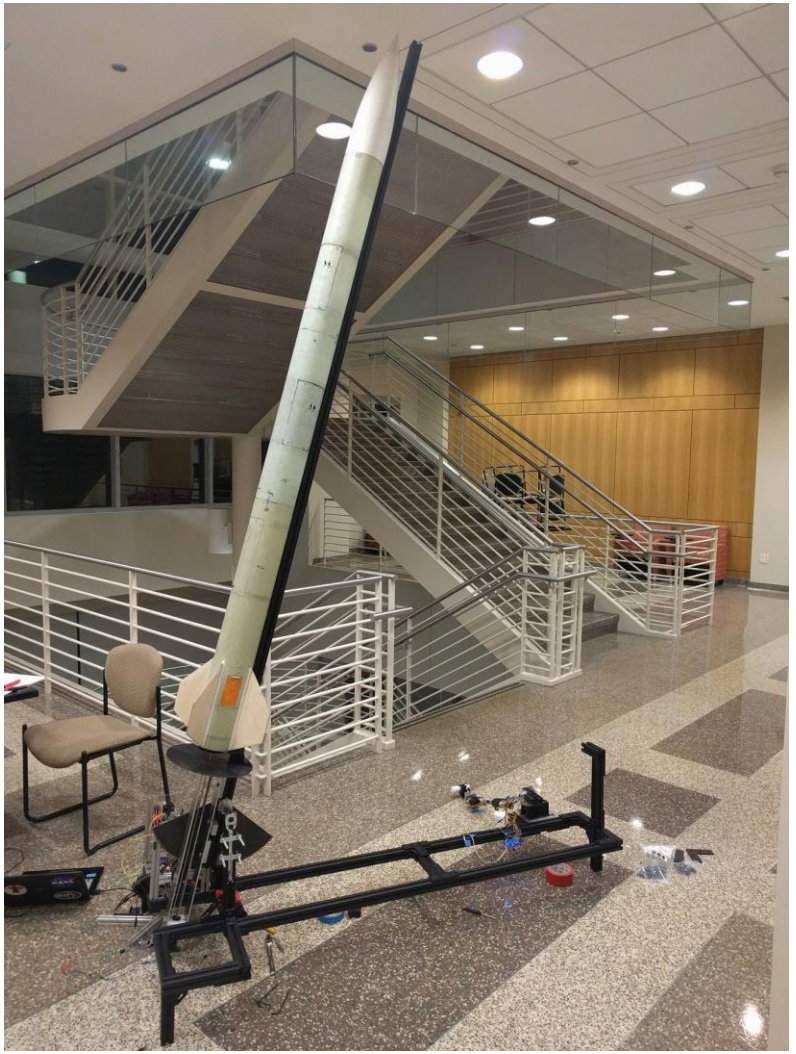
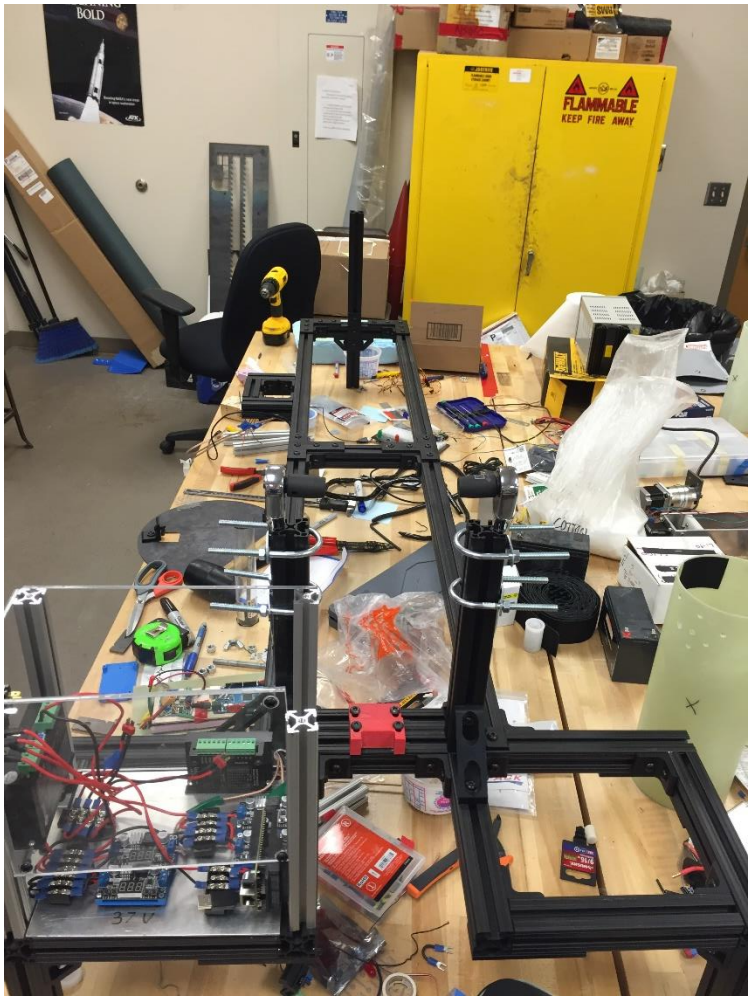
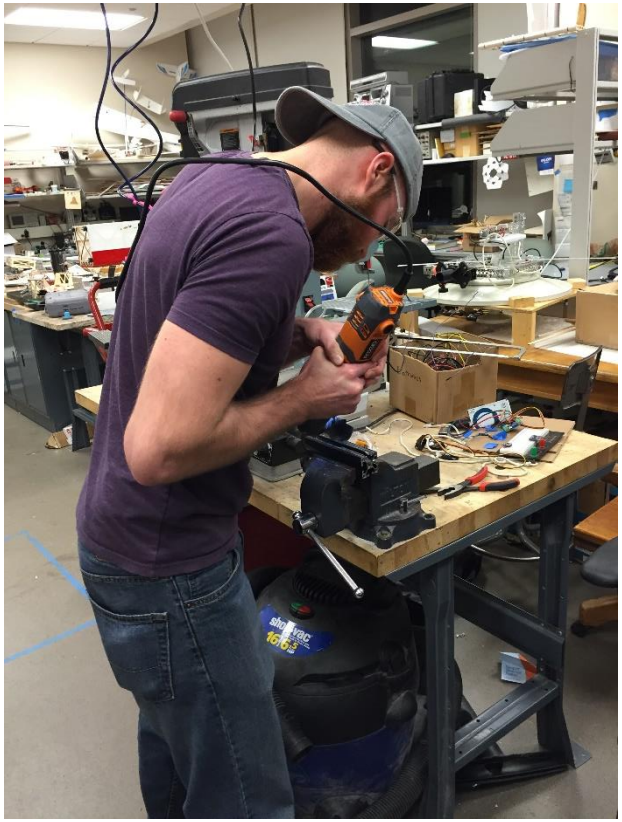
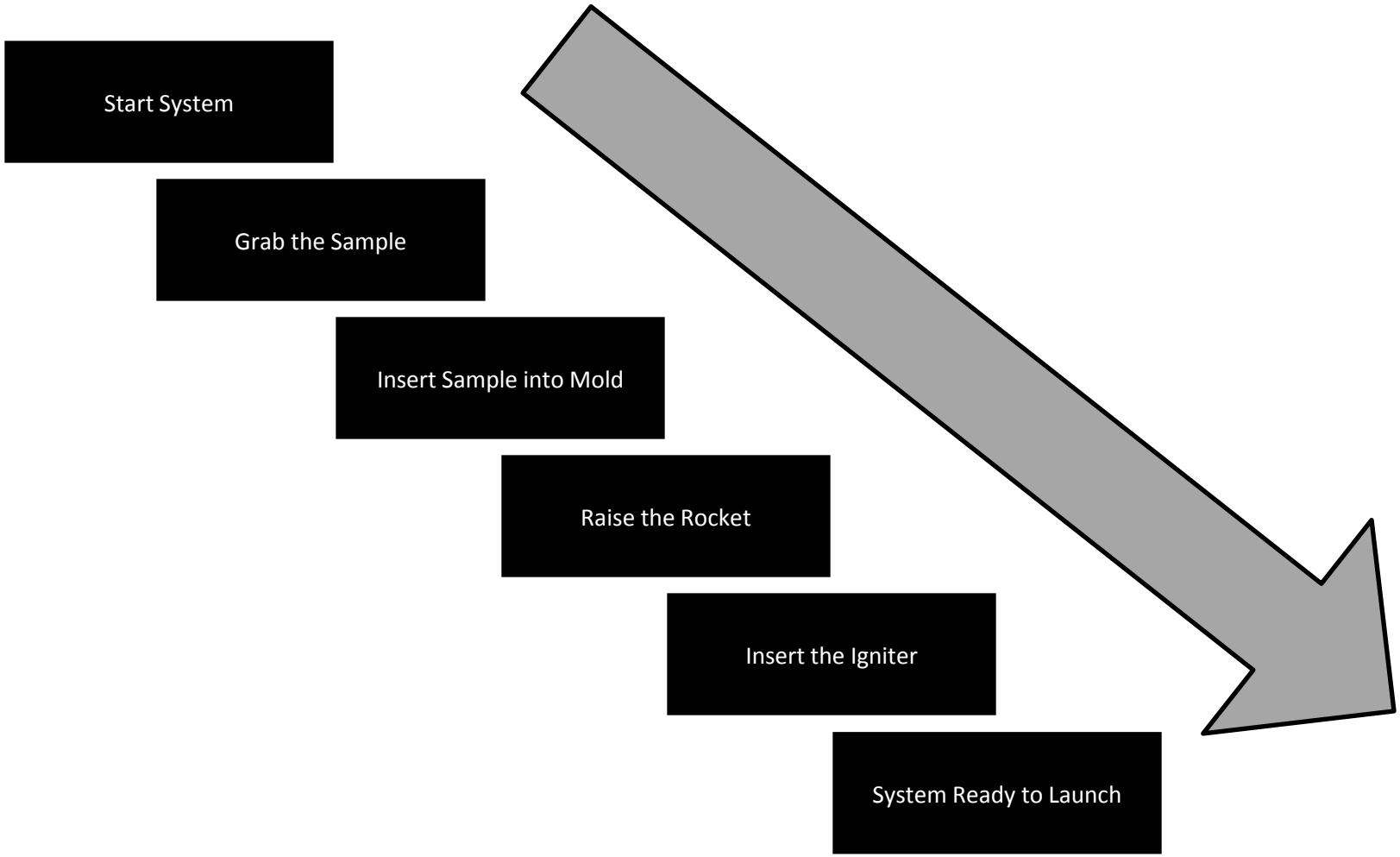


AGSE Construction





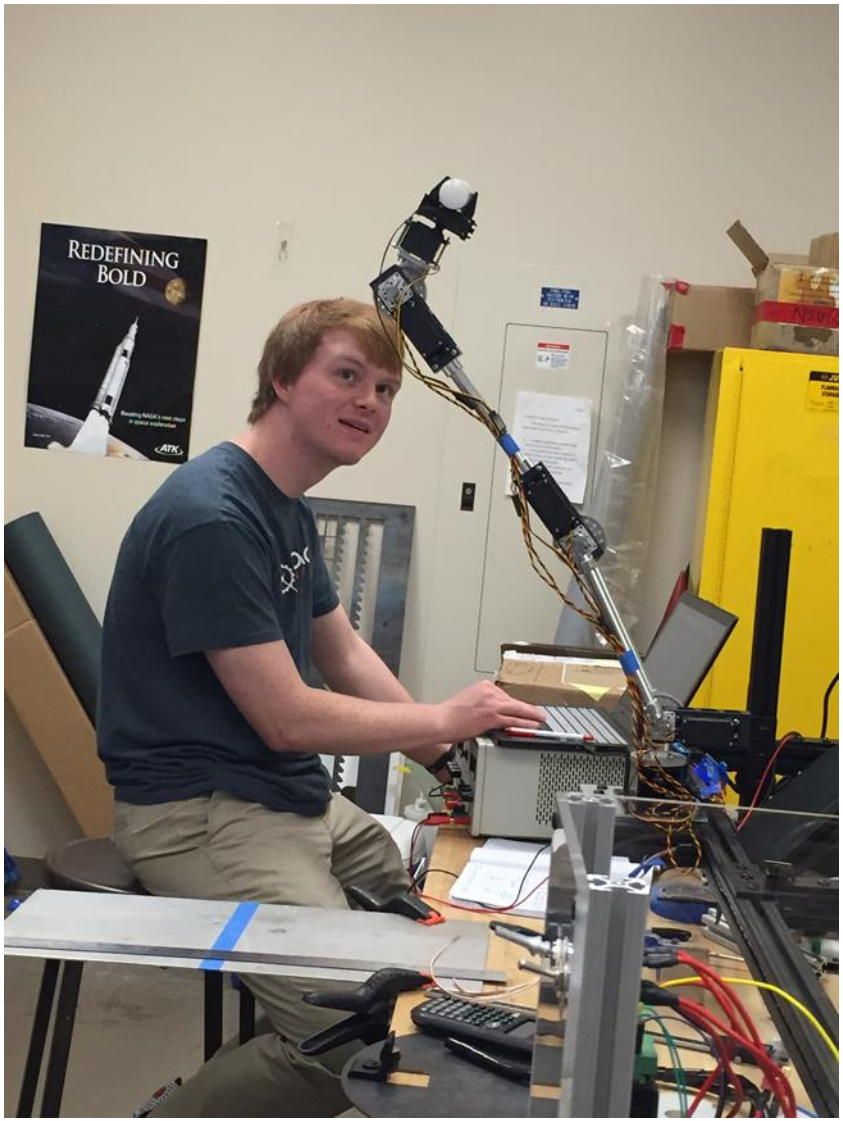
AGSE - Progression



Interfaces

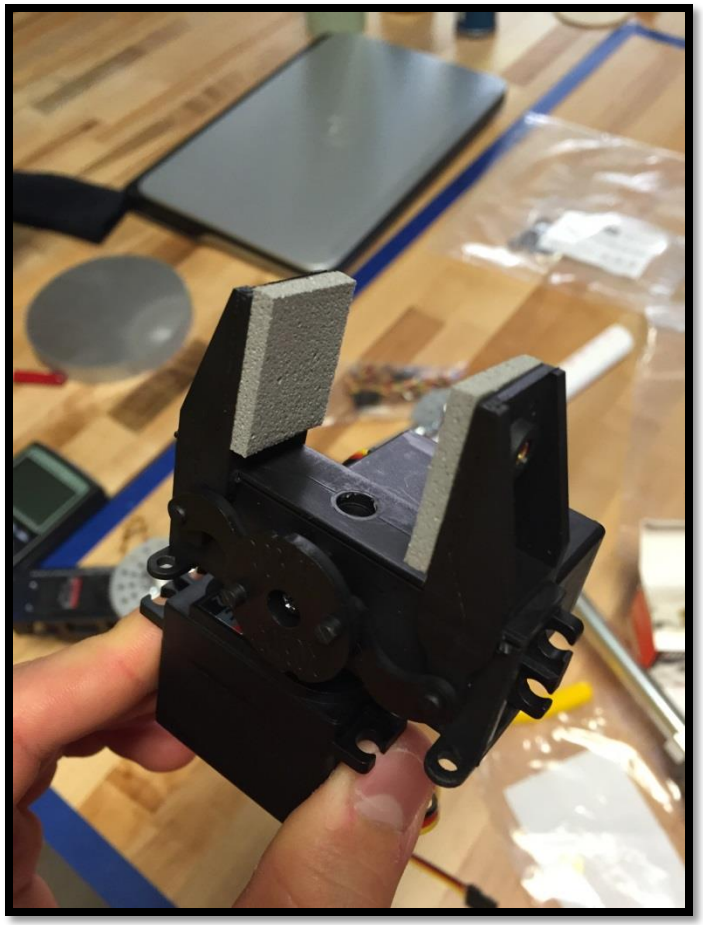
- AGSE and Launch Vehicle
  - Kill and pause switches on AGSE
  - Indicator LED on AGSE
  - Altimeter switches on Launch Vehicle
- Ground Station
  - AGSE Monitor
  - BRB900 GPS Tracker

Robotic Arm



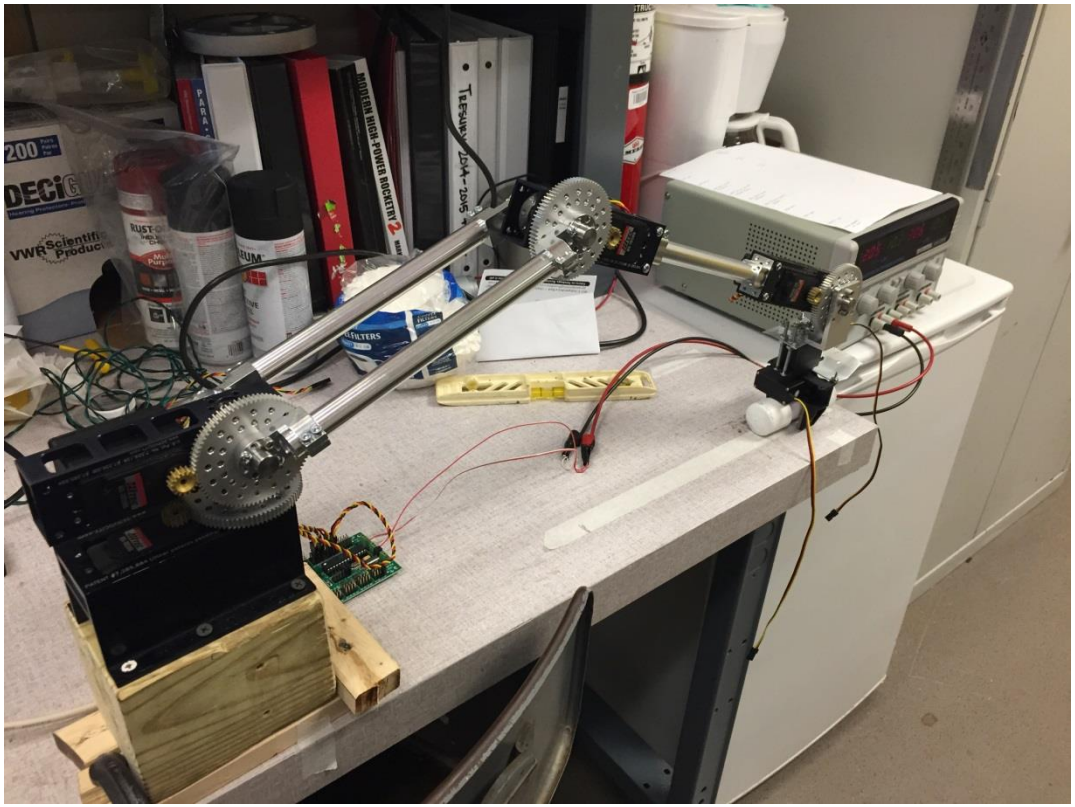
- 4 Degrees of Freedom
- 5:1 Gear Ratio
- 252 degrees of rotation at each joint
- Able to lift ~1 pound at 24 inches
- Uses 11.4 Volt power supply and has up to 10 amp current draw

Gripper



- Provides 2 additional Degrees of freedom
- 180 degrees rotation around wrist
- Able to open 1.3 inches
- Uses up to 6.4 Volt power supply

Arm Experiment

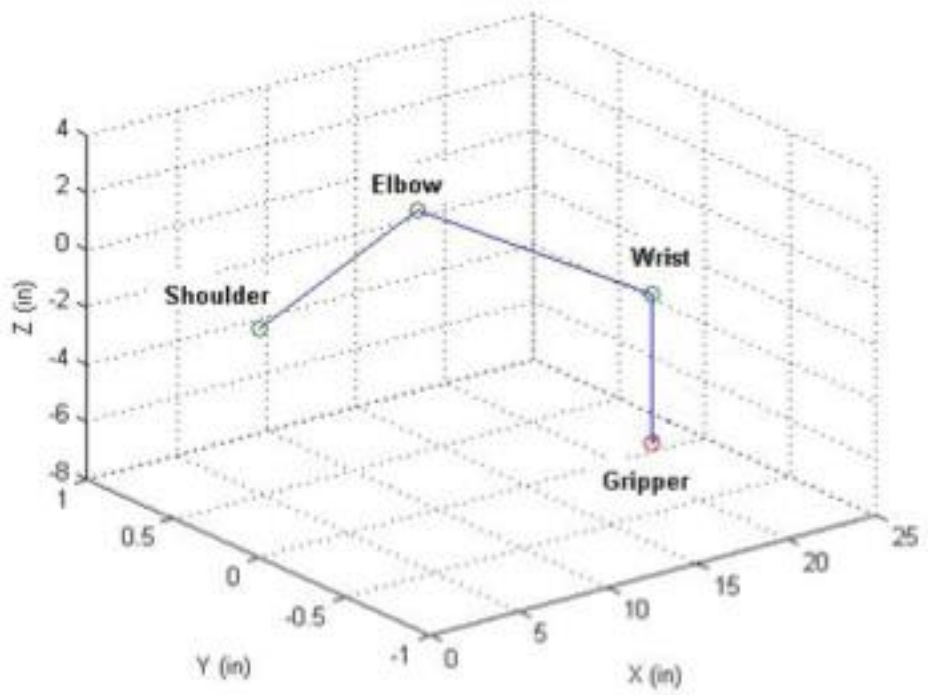


- 2 designated locations
- Sample was placed at each location
- Arm commanded to move to each location several times
- Code used in conjunction with servo utility

Arm Experiment

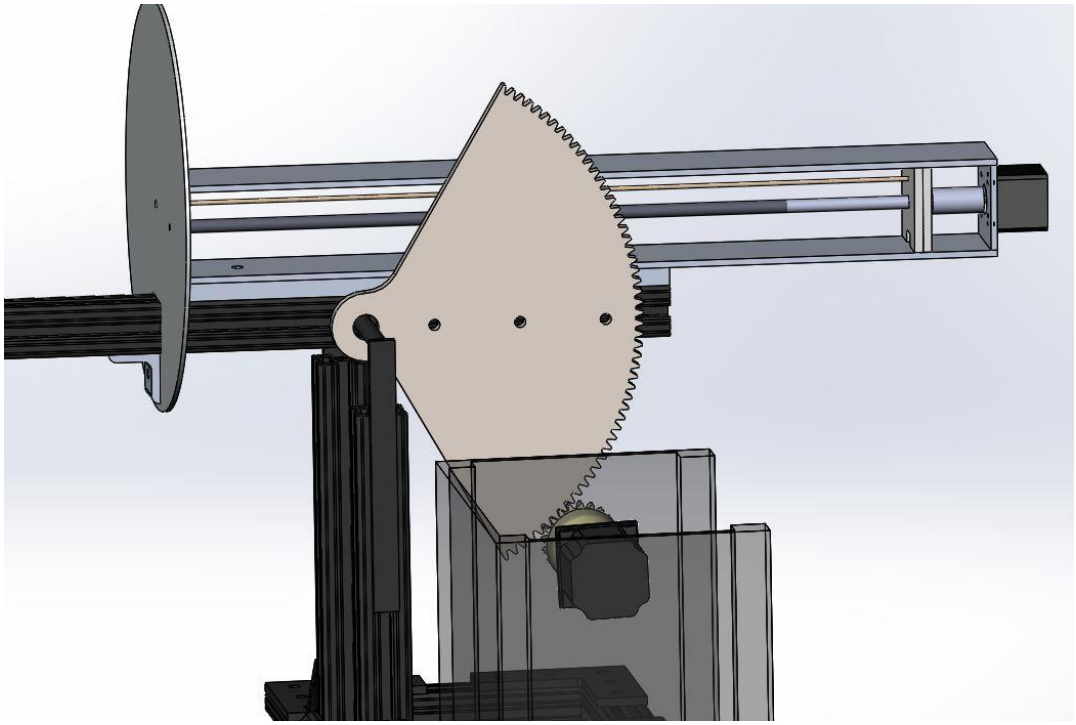
Robotic arm grappling payload sample

Model of Arm



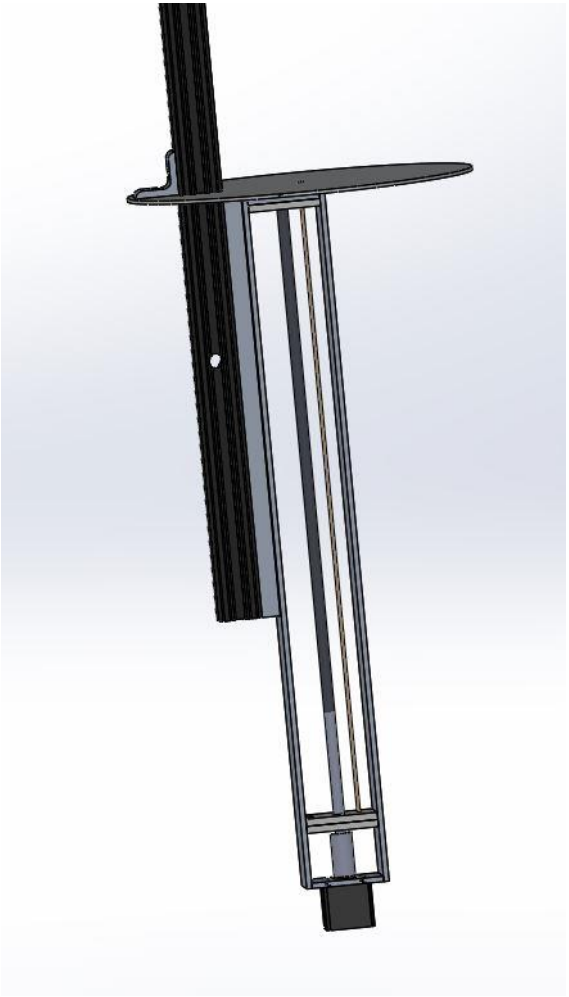
- MATLAB used to plot arm at different servo angles
- Code calculates angles and servo pulse widths

Raising the Rocket



- Sector Gear
  - 8 in radius
  - Mounted to the side of launch rail
- Drive Gear
  - 1 in radius
  - Keyway for connection to motor
- Planetary Gearbox Stepper Motor
  - NEMA 23 frame size
  - Max holding torque: 29.5 ft-lb
  - Required holding torque: 19.5 ft-lb
  - Leadshine M542 stepper driver

Igniter Insertion



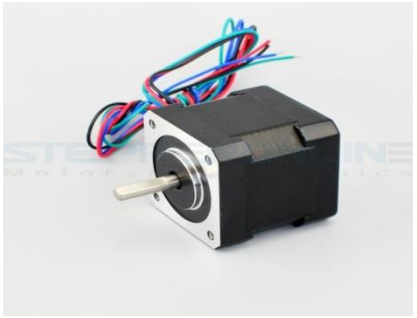
- NEMA 17 Stepper Motor
- ST-6128 Stepper Driver

Design Concept:

- Stepper motor rotates threaded rod
- Threaded Delrin square plate moves vertically due to side plates
- Igniter on dowel moves upward into rocket motor

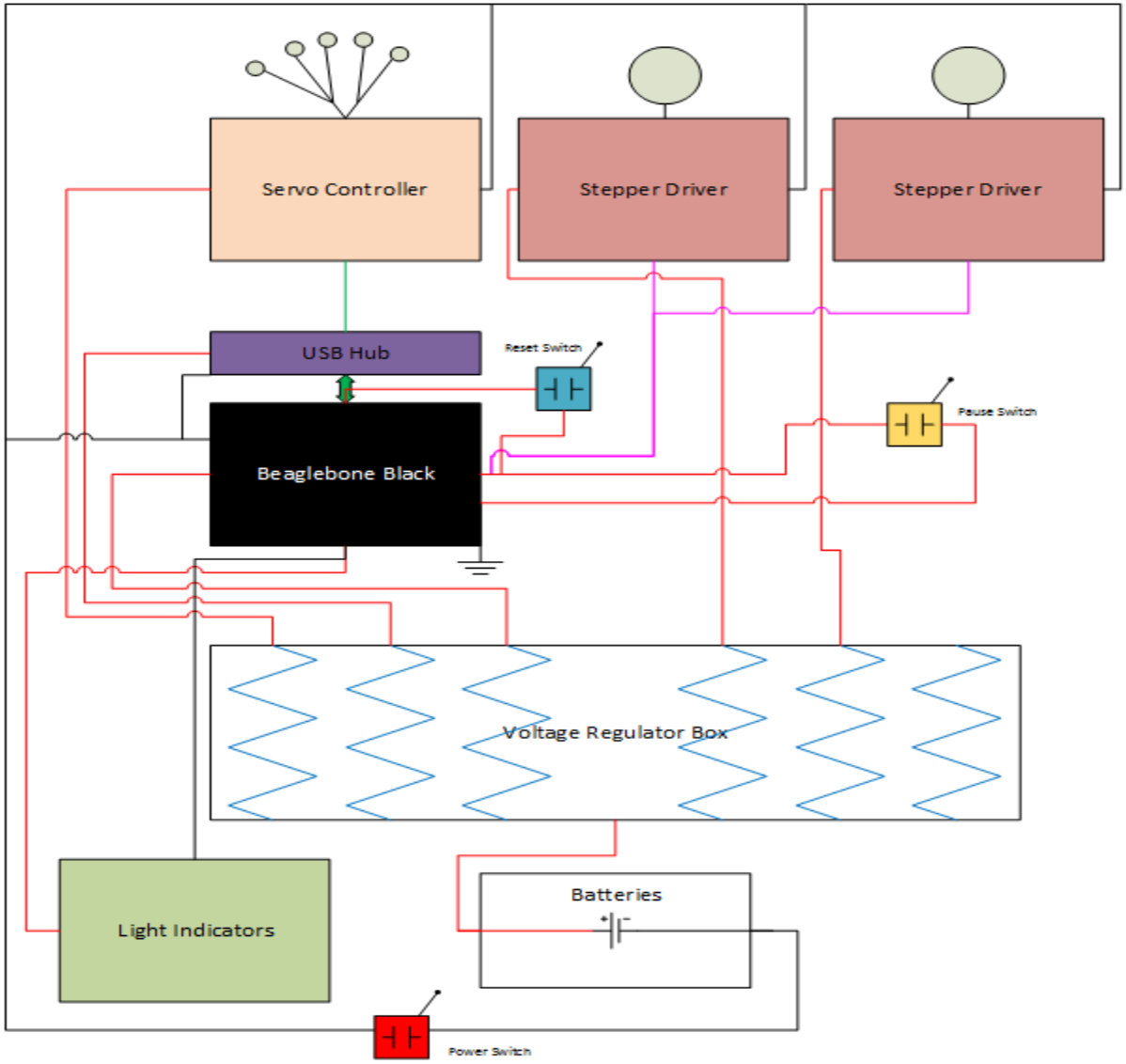
Experiment

- Successful verification of igniter insertion speed
- 21 inch translation in approx. 5 seconds



GPS Testing

AGSE - Electronics

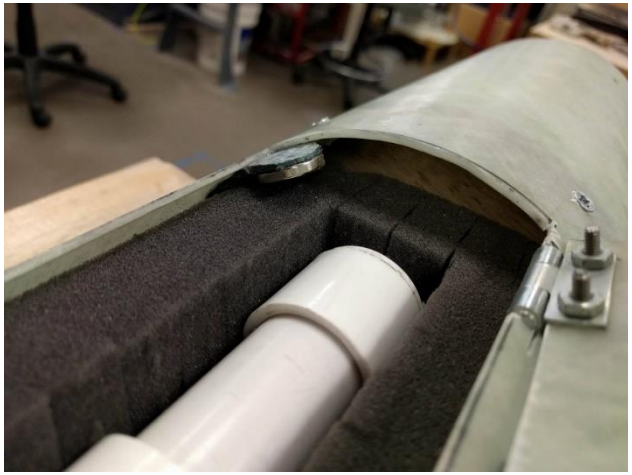


Requirement Verification

- Master and Pause Switches
- Indicator Lights
- AGSE Full System Optimization

Conclusion

- Launch Vehicle to Deliver Payload to 5280 ft.
- Full Scale Predictions and Results
- AGSE Designed to be sturdy, portable, and autonomous
- AGSE Subsystem Testing Verify Mission Success



Questions?