



NU HOPE



Northeastern University

High-altitude Object Protection Experiment

Agenda

- Overview of Vehicle Properties
- Stability Analysis
- Launch Vehicle Sections and Systems
 - Booster Stage
 - Interstage system
 - Payload
- Recovery
 - Drogues
 - Mains
- Electronics
- Payload Protection System
- Subsystem Test
- Updates

Overview of Vehicle Properties

Length	140 inches
Maximum Diameter	6.16 inches
Weight	46.149 pounds
Body Tube Material	BlueTube
Number of Fins	4
Motor	L1395 Bluestreak motor
Number of Electronics Bays	2
Number of Altimeters	6
Number of Main Parachutes	2
Number of Drogue Parachutes	2



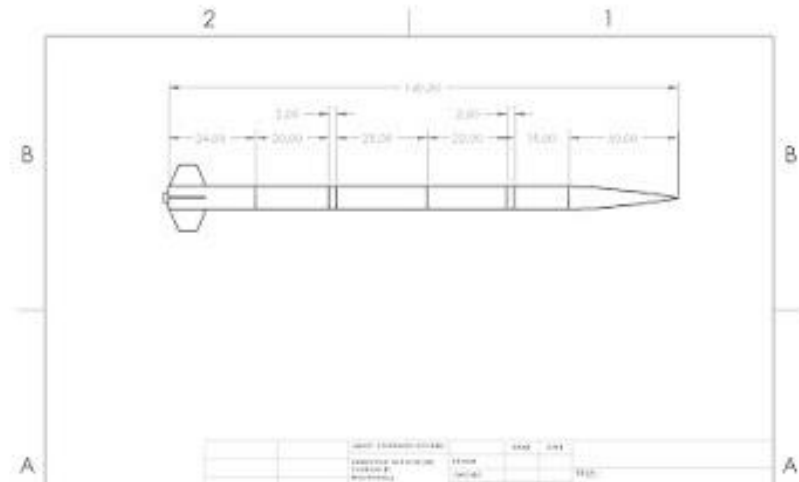
Stability Analysis

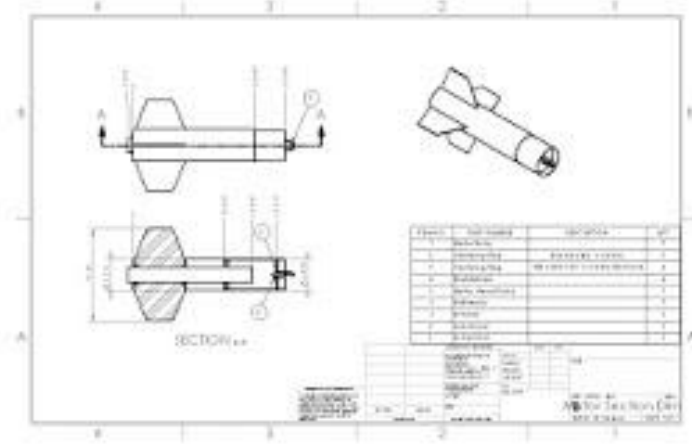
- Center of gravity = 85.881 inches
- Center of pressure = 111 inches
- Stability = 4.14 cal



Launch Vehicle Sections and Systems

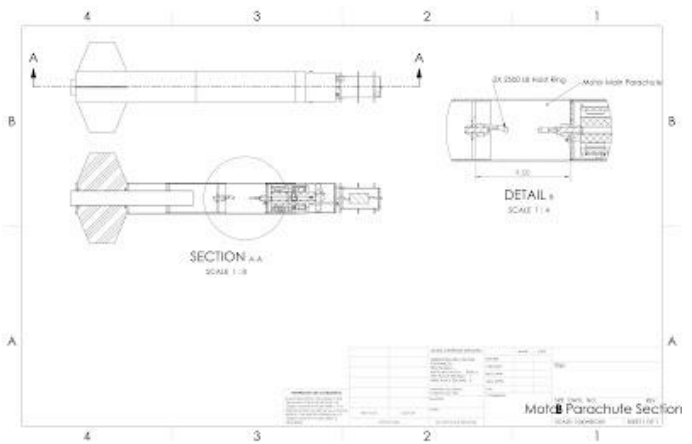
- Booster Stage
 - Motor Subsystem
 - Aft Parachute System
- Interstage System
- Payload Section
 - Nose Cone
 - PPS





← Motor Subsystem

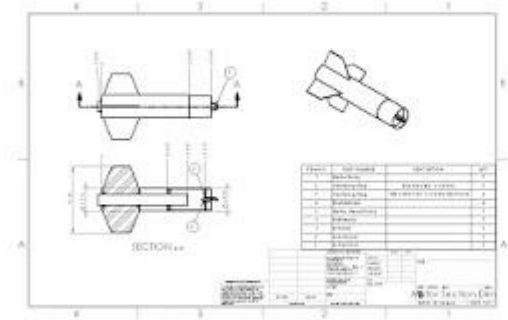
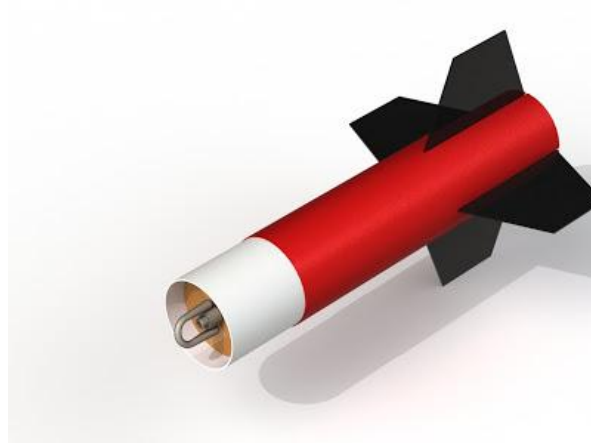
Booster Stage



← Aft-Parachute Subsystem

Motor Subsystem

- 4 Fiberglass fins
- Centering Rings
- Threaded Rods



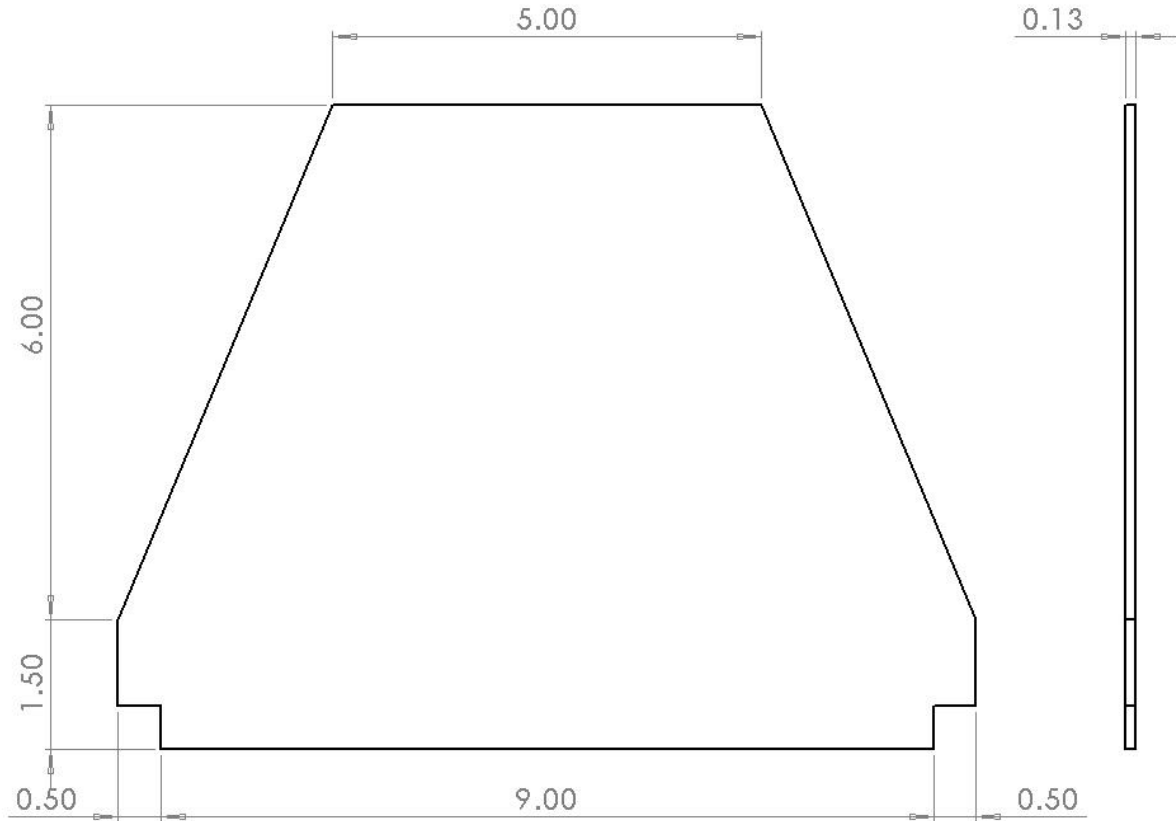
Motor Properties

- Pro75 4895L1395-P

Loaded Mass	9.53 lb
Burnout Mass	4.07 lb
Total Impulse	1101.46 lbf-s
Maximum Thrust	404.66 lb
Average Thrust	328.9 lb
ISP	211.09 s
Burntime	3.51 s

Fin Properties

- G10 Fiberglass
- Isosceles Trapezoid
- 4 utilized in the rocket



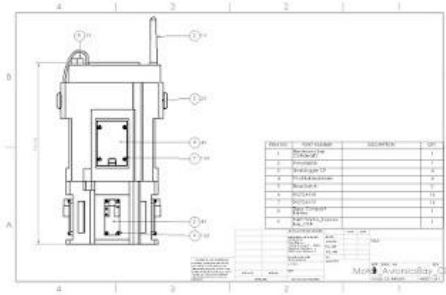
Aft Parachute Subsystem

- 18 inch drogue parachute
- 66 inch diameter main parachute
- Contains altimeters used to deploy the two parachutes



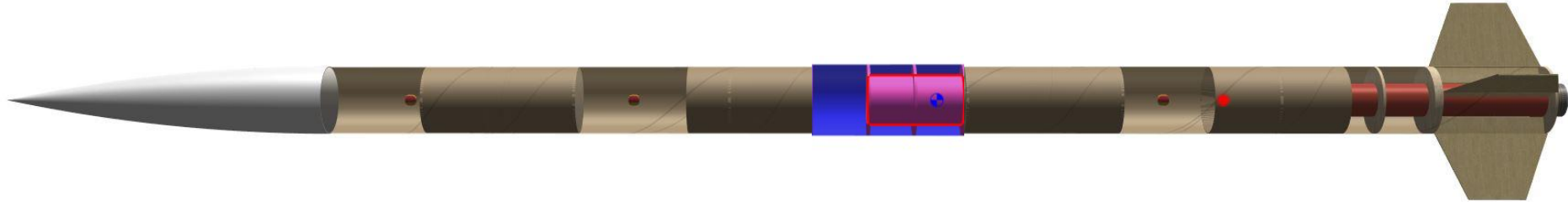
At Parachutes Subsystem Electronics bay

- Components
 - 4 x StratoLogger Altimeter
 - 4 x CT Components Keylock Switches
 - 4 x 9 Volt Batteries
 - Held in custom 9V battery holders
 - 1 x Big Red Bee GPS
- 3 - D Printed Housing
 - ABS 100% Infil
 - Threaded inserts to reinforce holes
 - Verify on subscale



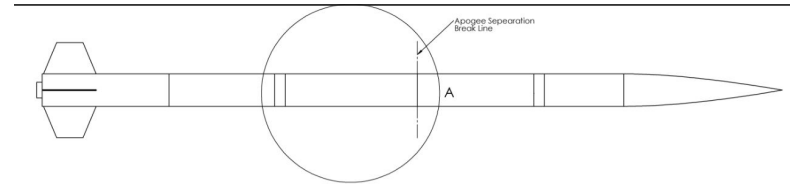
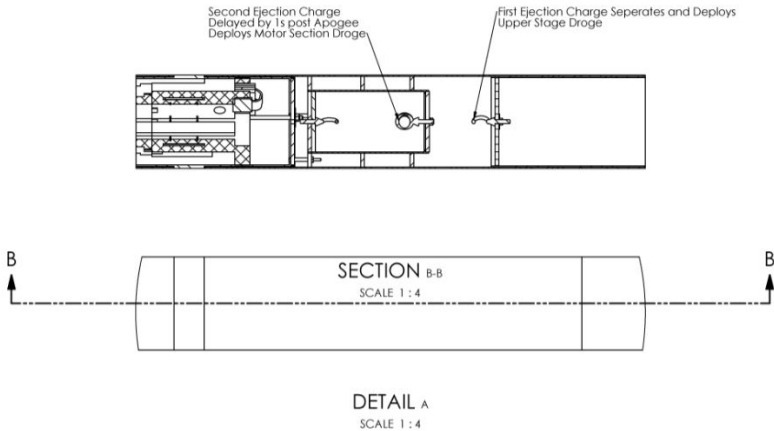
Interstage System

- Features dual deploy parachute system
- Solves previous conflict of colliding drogue parachutes

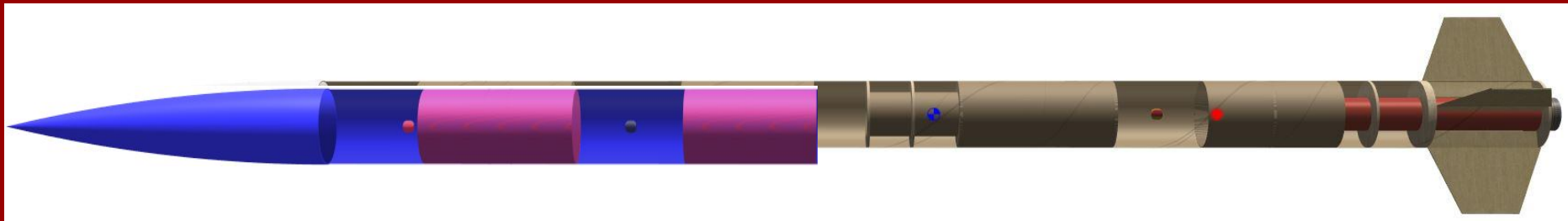


Interstage System (cont.)

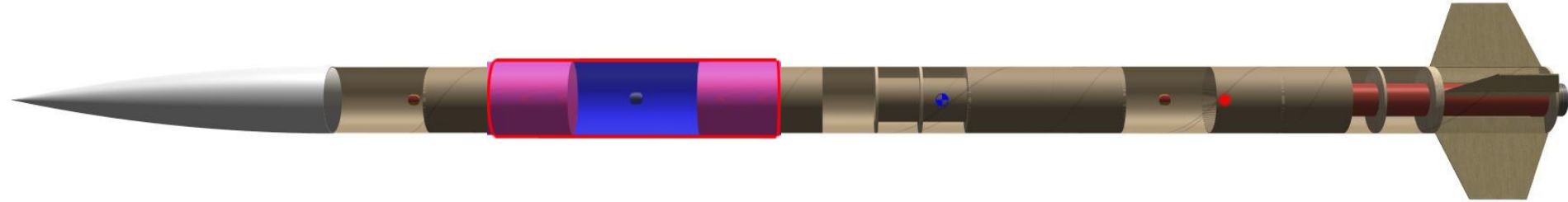
- Previous experiences have shown the feasibility and reliability of the system



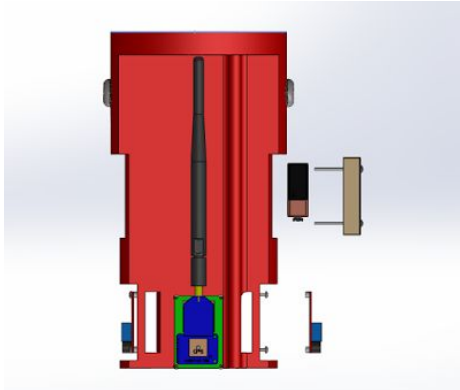
Payload



Payload Protection System, Canister

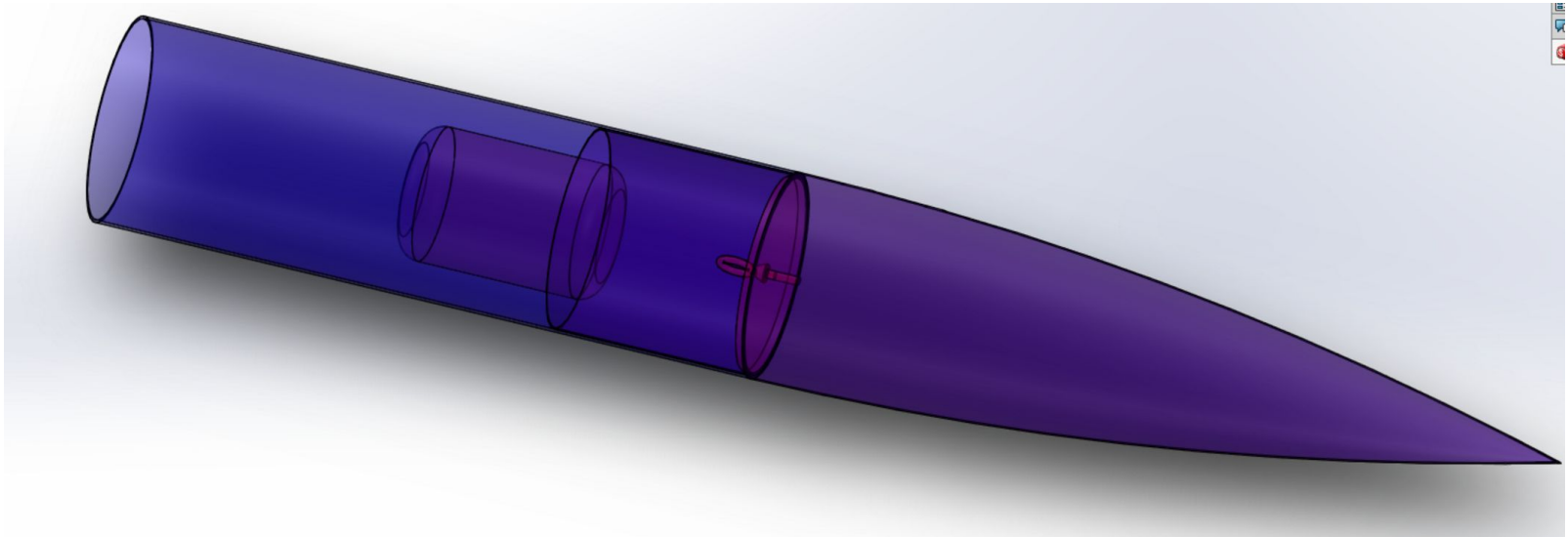


Payload Electronics Bay



Nose Cone

- Composed of Carbon Fiber
- Contains the 60 inch main parachute
- Contains electronics bay

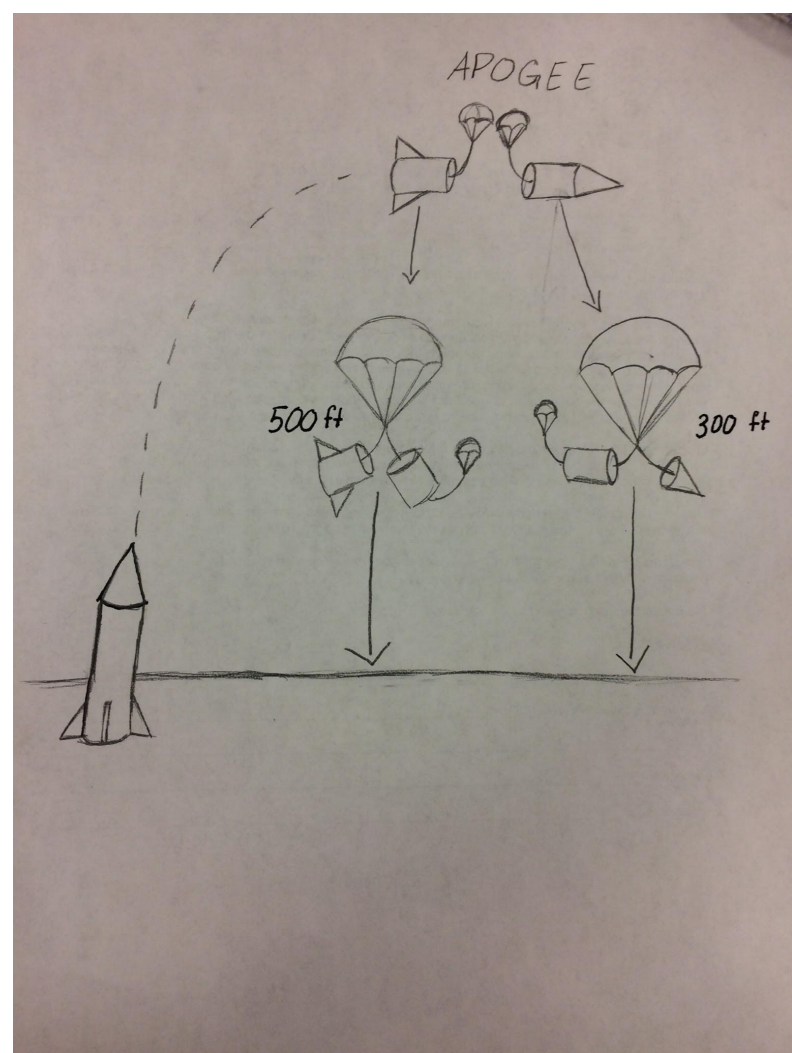


Recovery

Drogues and Mains

Launch Procedure

- Apogee of 5318 ft
- 2 instances of separation
 - Apogee
 - 300 ft or 500 ft
- Checklists!



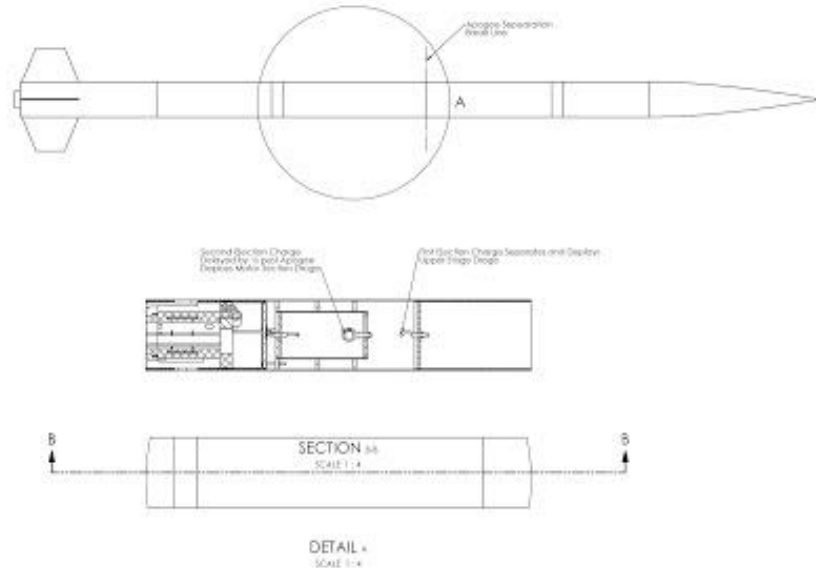
1st Separation

- Launch Vehicle reaches an apogee of 5318 ft
- The Booster Stage and the Payload Section separate, and drogues are deployed from each section
- The payload section has a velocity of 80 ft/s and the booster section has a velocity of 90 ft/s after drogue deployments



Apogee Event

- One drogue parachute deploys at apogee/initial separation
- Second drogue deploys after brief moment due to interstage



Recovery System After Drogue Parachute

- Altitude sensing electronics
- 18 in. drogue parachute
- Descent at 90 feet per second at apogee till 700 feet above ground
 - Secured via ¼ Eyebolt to ebay bulkhead
- 20 ft ¼ inch Kevlar

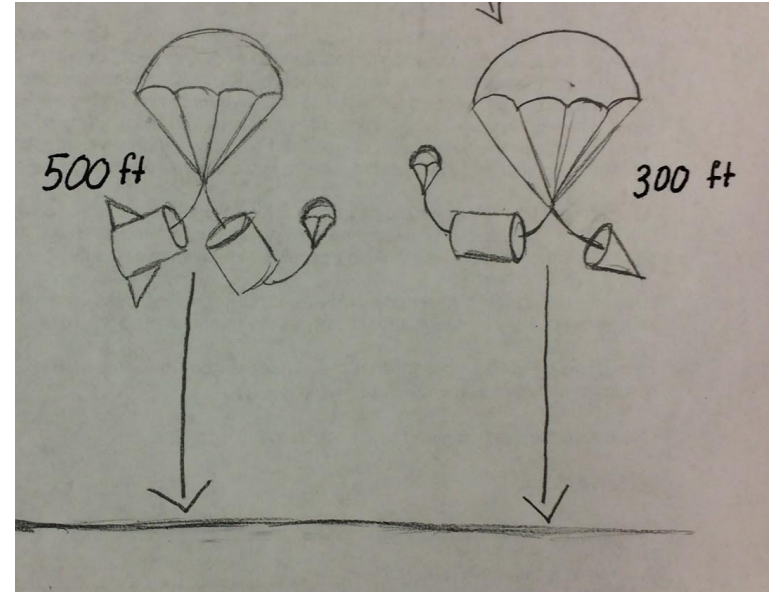
Nose Cone Drogue Parachute

- Diameter: 18 in
- Deployed from Drogue Parachute Interstage section
- Connected to $\frac{1}{4}$ Eyebolt
- 20 ft $\frac{1}{4}$ inch Kevlar



2nd Separation

- Begins at an altitude of 300 feet
- Payload Section splits
 - At 300
 - Nose Cone
 - Payload Protection System
- Booster Stage splits
 - At 500 feet
 - Aft Parachute Section
 - Motor Section
- Main Parachutes:
 - Payload Section deploys a 60" parachute
 - Booster Stage deploys a 72" parachute



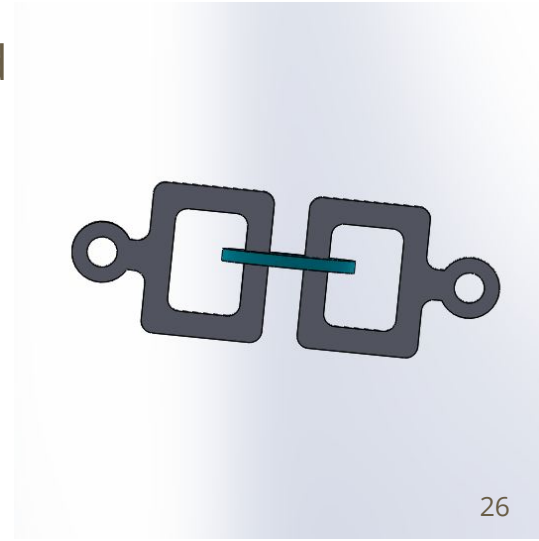
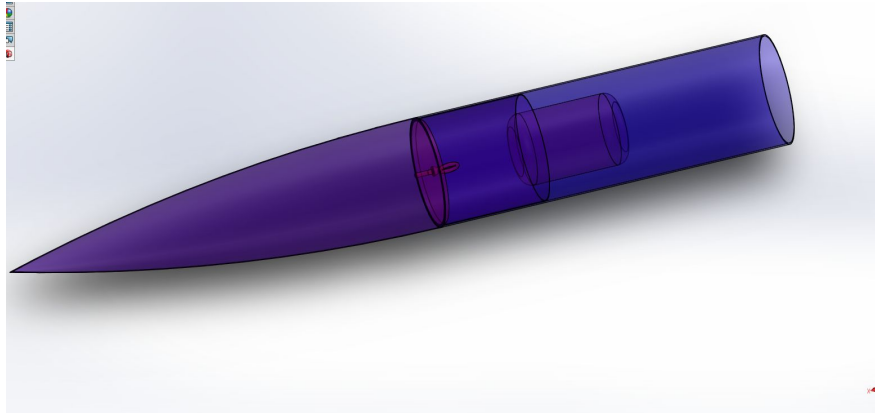
Recovery System Aft Main Parachute

- 66in. main parachute
- Deploys at 500 feet
- Motor subsystem and aft avionics will split
- Slows descent to 19 feet per second
- 40 ft ½ inch Kevlar



Nose Cone Main Parachute

- 60in main parachute, 40ft ½in kevlar
- Deploys at 300ft
- Nose cone separates with charge for passive release
- Slows to 18 ft/s
- Shock Absorption system attached to protect payload

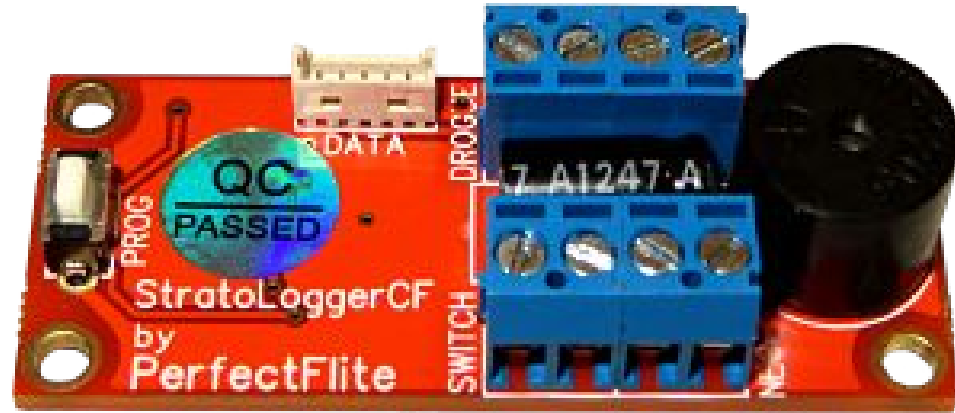


Electronics

Recovery, Motor, Nose Cone, and
Accelerometer

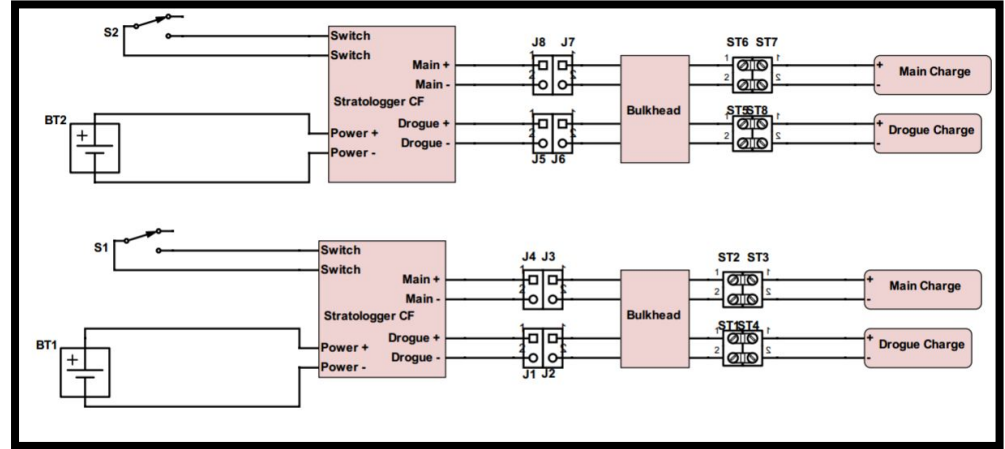
Recovery Electronics

Power	4V-16V, nominal 9V battery
Current Consumption	1.5 m
Launch Detect	160' to 300' AGL, default 160'
Main Deploy Altitude	100' AGL to 9,999' AGL
Maximum Altitude	100,000' MS
Altitude Resolution	1' up to 38,000' MSL < 2' to 52,000' MSL < 5' to 72,000' MSL
Measurement Precision	+/- (0.1% reading + 1 foot) typical
Flight Data Logged	Altitude, temperature, battery voltage
Recording Time Per Flight	Over 18mins
Operational Temperature	-40C to +85C (-40F to +185F)
Sample Rate	20 samples per second
Cost	\$54.95

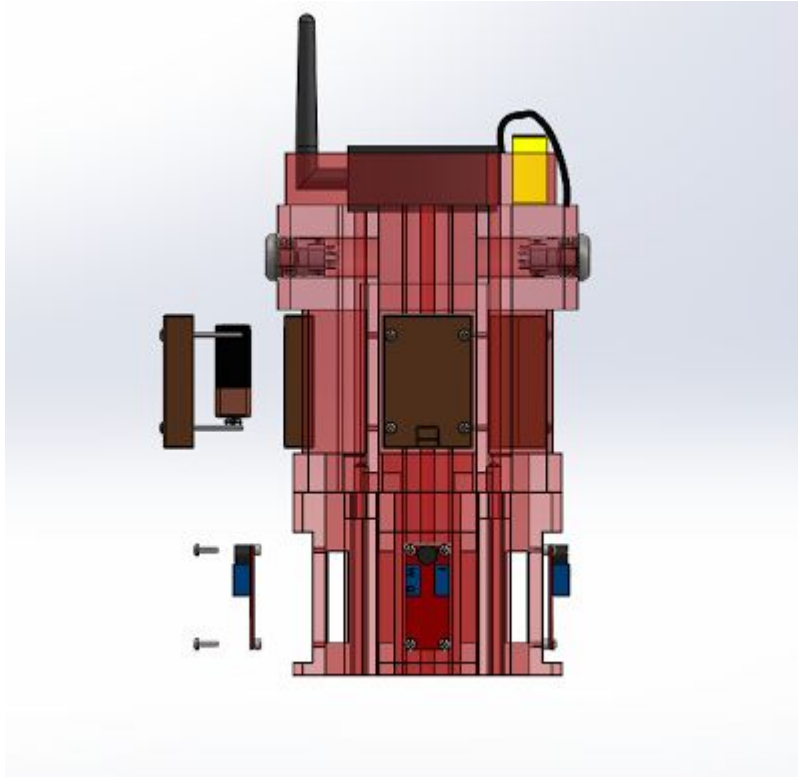


Recovery Wiring

- 9 Volt Batteries
 - Wired to StratoLogger “+” and “-”
- Independent Systems
- DPDT Keylock Switch
 - Wired to “switch” output

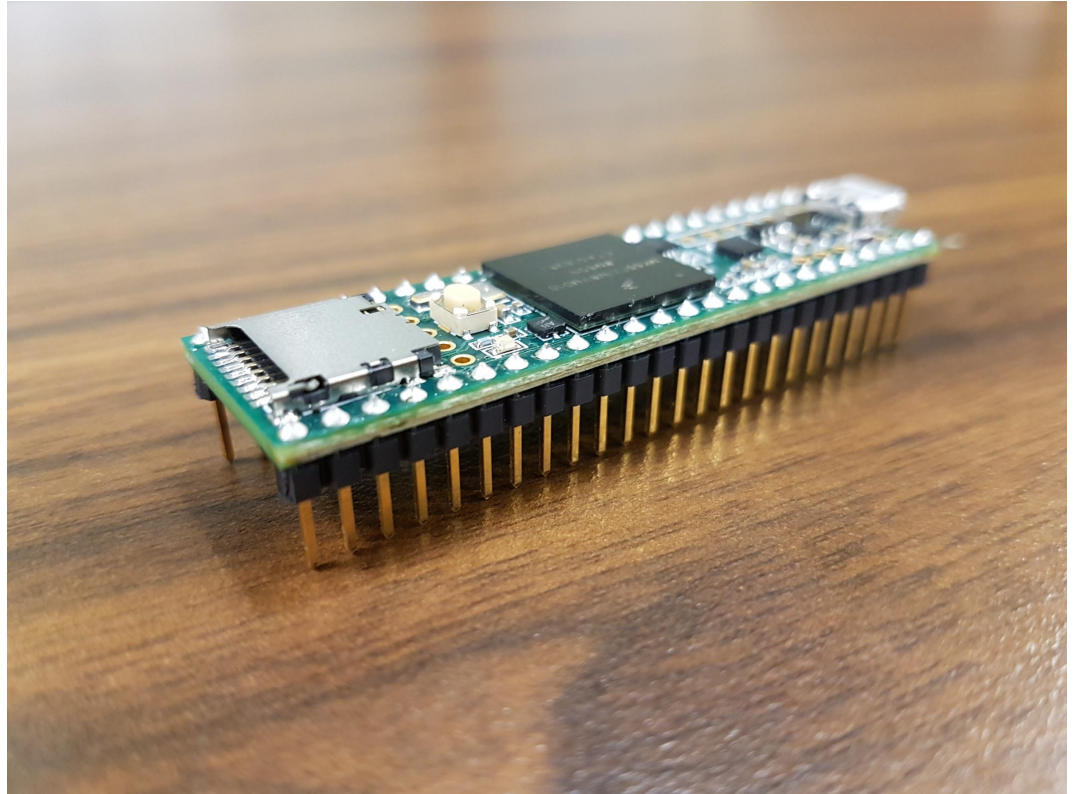


Motor Section Electronics Bay Exploded View



Payload Electronics

- 3-DOF Accelerometer
 - 24 g max acceleration,
 - 1000 Hz polling rate
- Teensy 3.6
Arduino-compatible
microcontroller
- Xbee radio transmitter
- GPS-breakout module
 - Big Red Bee GPS breakout



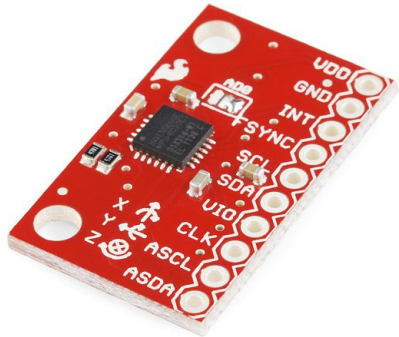
Nose Cone Electronics Bay

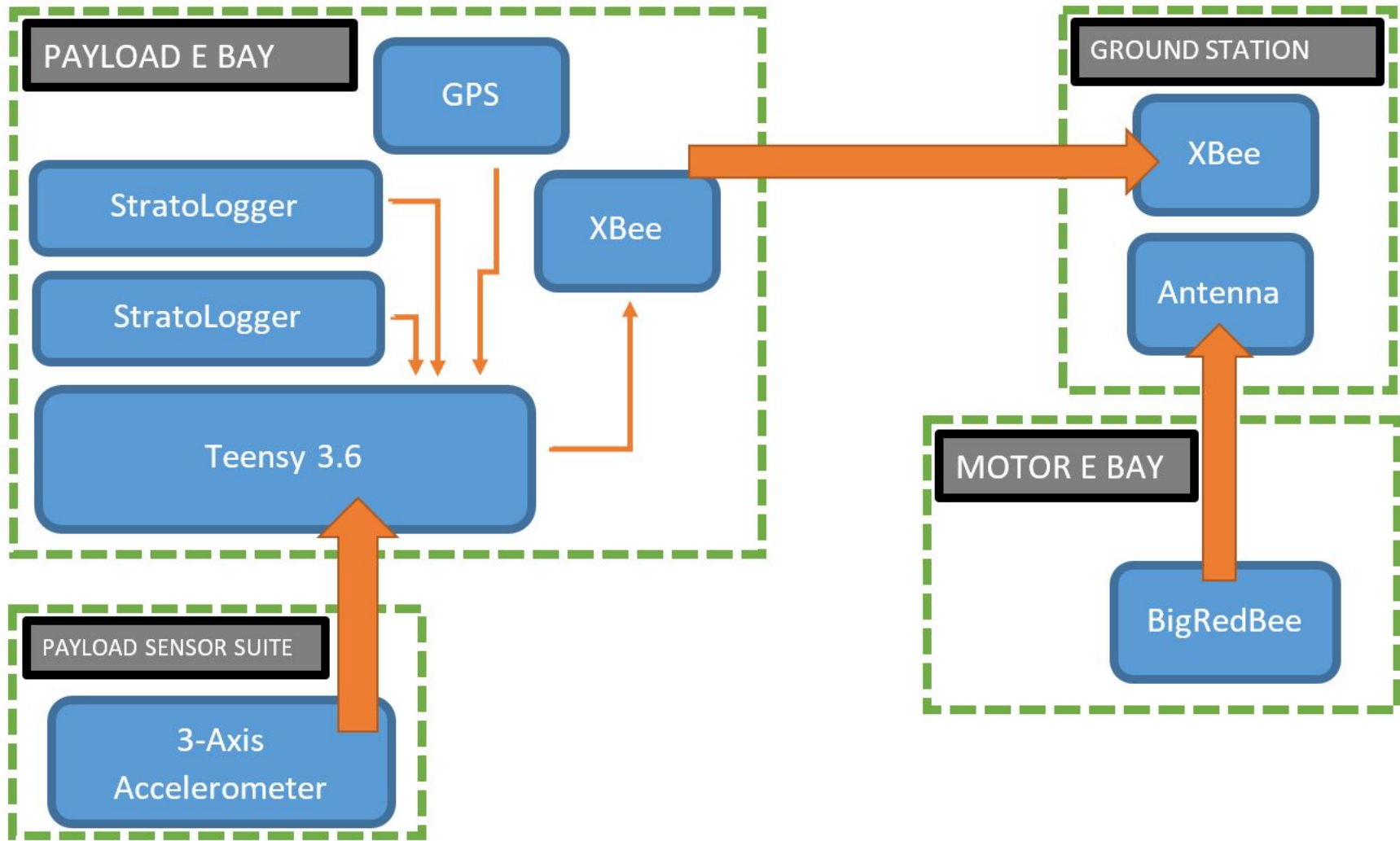
- XBee Pro XSC (S3)
- XBee Breakout Board
- Pulse W1063 Antenna
- ZIPPY Compact 2200mAh 3S 25C Lipo Pack
- Teensy 3.6
- Adafruit Ultimate GPS Breakout Board
- XBee Explorer Dongle (Ground Station)
- MPU 6050
- LIS 331



Accelerometer Sensor Options

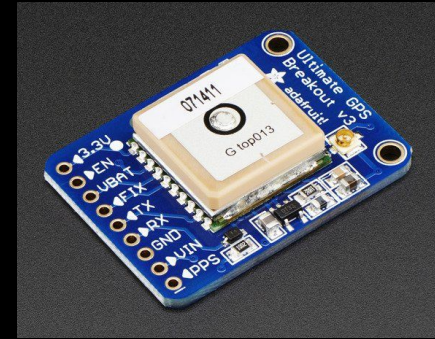
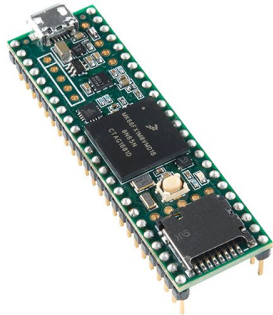
- MPU 6050
 - 1000Hz Polling Rate, 6 DOF, Accelerometer / Gyro combo
 - Max 16g max acceleration reading
- LIS 331
 - 1000Hz Polling Rate, 3 DOF, Accelerometer
 - Max 16g max acceleration reading





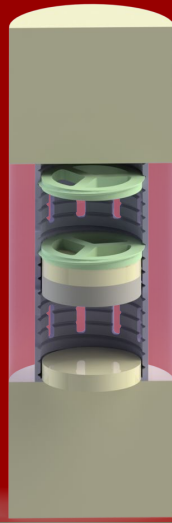
Telemetry

- The Adafruit GPS Breakout Board gets position data → Teensy 3.6
 - Position and accelerometer data → SD card
- Teensy 3.6 → XBee
- XBee → XBee Explorer Dongle at Ground Station
- Data stored and read out on Computer

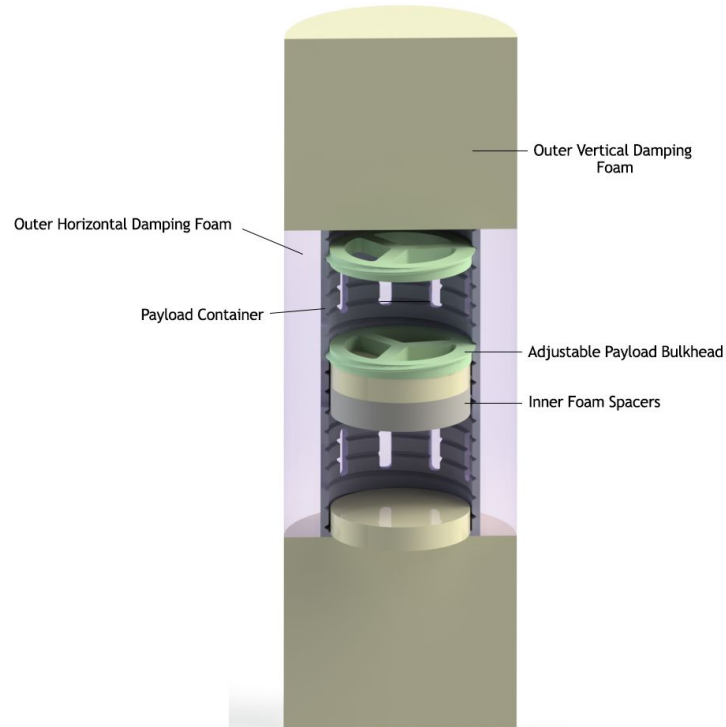


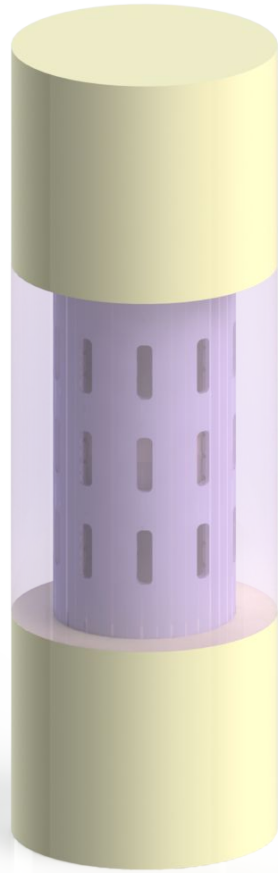
- BigRedBee gets position data → Ground Station
- Data stored and read out on Computer

Payload Protection System



Cross Section View of Payload Protection System







Subscale Tests

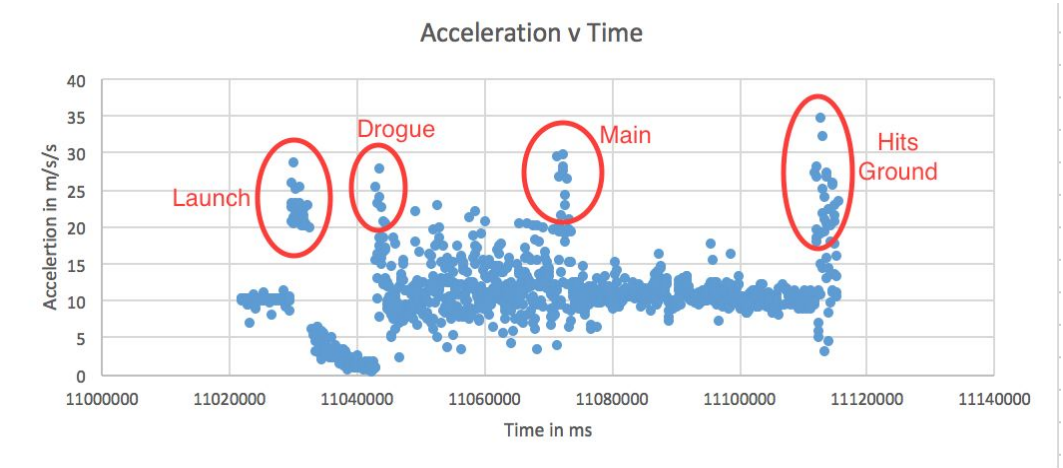
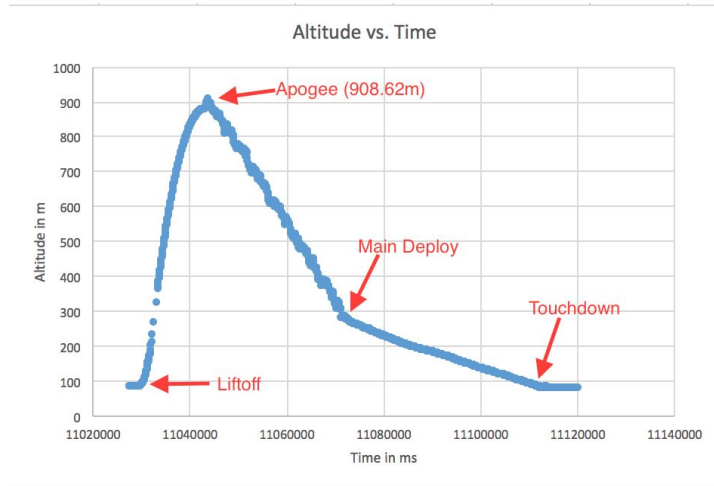


Subscale Launches

- Launched two subscales
 - RED 1 - No Telemetry - Flight test of launch vehicle
 - Successful, debugged issues with electronic logging system
 - Both drogue parachutes and the payload main parachute deployed
 - Booster main parachute did not deploy due to faulty wiring
 - RED 2 - Telemetry included
 - Fixed past problems
 - Successful, data recorded, discovered issues with maximum acceleration values.

Subscale Launch / Impact Testing

- Utilized the payload electronics system in order to determine the forces experienced in flight
 - Discovered that current sensors max out well below acceleration experienced



Updates

- Launch vehicle
 - Nose cone longer
 - Drogue size smaller
 - Hoist ring
 - Ebay design
- Electronics
 - Electronic system for subscale to collect acceleration data on payload throughout launch
- Payload prototype and test against maximum acceleration
- Further testing plans

Thank you for listening!

QUESTIONS?