Georgia Tech NASA Flight Readiness Review Teleconference

Presented By:

Georgia Tech Team ARES

Agenda

1. Team Overview (1 Min)
2. Changes Since CDR (1 Min)
3. Educational Outreach (1 Min)
4. Safety (2 Min)
5. Project Budget (2 Min)
6. Launch Vehicle (10 min)
7. Flight Systems (13 Min)
8. Questions (15 Min)

Georgia Tech ARES

NASA

Project KRIOS - FRR

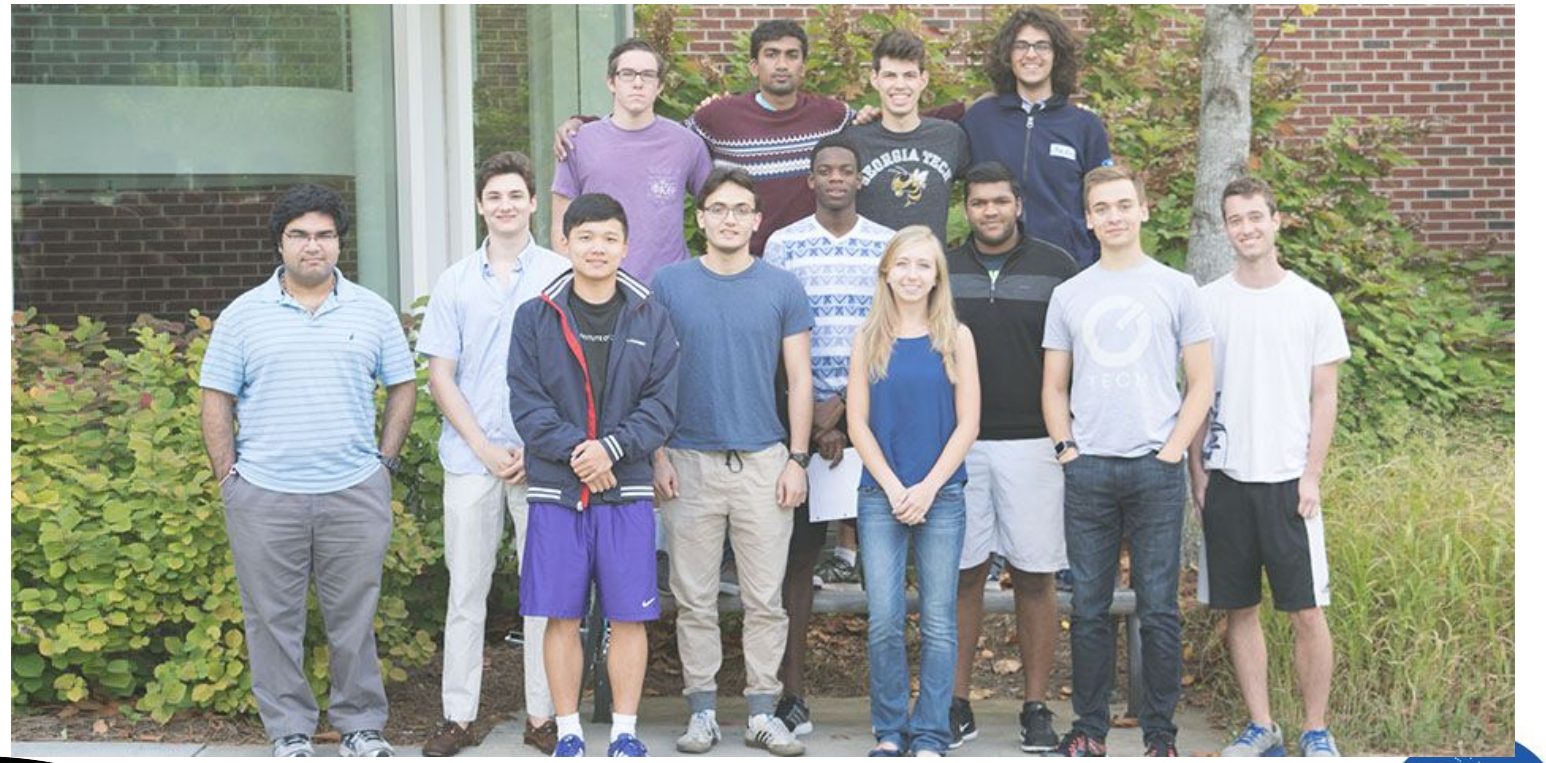
TEAM OVERVIEW

Georgia Tech ARES

NASA

Georgia Tech Team Overview

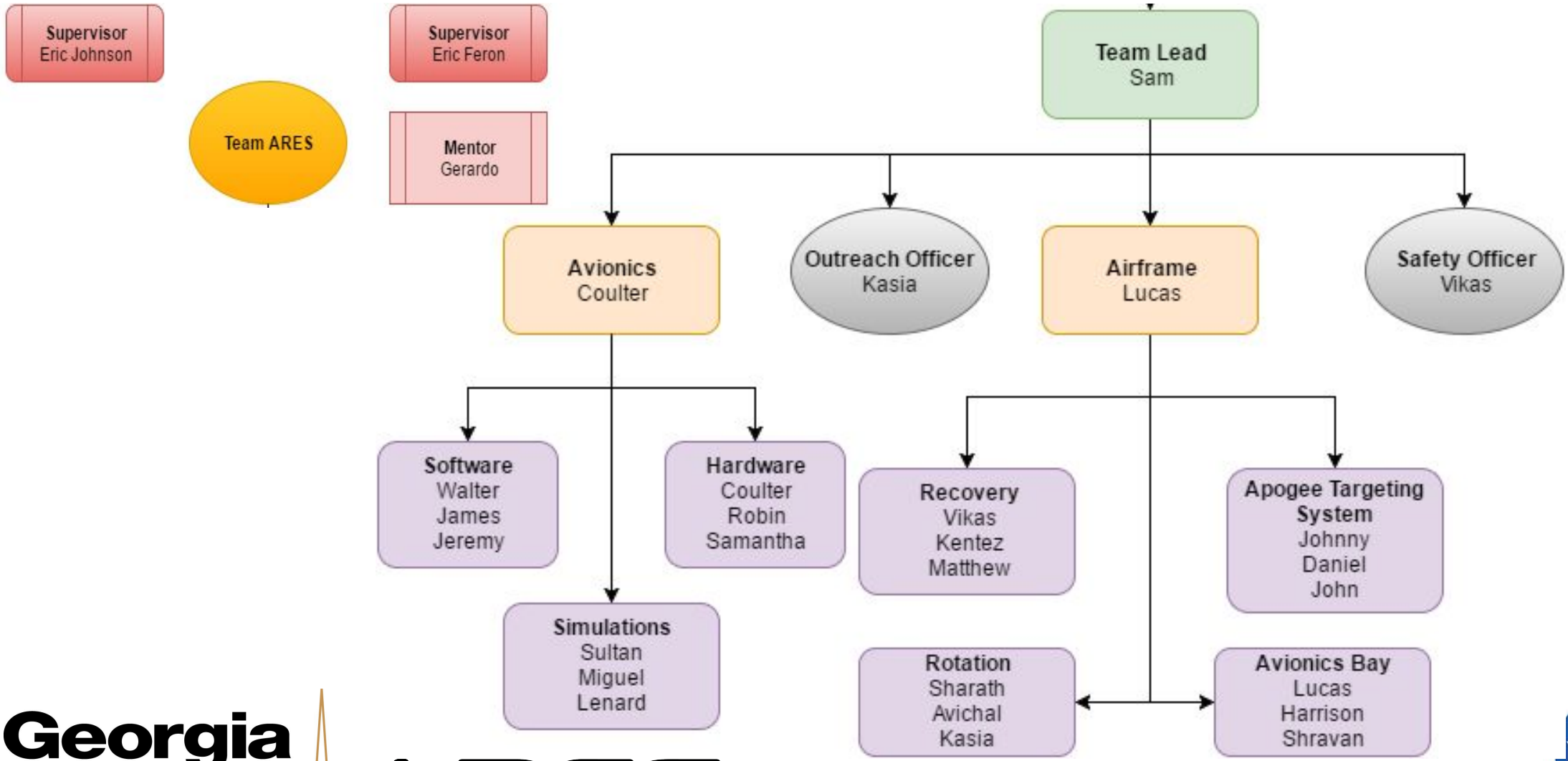
- 24 undergraduate members
- Highly integrated team across several disciplines
  - Mechanical Engineering
  - Aerospace Engineering
  - Electrical Engineering
  - Applied Mathematics



Georgia Tech ARES

NASA

Work Breakdown Structure



Georgia Tech ARES

Project KRIOS - FRR

CHANGES SINCE CDR

Georgia Tech ARES

NASA

Changes since CDR

Structural Changes

- parachute compartment lengths decreased
- MAS section length increased to maintain same total length and stability

Avionics Changes

- MBED ARM controller now controls Motor Actuation System instead of pixhawk

Project Plan Changes

- Did not Launch March 4th
- Sufficient funding has been acquired

Project KRIOS - FRR

EDUCATIONAL OUTREACH

Georgia Tech ARES

NASA

Educational Outreach

- **Peachtree Charter Middle School**
- **Atlanta Science Festival**
- **Engineering Merit Badge**

Georgia Tech ARES

Project KRIOS - FRR

SAFETY

Georgia Tech ARES

NASA

Risk Assessment & Launch Vehicle

- Hazard Identification
  - What has the potential to become a safety hazard?
- Risk and Hazard Assessment
  - What are the potential consequences of the hazard?
- Risk Control and Mitigation
  - What can be done to mitigate the risk?
- Reviewing Assessments
  - Are the mitigations working?

Project Hermes - FRR

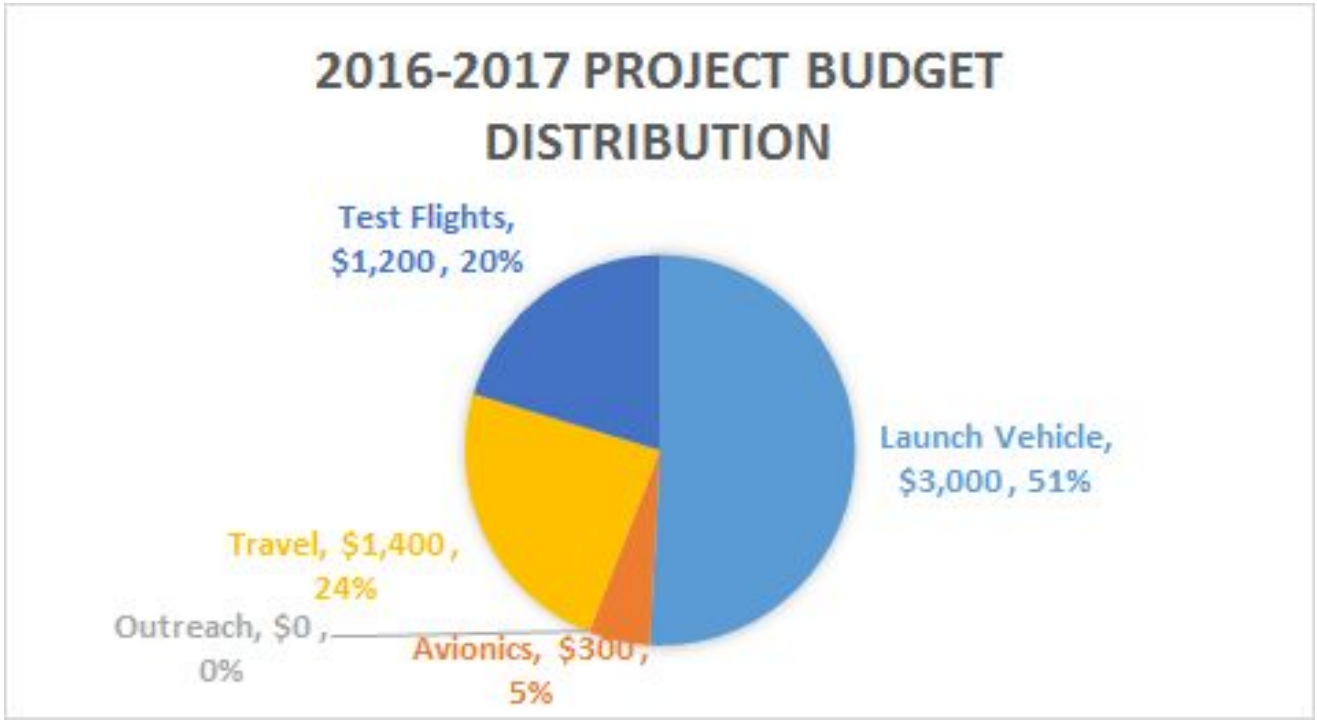
PROJECT BUDGET

Georgia Tech ARES

NASA

Project Budget Summary

Section	Cost
Launch Vehicle	$3,000
Avionics	$300
Outreach	$0
Travel	$1,400
Test Flights	$1,200
Total	$5,900



Georgia Tech ARES

NASA

Project KRIOS - FRR

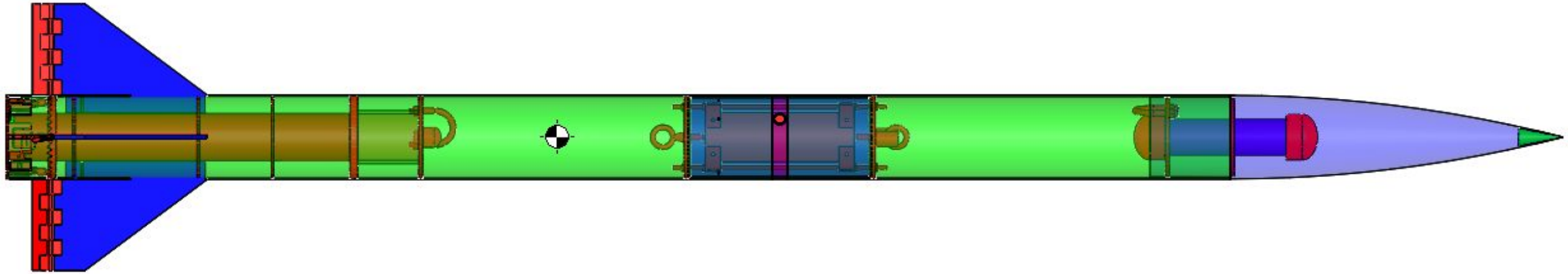
LAUNCH VEHICLE

Georgia Tech ARES

NASA

Launch Vehicle Summary

- Predicted apogee: 5284 ft
- Stability margin: 2.56
- Motor: Aerotech L1150
- Rail Exit Velocity: 76.2 ft/s
- Max Mach: 0.57
- Total weight: 541 oz
- Dual deployment with 45in and 120in TFR



Georgia Tech ARES

NASA

Modeling Forces on Bulkheads

- Pressure from Ejection Charges

Bulkhead	Amount of black powder(grams)	Volume of compartment(in^3)	Pressure on bulkhead (psi)
Main 1	3	594.8	9.9
Main 2	3	594.8	9.9
Drogue 1	3	297.4	19.8
Drogue 2	3	297.4	19.8

Modeling Forces on Bulkheads

- Pressure from Ejection Charges

Figure 3.3.2. Main 1 Ejection Charge Test

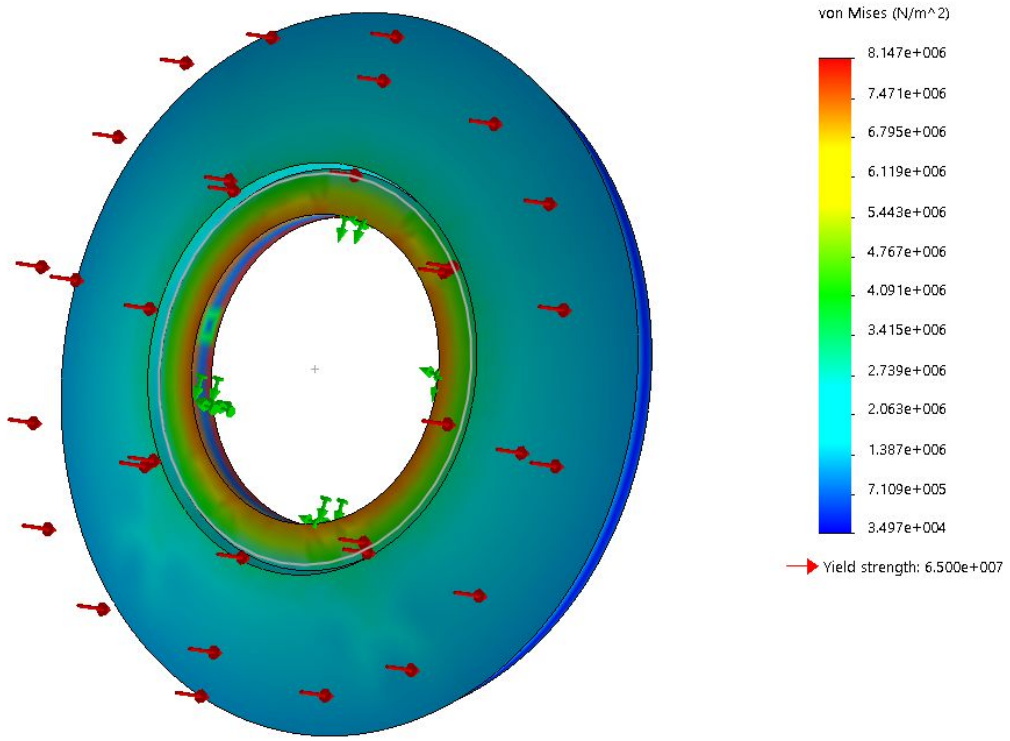
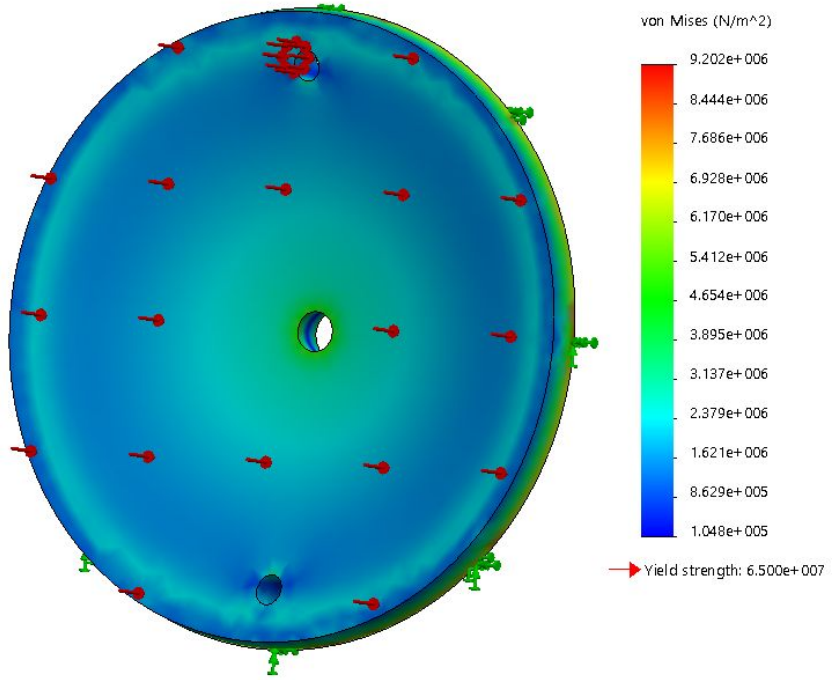


Figure 3.3.3. Main 2 Ejection Charge Test



Modeling Forces on Bulkheads

- Force from Parachute Drag

Forces from Main Chute

Wind Speed (mph)	Mass of Rocket (kg)	Mass of Booster/Avionics Bay(kg)	Accel (m/s^2)	Force (N) on Main 2
5	13.232	12.706	78.5	997.421
10	13.232	12.706	78.5	997.421
15	13.232	12.706	78.6	998.711
20	13.232	12.706	78.6	998.711

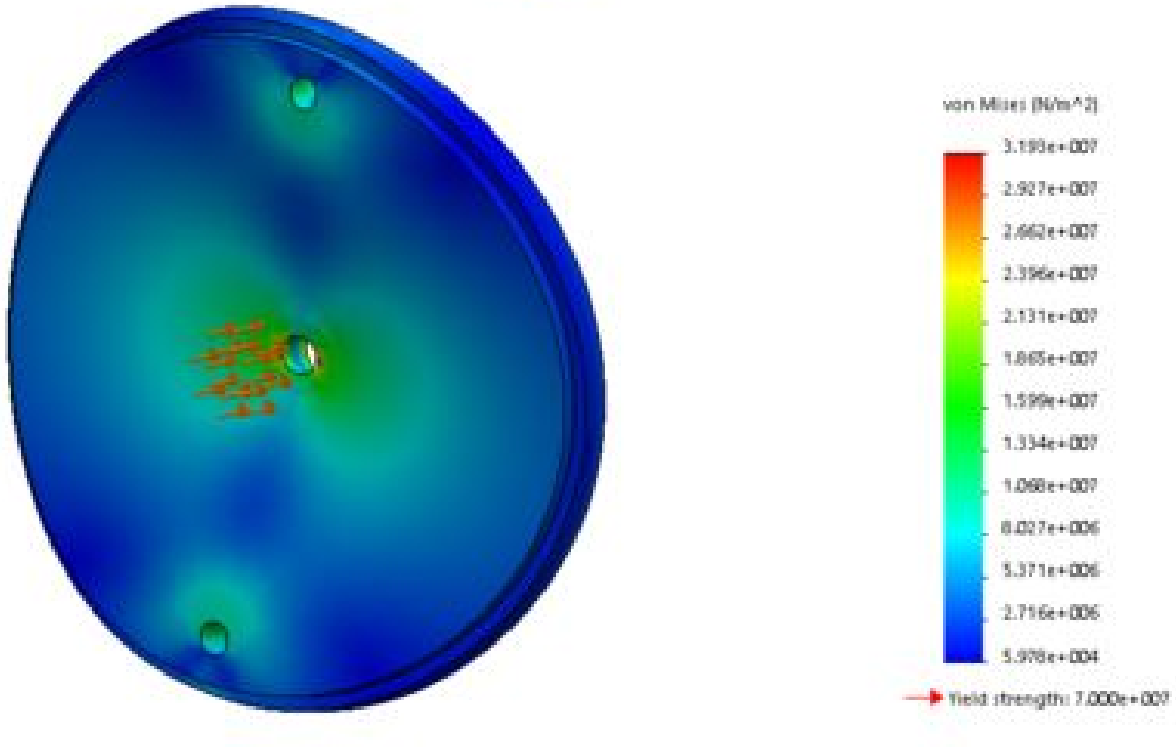
Forces from Drogue Chute

Wind Speed (mph)	Mass of Booster (kg)	Accel (m/s^2)	Force (N) on Drogue 2
5	9.469	78.5	743.296
10	9.469	78.5	743.296
15	9.469	78.6	744.243
20	9.469	78.6	744.243

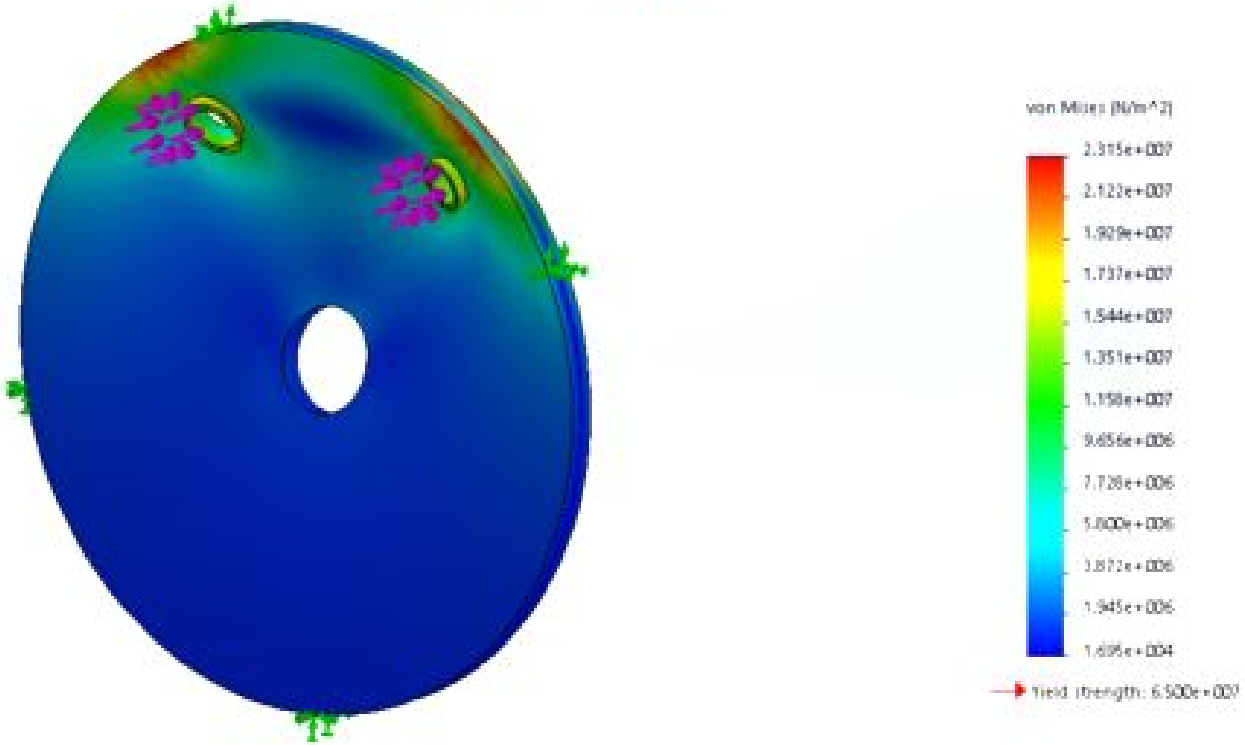
Modeling Forces on Bulkheads

- Force from Parachute Drag

Main 2 Parachute Deployment



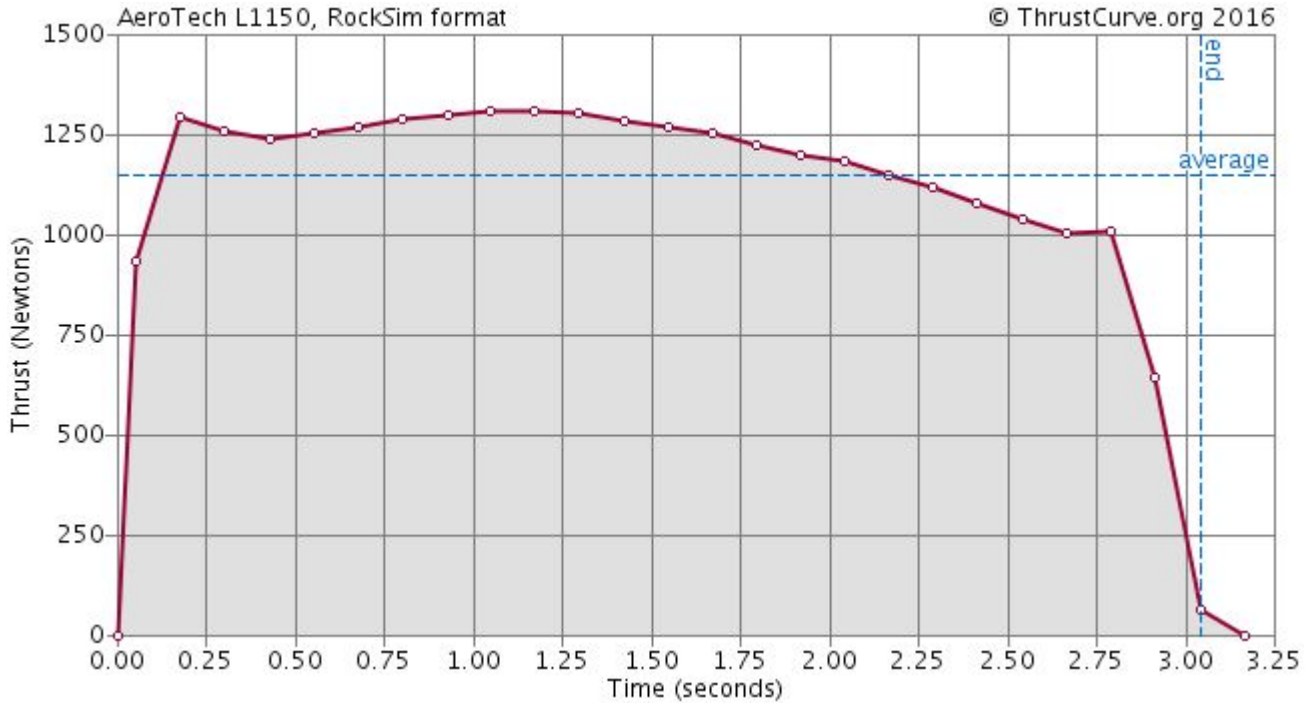
Drogue 2 Parachute Deployment



Motor Selection

Aerotech L1150

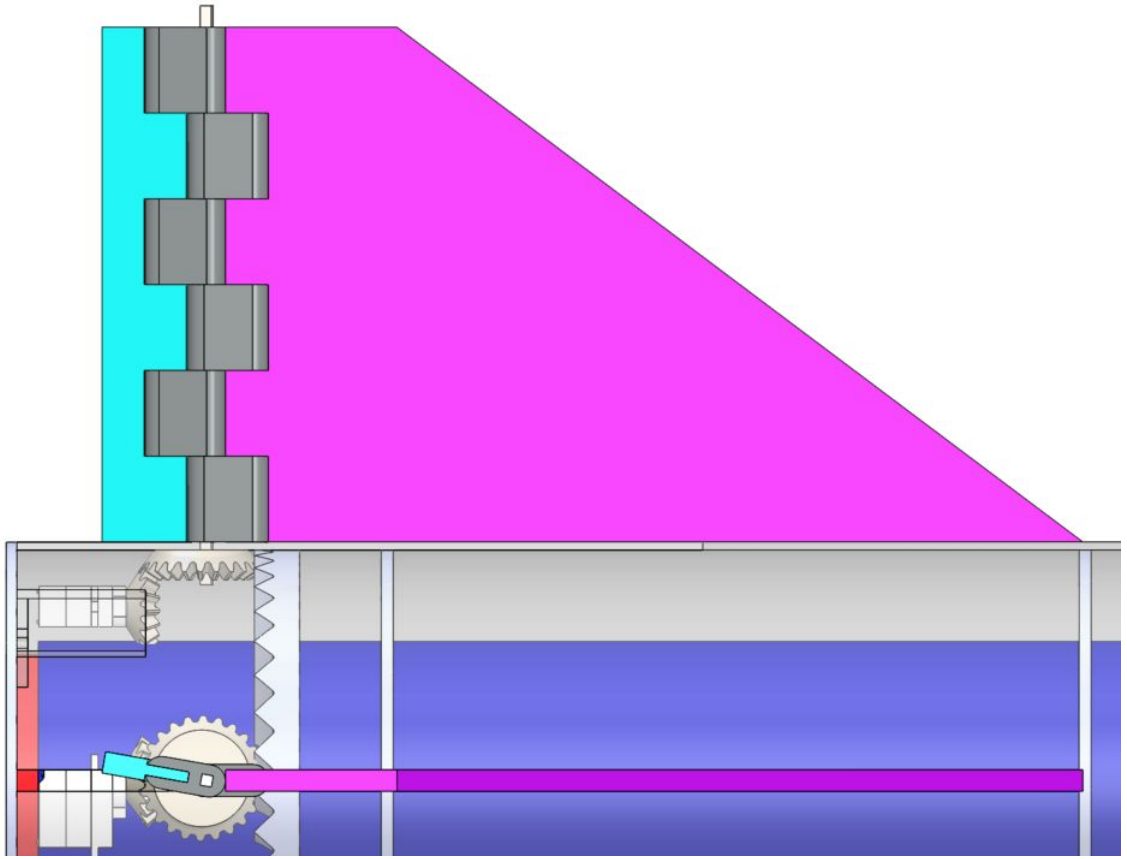
Aerotech L1150	
Diameter	75.00 mm
Length	53.1 cm
Propellant Weight	2065.3g
Overall Weight	3,673.6g
Average Thrust	1,102.2 N
Maximum Thrust	1,309.7 N
Total Impulse	3,488.6 Ns
Specific Impulse	96.9s?
Burn Time	3.2s

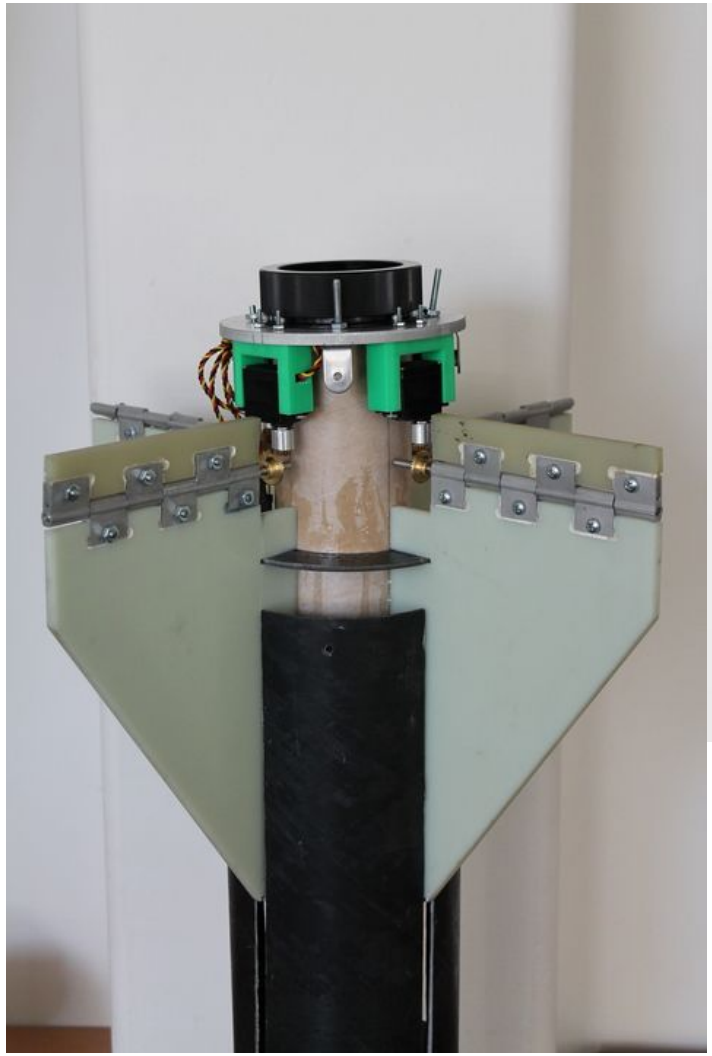


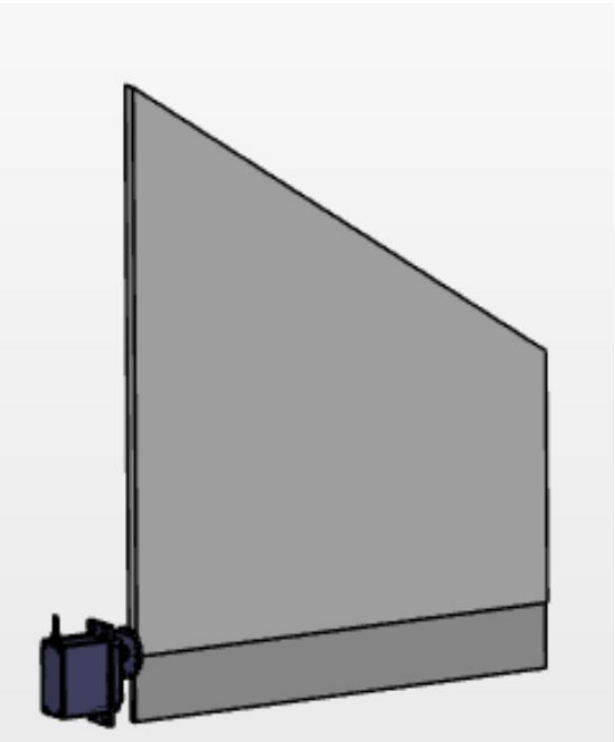
Georgia Tech ARES

NASA

Motor Actuation System



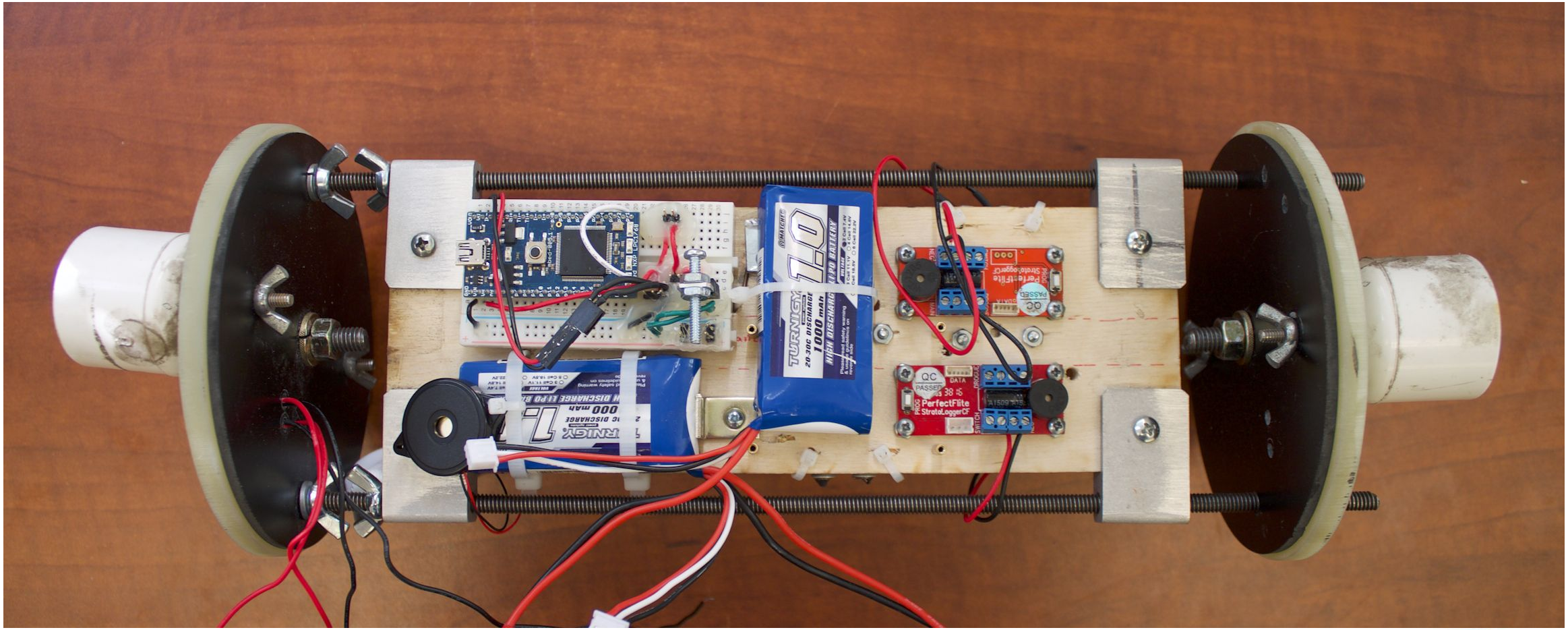




Georgia Tech ARES

NASA

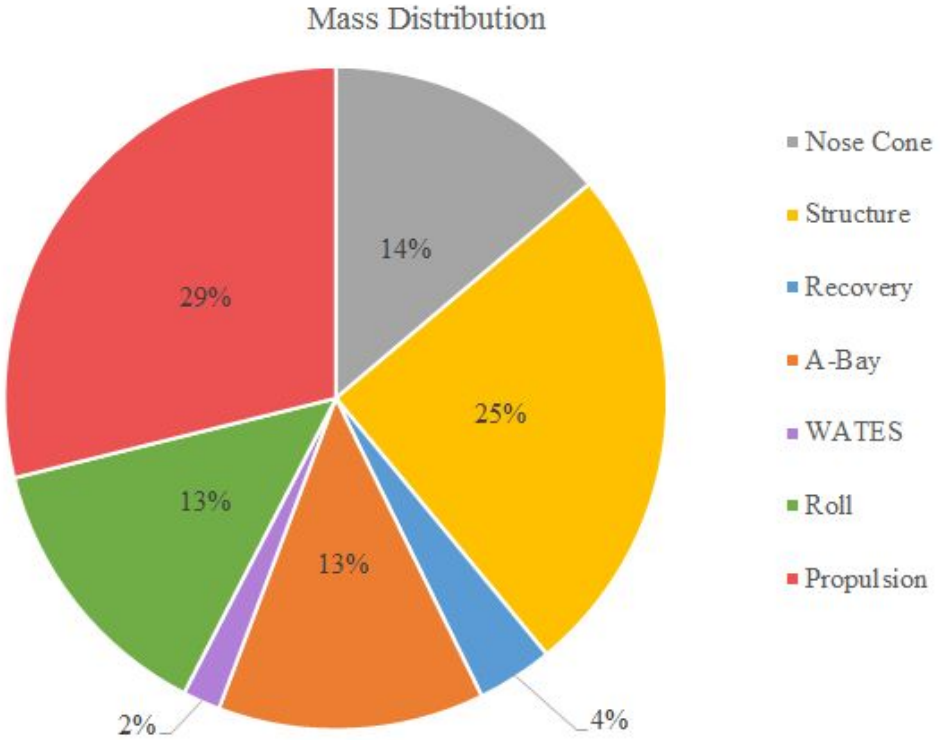
Avionics Bay



Georgia Tech ARES

NASA

Mass Breakdown



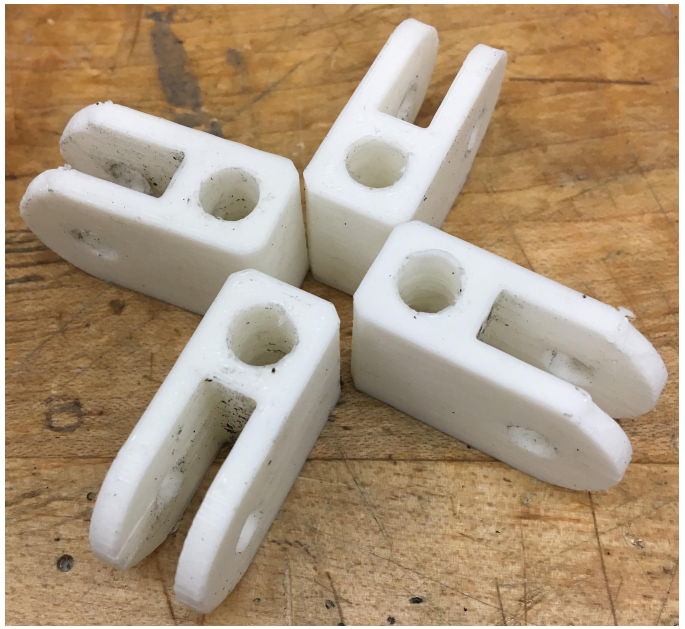
Subsystem	Mass (lb)
Nose Cone	4.577
Structure	8.34
Recovery	1.23
A-Bay	4.3
MAS	0.607
Roll	4.49
Propulsion	9.55
Total	33.394

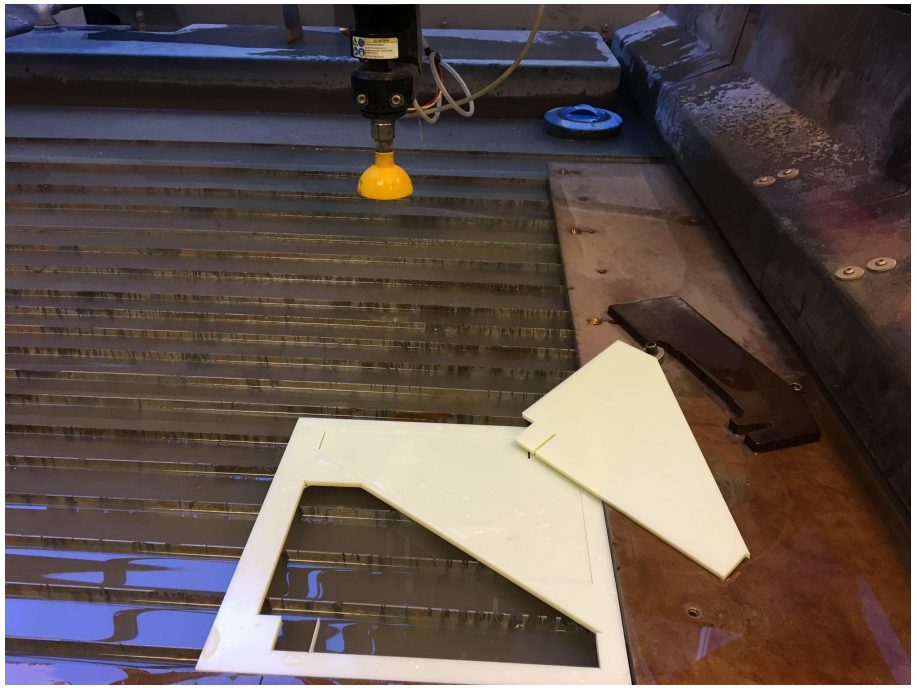
Georgia Tech ARES

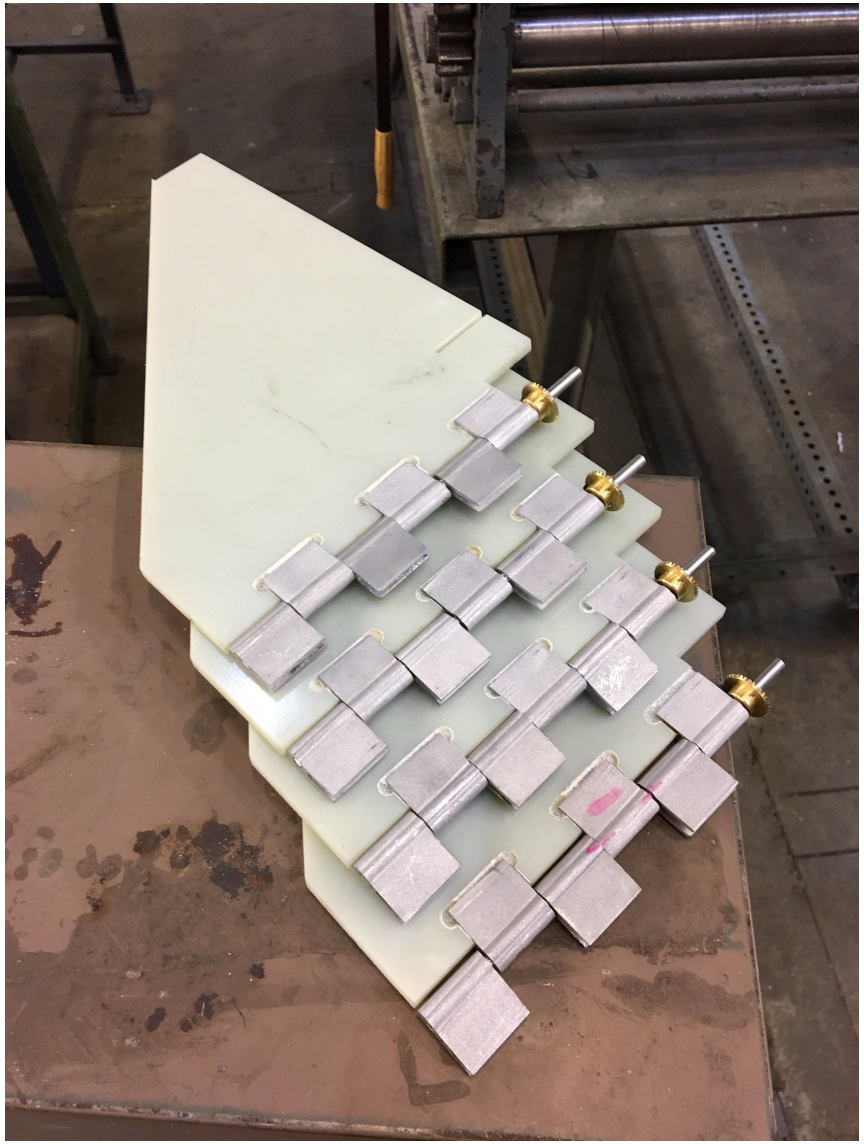
NASA

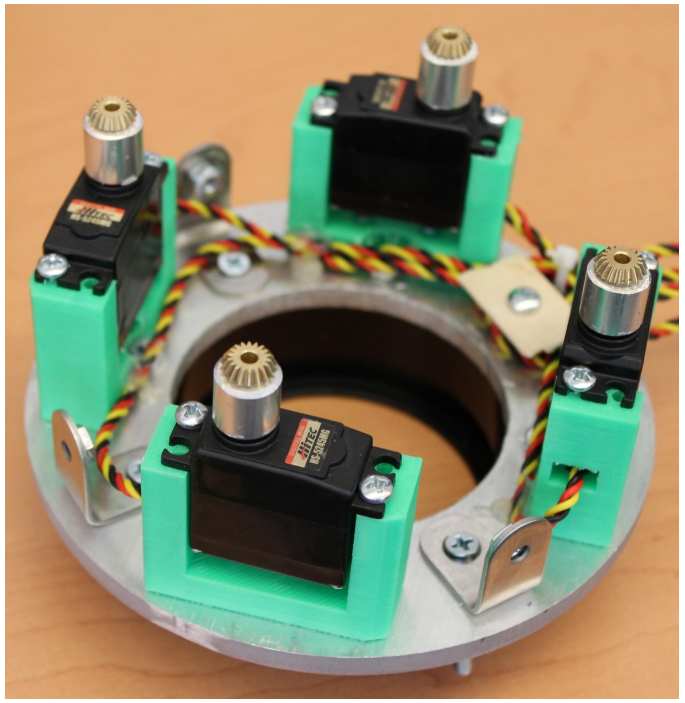
Fabrication Tasks

#	Task Description	Material Handled	Fabrication Techniques	ETA	Fabrication Locations	Safety Precautions
1	3D Print Servo Brackets	PLA/ABS	3D Printer	< 1hr	Inv Studio / AE MakerSpace	N/A
2	Cut Motor Tube to Length	Cardboard	Chop Saw	< 1hr	Inv Studio / SCC	N/A
3	Cut Tubing to Length	Fiberglass	Chop Saw	< 1hr	Inv Studio	2 ppl, shop vac, N95/P95 mask
4	Drill Shear Pin Holes (8)	Fiberglass	Drill	< 1hr	RR room / Inv Studio	2 ppl, shop vac
5	Drill Rivet Holes (4)	Fiberglass	Drill	< 1hr	RR room / Inv Studio	2 ppl, shop vac
6	Drill wire routing holes	Fiberglass	Drill	< 1hr	RR room / Inv Studio	2 ppl, shop vac
7	Drill Holes for Bottom Plate	6061 Aluminum	Drill	< 1hr	RR room / Inv Studio	
8	Slots into Body Tubing	Fiberglass	Jigsaw/Bandsaw/ Chop Saw/Mill	2 hrs	Inv Studio / SCC	2 ppl, shop vac, N95/P95 mask
9	Cut out Thrust Plate	Plywood	Laser Cutter	< 1hr	Inv Studio / AE MakerSpace	N/A
10	Fin Features for Brackets	Fiberglass	Mill	1-2 hrs	BME Shop	2 ppl, shop vac, N95/P95 mask
11	Flap Features for Brackets	Fiberglass	Mill	1-2 hrs	BME Shop	2 ppl, shop vac, N95/P95 mask
	Flats into Shafts	1024 Steel	Mill/Grinder	1-2 hrs	Montgomery MM	N/A
	Fin Brackets	6013 Aluminum	Waterjet	1-2 hrs	Inv Studio / SCC	N/A
	Avionics Bay Tray Brackets	6013 Aluminum	Waterjet	1-2 hrs	Inv Studio / SCC	N/A
	Fins Cut Out	Fiberglass	Waterjet	2 hrs	Inv Studio	N/A
	Avionics Bay bulkheads (2 coupler, 2 body)	Fiberglass	Waterjet	1-2 hrs	Inv Studio	N/A
	Cut Out Bottom Plate	6061 Aluminum	Waterjet	1-2 hrs	Inv Studio / SCC	N/A
	Cut Out Bevel Ring Gear	6061 Aluminum	Waterjet	1-2 hrs	Inv Studio	N/A
	Cut Out Flaps	6061 Aluminum	Waterjet	1-2 hrs	Inv Studio	N/A
	Set Screws for gears / servo hub attachments	Brass / Aluminum	Drill, Saws, etc...	2 hrs	Anywhere you can	N/A
	Cut servo hub to length	Aluminum	Band Saw	<1hr	Inv Studio	N/A
	Drill gears bore diameter	Brass	Drill	<1hr	Inv Studio	N/A










CELTIC


3M

Thrust-to-Weight Ratio *

Thrust/Weight

Avg. Thrust = 1,102.2 N

Weight = 15.37 kg * 9.81 m/s2

Thrust-to-Weight Ratio =7.312

Georgia Tech ARES

NASA

Rocket Flight Stability

Stability Analysis	
Center of Pressure (in from nose)	80.98
Center of Gravity (in from nose)	66.741
Static Stability Margin	2.56
Static Stability Margin (off launch rail)	2.1
Thrust-to-Weight Ratio	7.312
Rail Size and Length (in)	1010, 144 in
Rail Exit Velocity (ft/s)	76.2

Georgia Tech ARES

NASA

Parachutes - Specifications

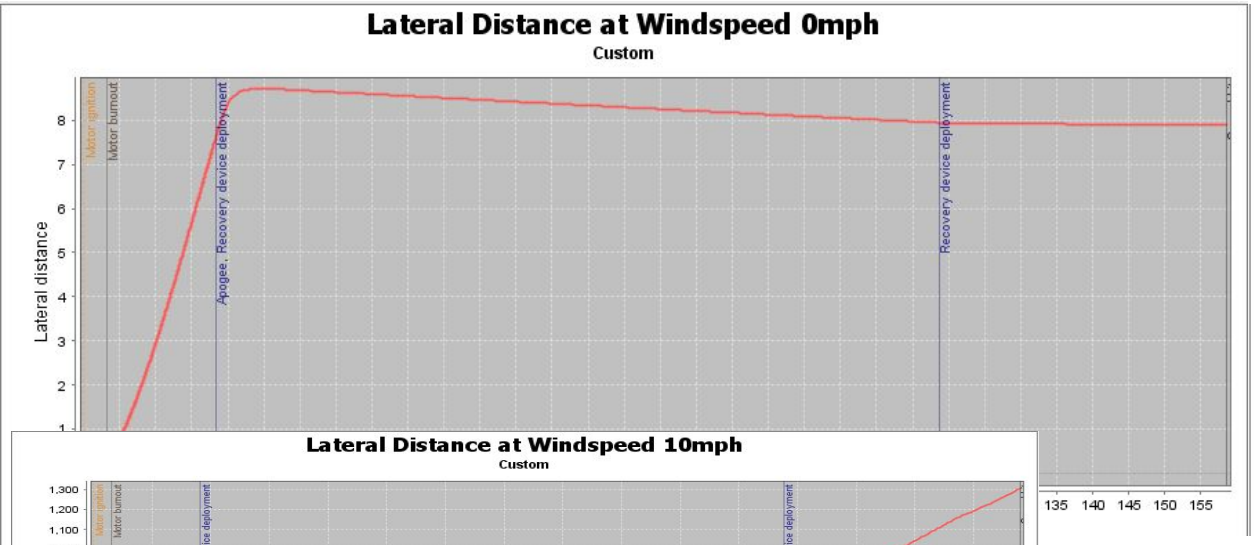
Sizes	Main: 120” Drogue: 48”, composed of risptock nylon
Recovery Harness Type	Main: TFR, Drogue: TFR
Length	Main: 16’, Drogue 16’
Descent Rates	68.56ft/s, 18.54ft/s

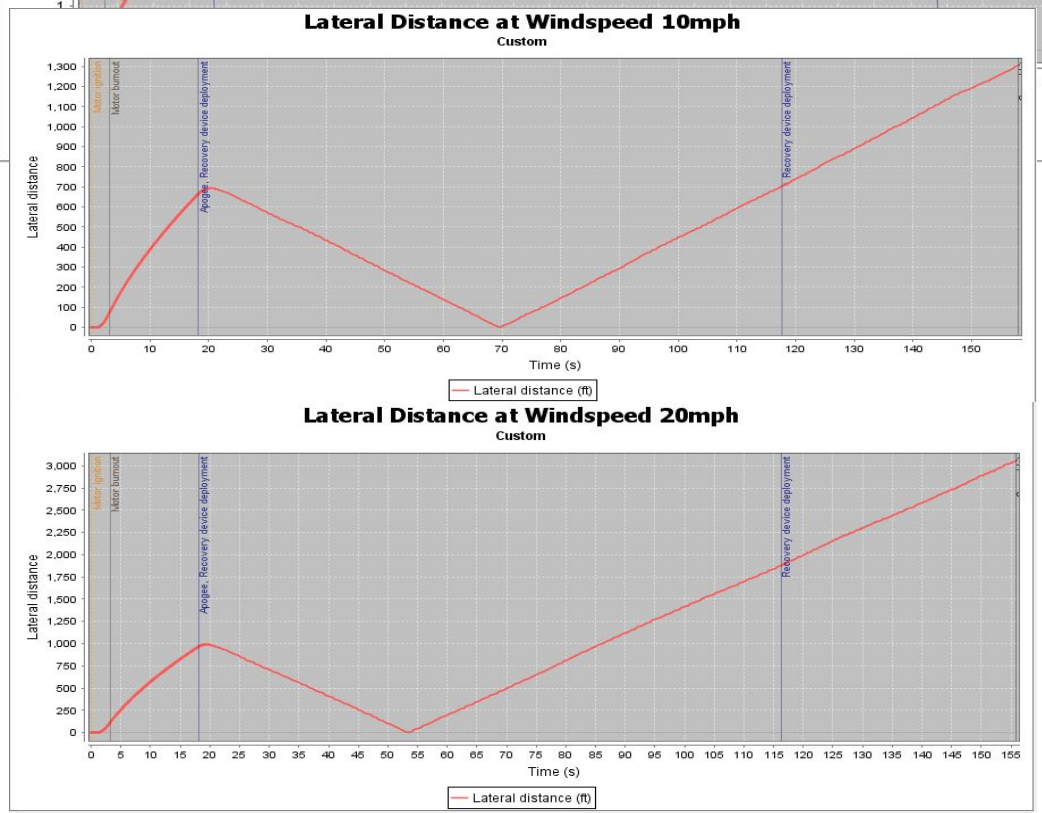
Section	**Mass(lb)**	**Kinetic Energy (ft-lbf)**
Nose Cone	9.177	49.05
Avionics	7.53	40.27
Booster	16.03	87.32

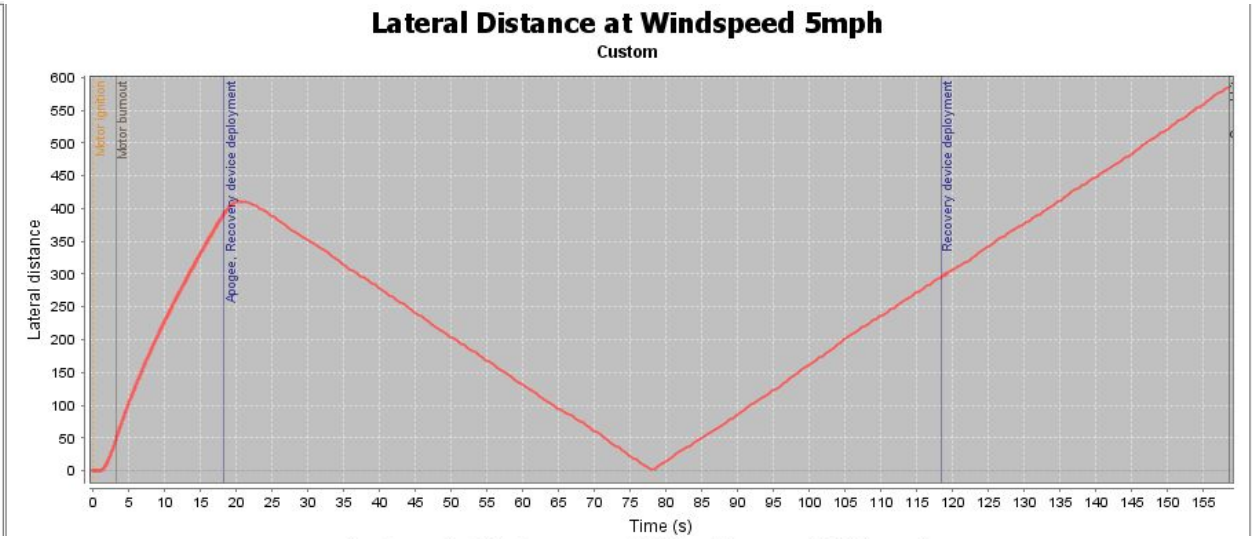
Georgia Tech ARES

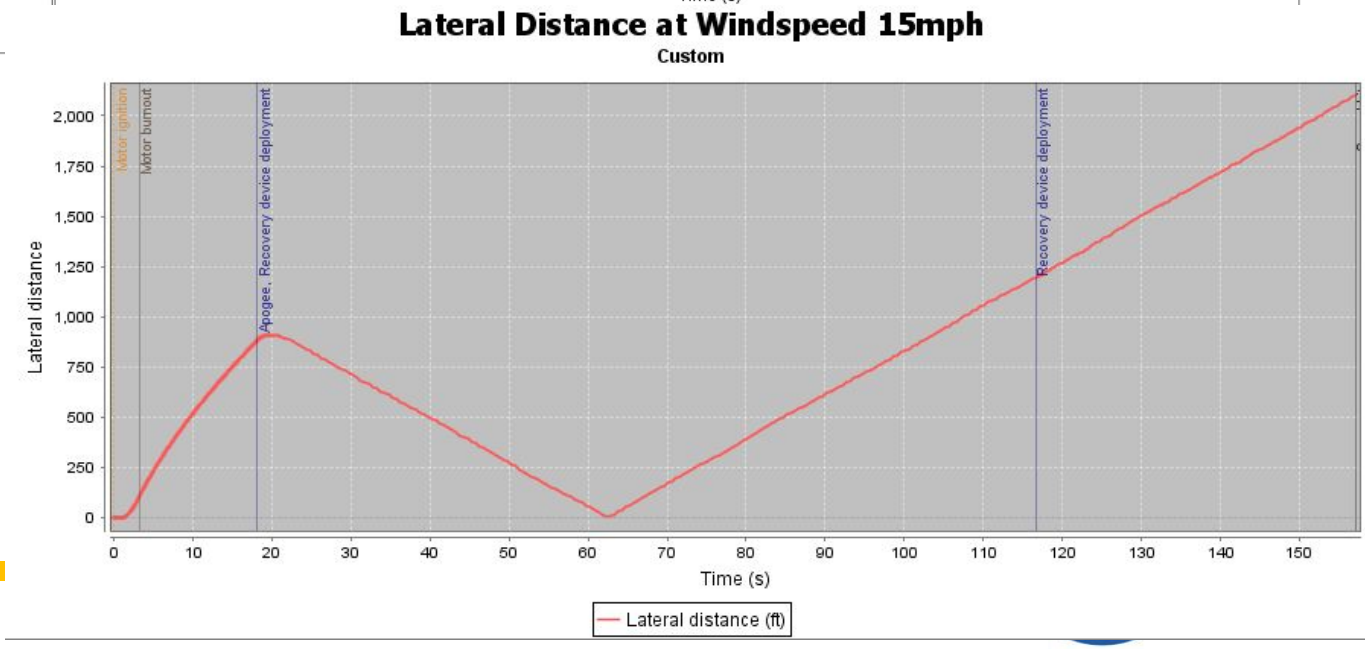
NASA

Mission Performance - Drift Profile









Launch Vehicle Kinetic Energy

Launch Vehicle Section	Velocity (ft/s)	Kinetic Energy (ft-lbf)
Upper Section	18.5	36.5
Avionics Bay	18.5	45.3
Booster Section	18.5	73.14

Calculations:

220oz * 1lbf / 16oz * 1 slug / 32.17lbf = .427 slugs

Ek = .5 * m * v^2

Ek = .5 * .404 slugs * (18.5 ft/s)^2

Ek = 73.14 lbft

Georgia Tech ARES

NASA

Test Plan Overview

Component	*Test*	*Verification Method*
Roll system	Wind Tunnel	Quantitative Analysis
Bulkhead strength	Tensile Loading Machine	Quantitative Analysis
Thrust Plate	Bend test and pressure test to verify rigidity until breaking point.	Quantitative Analysis
Payload Bay	Payload retention force measurement test.	Quantitative Analysis
Avionics Bay	Altimeter accuracy and accelerometer performance test.	Quantitative Analysis
Recovery System	Recovery system ground test fire.	Inspection
Fins	Fin attachment robustness test along two axis.	Quantitative Analysis
Launch Vehicle Assembly	Vehicle will be completely assembled under a time constraint to verify efficiency and effectiveness.	Inspection

Georgia Tech ARES

NASA

Project KRIOS - FRR

FLIGHT SYSTEMS

Georgia Tech ARES

NASA

Flight Systems: Avionics Main Components

Avionics Components

Part	***Function***	Software
Eggfinder TX/RX Module	GPS module - used for in-flight telemetry data and post recovery location.	TBD
mbed LPC 1768	Microcontroller - used to actuate servo motors based on in-flight data	Programmed in C++ through the MBED developer.
Pixhawk	Autopilot IMU - used to report, collect, and store data on roll, velocity, and apogee.	Mission Planner flight control GUI
StratologgerCF Altimeter (x2)	Altimeter - Used to deploy Main and Drogue Chute at desired apogee.	Perfectflite datacap

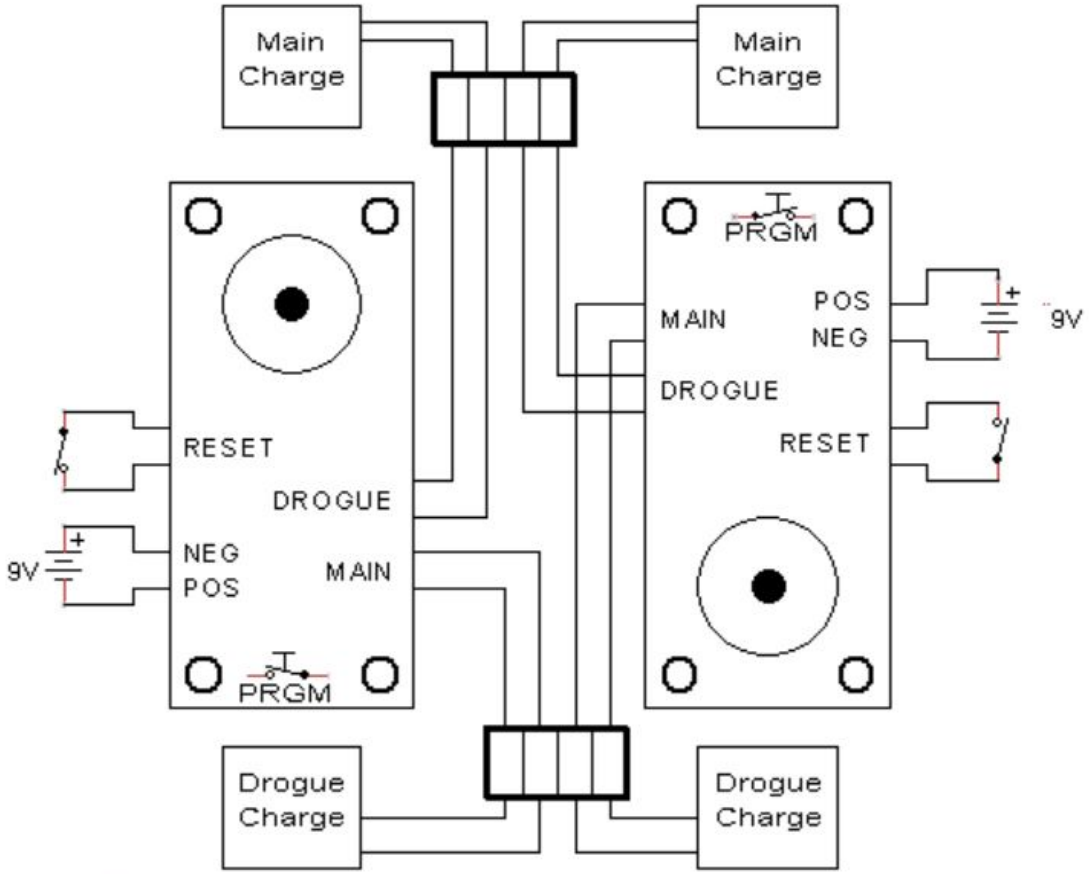
Georgia Tech ARES

NASA

Flight Systems: Responsibilities

Requirement	Design Feature to Satisfy Requirement	Requirement Verification	Success Criteria
The vehicle will perform a successful recovery	Dual Redundant StratologgerCF altimeter	Sub-scale launch	The rocket is recovered unscathed.
The vehicle will be tracked in real-time to locate and recover it	GPS receiver module will be housed in the vehicle and base station	Full-scale launch	The vehicle will be located quickly using a ground station.
The data of the vehicle's flight will be recorded	Pixhawk will record and store desired parameters	Full-scale launch	The data will be obtainable,, readable, and accurate post recovery
The rocket will perform two complete rolls, followed by a counter roll post motor burnout.	The mbed will actuate motors that drive flaps to induce a roll moment.	Full-scale launch	The rocket rotates at least twice and returns to a zero roll rate in between motor burnout and drogue deployment.

Flight Systems: Recovery



Altimeters are independently powered using 9V DC batteries.

Main and Drogue have dual charge firings with one altimeter delaying its output by one second.

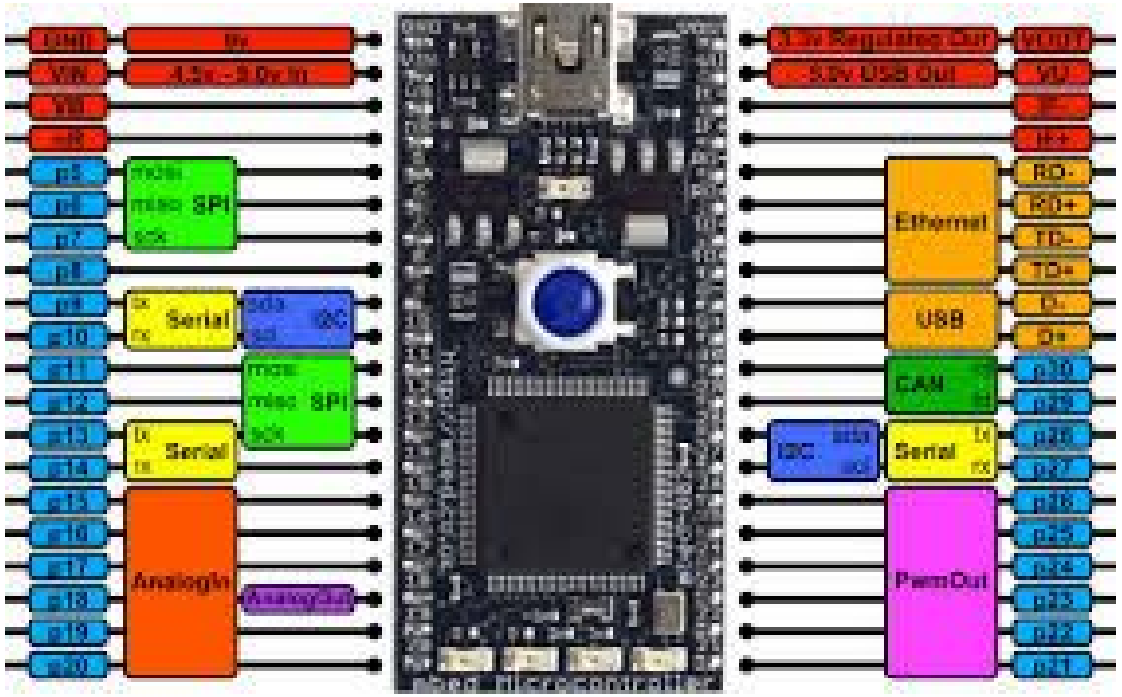
Resets are wired to key switched that protrude from the rocket tube.

Georgia Tech ARES

NASA

Flight Systems: Motor Actuation System

MBED ARM Microcontroller

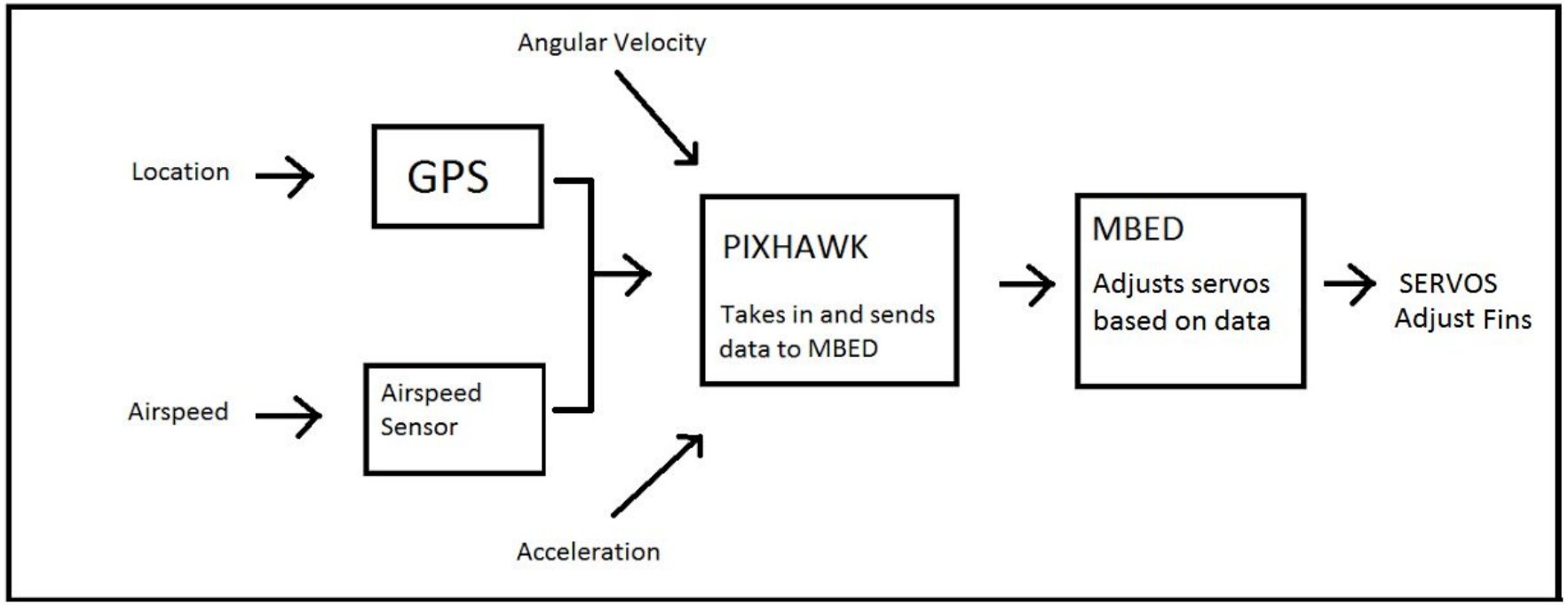


HS-5085MG High-power servo

Georgia Tech ARES

NASA

Flight Systems: Motor Actuation System Software



Georgia Tech ARES

NASA

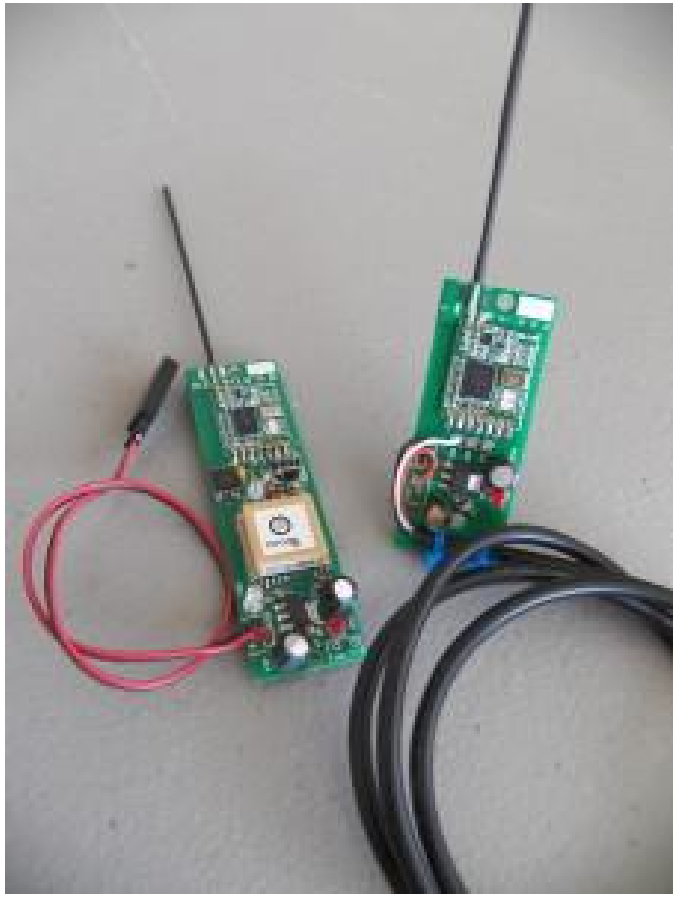
Flight Systems: Data Collection

1. Spektrum DSM receiver
2. Telemetry (radio telemetry)
3. Telemetry (on-screen display)
4. USB
5. SPI (serial peripheral interface) bus
6. Power module
7. Safety switch button
8. Buzzer
9. Serial
10. GPS module
11. CAN (controller area network) bus
12. I²C splitter or compass module
13. Analog to digital converter 6.6 V
14. Analog to digital converter 3.3 V
15. LED indicator

Georgia Tech ARES

NASA

Flight Systems: Telemetry



Equipment:

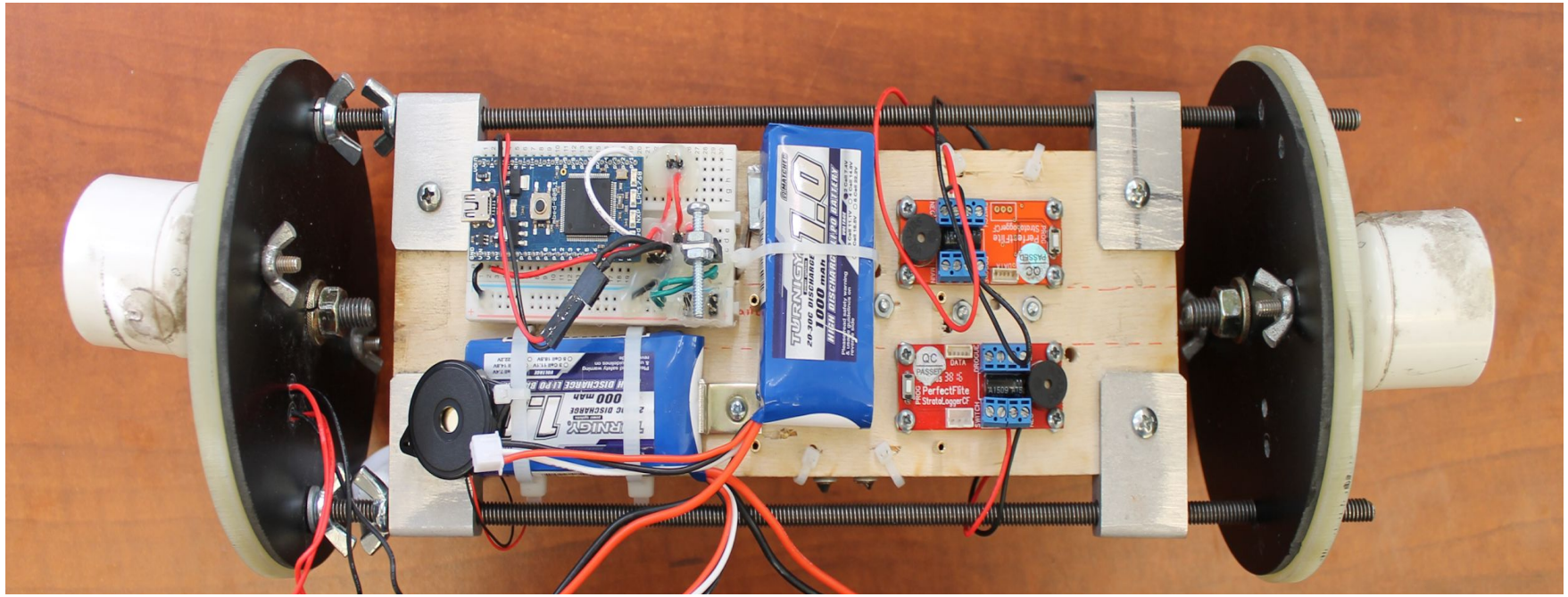
- Eggfinder TX (Transmitter)
- Eggfinder RX (Receiver)

Georgia Tech ARES

NASA

Flight Systems: Power/Safety

Redundancy
Safety switches
Rail Switch



Georgia Tech ARES

NASA

Flight Systems: Testing Overview

Wind Tunnel: Test Cd of flaps against simulation, and ability for servos to withstand the given pressures

Flight Simulation: Forged flight data will be fed to the sensors and the response efficacy will be analyzed.

Power Consumption: Full charged power supply will be connected to flight systems to see its maximum lifespan.

Questions

Questions?