Project A.P.E.S.
Preliminary Design Review

Presented by:

Georgia Institute of Technology
Mile High Yellow Jackets

Agenda

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

Project A.P.E.S. PDR

TEAM OVERVIEW

Georgia Tech Team Overview

- 13 person team composed of both undergraduate and graduate students
  - Graduate Students: 3
  - Undergraduates: 10

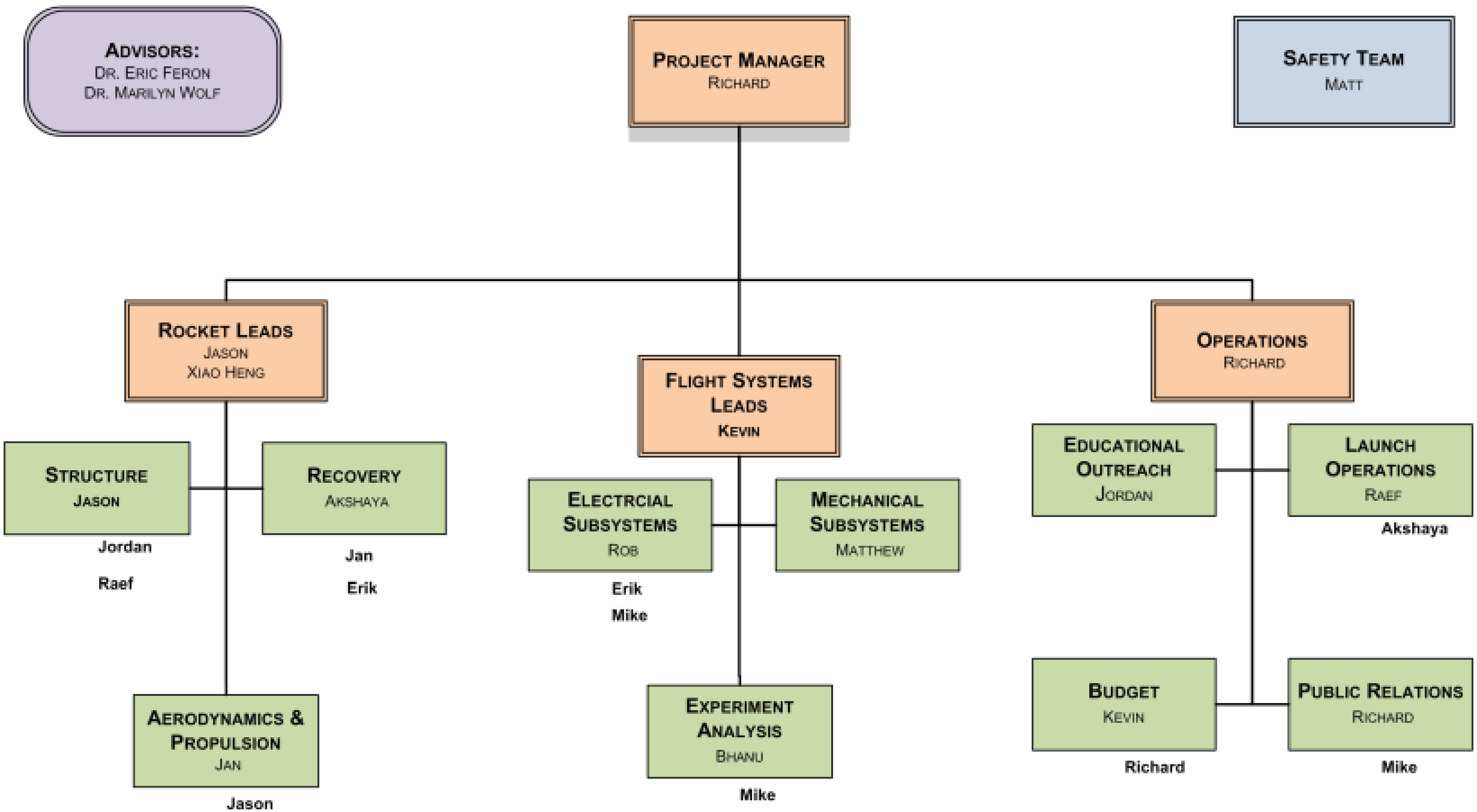
- Highly Integrated team across several disciplines

Field	No. of Students
Aerospace Engineering	9
Mechanical Engineering	1
Computer Science/ Computer Engineering	2
Electrical Engineering	3
Mathematics	1

Work Breakdown Structure

2011-2012 Mile High Yellow Jackets

Georgia Institute of Technology



Georgia Tech USLI UNIVERSITY STUDENT LAUNCH INITIATIVE

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CHANGES SINCE PROPOSAL

Changes Since Proposal

Rocket:

- No changes since proposal

Payload & Flight Systems

- Removed accelerometers from the A.P.E.S. feedback control loop
- Laser infrared systems have been substituted with a Camera Cube and IR sensor
- Changed Flight computer from the Parallax Propeller Chip to the Atmega 2560
- Design paradigm of the platform has changed.

Activity Plan:

- No changes since proposal

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EDUCATIONAL OUTREACH

Educational Outreach

- Goal: *Promote Interest in the Science, Technology, Engineering, and Mathematics (STEM) fields.*

- As of PDR, Mile High Yellow Jackets have planned two (2) Educational Outreach Events

- Young Astronauts Program
  - Work in conjunction with the GaTech Space System Design Lab and Madras Middle School in Newnan, Ga
- FIRST Lego League
  - Engineering competition held for Middle School students to build and compete with autonomous MINDSTORMS robot.

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SAFETY

Risk Assessment

- 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 Elimination
  - What can be done to mitigate the risk?
- Reviewing Assessments
  - Are the mitigations working?

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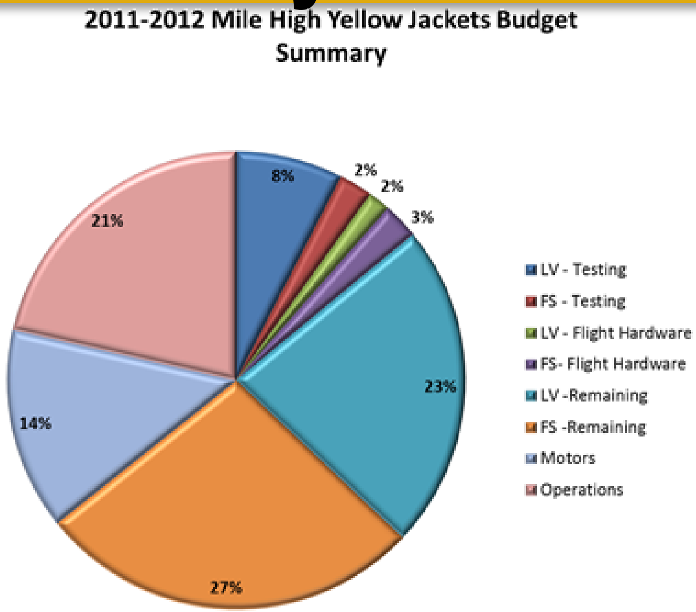
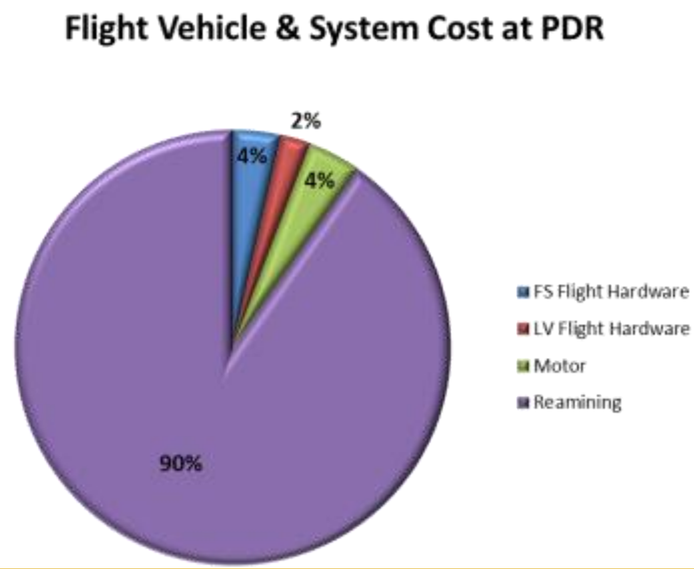
PROJECT BUDGET

Project Budget Summary

Organization	*Amt.*
GA Space Grant Consortium	$3,500
GA Tech AE Department	$1,000
GA Tech SGA	$1,000
Scitor Corporation	$500
SpaceX	$1,000
Total:	$7,000

Subsystem	*Amt.*
Launch Vehicle & Motors	$3,250
Flight Systems	$2,.250
Operations	$1,500
Total:	$7,000





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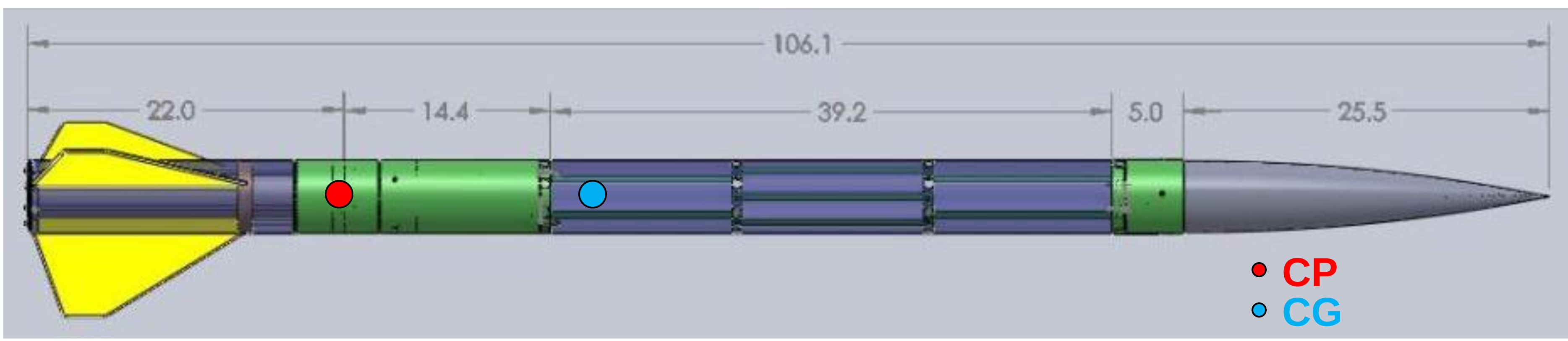
LAUNCH VEHICLE

Vehicle Summary

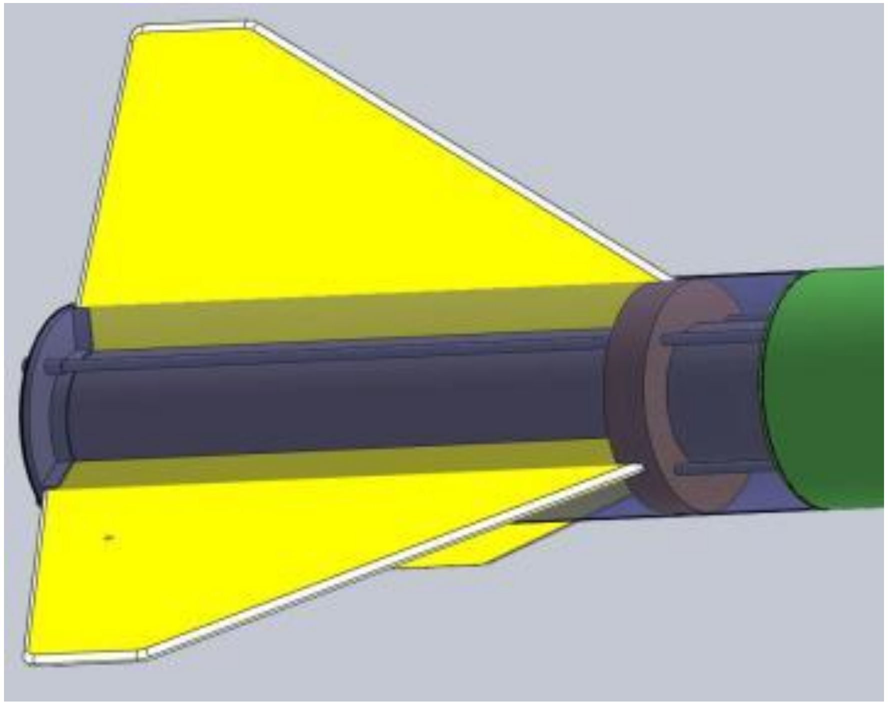
- Predicted apogee: 5259 ft
- Stability margin: 3.6 calibers
- Motor: AeroTech L1390
- 47 fps at 60 inches up the rail
- Max Mach 0.55
- Total weight: ~41 lbs
- Dual deployment



Rocket Fins

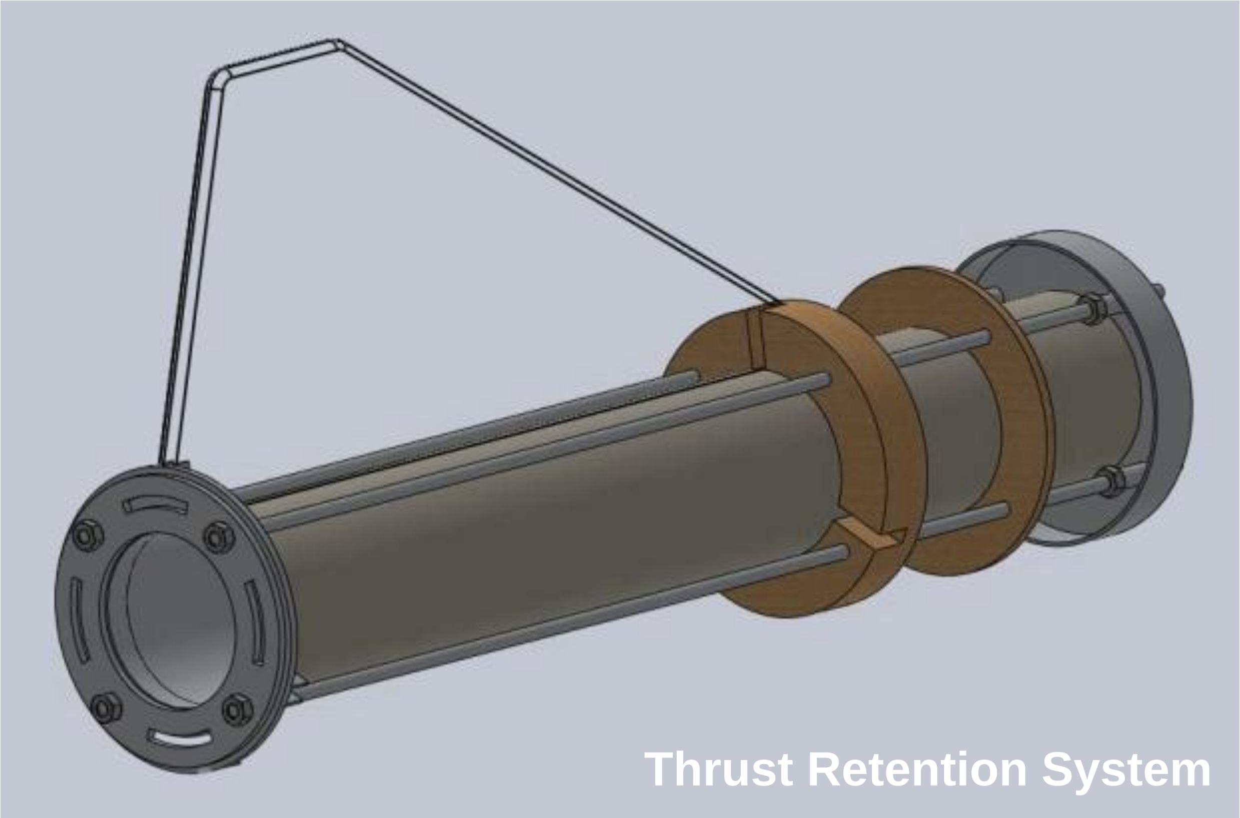
- Material: Carbon fiber honeycomb
- Attachment: Epoxy

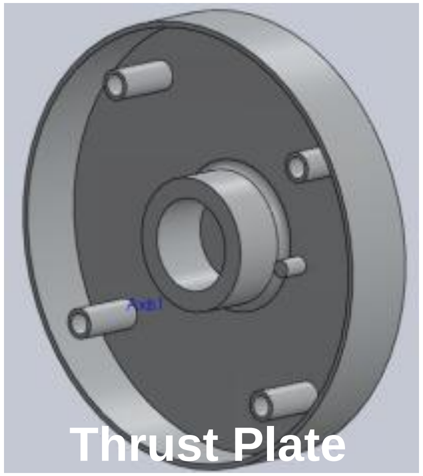
Variable	Value
Number of fins	3
Root chord	15 in
Tip chord	3 in
Height	6 in
Sweep Angle	58.6°
Sweep Length	9.8 in

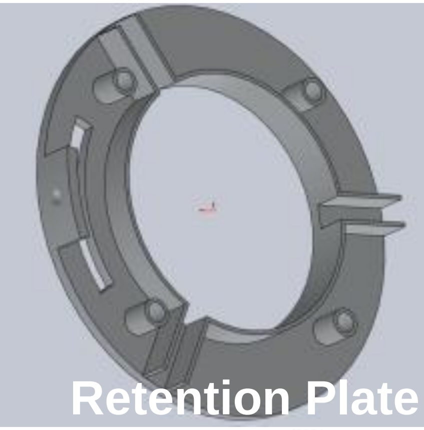


Booster Section

- Material: Aluminum, wood, and fiberglass
- Attachment: Nuts, bolts, and epoxy

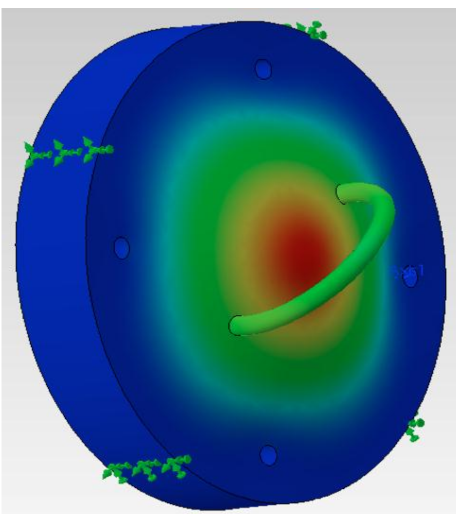


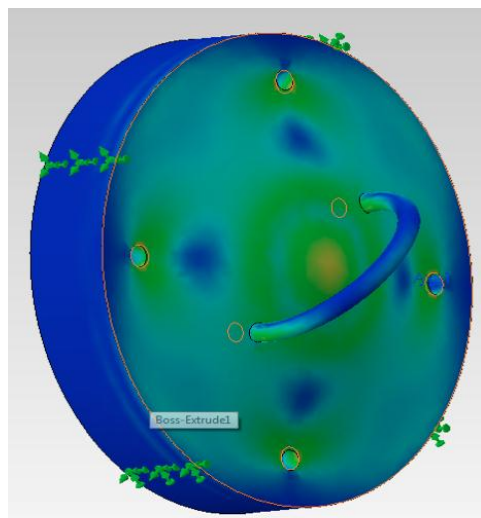


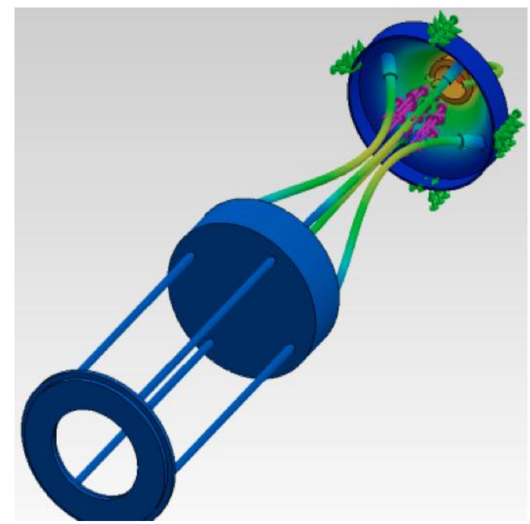


FEA Analysis & Results

	Force applied (lb_f)	Max displacement (inches)	Max stress (psi)	Safety factor
Thrust Plate	408	.00318	10,053	3.65
Assembly	408	.00417	9,620	3.72

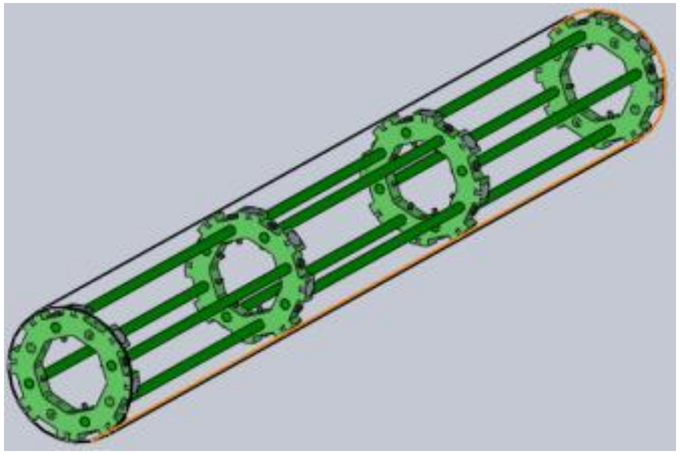


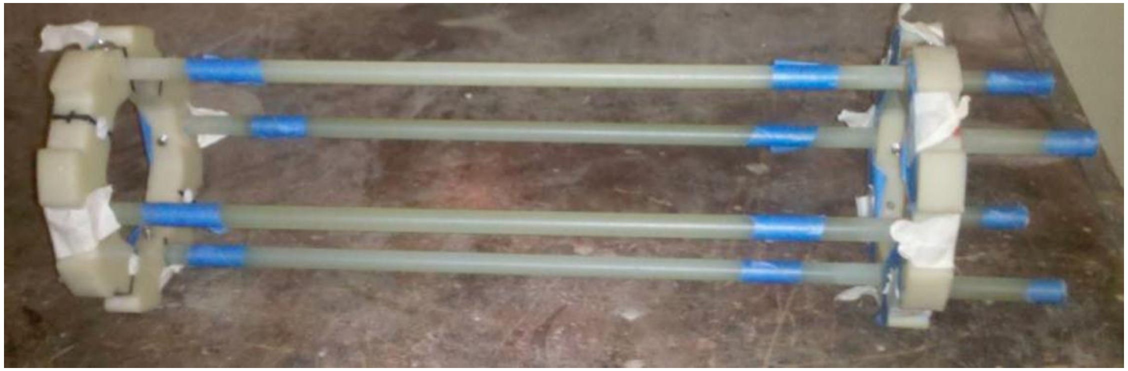




Payload Section

- Material: G10 Fiberglass, bolts





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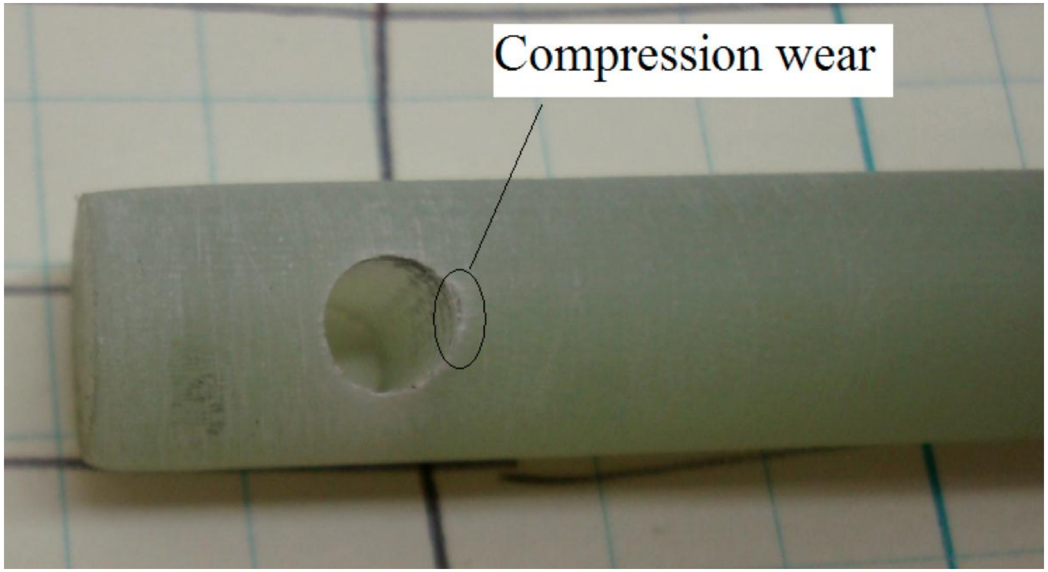
Payload Structure Impact Test

Impactor mass (kg)	Factor of Safety	Impact Energy (J)	Impactor Height (in)	Stringer length (in)	Notes
3.98	1	5.23	11.08	14	Pass
3.98	2	10.47	22.16	14	Pass
3.98	3	15.70	33.24	14	Pass



Payload Structure – Test Result

Fastener location	F.S. = 1	F.S. = 1.5	F.S. = 2	F.S. = 2.5	F.S. = 3
1	p	P	p	p	P
2	P	P	P	P	P
3	P	P	P	P	P
4	P	P	P	P	P
1A	P	P	P	P	X
2A	P	P	P	X	X
3A	P	P	P	X	X
4A	P	P	P	P	P
5	P	P	P	P	P
6	P	P	P	P	P
7	P	P	P	P	P
8	P	p	P	P	P

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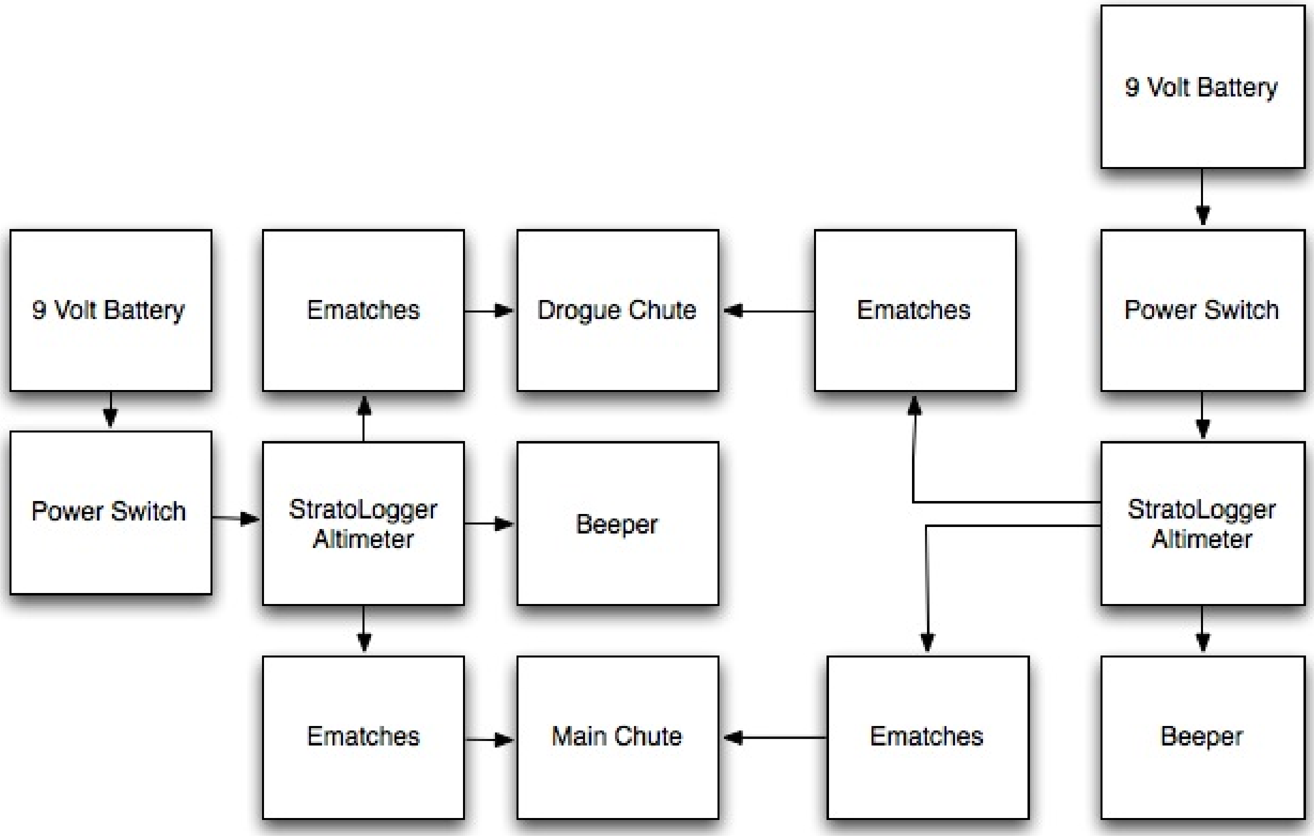
Recovery

- Dual deployment system
- Altimeter: 2 Perfect Flite StratoLogger's for redundancy

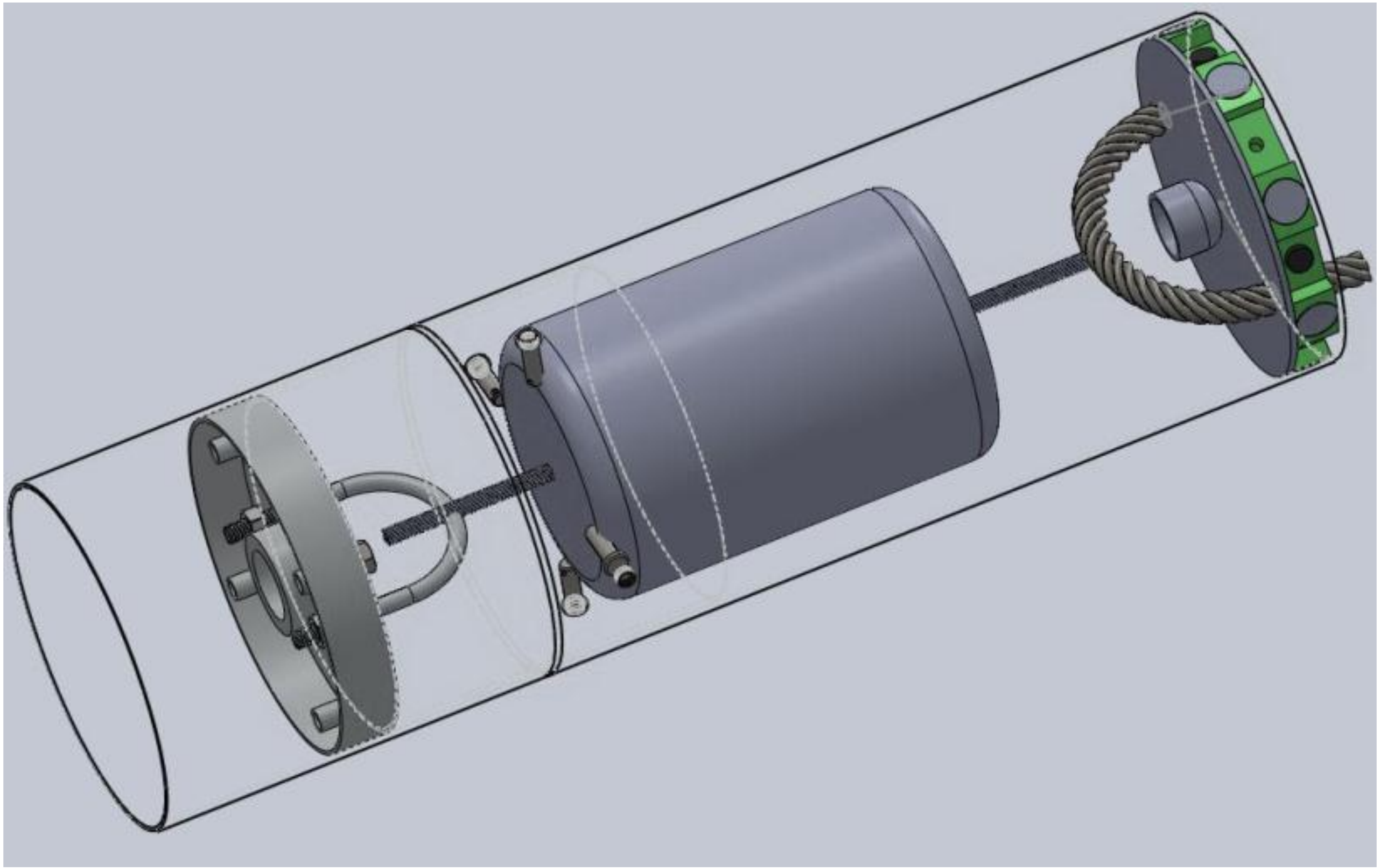


Ejection Charges

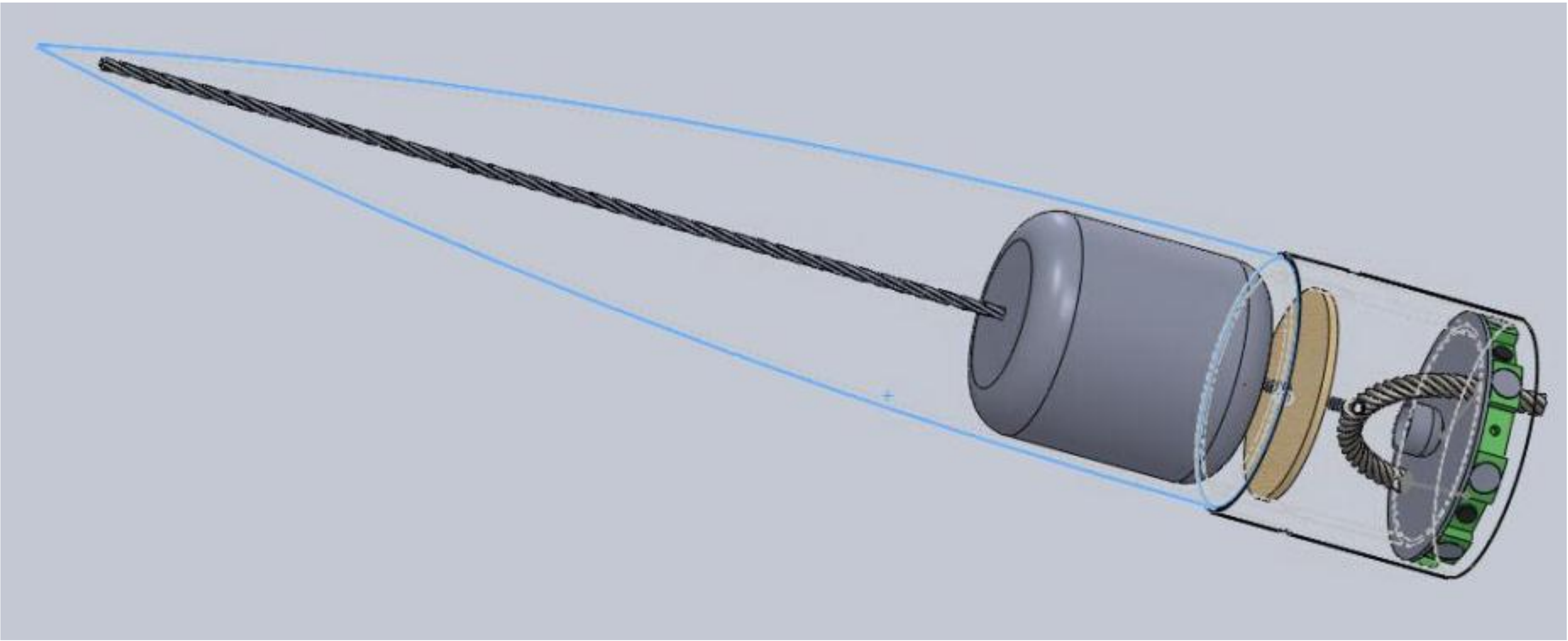
- Black powder ejection charges
- Ground testing will be perform prior to CDR

	Main Parachute	Drogue Parachute
Total Pressurization	23.7 psi	24.7 psi
Differential Pressurization	10 psi	9 psi
Amount of black powder	1.52 grams	0.91 grams

Recovery – Main

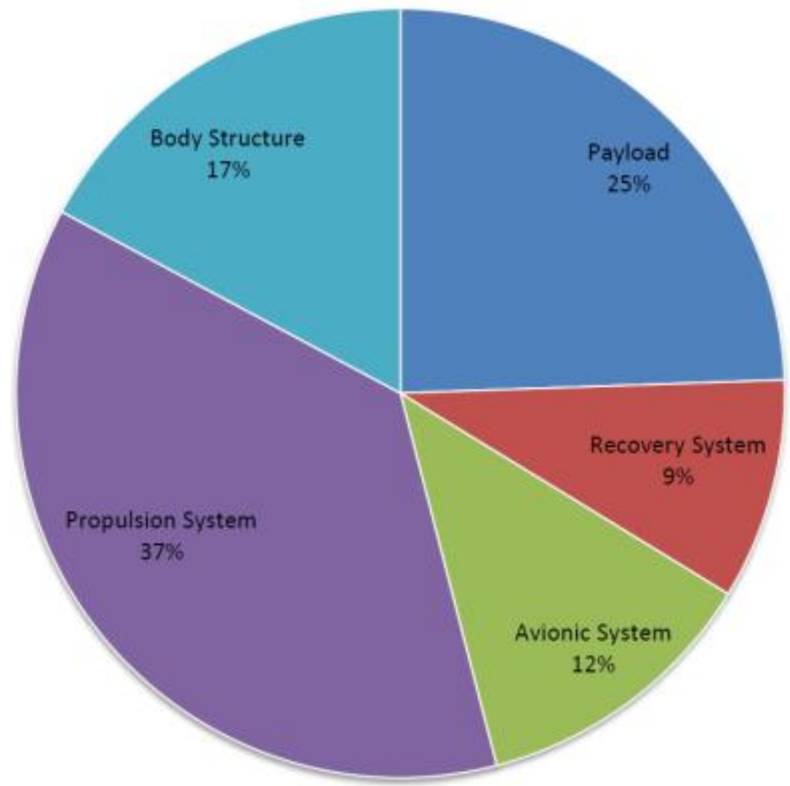


Recovery – Drogue



Mass Breakdown

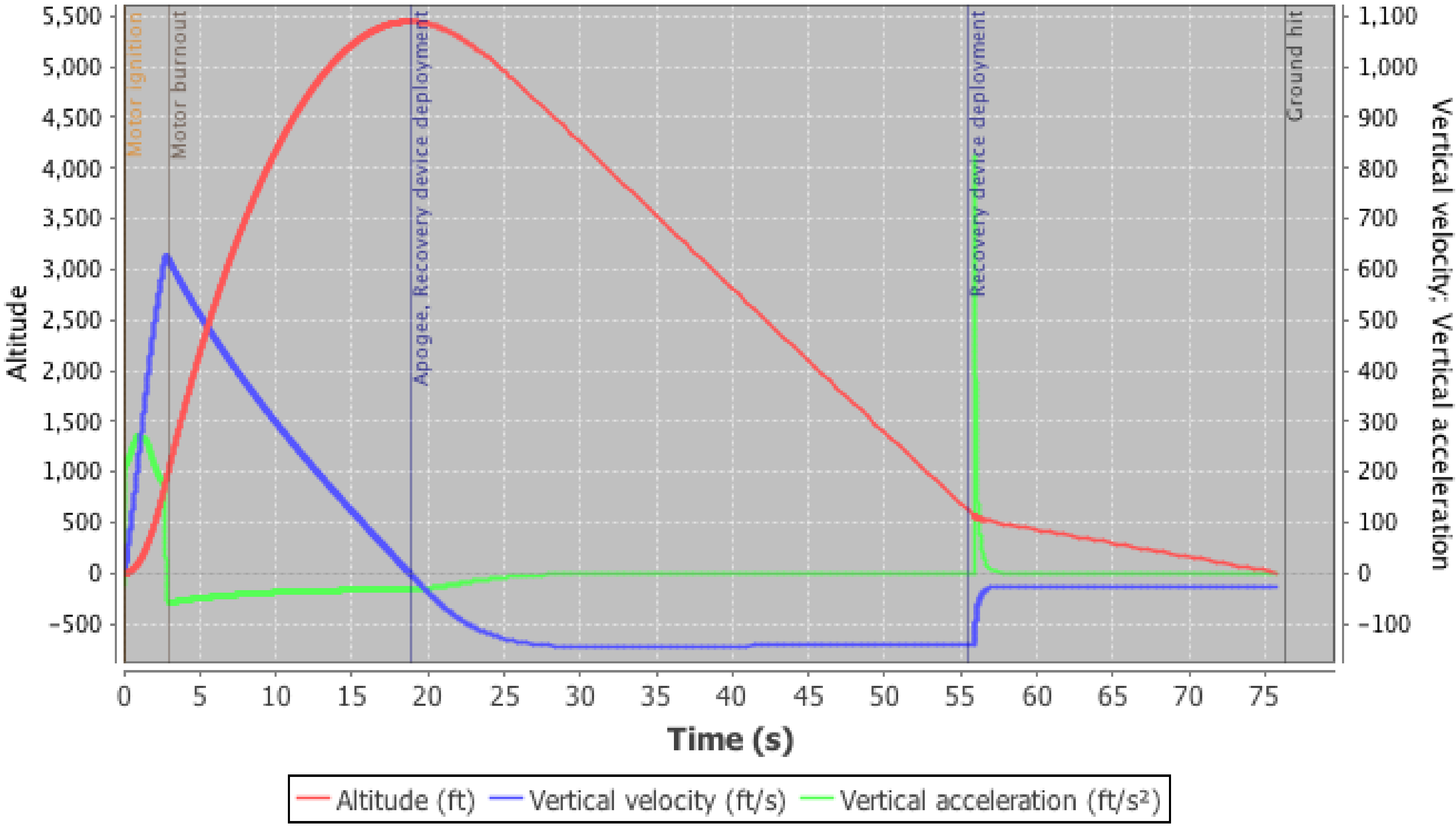
Component	Weight (lbs)
Nose Cone	1.6
Avionics System	5.0
Engineering Payload	10.0
Payload Structure	3.5
Recovery Structure	5.4
Booster Structure	6.4
AeroTech L1390	8.6
Total	**40.5**



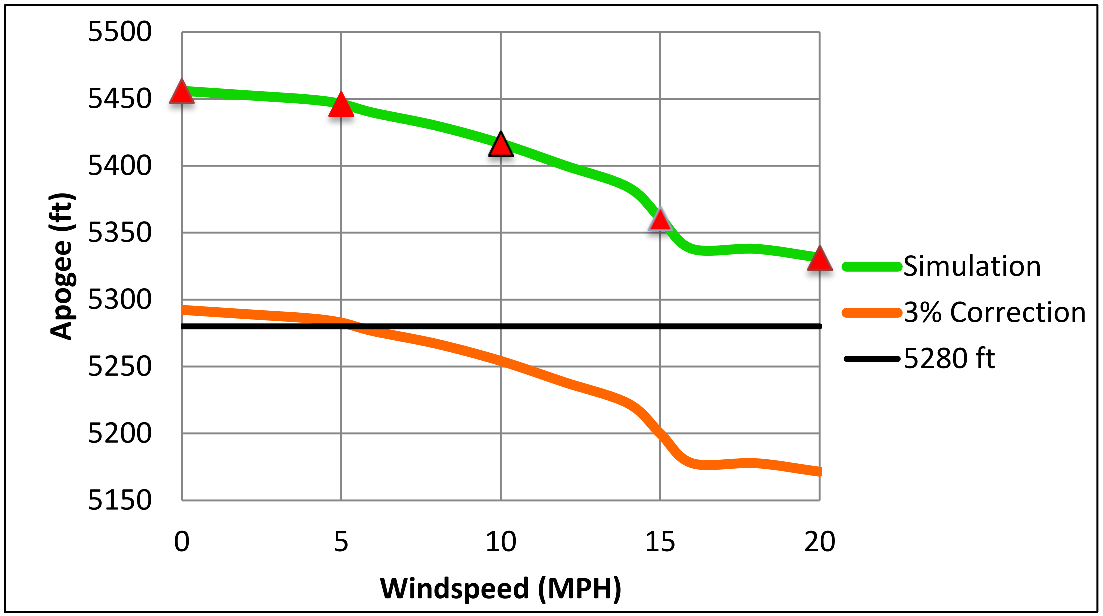
Motor Selection

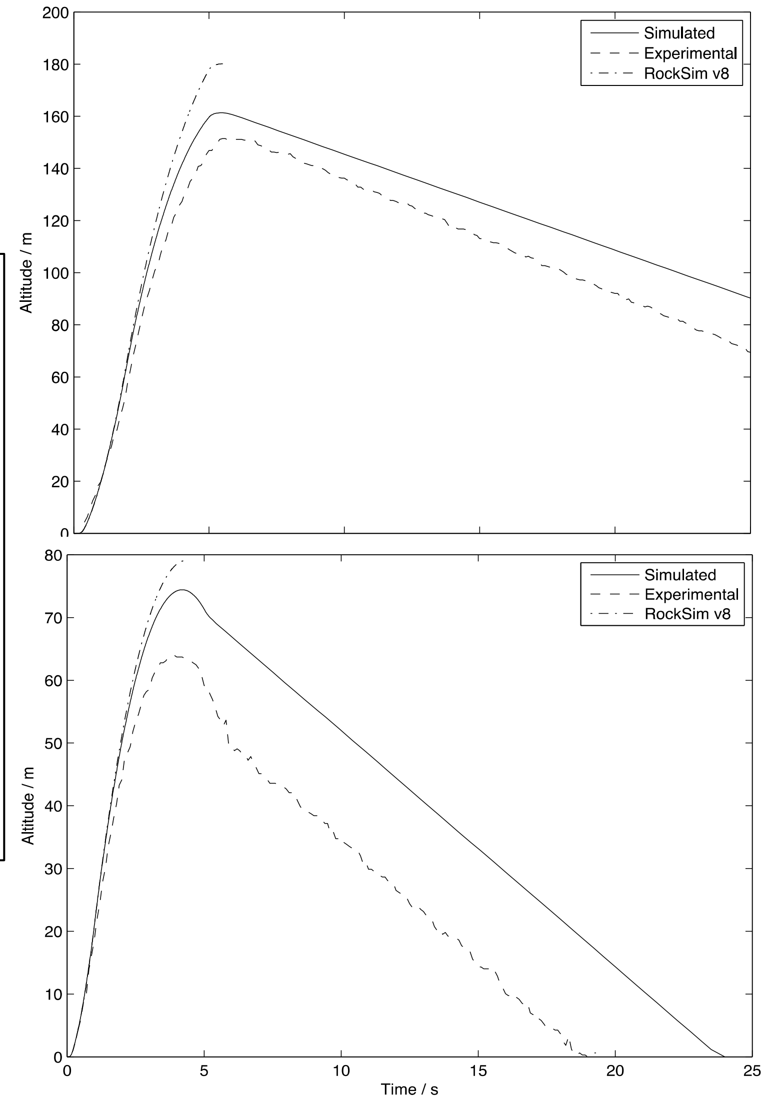
Total Weight without Motor (lbs)	Total Weight with Motor (lbs)	Motor Required	Apogee (ft)
28	36.0	AeroTech L1150R-P	5242
30	38.0	AeroTech L850W-P	5253
32	40.0	AeroTech L1520T-PS	5170
32	40.5	AeroTech L1390G-P	5440
33	41.5	AeroTech L1390G-P	5259

Flight Profile

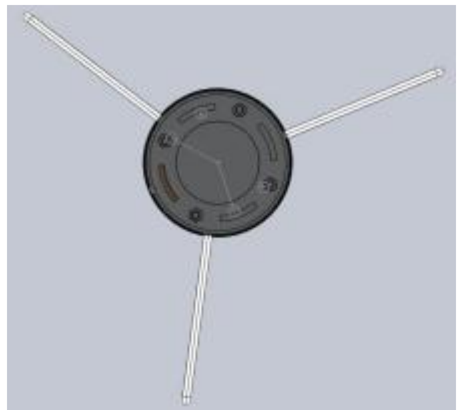


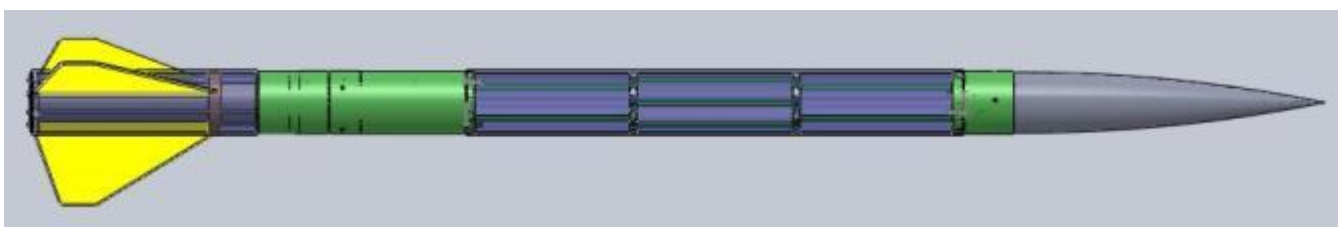
Drift Profile

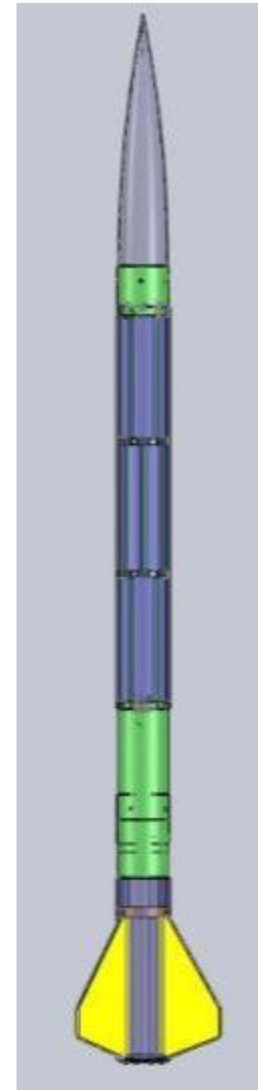




Finish Product







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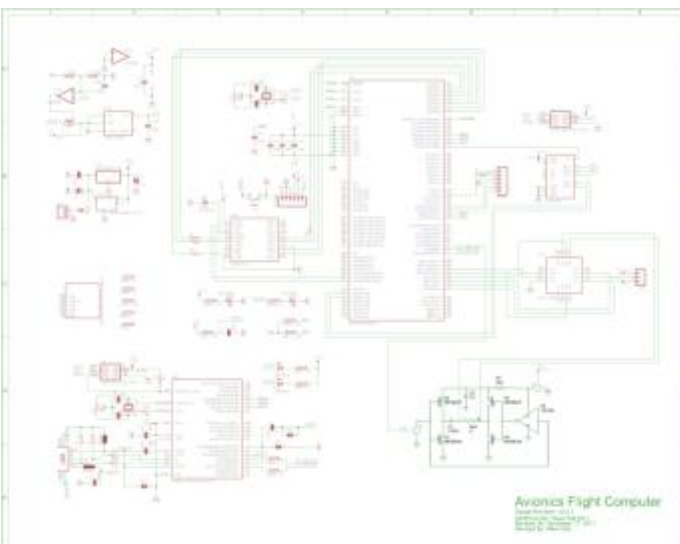
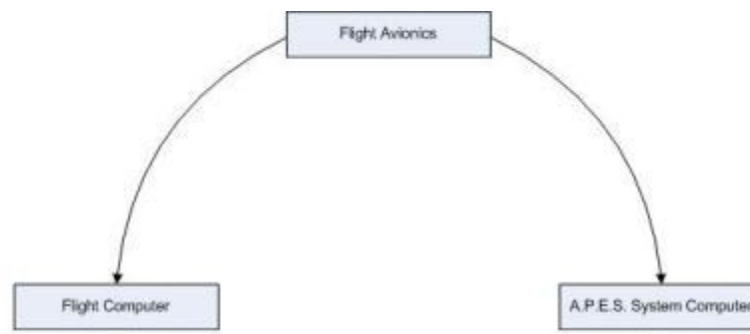
FLIGHT SYSTEMS & PAYLOAD

Flight Systems Responsibilities

- Payload
- Avionics
- Communications
- A.P.E.S. Ground Testing

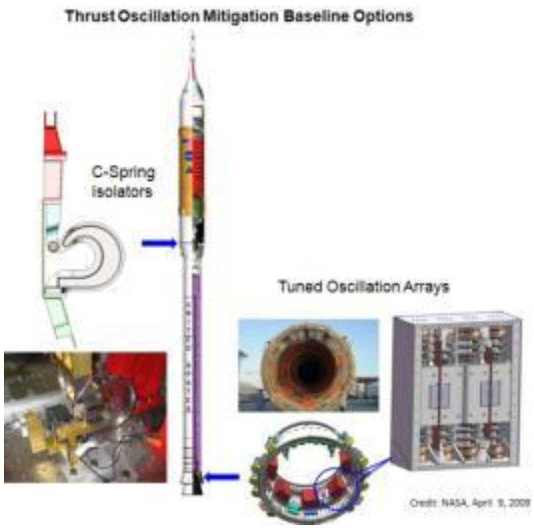




Flight Systems: Payload

- Current solutions to the problem of eliminating natural frequency oscillations
  - Mechanical C-Spring Isolators
  - Tuned Oscillation Arrays

- Use of advanced isolation components adds mass and design constraints



Flight Systems: Science

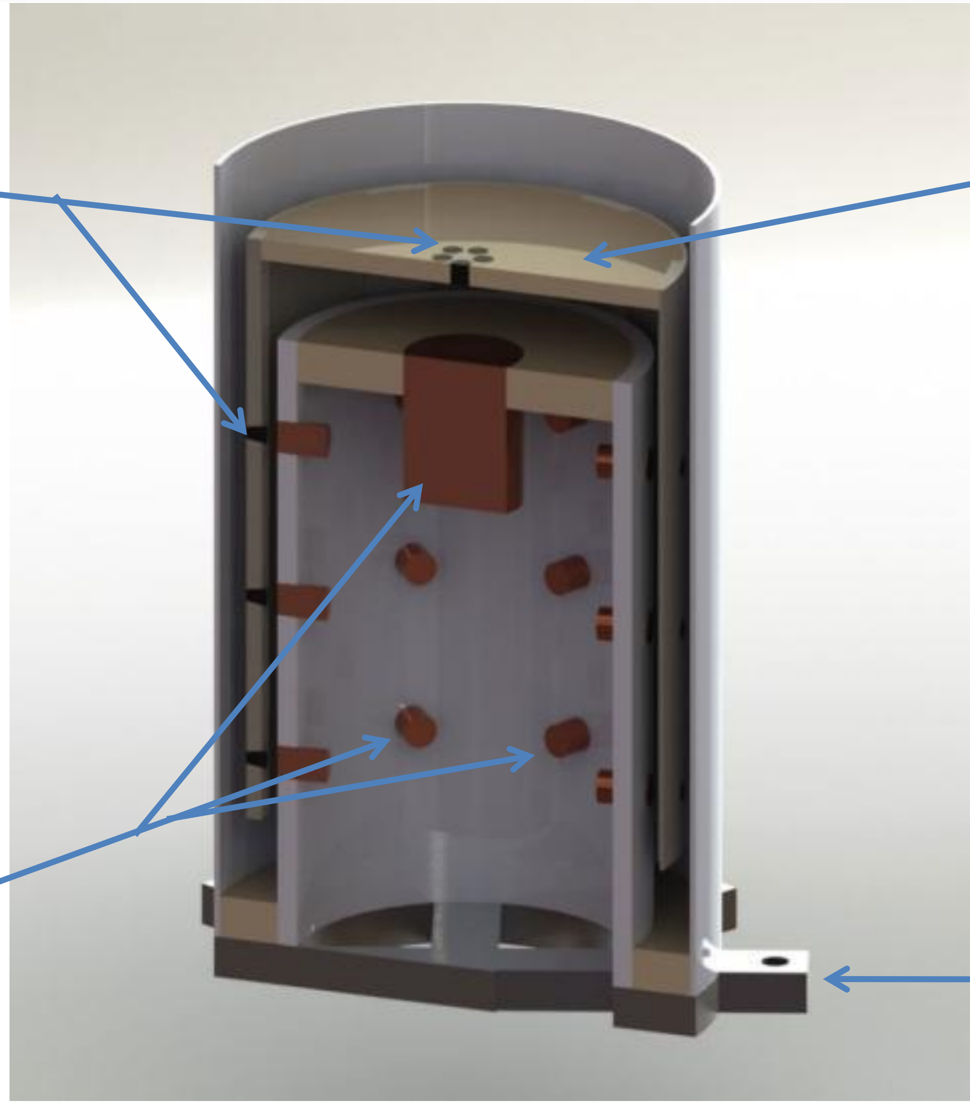
- Interaction of magnetics fields and permanently magnetic or ferromagnetic substances
- For ferromagnetic substance:

$$\mathbf{F}(\mathbf{r}, \mathbf{m}_s, \mathbf{m}) = \frac{3VN^2I^2S^2\mu\chi_m}{16\pi^2r^7}[(\hat{\mathbf{n}}\cdot\hat{\mathbf{r}})\hat{\mathbf{n}} - \hat{\mathbf{r}} - 4(\hat{\mathbf{n}}\cdot\hat{\mathbf{r}})^2\hat{\mathbf{r}}]$$

- For permanently magnetic substance:

$$\mathbf{F}(\mathbf{r}, \mathbf{m}_s, \mathbf{m}) = \frac{3VNIS\mu_0}{4\pi r^4}[(\hat{\mathbf{n}}\cdot\hat{\mathbf{r}})\mathbf{M} + (\mathbf{M}\cdot\hat{\mathbf{r}})\hat{\mathbf{n}} + (\hat{\mathbf{n}}\cdot\mathbf{M})\hat{\mathbf{r}} - 5(\hat{\mathbf{n}}\cdot\hat{\mathbf{r}})(\mathbf{M}\cdot\hat{\mathbf{r}})\hat{\mathbf{r}}]$$

Flight Systems: A.P.E.S.



Flight Systems: Ground Testing

Flight Systems: Ground Testing

- Setting up for initial testing

- Angled feet used to raise the ground test platform off the ground

Flight Systems: Ground Test Plan

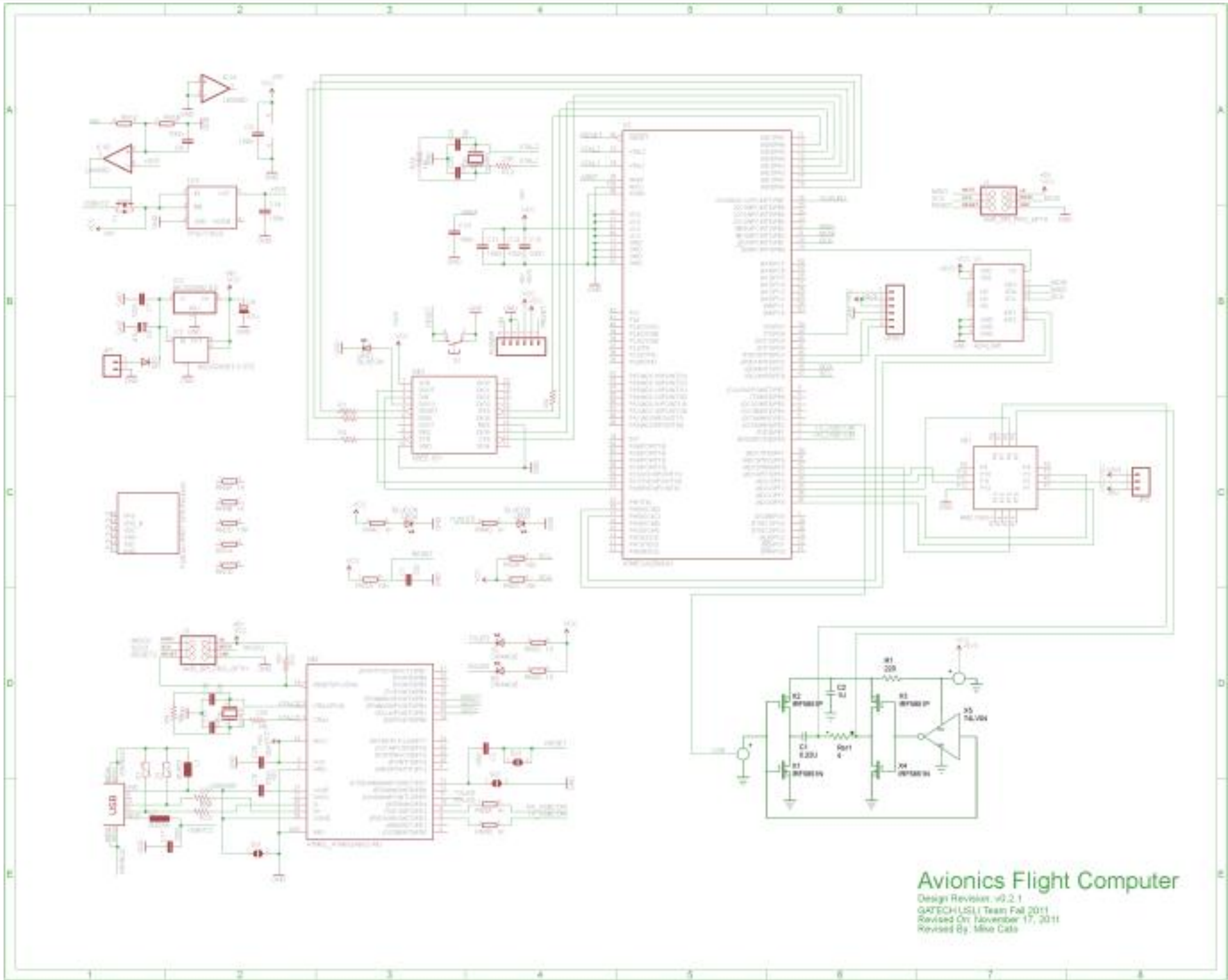
Goals:

1. Develop Control Theories
2. Confirm Force Equations
3. Produce Flight Experiment

Ground Test Sequence

1. Sensor Calibration
2. 1-D Testing
3. 2-D Testing
4. 3-D Testing
5. Flight Model Test

Flight Systems: Avionics



Flight Systems: Avionics

Custom flight computer board

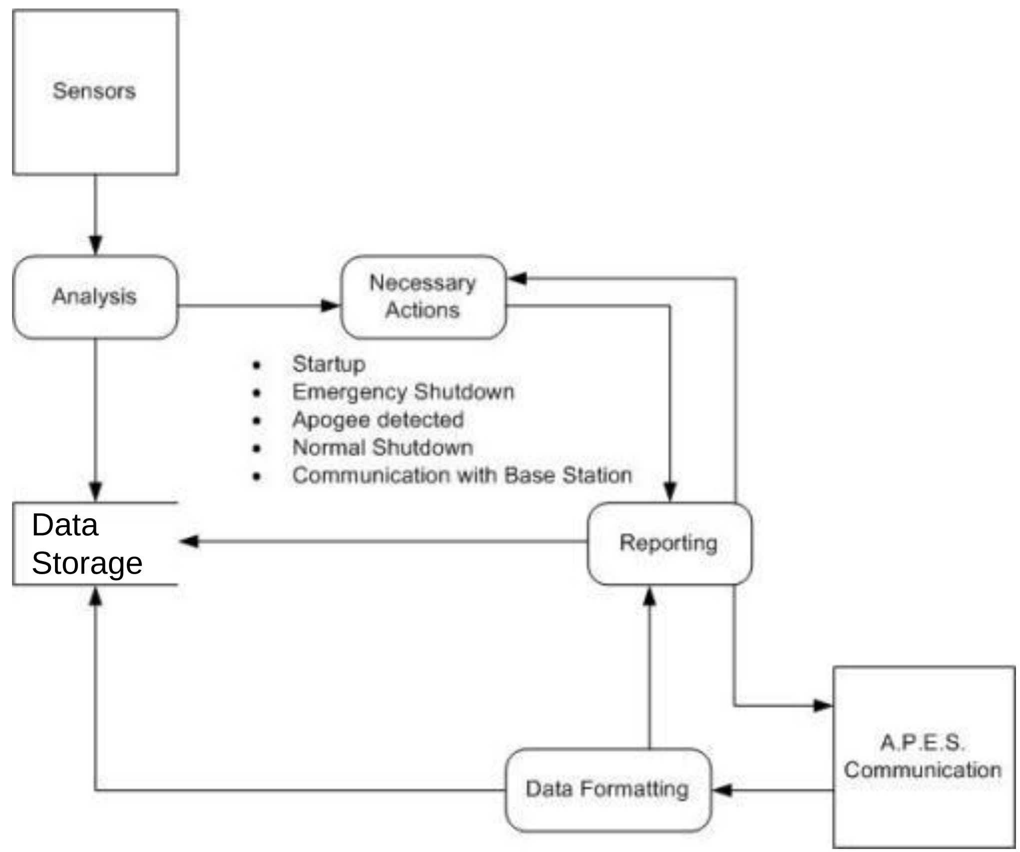
- ATmega 2560

- OpenLog

- Fastrax GPS

- Xbee Pro

- Sensors

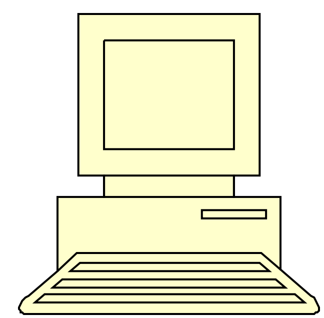


Flight Systems: Ground Station

GPS Data

Xbee Explorer

- GPS Data will be received via Xbee pro
- Xbee Explorer will convert data packets
- Data sent to computer

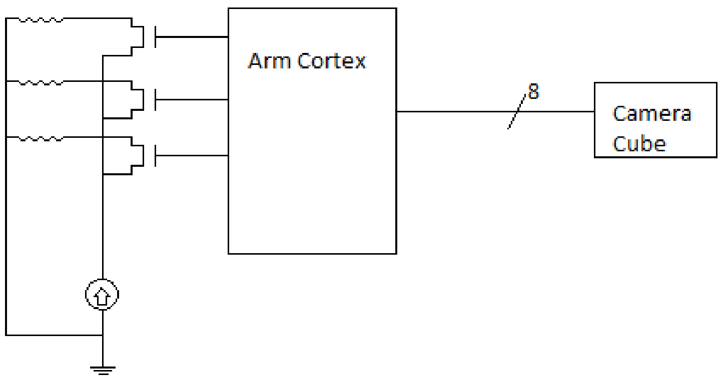


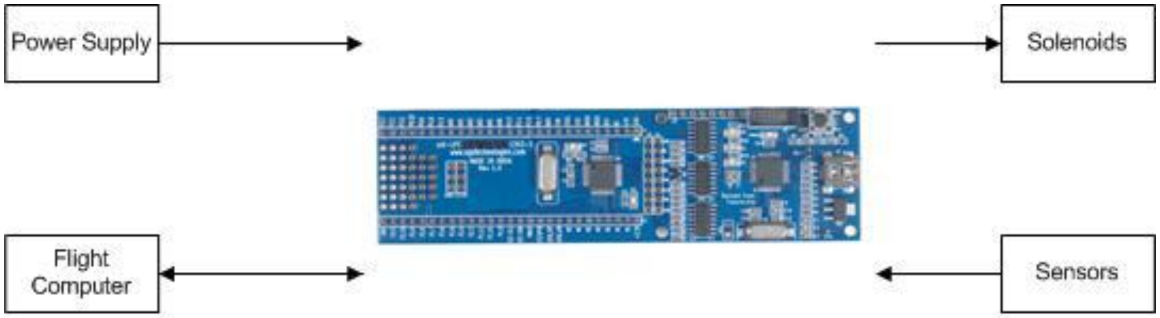
Flight Systems: A.P.E.S. Computer

- Commercial Board
  - ARM Cortex M3 Processor
- Primary Sensor:
  - Camera Cube
- Secondary Sensor:
  - IR Sensor

Flight Systems: A.P.E.S. Computer

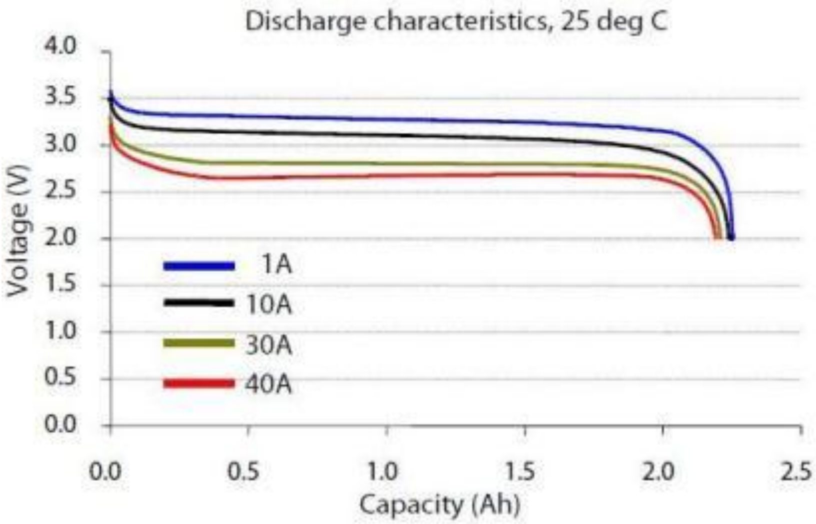
- UART Communication with ATmega processor
- PWM Control of MOSFETS
- High computing performance: 100 MHz



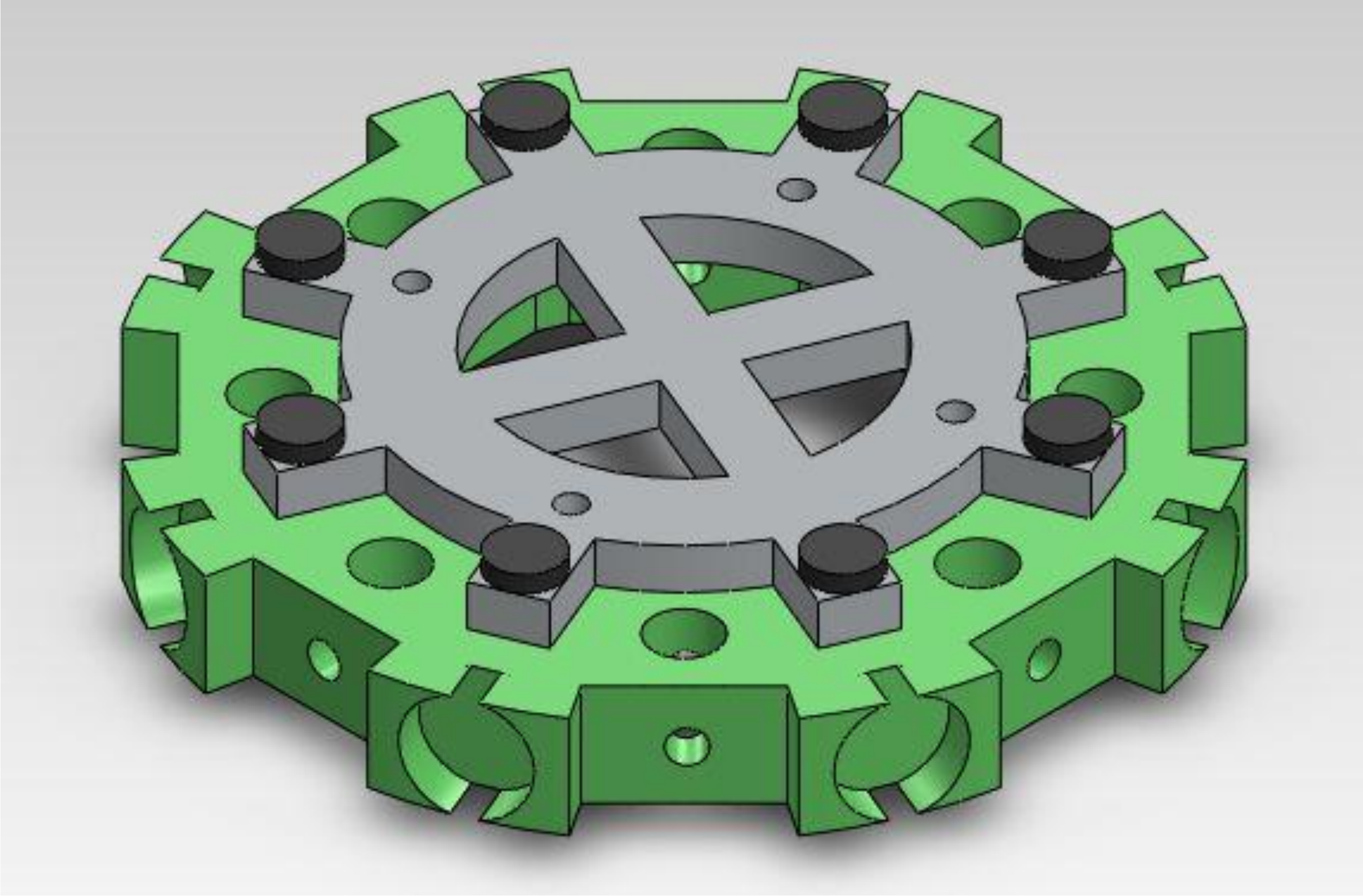


Flight Systems: A.P.E.S. Power

- 2.300 Ah at 3.3V
- Max Continuous Discharge: 70 A
- PWM supply for solenoids

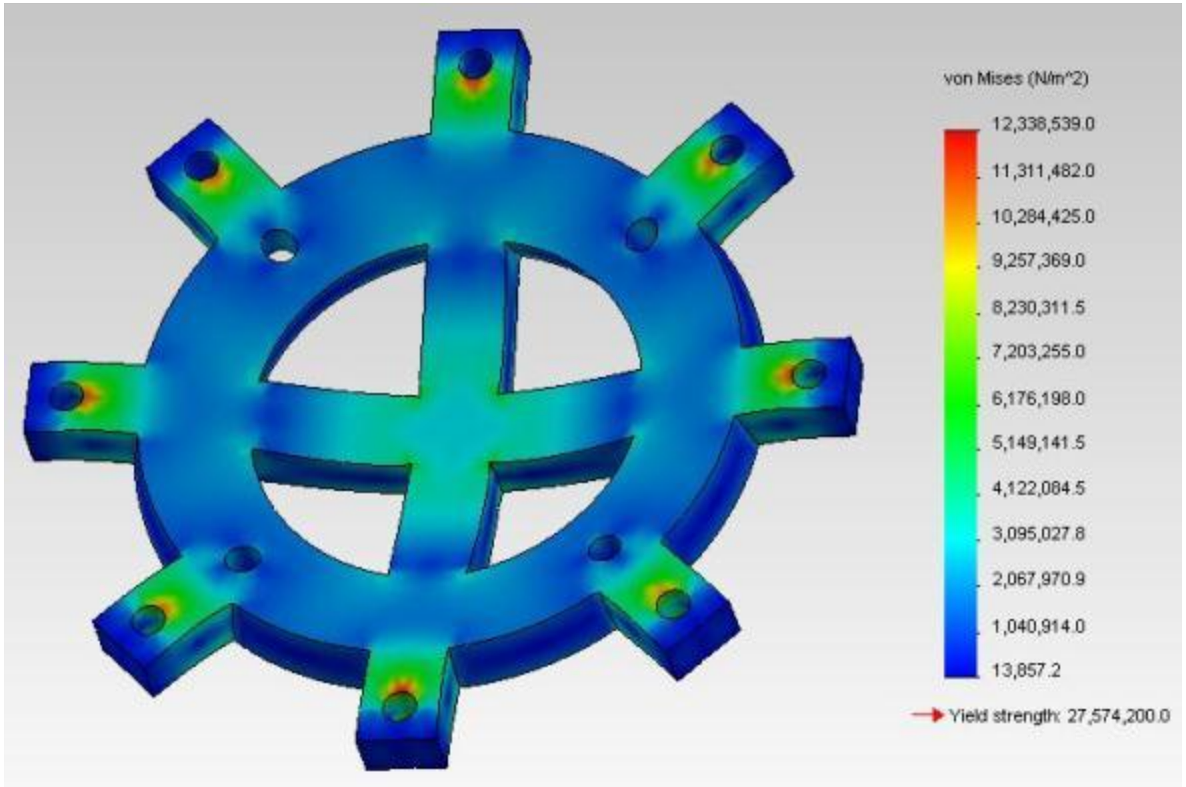


Flight Systems: Universal Mounting Bracket



Flight Systems: Universal Mounting Bracket

- Repeatable manufacturing
- Few constraints on Payloads
- Ease of mounting hardware
- High durability



**Deformation Exaggerated

Questions?