Georgia Tech CDR VTC Slides

Project Simple Complexity

2014-2015 Critical Design Review

VTC Slides

January 2015

Agenda

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

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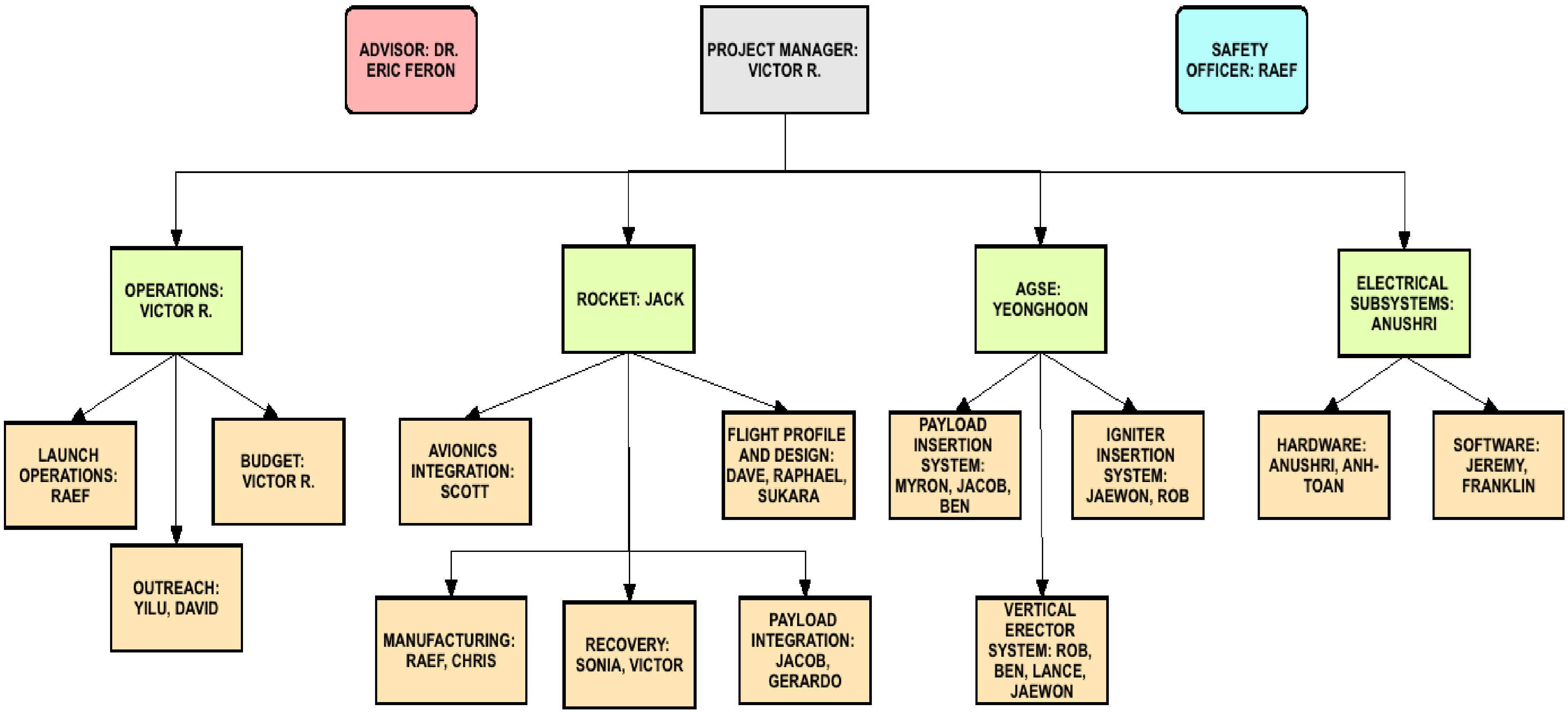
TEAM OVERVIEW

Georgia Tech Team Overview

- 23 person team composed of both undergraduate and graduate students
  - Graduate Students: 3
  - Undergraduates: 20
  - Highly Integrated team across several disciplines

Field	No. of Students
Aerospace Engineering	15
Mechanical Engineering	1
Electrical Engineering	3
Computer Engineering	2
Chemical Engineering	1
Industrial Engineering	1

Work Breakdown Structure



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CHANGES SINCE PDR

Changes Since PDR

Rocket:

- Packed parachute size & shock cords changed
- Change in parachute bay size affected:
  - Change in body dimensions
  - Change in motor selection
    - Now using Cesaroni J760

AGSE:

- Robotic arm DOF change (6 to 5 DOF) & servo motor selection change
- Structural details to VES & IIS introduced

Activity Plan:

- New team logo introduced

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EDUCATIONAL OUTREACH

Educational Outreach

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

- As of CDR, Team A.R.E.S. has planned two (2) Educational Outreach Events

- Douglass High School
  - Work in conjunction with the Douglass High School doing projects related to the competition.
- 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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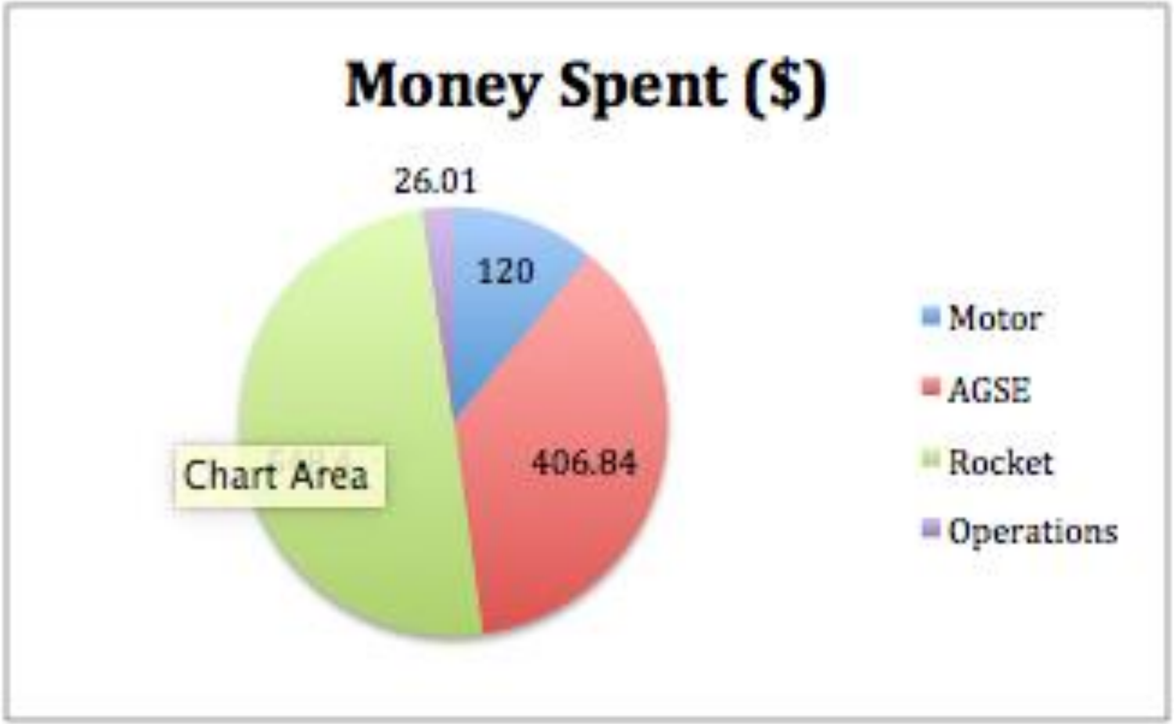
PROJECT BUDGET

Project Budget Summary

2014-2015

Section	Cost
Flight System	$2172.74
Rocket	$913.39
Testing	$1,096.07
Travel	$1,200.00
Outreach	$800.00
Total Budget	$6,410.55

Subsystem	Amount ($)
Launch Vehicle & Motors	1,461.83
Flight Systems & AGSE	2,721.18
Operations	2,000.00
Total:	6189.01



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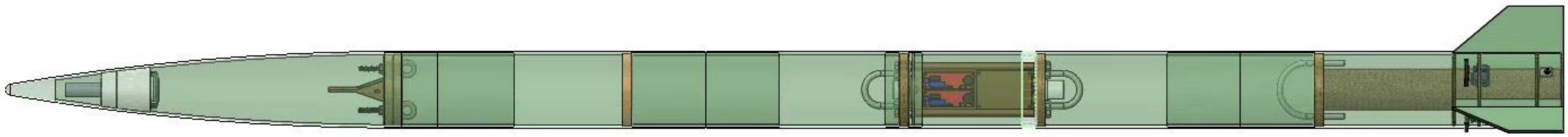
LAUNCH VEHICLE

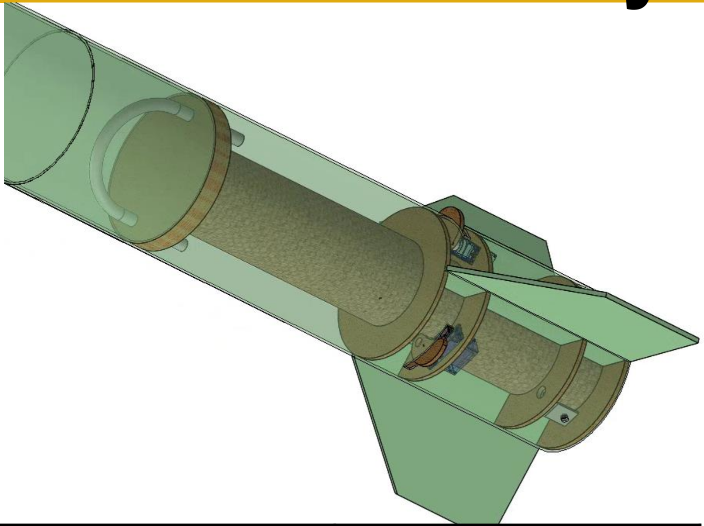
Vehicle Summary

- Predicted apogee: 3000 ft
- Stability margin: 1.83 calibers
- Motor: Cesaroni J760
- Launch Vehicle Dimensions:
  - Length: 80.875”
  - Diameter: 4.03”
  - Fins
    - Height: 3”
    - Root chord: 6”, Tip chord: 3”
- Rail Exit Velocity: 72 ft/s
- Total weight: 17.04 lbs
- Thrust-to-weight ratio: 7.6
- Dual deployment recovery, additional recovery for nosecone with payload



Launch Vehicle Booster Inner Assembly

- Fin Material: G10 Fiberglass
- Fin Attachment: Epoxy
- Fin/ATS/U-bolt bulkhead part of removable assembly
  - –Remove screws inside of rocket, slide out back
  - –Access to servo motors



Variable	Value
Number of fins	3
Root chord	6 in
Tip chord	3 in
Height	3 in
Sweep Angle	45˚
Sweep Length	3 in

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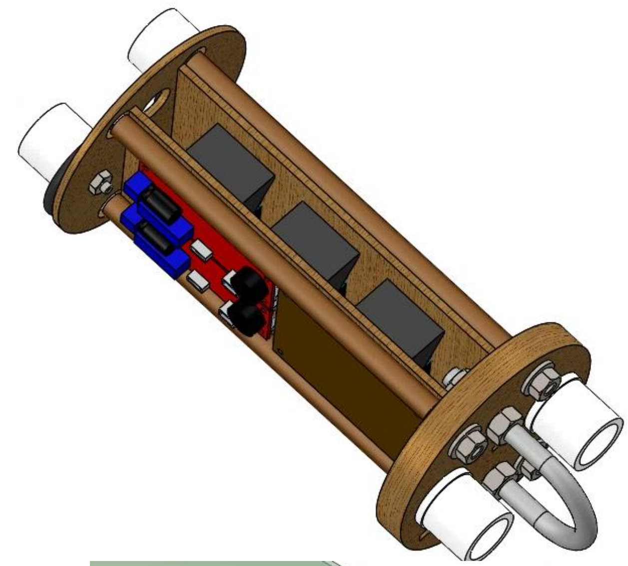
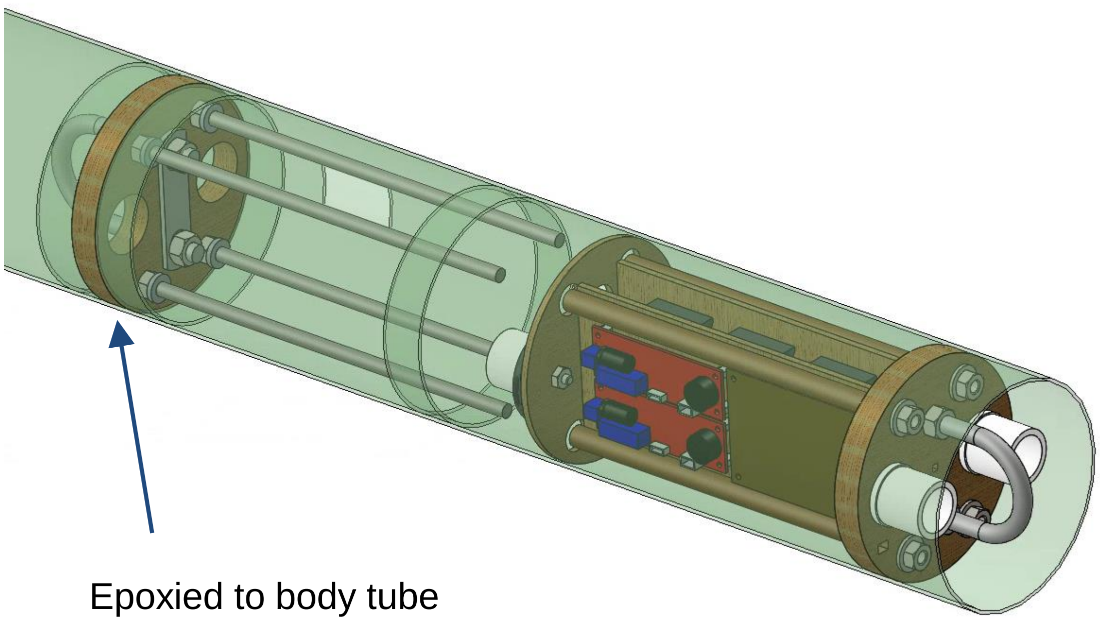
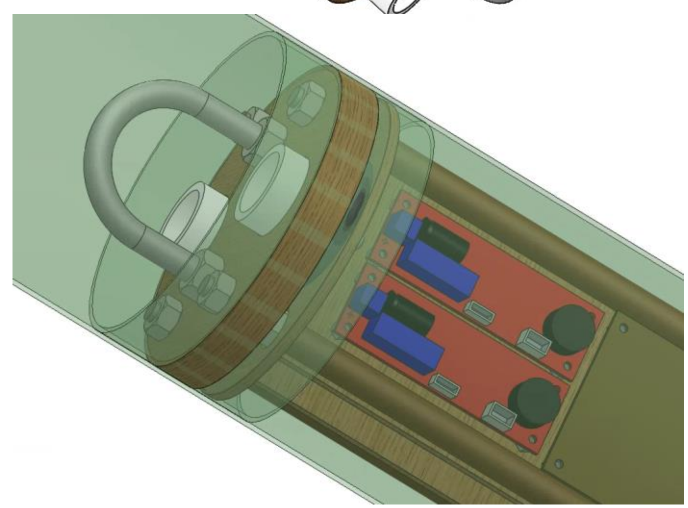
Launch Vehicle Avionics Bay Assembly

- Processor, sensors, camera, ejection charges
- Mounted on rails for easy insertion





Epoxied to body tube



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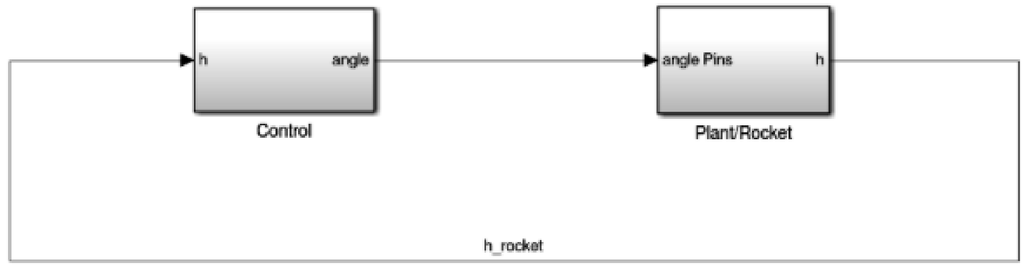
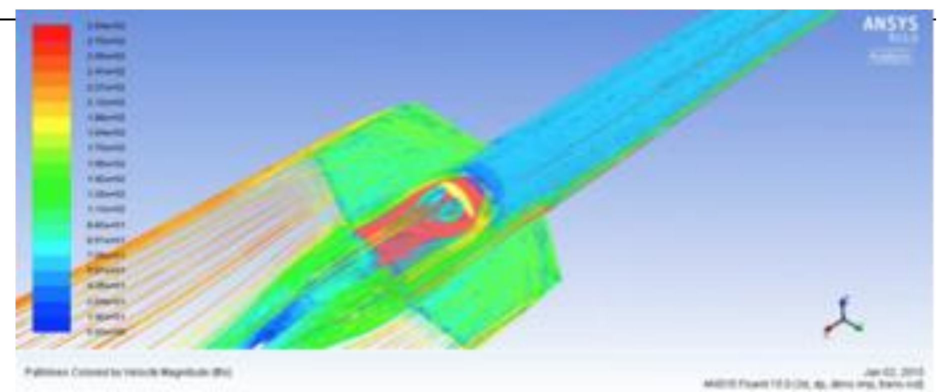
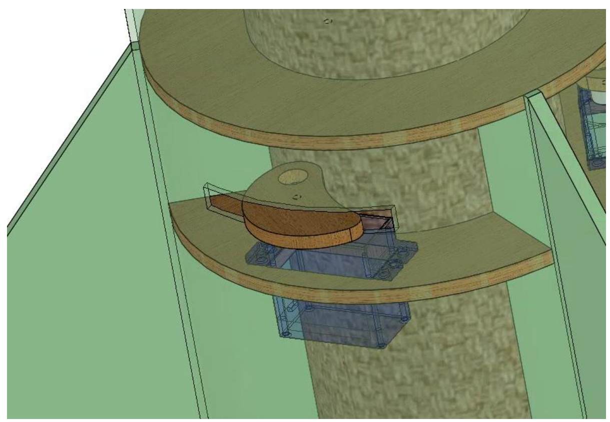
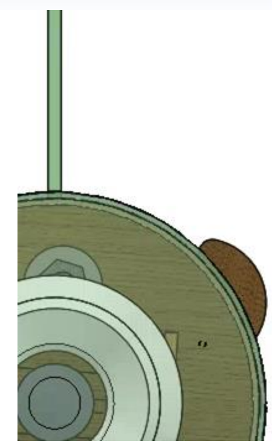
Apogee Targeting System

- Controls drag of rocket from error in altitude against time
- 3 servo motors actuate plates into free stream
- Sample altitude at time and compare to table of ideal flight path in memory









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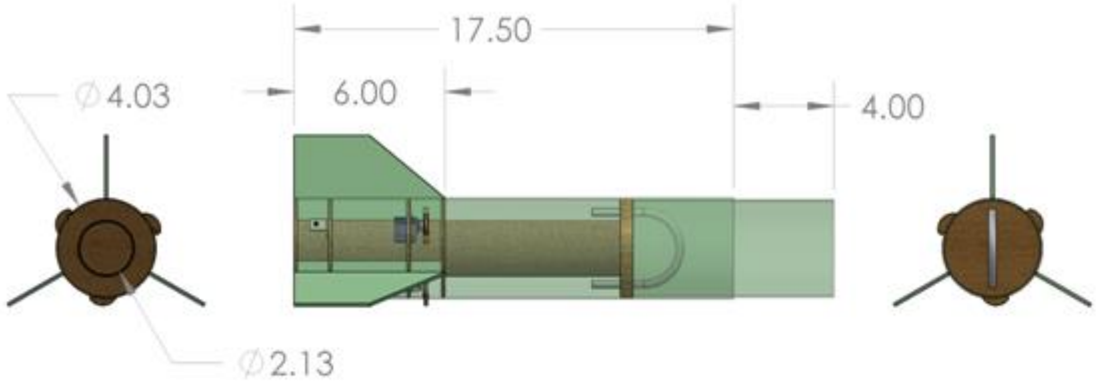
Kinetic Energy Breakdown

Recovery Phase	Mass Source	Drag Source	Terminal Velocity (ft/s)	Terminal Kinetic Energy (lbf-ft)
Drogue Deployed	Total Dry Mass	Drogue Parachute	50.85	637.71
Drogue sans Payload	Total Dry Mass-Payload	Drogue	46.47	444.78
Payload Deployed	Payload Mass	Payload Parachute	20.05	4.51
Main Sans Payload	Dry Mass - Payload Mass	Drogue + Main Parachute	18.53	70.72

Parachute	Diameter (in)	Area (sq. in)	Cd
Main Parachute	60 (+triangles)	5077	0.8
Drogue Parachute	28 (+triangles)	975	0.8
Payload Parachute	36	1018	0.8

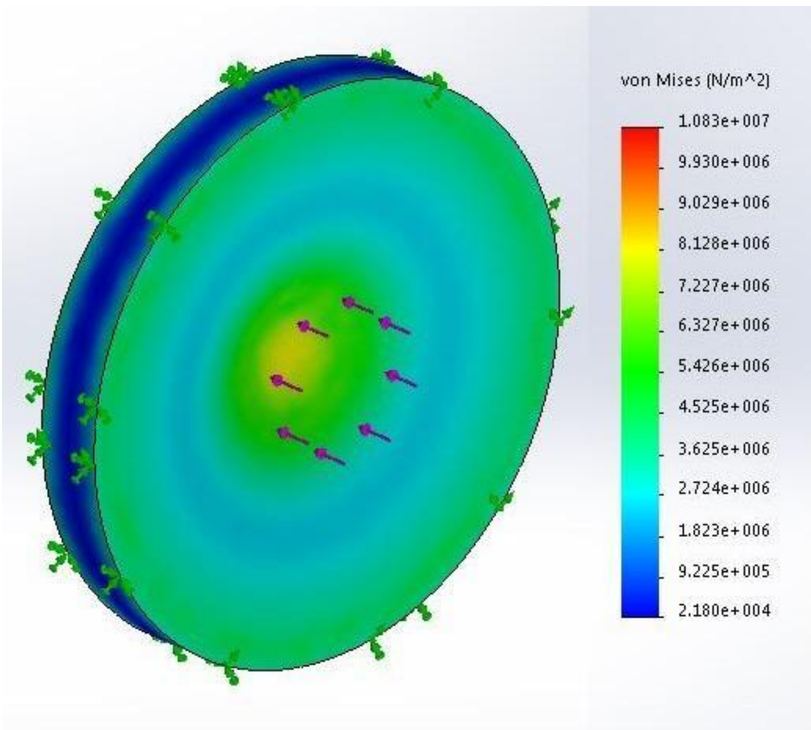
Booster Section

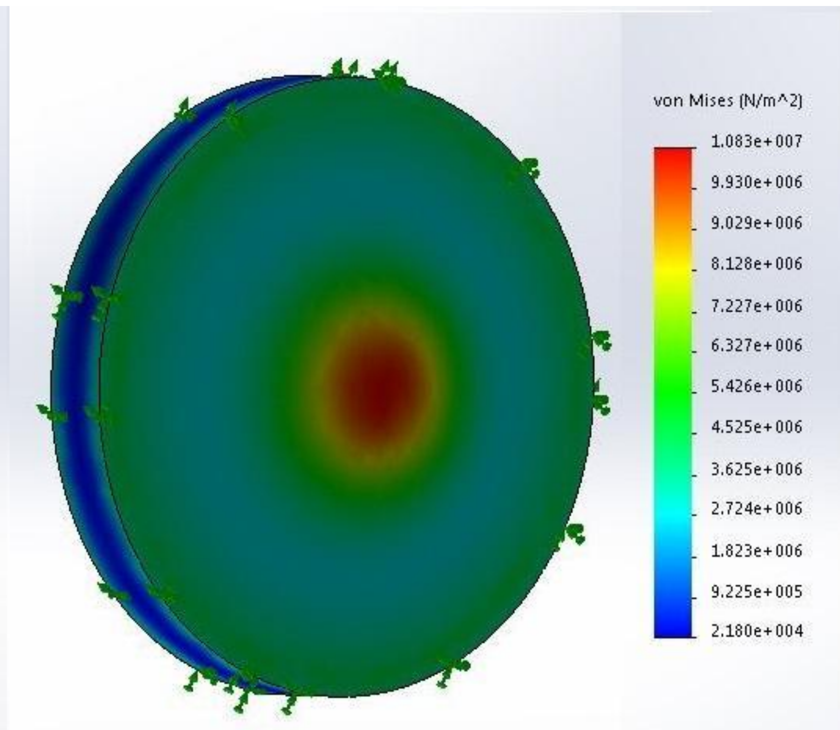


- Material: Plywood & G10 fiberglass
- Attachment: Nuts, bolts, brackets and epoxy

FEA Analysis and Results

	Force Applied(lbs)	Max Displacement(in.)	Maximum Stress(psi)	Safety Factor
Thrust Plate	421	0.01	145	2.88





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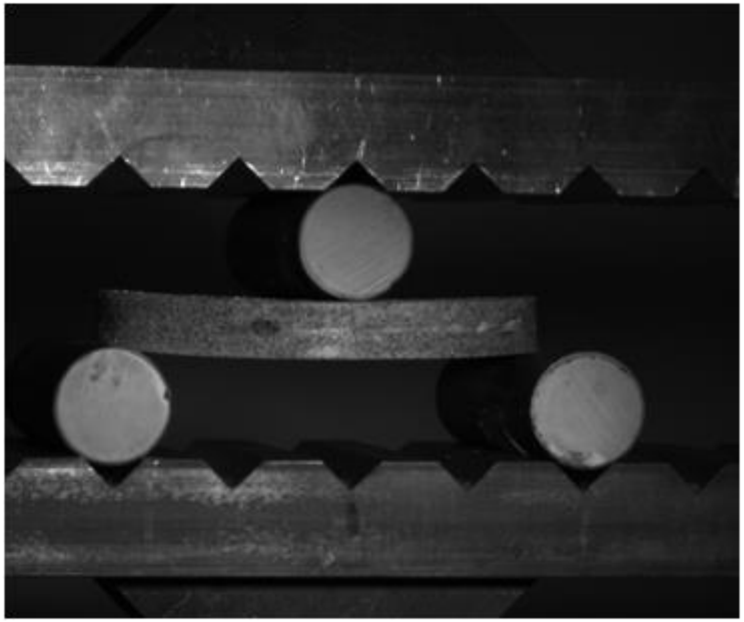
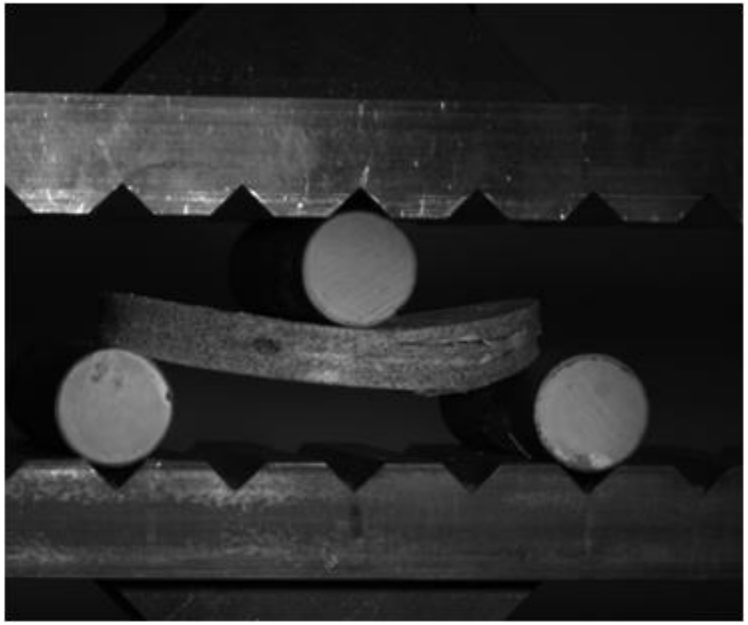
Thrust Plate Failure Analysis

	Force Applied(lbs)	Max Displacement(in.)	Safety Factor
Thrust Plate	443	0.1096	2.88
Thrust Plate Shoulder	220	N/A	1.05



Test Article at 443 lbs



Test Article at Failure (605 lbs)

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Fin Testing

$$D = \frac{1}{2} * \rho * V^2 * Area * C_d$$

Variable	Value
C_d	1.28
Air Density(slug/ft^3)	.00234
V_{max}(ft/s)	489
Fin Area(ft^2)	.0026
Drag(lb$_f$)	.93
Test Article Force(lb$_f$)	20

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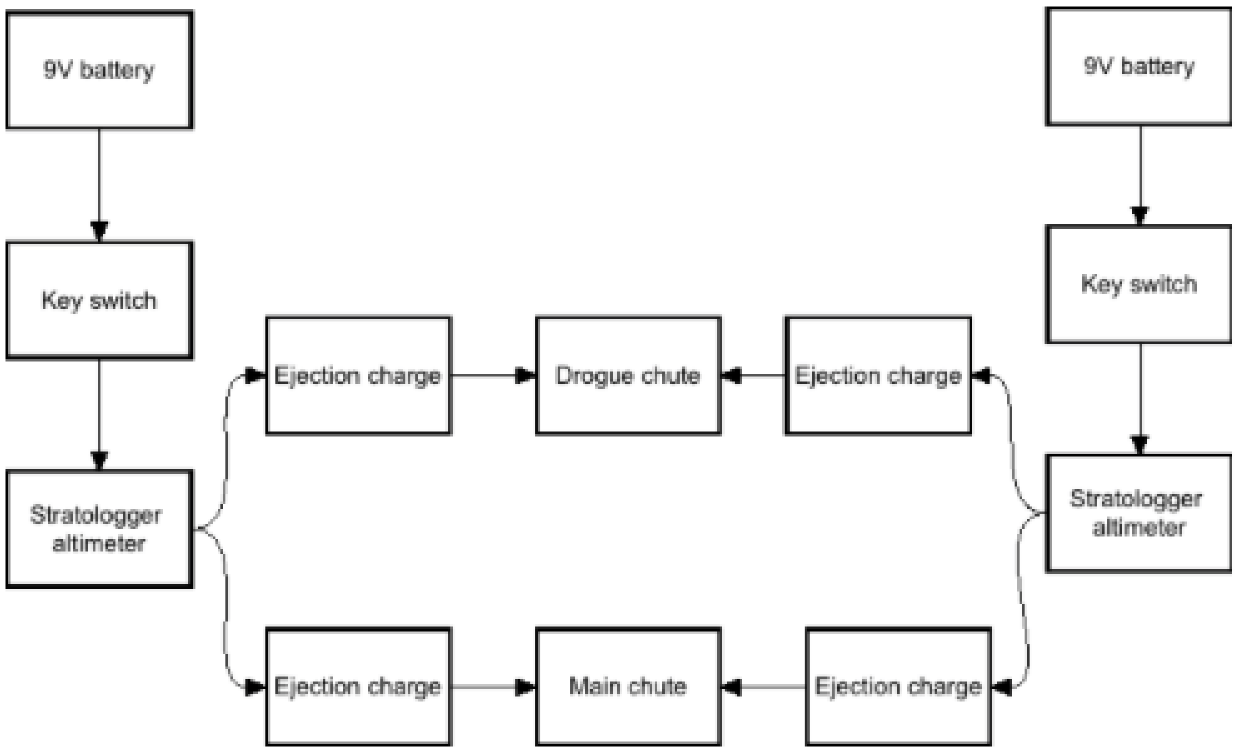
Recovery

- Dual deployment system
- Altimeter: 2 StratoLoggers for redundancy



Recovery System Procedures & Results

- Parachute deployment tests successfully conducted
- No photographic records due to technical issues and time of day during testing.

Ejection Charges

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

	Main Parachute	Drogue Parachute
Total Pressurization	22.36 psi	18.6 psi
Differential Pressurization	9.2 psi	5.42 psi
Amount of black powder	1.76 grams	1.79 grams

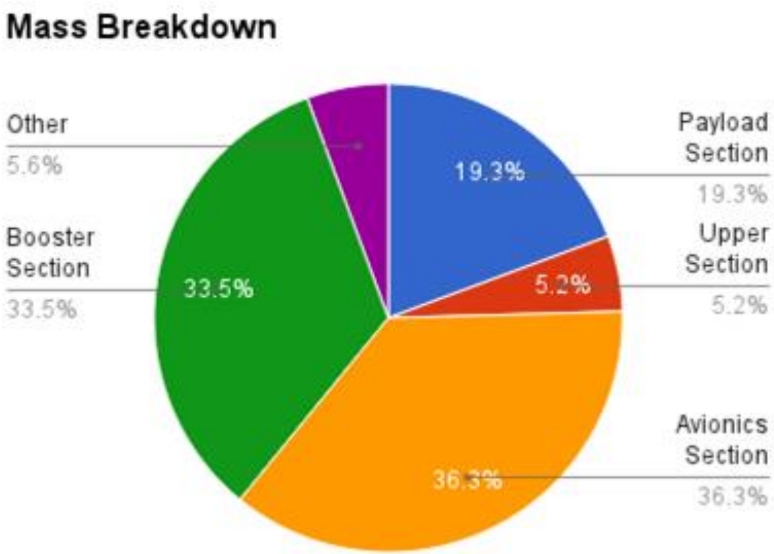
Recovery System

Recovery System Properties				
Drogue Parachute				
Manufacturer/Model	Unknown			
Size	28 Inches			
Altitude at Deployment (ft)	3000			
Velocity at Deployment (ft/s)	0			
Terminal Velocity (ft/s)	50			
Recovery Harness Material	Tubular Nylon			
Harness Size/Thickness (in)	0.375			
Recovery Harness Length (ft)	20			
Harness/Airframe Interfaces	Swivel will attach parachute to a shock cord, which will attach to U-bolts attached to bulkheads in booster and avionics sections. (Sections 1 and 2)			
Kinetic Energy of Each Section (ft-lbs)	Section 1	Section 2	Section 3	Section 4
	0	0	0	0

Recovery System Properties				
Main Parachute				
Manufacturer/Model	Unknown			
Size	52 inches			
Altitude at Deployment (ft)	600			
Velocity at Deployment (ft/s)	54.7			
Terminal Velocity (ft/s)	18.1			
Recovery Harness Material	Tubular Nylon			
Harness Size/Thickness (in)	0.375			
Recovery Harness Length (ft)	4.33			
Harness/Airframe Interfaces	Swivel will attach parachute to a shock cord, which will attach to U-bolts attached to bulkheads in avionics and upper sections. (Sections 2 and 3)			
Kinetic Energy of Each Section (ft-lbs)	Section 1	Section 2	Section 3	Section 4
	28	34	8	5

Mass Breakdown

- 605g extra mass included for margin



Section	Mass (g)	Weight (lbs)
Payload Section	1483	3.27
Upper Section	400	0.88
Avionics Section	2787	6.14
Booster Section	2566	5.66
Other	432	0.93

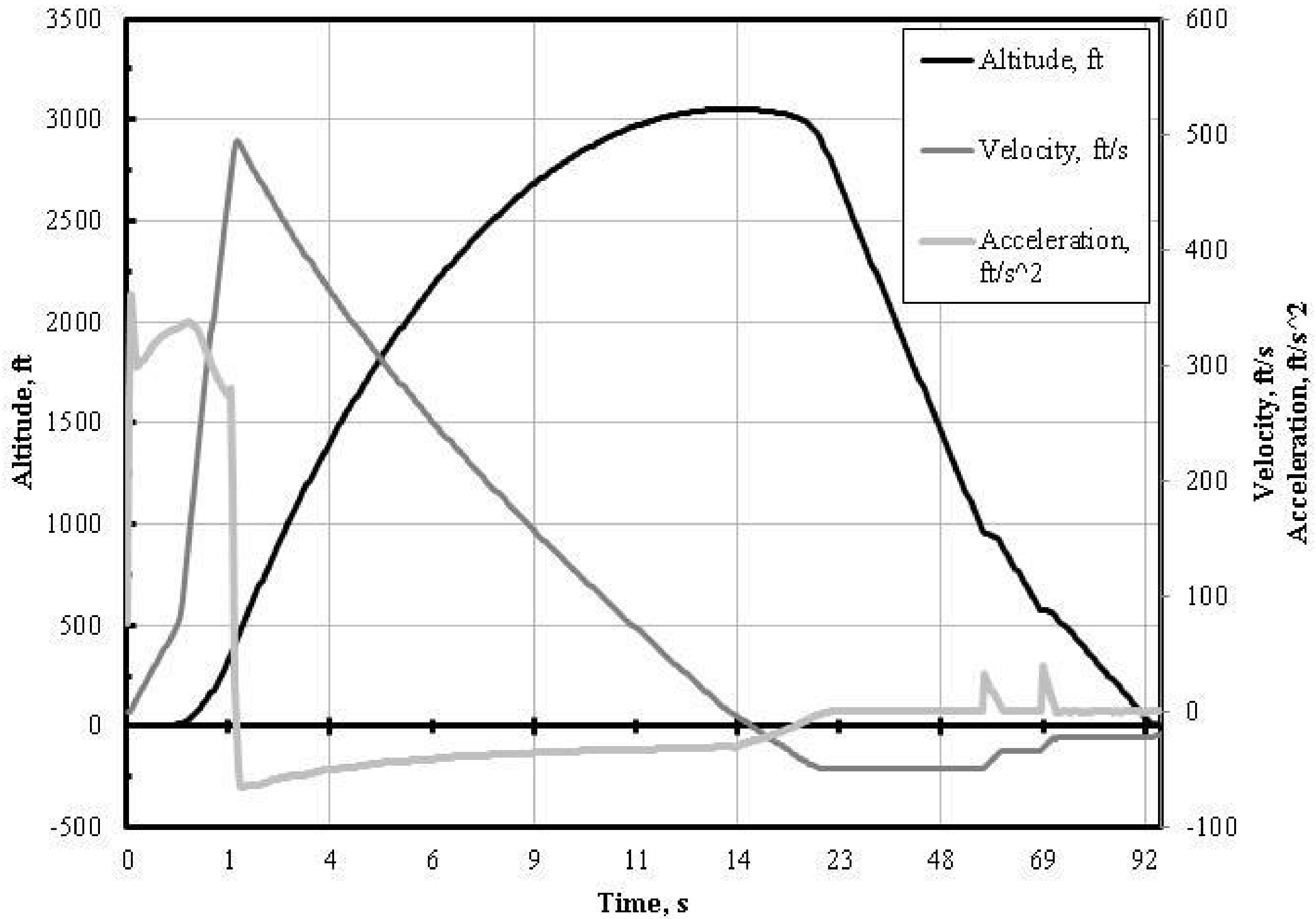
Motor Selection

Cesaroni J760

Mass margin: 600 grams

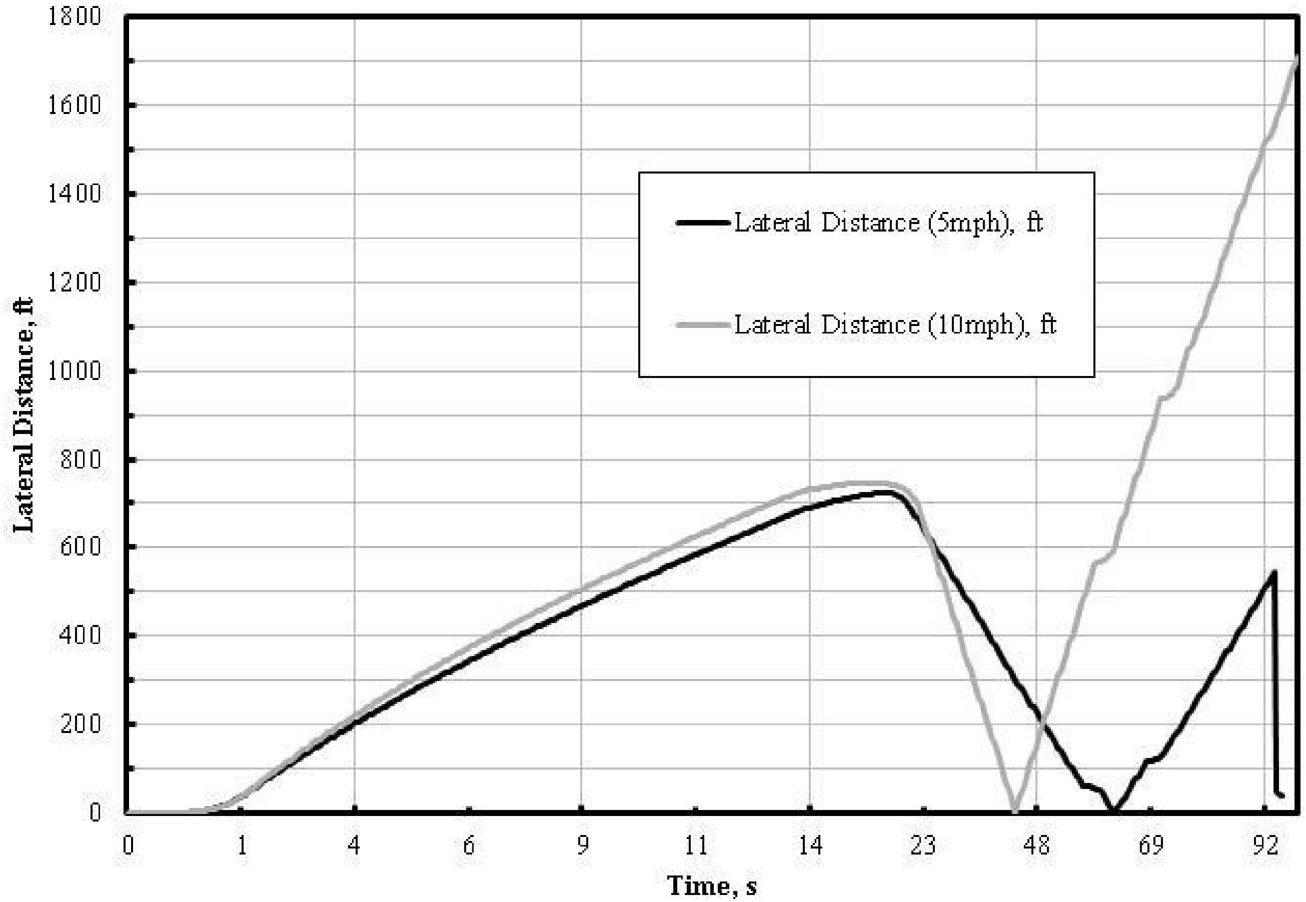
Total Impulse	285 lb-s
Average Thrust	170 lb
Maximum Thrust	211 lb

Flight Profile

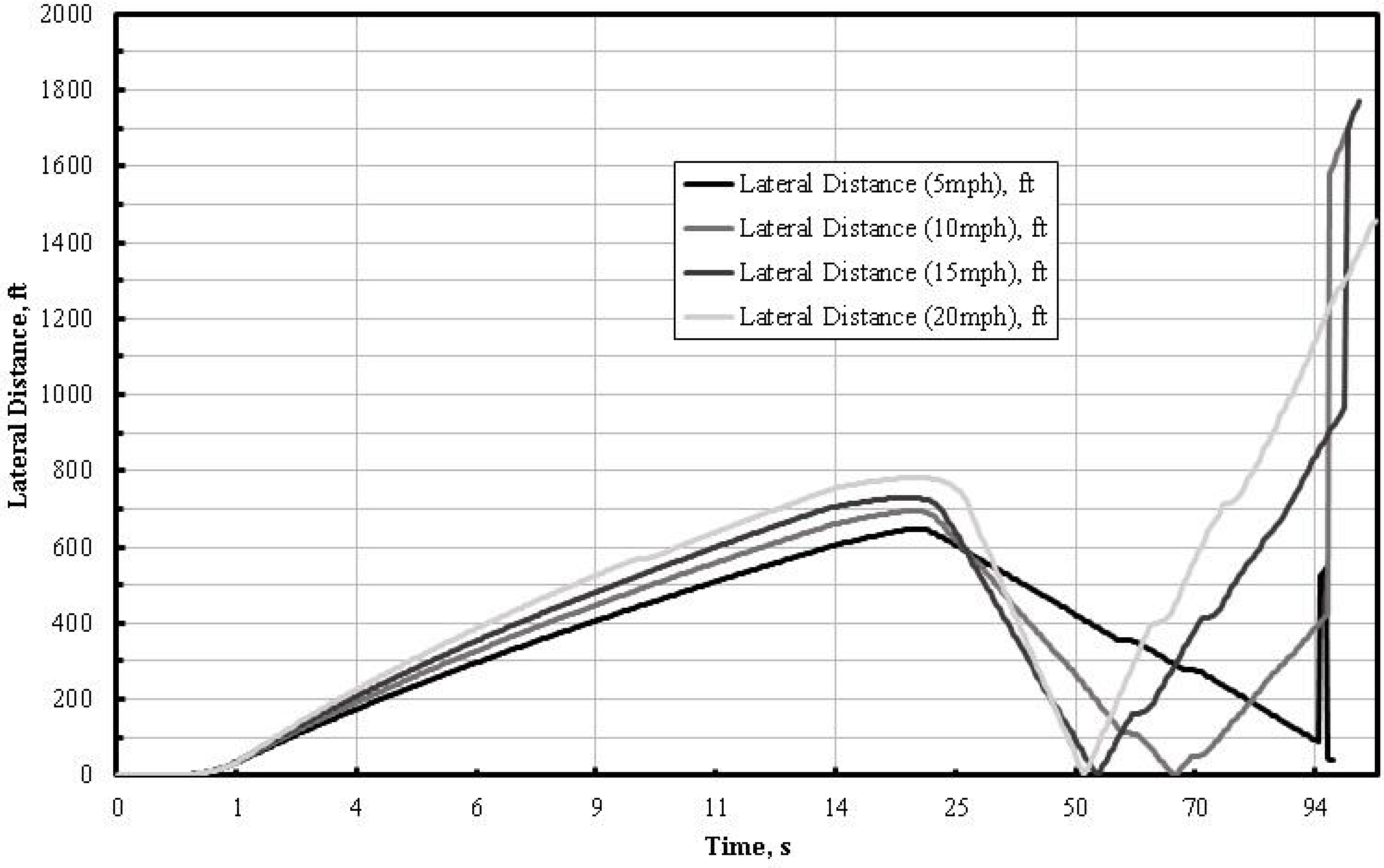


Drift Profile

Predicted drift from the launch pad with 5 and 10 mile per hour wind

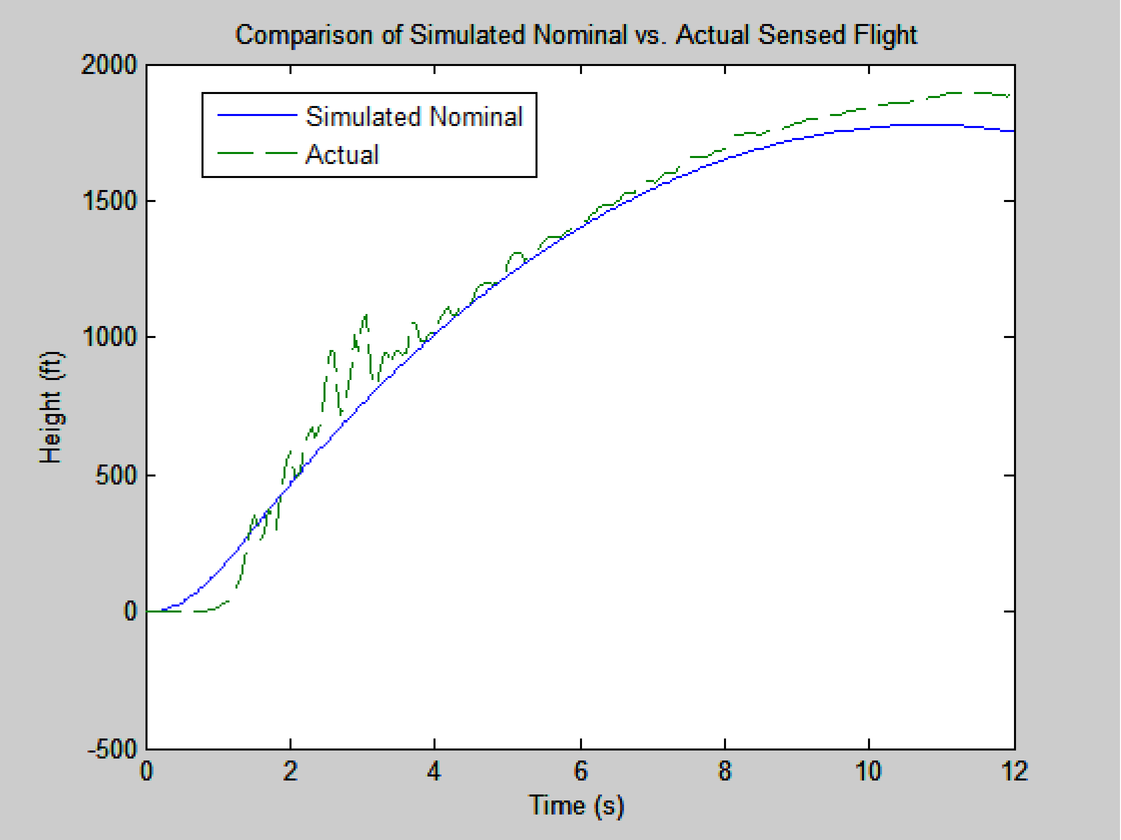


Drift Profile



Subscale Launch & Results

- Takeoff weight 8.54 lbs
- I305 Motor
- ATS Pins at nominal 35° extension
  - Data on drag coefficient profile
- Compared to Simulink model for validation



Design Verification & Mission Objectives

- In-house simulation software compared to OpenRocket and sub-scale launch
- Full-scale test launch will be conducted for final tuning of prediction model and ballast mass
- Electronics testing
  - Continued development on simulink model to include physical hardware in simulation loop

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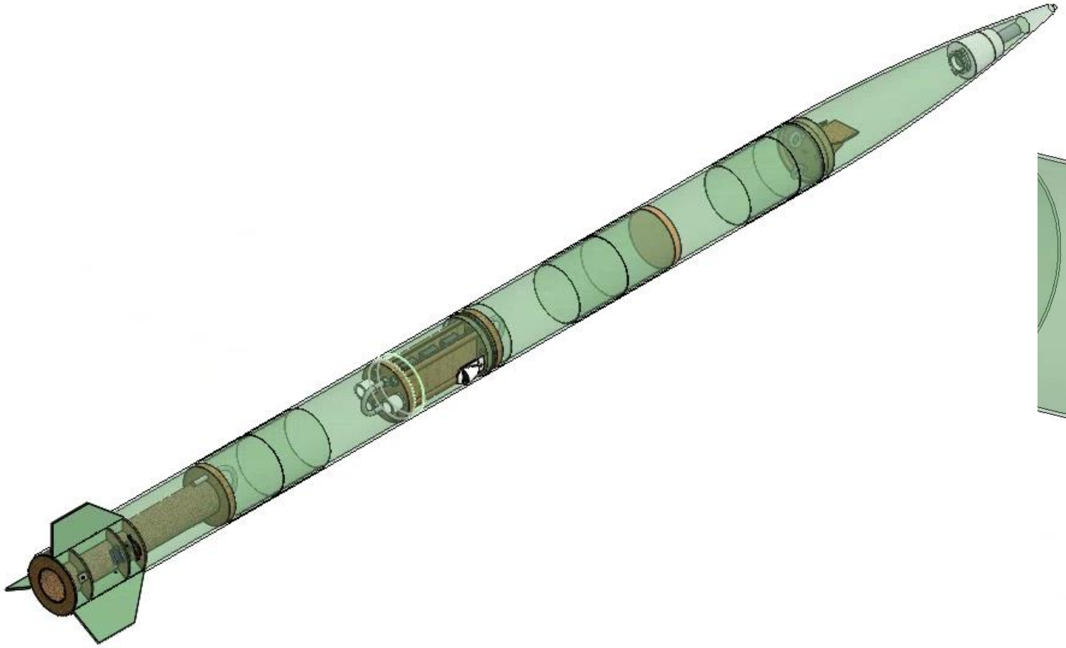
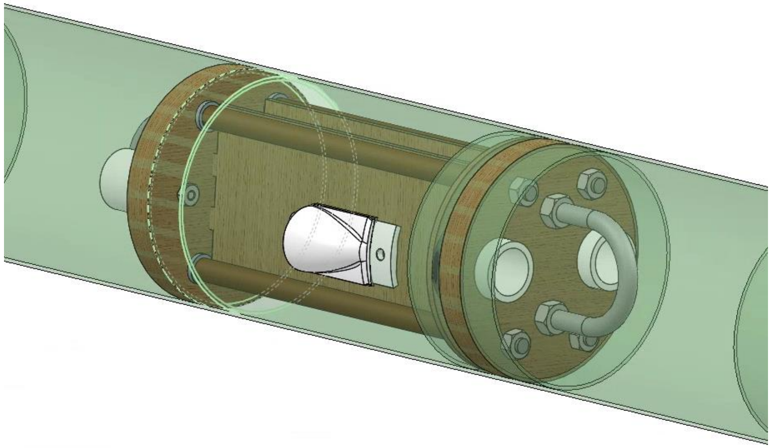
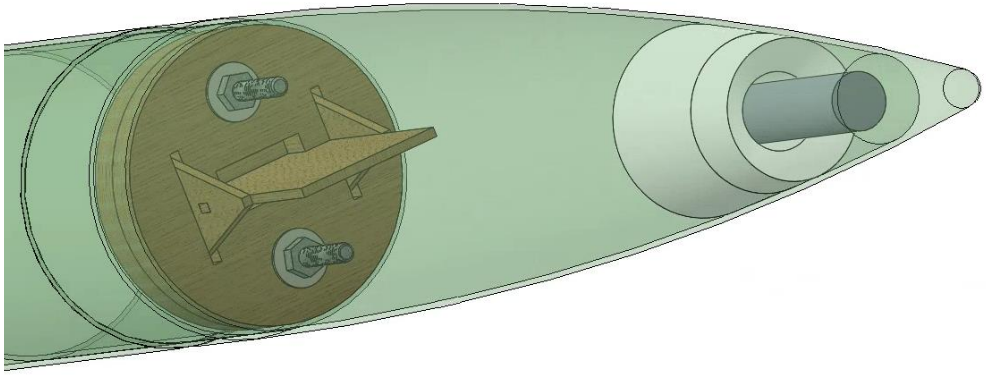
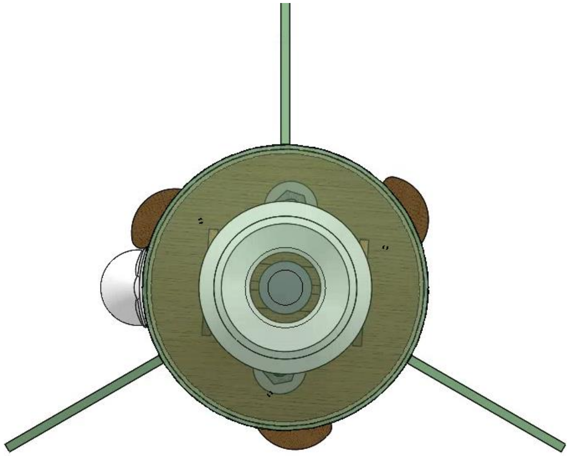

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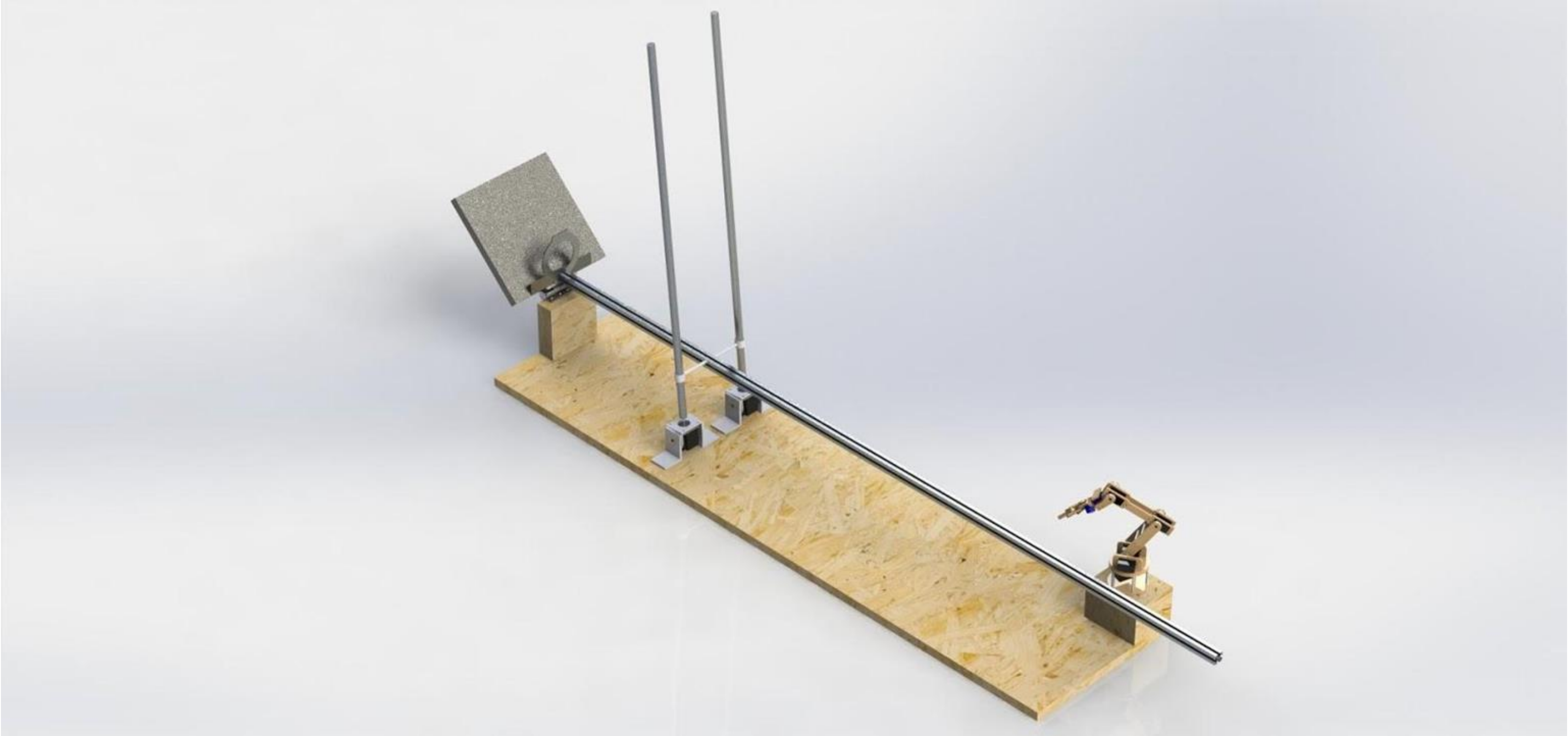
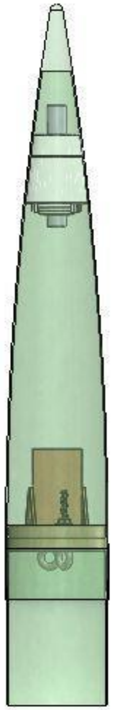
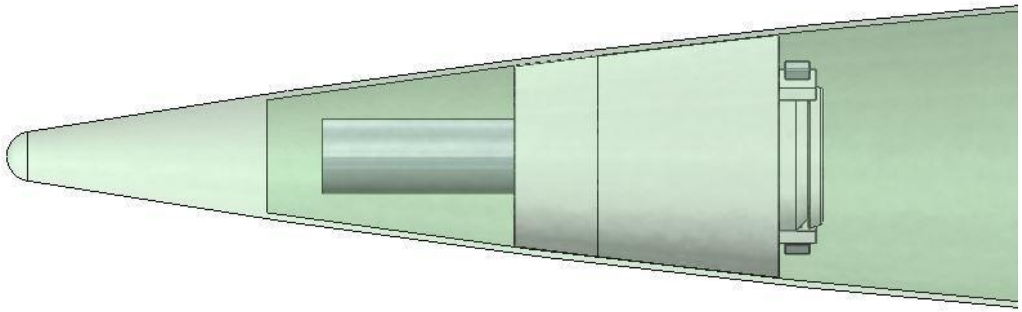
AGSE

AGSE: Final Design & Dimensions



AGSE & Launch Vehicle Interfaces





AGSE: Key Design Features

PLIS

- 5 DOF Robotic Arm (Payload capture and insertion)
- Nose cone detachment mechanism

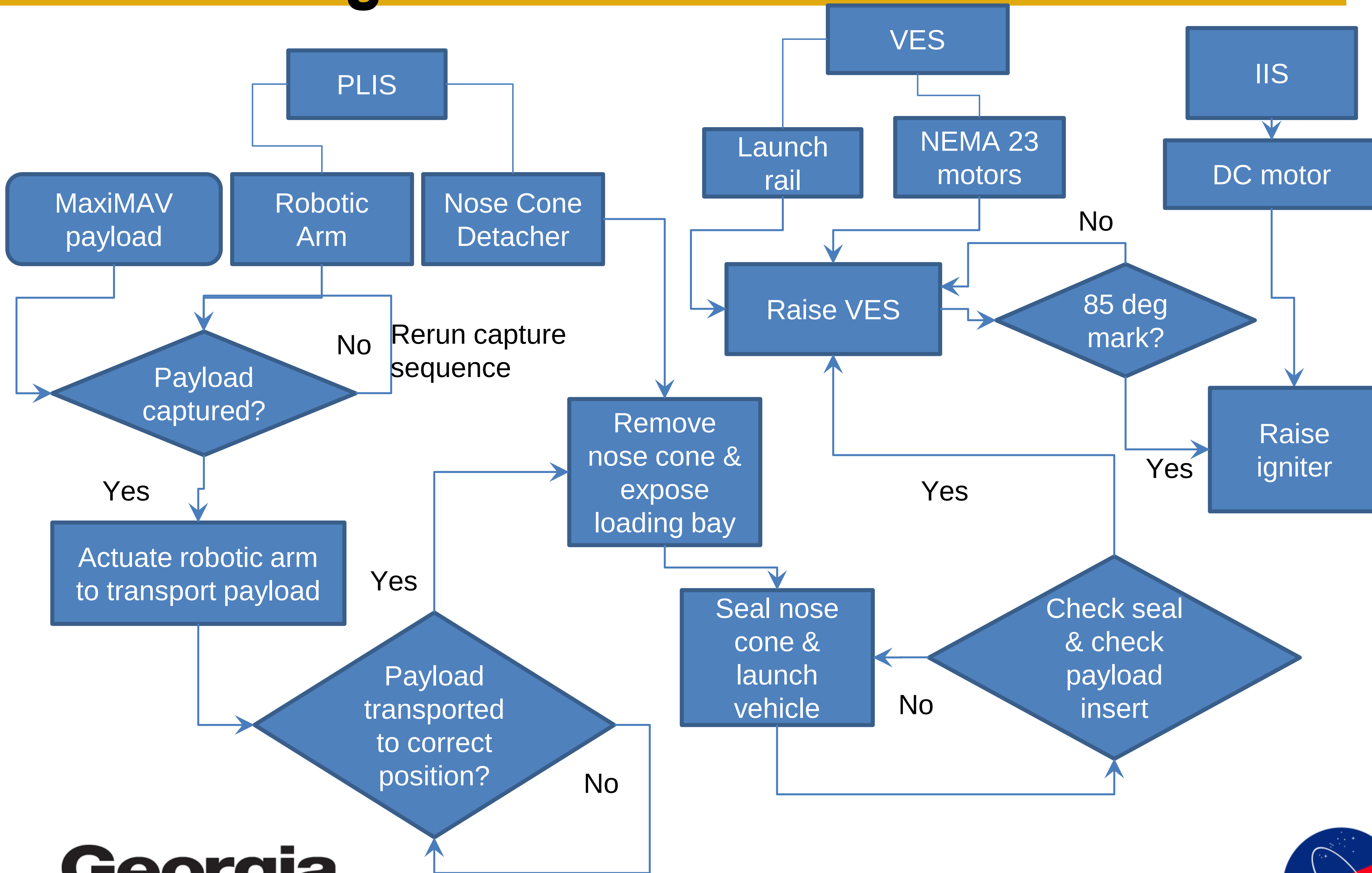
VES

- 8 ft extrusion rod to act as launch rail
- Threaded rod + NEMA 23 Stepper motors complex driving the VES.

IIS

- Rack and pinion gear system driven by a DC motor.
- Manufactured from metals with high temperature tolerance

AGSE: Integration



AGSE: Manufacturing Plans

PLIS:

Robotic Arm Status: In progress

- Components laser cut
- Additional parts, Arduino Due and servo motors have been ordered
- Final assembly required

Nose cone detacher: TBD

- Materials ready to order
- Parts ready to order

VES Status: In progress

- Critical components ordered (launch rail, support rails, NEMA 23 steppers)
- Additional materials ready to order
- Assembly pending

IIS Status: In progress

- DC motor & materials ordered
- Additional materials ready to order and process
- Assembly pending

AGSE: Testing Plans

Component Testing

- Testing of the functionality of the PLIS, VES, and IIS will be conducted before integration

Functional Testing

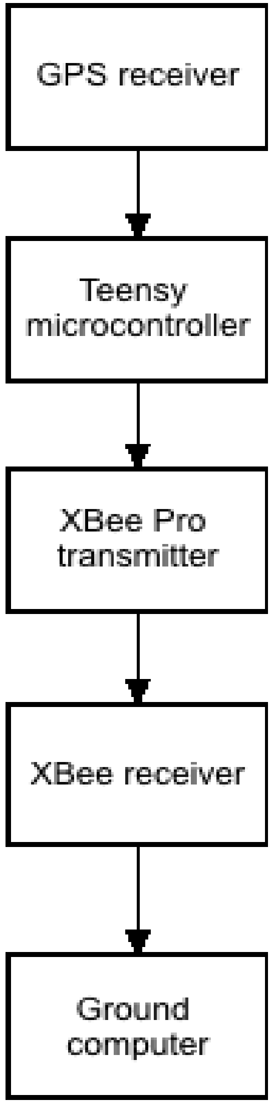
- Functional testing will be conducted in parallel with component testing
- Black-box testing will be carried out by executing the AGSE program over multiple trials
  - Trials will extensively cover various scenarios of the AGSE

Static Testing

- Takes place throughout development cycle and troubleshooting
- Used to identify the logic of the program

Flight Systems: Ground Station

- GPS (GP-635T) coordinates will be sent to the receiver using the XBee Pro 900 RF module.
- They are then displayed on the computer by using the XBee Explorer USB.



Questions?