Georgia Tech NASA Critical Design Review Teleconference

Presented By:

Georgia Tech Team ARES

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. Flight Systems (13 Min)
8. Questions (15 Min)

Project KRIOS- CDR

TEAM OVERVIEW

Georgia Tech Team Overview

- 24 person team composed of both undergraduate and graduate students
  - Undergraduates: 24
- Highly Integrated team across several disciplines

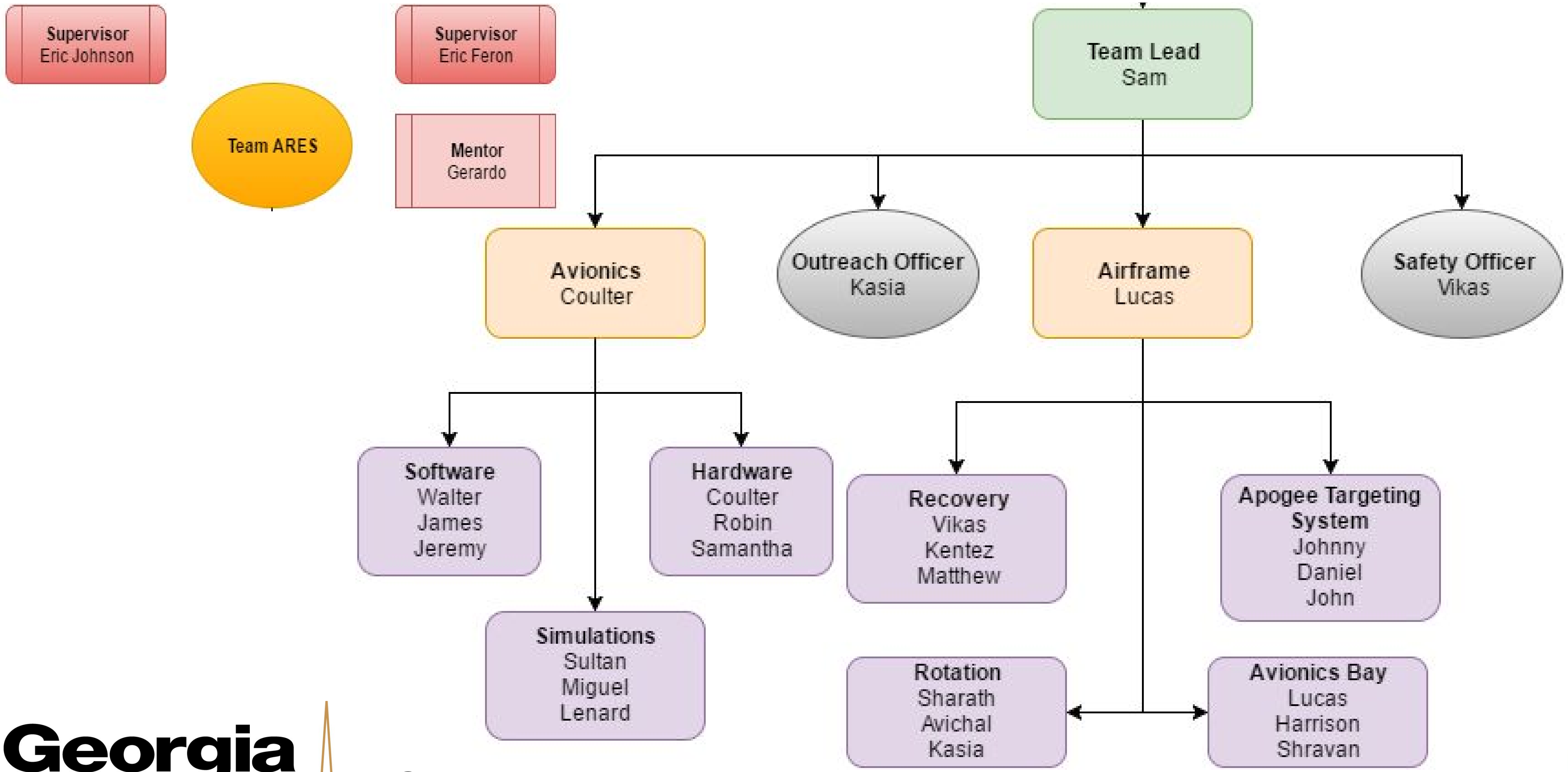
  -Mechanical Engineering

  -Aerospace Engineering

  -Applied Mathematics

  -Electrical Engineering

Work Breakdown Structure



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CHANGES SINCE PDR

Changes since PDR

Launch Vehicle

- ATS System (now removed)
  - was advanced to satisfy mechanical and stability concerns
  - programming concern, not enough active members to push development
- Roll Inducing Mechanism
  - Servo placement moved to space between 5.5 in tube and Motor tube
  - Gear system used to mechanically prevent misalignment
- Parachute Compartment Resizing
  - Subscale proved that over packing can prevent deployment
  - Compartments have been lengthened using SkyAngle reference sheet + 30% tolerance
- Method of Separation
  - In the Subscale, ejection charges pushed parachutes into compartments
  - New design to ensure charges push parachutes out of separated sections
- New Parachutes → 120 in Main, 45 in Drogue (both ~ 0.75 cd)

Changes since PDR

Flight Systems

- PIXHAW K replacing IMU, gyroscope, and accelerometer, and Teensy

Project Plan

- Subscale Launch Jan 14th
- Outreach details made for Merit Badge clinic and after school program

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EDUCATIONAL OUTREACH

Educational Outreach

-Peachtree Charter After School Program

-Boy Scout Merit Badges

-CEISMC GT

-Atlanta Science Festival

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SAFETY

Risk Assessment & Launch Vehicle

General Objectives

- Proper construction and assembly of both the launch vehicle itself and the launch vehicle recovery subsystem.
- The majority of dangers/failures can be dealt with during assembly and construction.
- All risks involved will be mitigated as long as team members follow all safety guidelines while constructing and launching the launch vehicle
- A successful launch will include successful recovery as well as no injuries whatsoever to any team member.

Risk Assessment & Launch Vehicle

Functionality of Areas with High Importance

- Integrity and Reliability of Recovery System
  - Bulkheads must sustain pressure created by ejection charges
  - Bulkheads must withstand tensile stress of parachutes
  - Shock cord must withstand tensile stresses of both deployments
  - Parachutes and Shock cords must not be damaged from ejection charges

- Integrity of Motor Retention System
  - Thrust plate must easily withstand max thrust delivered by motor
  - Motor retainer must prevent motor from falling out after burnout

Risk Assessment & Launch Vehicle

Continued…

- Stability Impacts of Roll Induction Mechanism
    - All flaps must be in same angled position at all times
    - Max servo power draw should never exceed supply
    - Susceptibility of Avionics Equipment to Environmental Effects
    - Altimeters must not be affected by the pressures created by ejection charges

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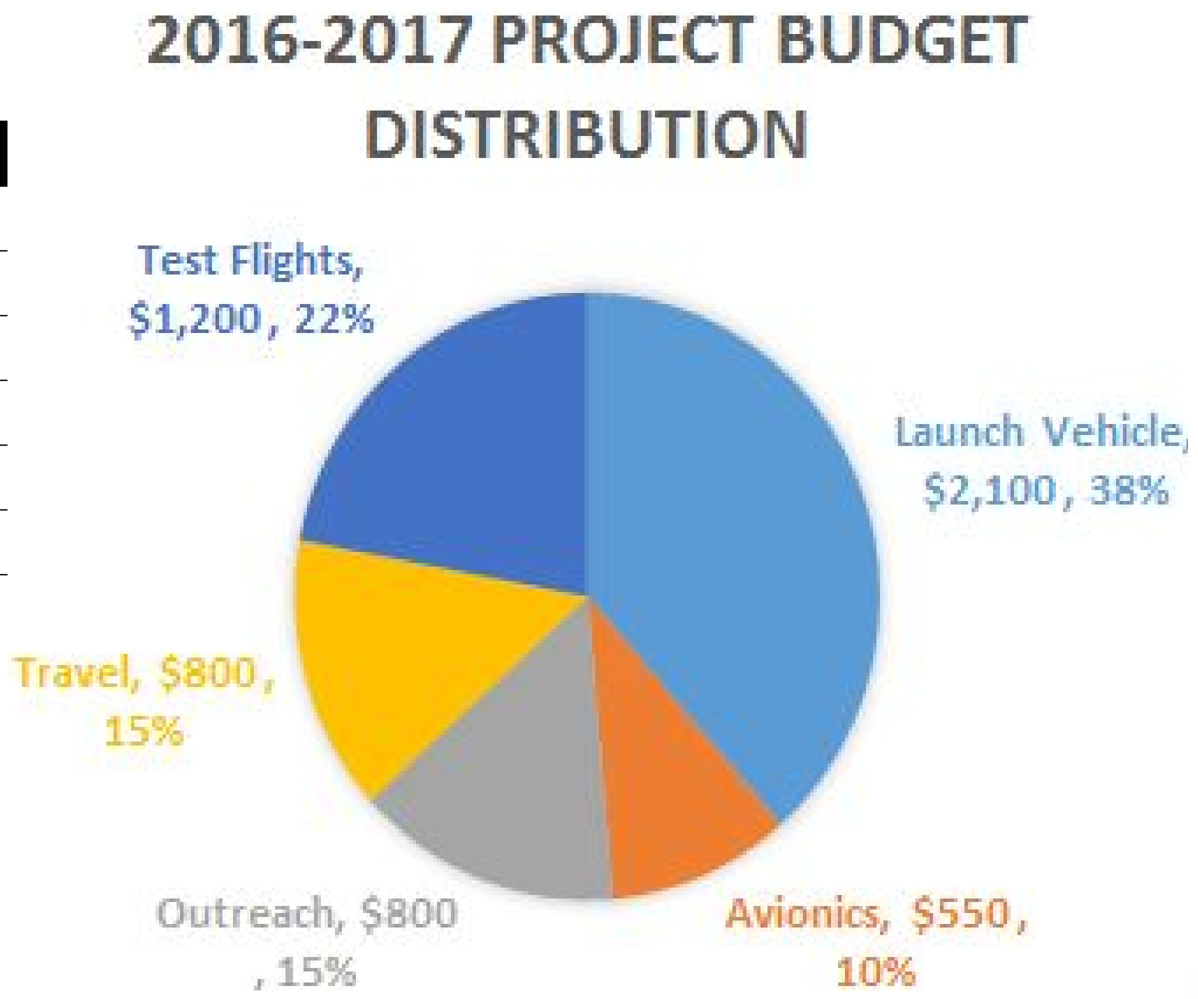
PROJECT BUDGET

Project Budget Summary

Section	Cost
Launch Vehicle	$2100
Avionics	$550
Outreach	$800
Travel	$900
Test Flights	$1200
Total	**$5450**



Verification Plan Status

Creating accurate model for WATES- collected subscale data

Maximum accessibility and minimum setup- redesigned A-bay

Ensuring dual redundancy and parachute deployment- designing larger couplers and better parachute packing systems, offset altimeter charges

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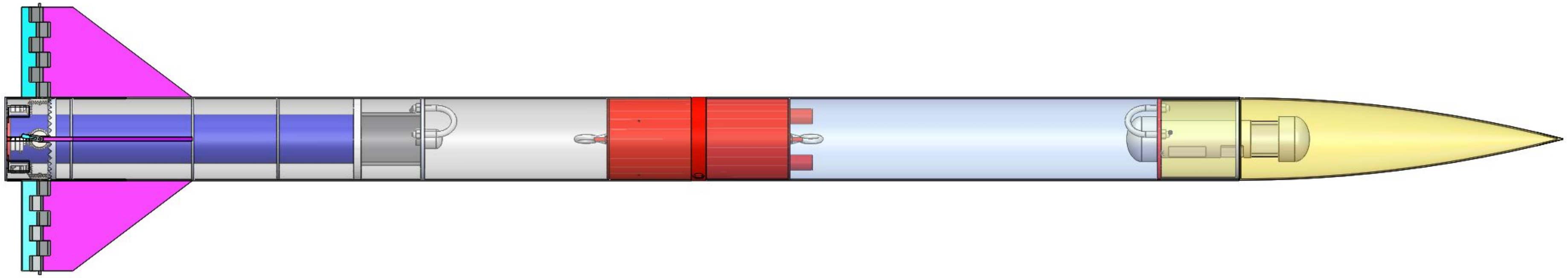
LAUNCH VEHICLE

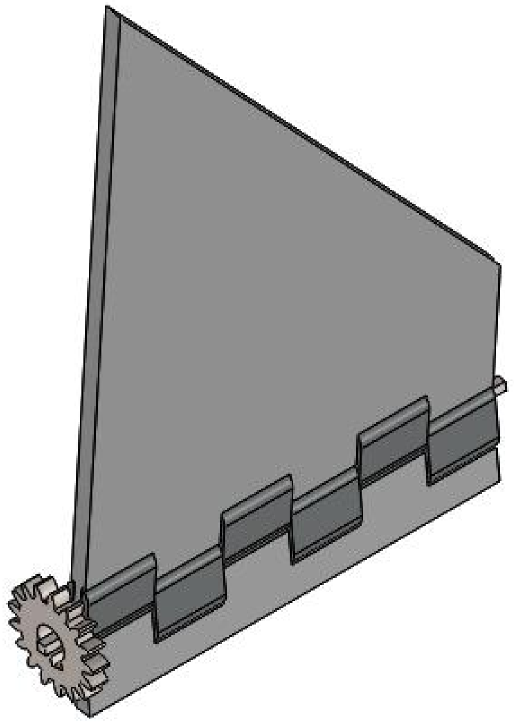
Launch Vehicle Summary

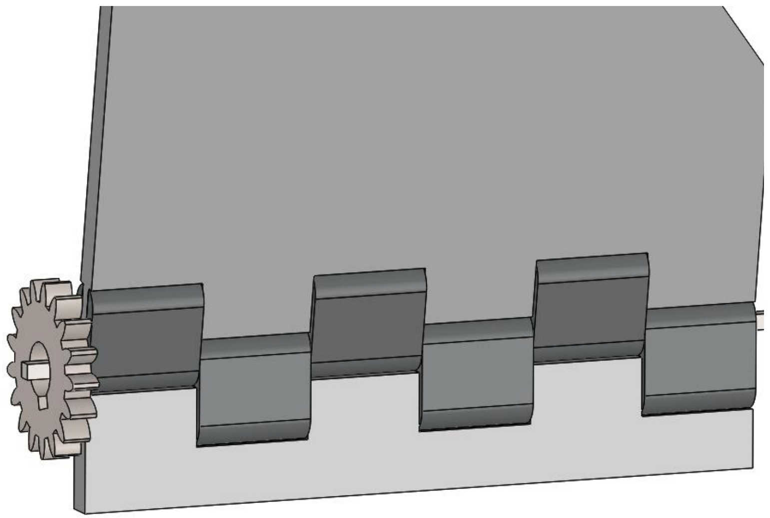
- Predicted apogee: 5297 ft
- Stability margin: 2.47 calibers
- Motor: Cesaroni L1150R
- Main Chute: TFR 120 in, 0.75 cd
- Drogue Chute: TFR 45 in, 0.75 cd
- Shock Cord Size: 1 in Tubular Nylon
- Shock Cord Length: 36 ft total
- Velocity off 8 ft Rail: 61.3 ft/s
- Max Velocity: 0.5767 mach
- Total weight: 545 oz



Fins

- Consists of one main fin, one hinge mechanism, and one flap
- Fin and flap are made from fiberglass, hinge mechanism made from strong steel material
- Fin and flap size chosen after analyzing OpenRocket CP locations

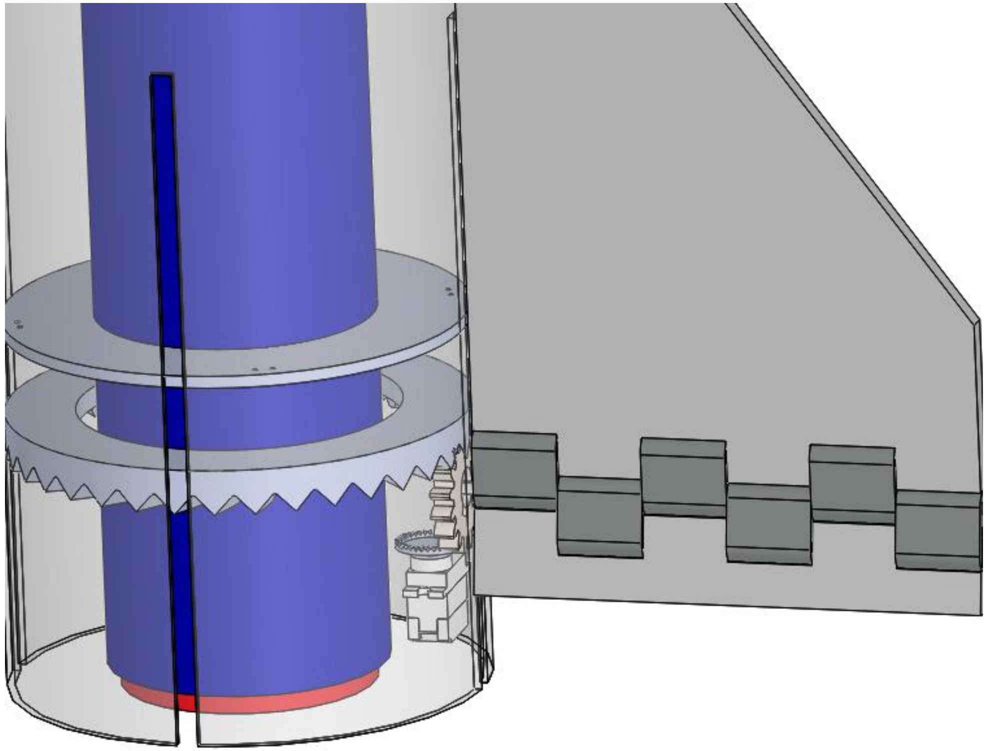




Roll Control System

- The launch vehicle is to be outfitted with 4 adjustable fins attached to the end of 4 stationary fins

- large gear ring that will constrain all the variable fins to the same orientation



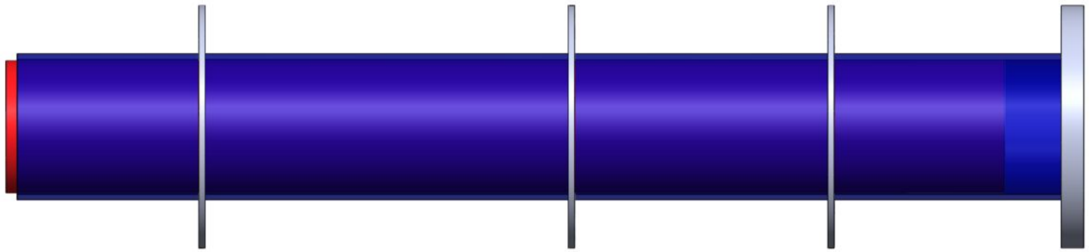
Booster Section

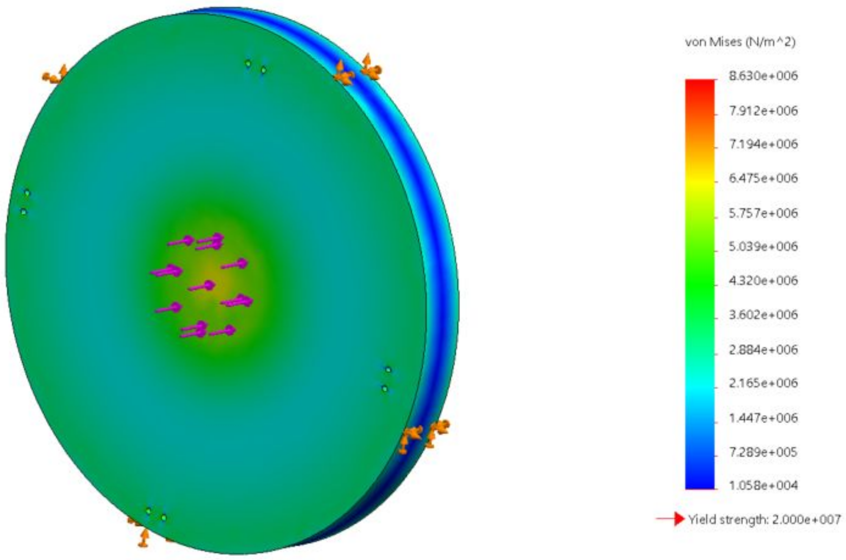
Assembly

1. Rings epoxied to exact locations along motor tube
2. Thrust plate epoxied to outer 5.5 in tube
3. Centering rings epoxied to outer 5.5 in tube
4. Then fins can be mounted over bottom centering ring
5. Roll induction system installed between 5.5 in tube and motor tube

Materials and Manufacturing:

- Centering Rings: G10 Fiberglass, Waterjet
- Cardboard Tube: Circular Saw
- Thrust Plate: Plywood, Laser Cutter





Verification of integrity under max load

Motor Selection

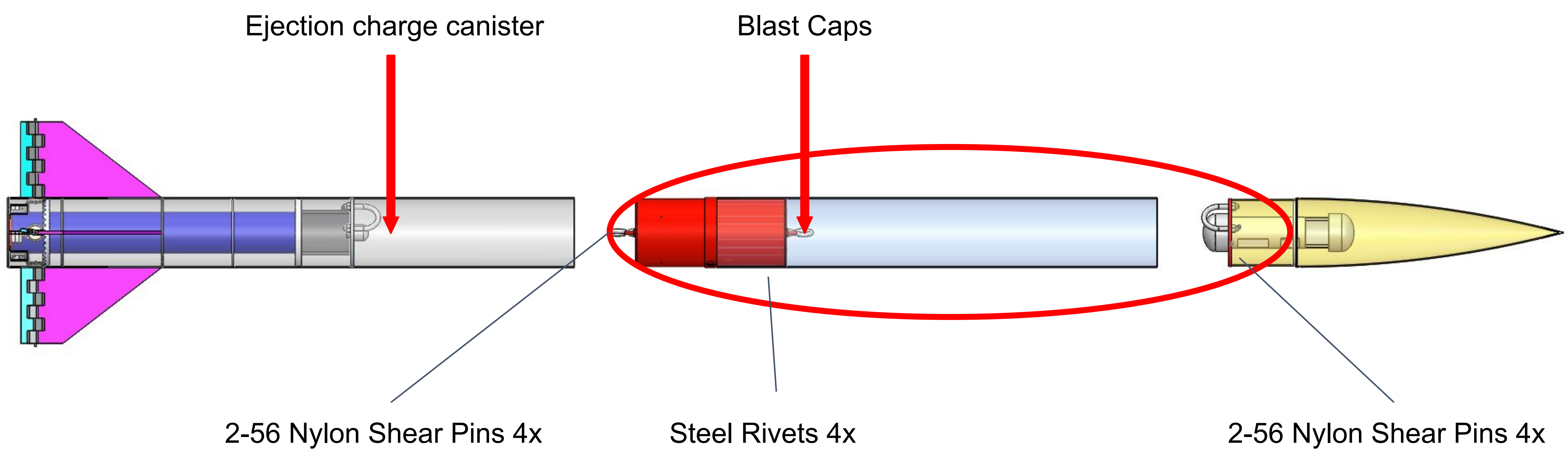
Technical Specifications

- Aerotech L1150
- Diameter: 75mm
- Propellant: APCP
- Casing: RMS 75/3840
- Avg Thrust: 247.4 lb
- Total Impulse: 784.3 lbf-s
- Loaded Mass: 130 oz
- Post-Burnout Mass: 56.7 oz
- Predicted Apogee 5297 ft

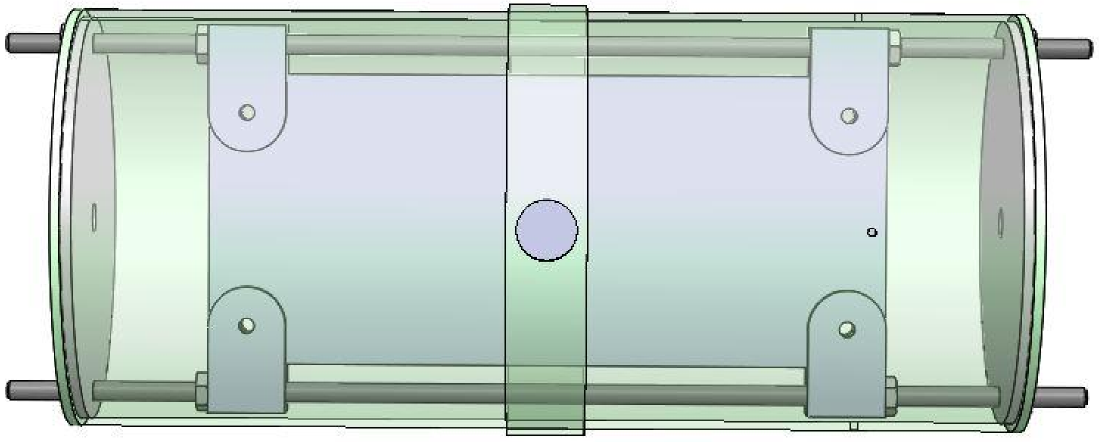
Reasons for Selection

- Higher avg. thrust than other of similar impulse
- More time to control roll-induction mechanism
- Results in most reasonably close apogee
  - Predicted apogee assumes about 65 oz of added mass
  - Unexpected weight of fasteners and epoxy can be compensated by removing from MAS and CG Adjustment system
  - Subscale was heavier than predicted
- No other motor available that came close to same impulse

Avionics Bay - Separation



Avionics Bay - Assembly

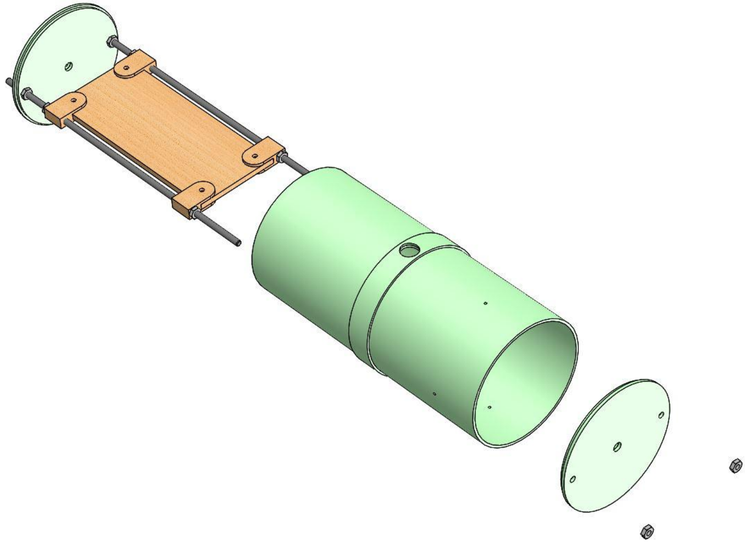


Things Learned From Subscale Launch:

- Wiring both ends of bay become difficult when bulkheads are epoxied in
- Less wire = less chance of tangling and pulling connections loose
- Nuts come loose from vibrations → use loctite

Assembly Description

- Tray riding on two threaded rods, fixed in place via nuts
- Bulkheads are 2-piece assemblies to make better air seal
- Bulkheads clamped on each side of coupler tube with nuts
- 2 master key switches
- One coupler end has shear pin holes, the other has larger holes for rivets



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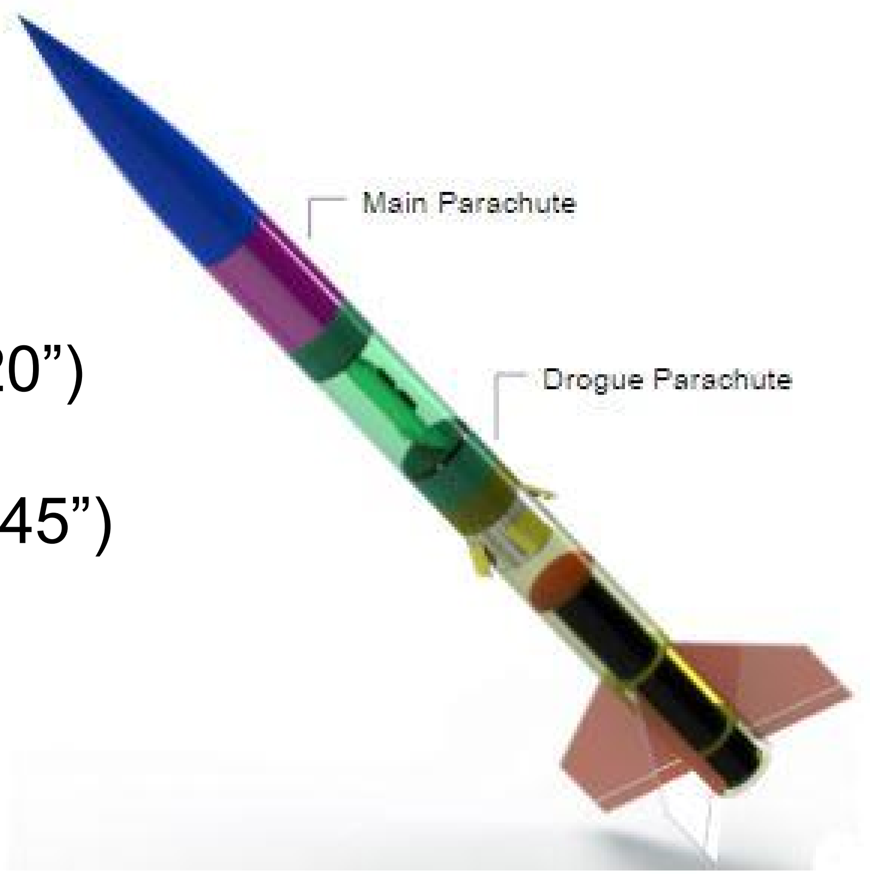
Recovery System

-Dual Redundancy: 2 Stratologger CFs

-Offset altimeter charge firings

-Main Parachute above Avionics Bay (120”)

-Drogue Parachute below Avionics Bay (45”)



Kinetic Energy at Landing

Using a 120” main parachute and 45” drogue parachute, the rocket will land at 18.9 ft/s

$KE = .5*m*v^2$

$75\text{ft-lbf} >= .5*m_{section}*(18.9\text{ft/s})^2$

Section	Mass (oz)	Kinetic Energy after Drogue Deployment (ft-lbf)	Kinetic Energy after Main Deployment (ft-lbf)
Booster (empty)	261.7	633.63	72.2
Avionics	114.2	347.57	39.59
Nosecone	96.8	294.62	33.55

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Mass Breakdown

Booster Section Total: 334 oz		Avionics Section Total: 114.2 oz		Nosecone Section Total: 96.8 oz oz	
Components	Mass (oz)	Components	Mass (oz)	Components	Mass (oz)
Motor Tube	5.73	5.5” Tube	1.69	Nosecone	17
Centering rings	8.12	Coupler Tube	22	Centering rings	4.18
Bulkhead	6.07	Avionics Eqpt	18	GPS PVC Tube	4.47
Thrust Plate	12.1	Bulkheads	11.68	GPS Package	4
MAS	50.9	5.5” Tube (2)	60.8	CG Adjustment	17
Fins	23.4	-	-	Main Chute	45
Drogue Chute	6	-	-	Shock Cord	5.61
Shock Cord	5.61	-	-	-	-
5.5” Tube	73.7	-	-	-	-
Fin-Spin Mech	8	-	-	-	-
Loaded Motor	130	-	-	-	-

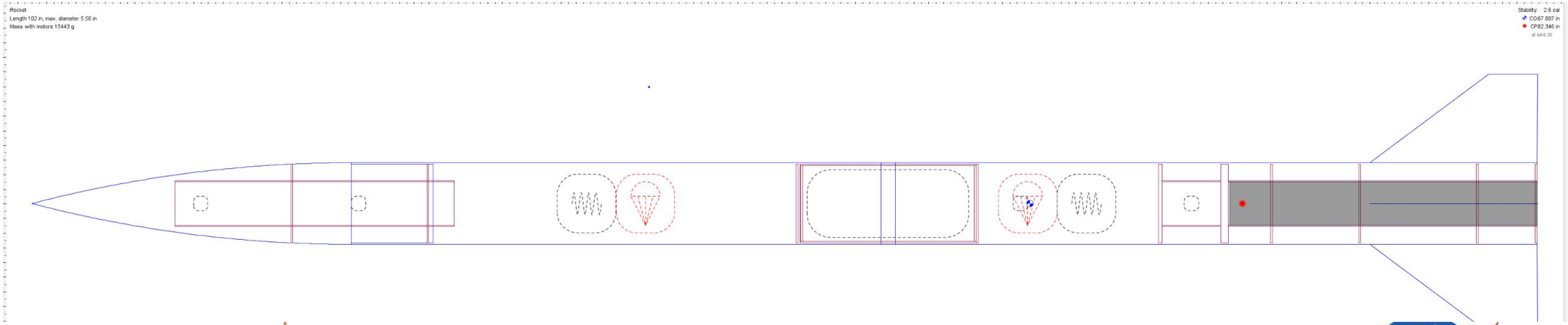
Thrust-to-Weight Ratio *

Max thrust from L1150 = 294.4lbs

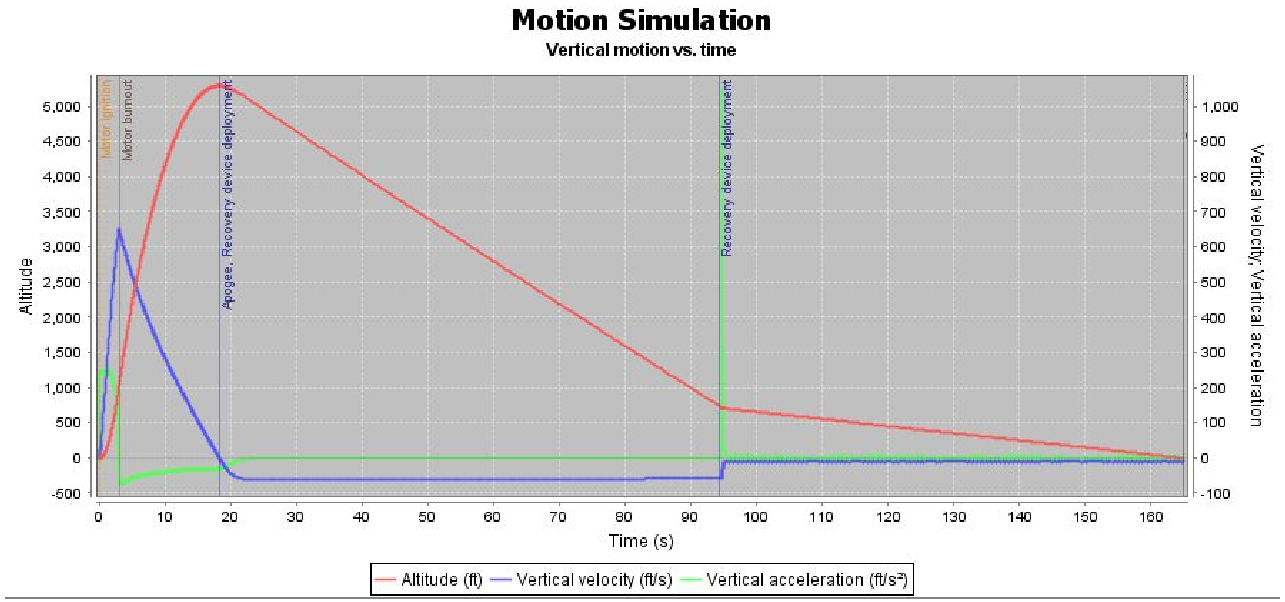
294.4lbs/34lbs = 8.8

Rocket Flight Stability

Variable	Value
Stability	2.6 cal
Centre of Gravity	67.887 in
Centre of Pressure	82.346 in

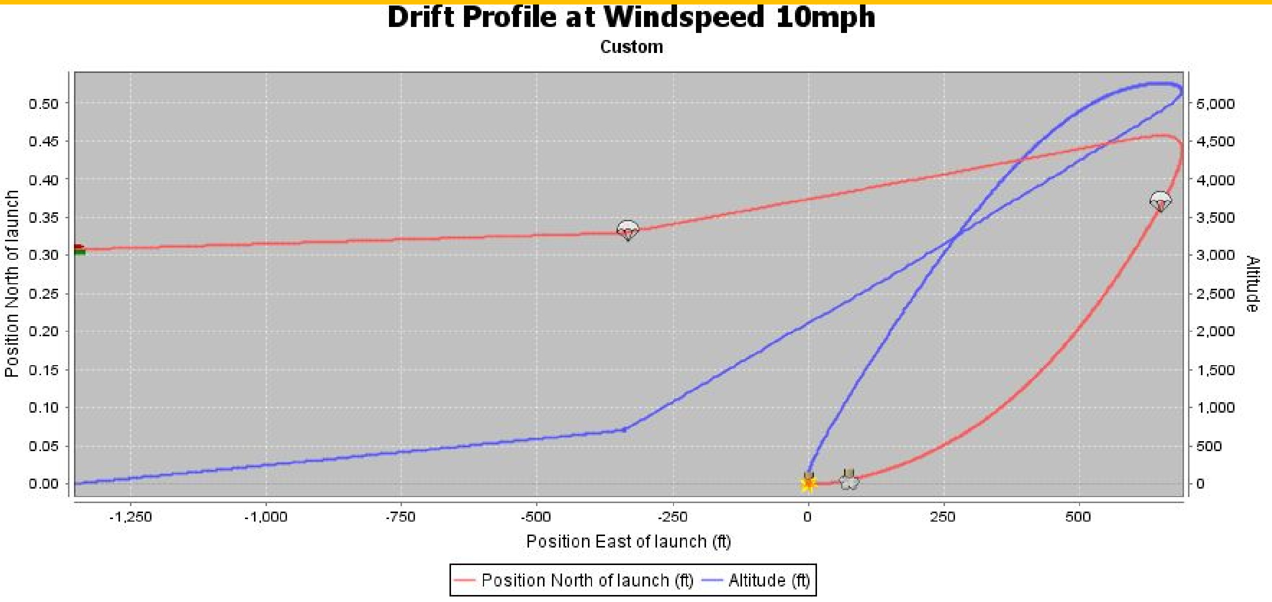


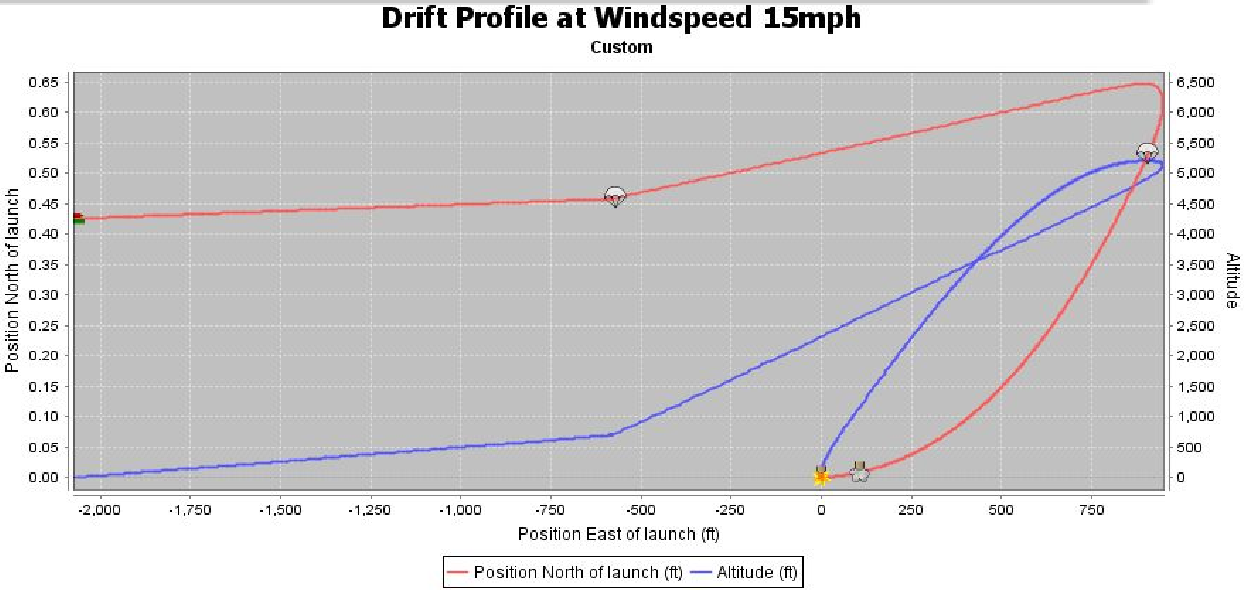
Mission Performance – Flight Profile

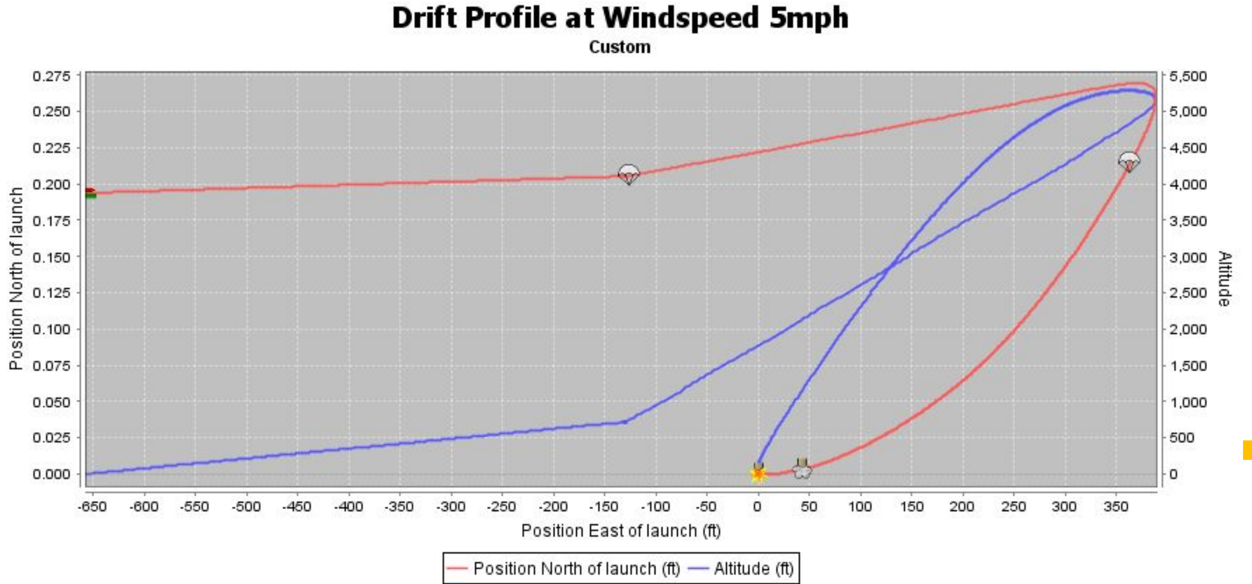


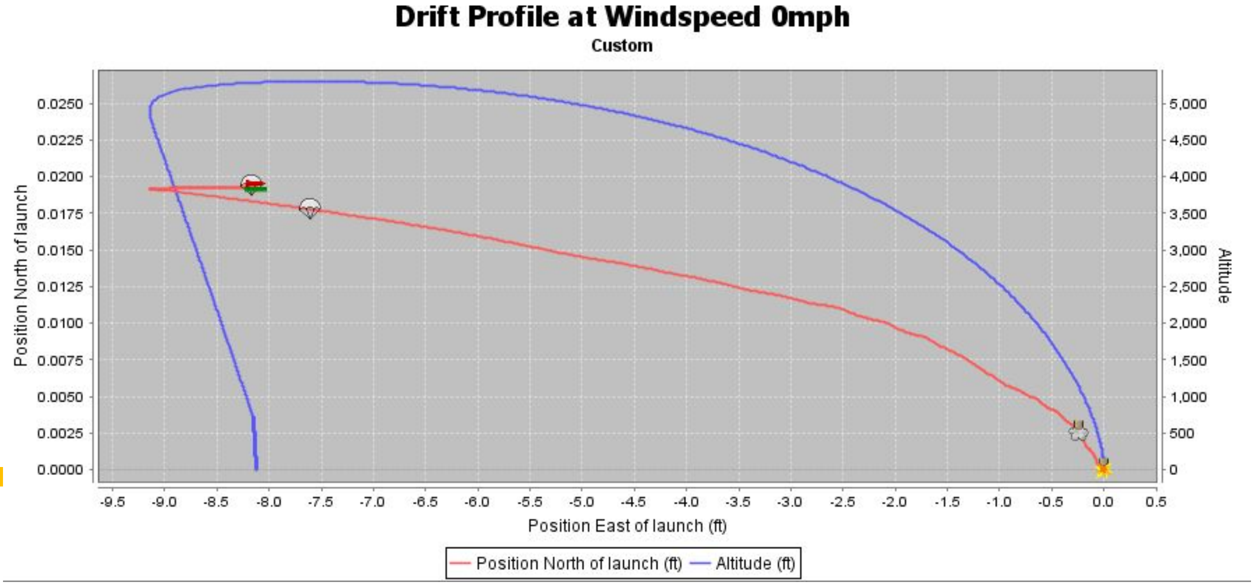
Event	Time(s)	Altitude (ft)	Total velocity (ft/s)	Total acceleration (ft/s²)	Drag force (N)	Drag coefficient
Ignition	0	0	0	13.36	0	0.59769
Lift Off	0.06	0.086	4.886	174.3	0.014	0.57316
Launch rod disengaged	0.21825	3.413	39.28	241.98	0.727	0.4485
Burnout	3.175	1149.	637.9	74.45	172.4	0.49114
Apogee	18.32	5289.	14.43	31.77	0.044	0.50164
Drogue Chute	18.38	5289.	20.22	31.96	13.51	
Main Parachute	94.85	711.2	58.77	0.235	131.2	
Ground Impact	165.03	-2.1046	10.867	6.53	153.62	

Mission Performance - Drift Profile

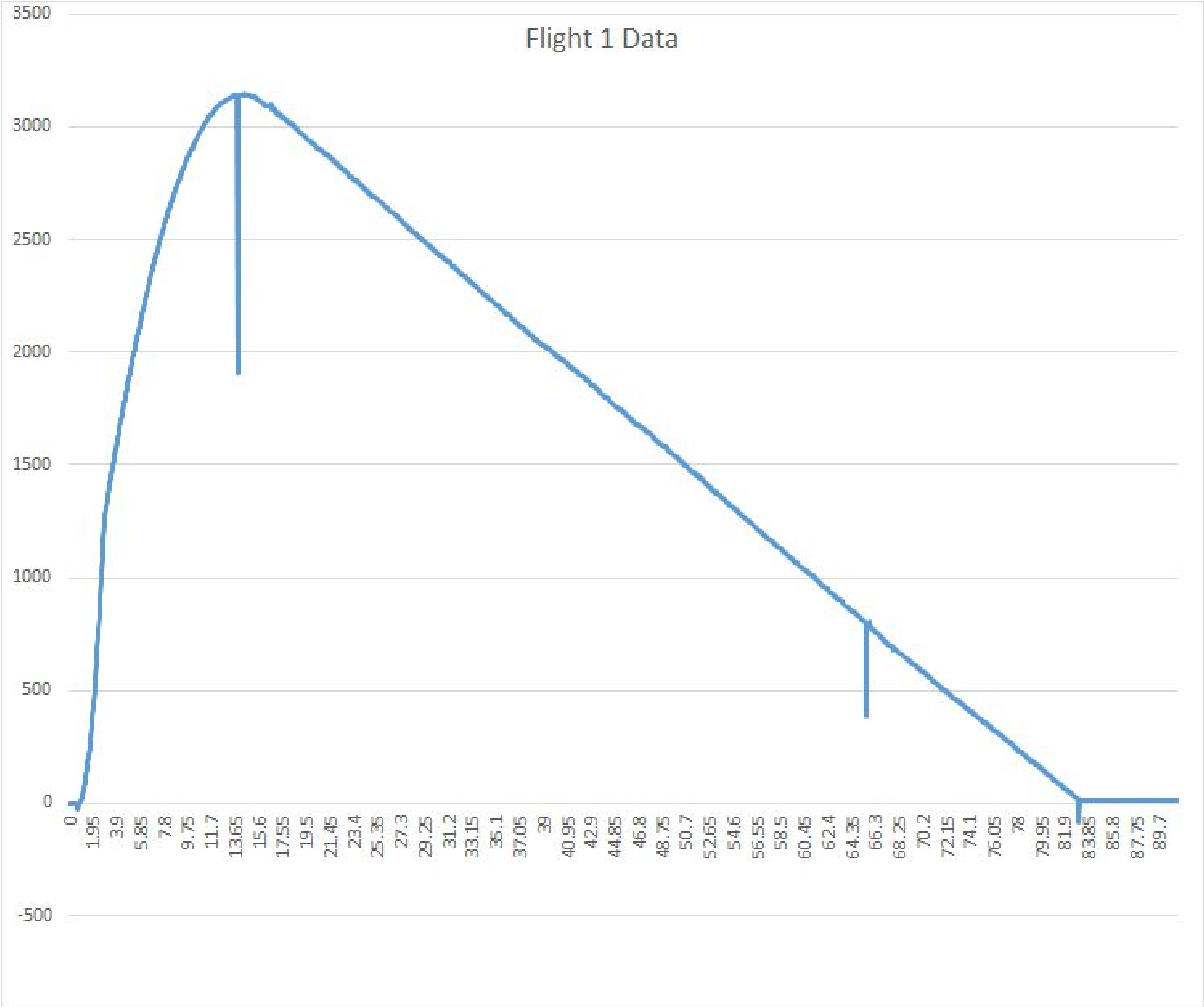


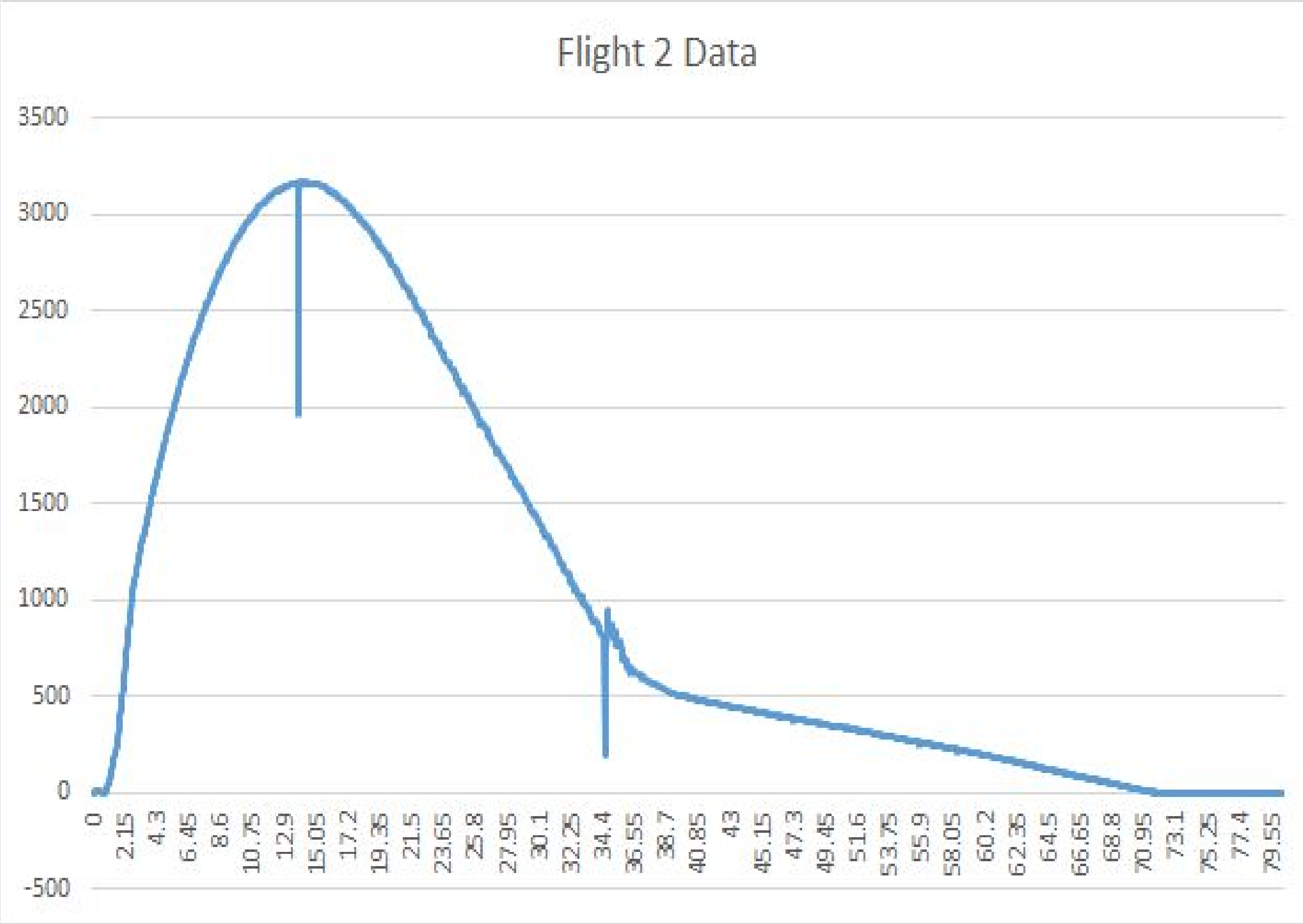






Subscale Launch Results





Flight 1- Apogee 3145ft

Flight 2- Apogee 3166ft

Subscale Launch Results- Design Changes

- Avioinics Bay rehaul- more accessibility
- WATES effective system
- Offset altimeter deployment signals
- Smaller keyswitches
- Switching main and drogue parachute locations

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FLIGHT SYSTEMS

Flight System Responsibilities

Outline of Success Criteria

Requirement	Design Feature to Satisfy Requirement	Requirement Verification	Success Criteria
The vehicle shall not exceed an apogee of 5,280 feet	Calculated rocket mass	Full-scale flight test	Apogee within 1% of target
The vehicle will be tracked in real-time to locate and recover it	Eggfinder GPS module will be used in the vehicle and base station	Full-scale flight test	The vehicle will be located on a map after it lands for recovery
The data of the vehicle's flight will be recorded	Pixhawk has sd card storage	Full-scale flight test	The data will be recovered and readable after flight
The vehicle will complete a moment and counter moment inducing roll	Pixhawk servo rail will strategically actuate motor system.	Full-scale flight test	Rolling at least 2 full rotations, and rotating the other way to the initial position

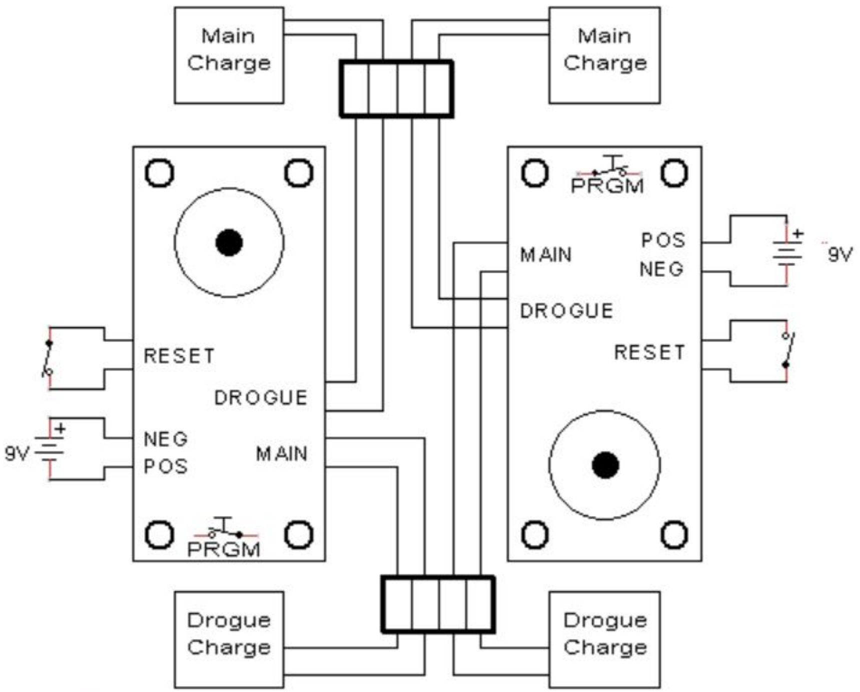
Flight Systems: Avionics

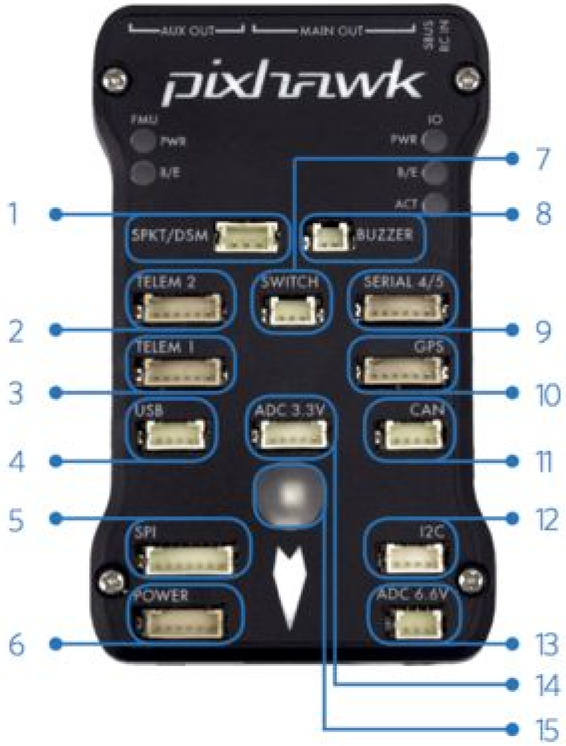
Avionics Components

Part	Function
Stratologger SL100	Altimeter - used to receive and record altitude
Pixhawk px4	Autopilot control system. equipped with 9 DOF MEMS and 14 pwm_out.
Air Speed sensor	Reports exterior air speed. USeful for roll calculations.
Eggfinder TX/RX Module	GPS module - used to track the rocket in real time
9V Alkaline Batteries	Used to power all Avionics components and ATS

Flight Systems: Avionics

Recovery System





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

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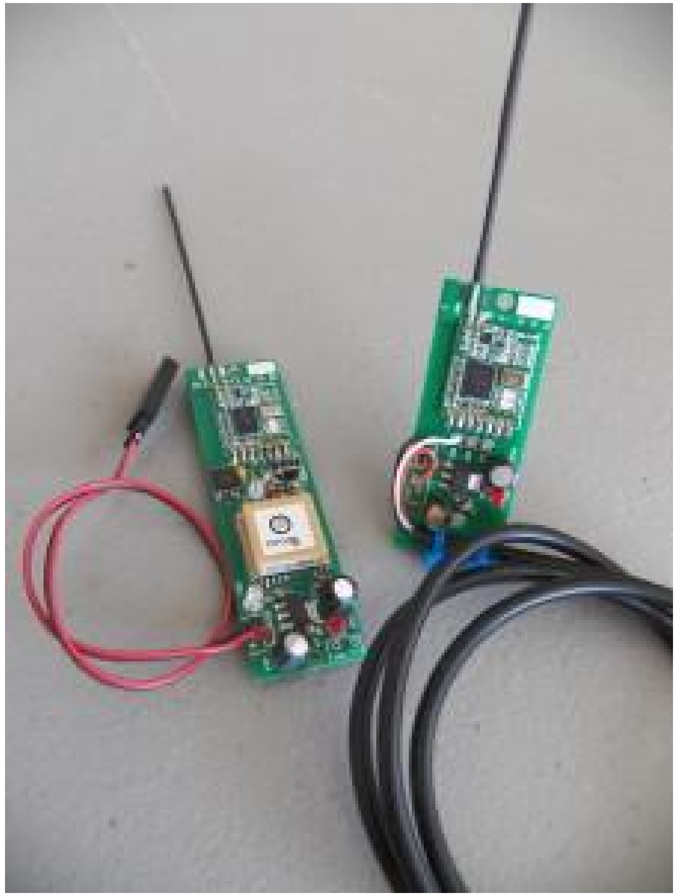
Flight Systems: Ground Station



Equipment:

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

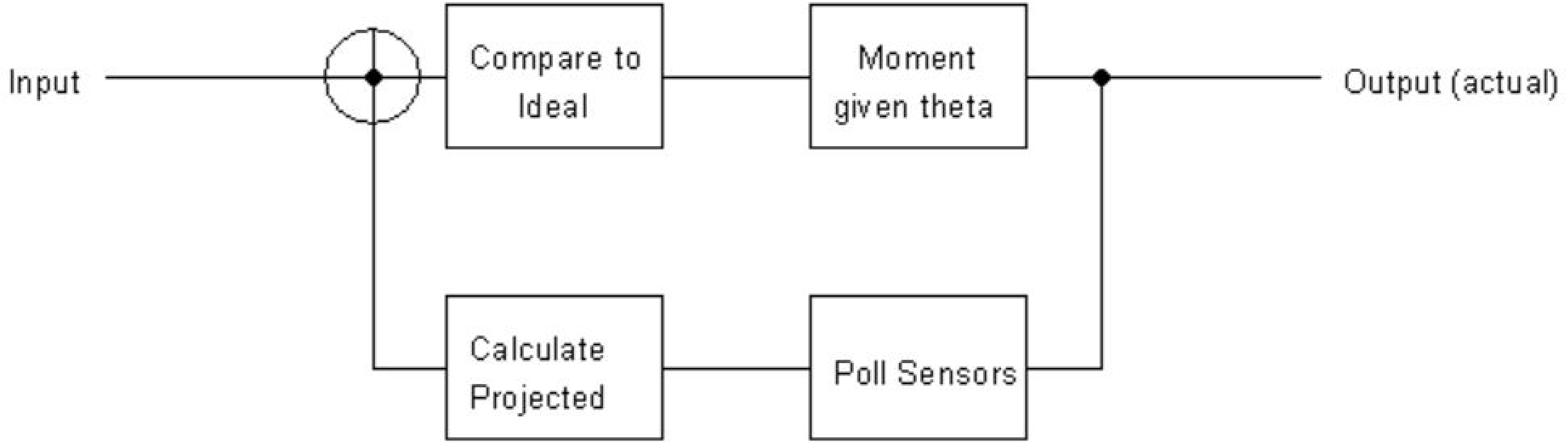
Payload Integration

- Roll Control- 4 servos hooked up to power and Pixhawk in Avionics bay through disconnectable wiring lining down the booster section
- Altimeters hooked up to ejection charges in coupler sections
- Servos connected to shafts turning the fin flaps

Interfaces

- Pixhawk controls servos actuating roll control flaps
- GPS sending signals to a ground receiver
- Altimeters hooked up to ejection charges in coupler sections

Flight Systems: System Block Diagram



Flight Systems: ATS Power

- 9-volt alkaline batteries will be used independently to power each stratologger altimeter as well as the Pixhawk

- High torque servo motors will be used to actuate roll flaps. An independent 7.4V NiMH source will be used to power the servo rail.

Flight Systems: Testing Overview

Wind Tunnel: Test flap actuation under load

Flight Simulation: simulated flight data will be tested for run-time efficiency to ensure that calculations can be completed both accurately and timely.

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

Stress Tests -Bulkheads, Thrust Plate

Ejection Charges

Questions

Questions?