ASTRO CATS

Preliminary Design Review Presentation

Team

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Presentation Outline

- Project Statement
- Project Budget, Schedule and Objectives.
- Vehicle dimensions, materials, and justifications
- Static Stability Margin
- Plan for vehicle safety verification and testing
- Baseline motor selection and justification
- Thrust-to-weight ratio and exit rail velocity
- Launch vehicle verification and test plan overview
- Drawing/Discussion of each component and subsystem
- Baseline Payload Design
- Payload verification and test plan overview
- Upcoming Team Events

Project Statement

The Astro Cats will win the NASA University Student Launch by developing a vehicle capable of deploying a planetary probe to approximately 1 mile above ground level. The probe will be deployed via a custom fairing system and will capture atmospheric data. The data will then be transmitted via radio to a ground station. This system will be developed for under $7,500.

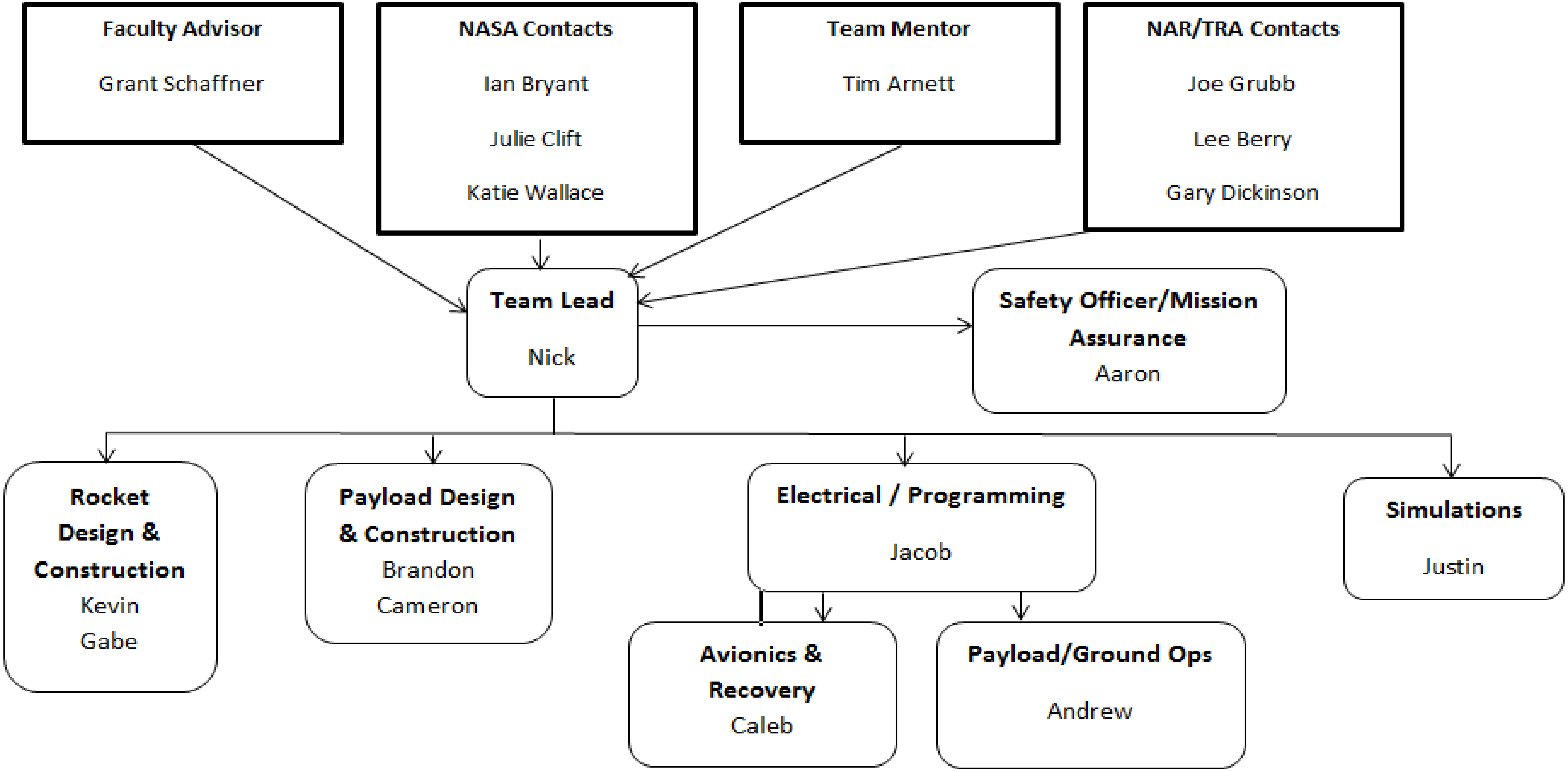
Level 1 Safety Analysis

- Please be aware of any hazards that exist in the room
  - Tripping hazards – cords, chair legs, and backpacks
  - Pinch points – hands with doors and hands in between chairs and desks

- In the event that we need to evacuate please exit the building out the main entrance and meet in quad.

- In the event that we need to shelter in place please make your way to the 400 level of Baldwin and shelter in the hallway.

Work Breakdown Structure



Project Budget

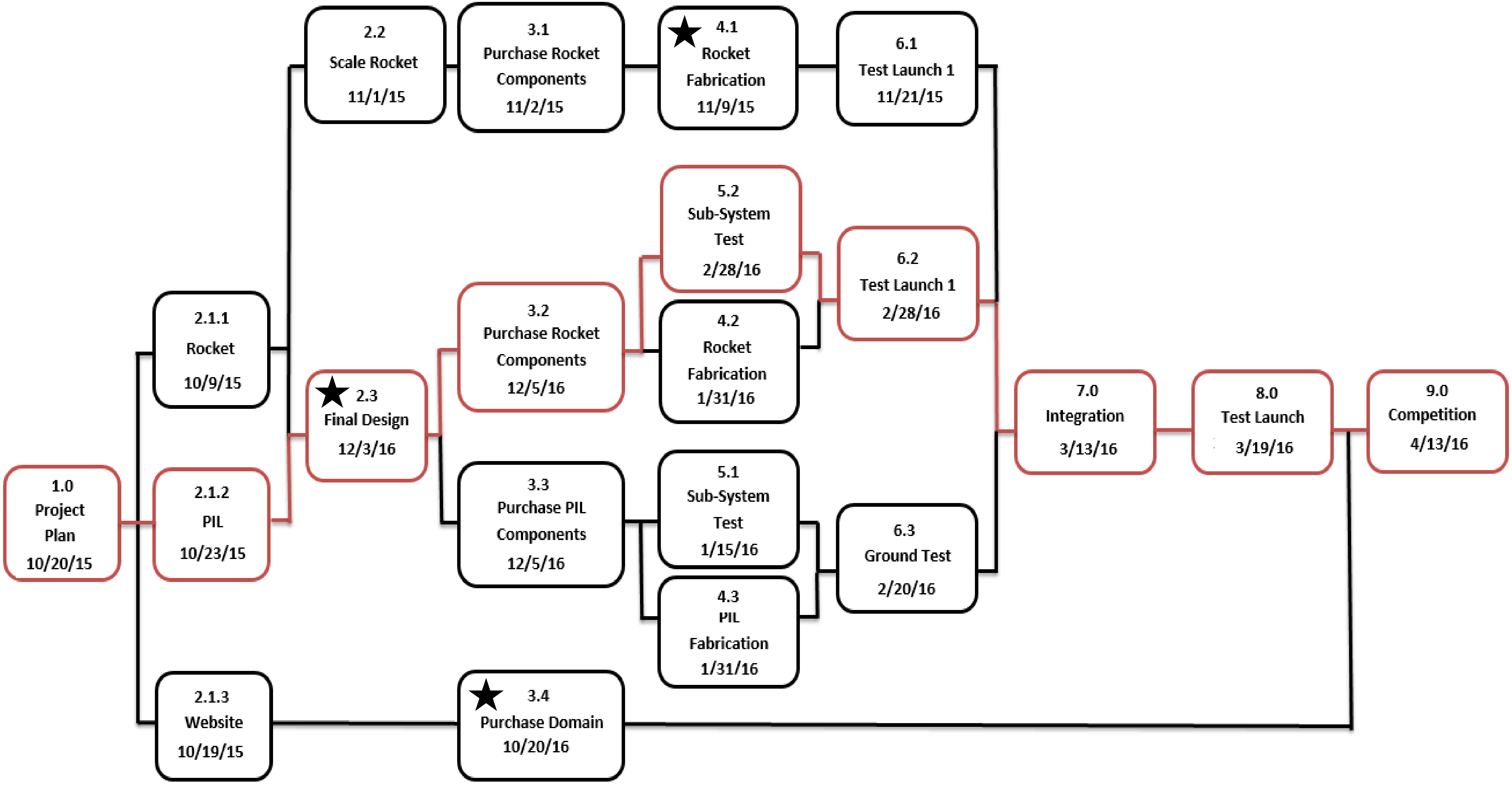
- Started purchasing components Oct 14th
- Currently under initial proposed budget by $991

Expense Summary	
Travel	$ 3,442.00
Rocket	$ 1,344.38
Payload	$ 2,833.46
Educational	$ 70.00
Total	$ 7,689.84

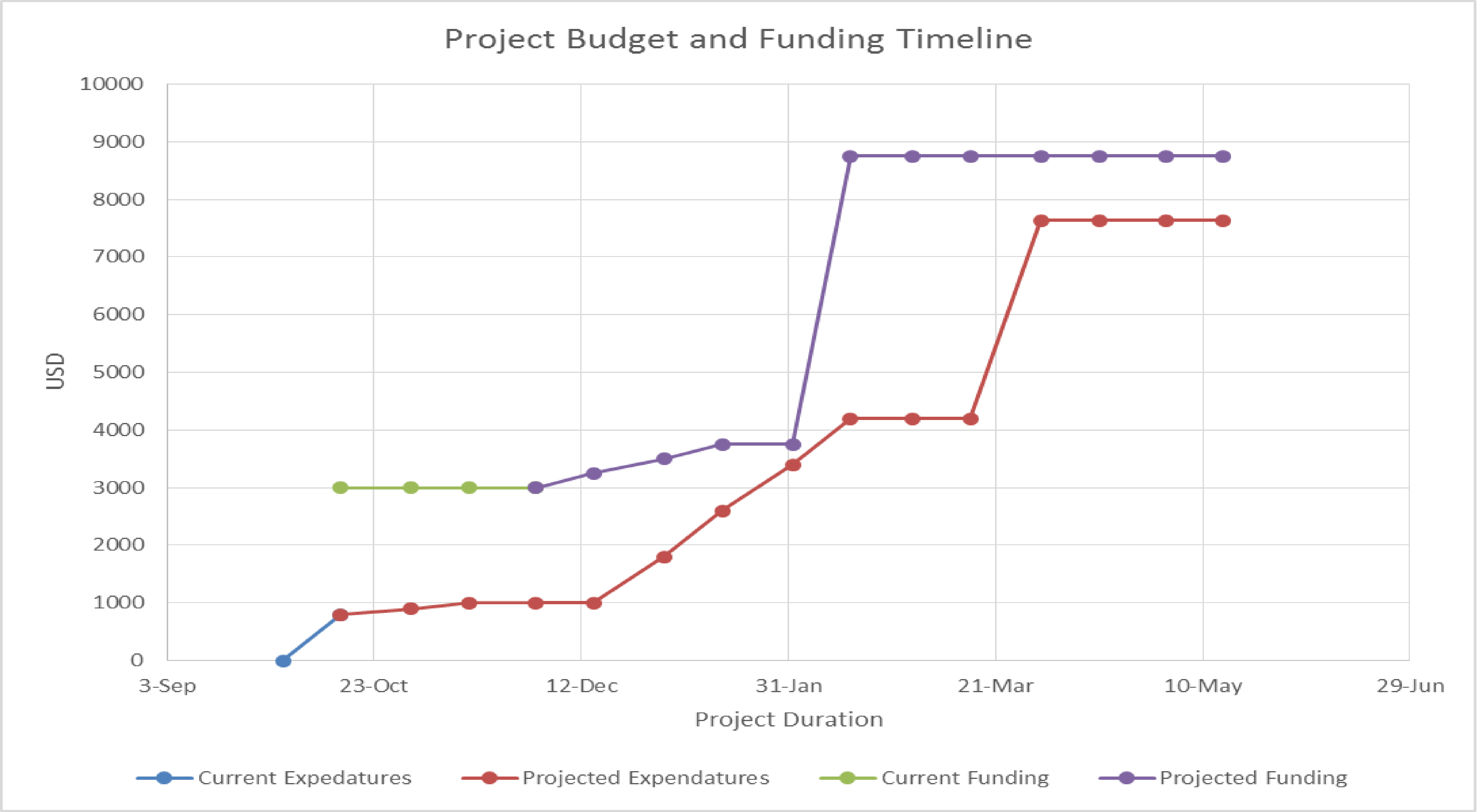
Project Funding

- Already secured funds from UC SEDS & Aero department
- Plan to present project presentation to companies requesting funds in December
- In the process of completing OSGC Grant

Funding Summary		
Item	Amount	
UC SEDS	$	2,333.00
UC Aero Department	$	667.00
Outside Sponsers	$	500.00
OSGC	$	5,000.00
TOTAL	$	8,500.00



2.2
Scale Rocket
11/1/15
3.1
Purchase Rocket
Components
11/2/15
4.1
Rocket
Fabrication
11/9/15
6.1
Test Launch 1
11/21/15
5.2
Sub-System
Test
2/28/16
6.2
Test Launch 1
2/28/16
2.1.1
Rocket
10/9/15
3.2
Purchase Rocket
Components
12/5/16
4.2
Rocket
Fabrication
1/31/16
2.3
Final Design
12/3/16
7.0
Integration
3/13/16
8.0
Test Launch
3/19/16
9.0
Competition
4/13/16
1.0
Project
Plan
10/20/15
2.1.2
PIL
10/23/15
3.3
Purchase PIL
Components
12/5/16
5.1
Sub-System
Test
1/15/16
6.3
Ground Test
2/20/16
4.3
PIL
Fabrication
1/31/16
2.1.3
Website
10/19/15
3.4
Purchase Domain
10/20/16


Project Budget and Funding Timeline
USD
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
3-Sep
23-Oct
12-Dec
31-Jan
21-Mar
10-May
29-Jun
Project Duration
Current Expedatures
Projected Expendatures
Current Funding
Projected Funding

Launch Vehicle Objectives

- Vehicle shall deliver the payload to as close to 5,280 ft (AGL) as possible.
- Vehicle shall be reusable after recovery.
- Tracking bay shall transmit position data back to ground station.
- At landing, each independent section of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf.
- Vehicle will deploy parachutes via stratologger altimeters

Payload Objectives

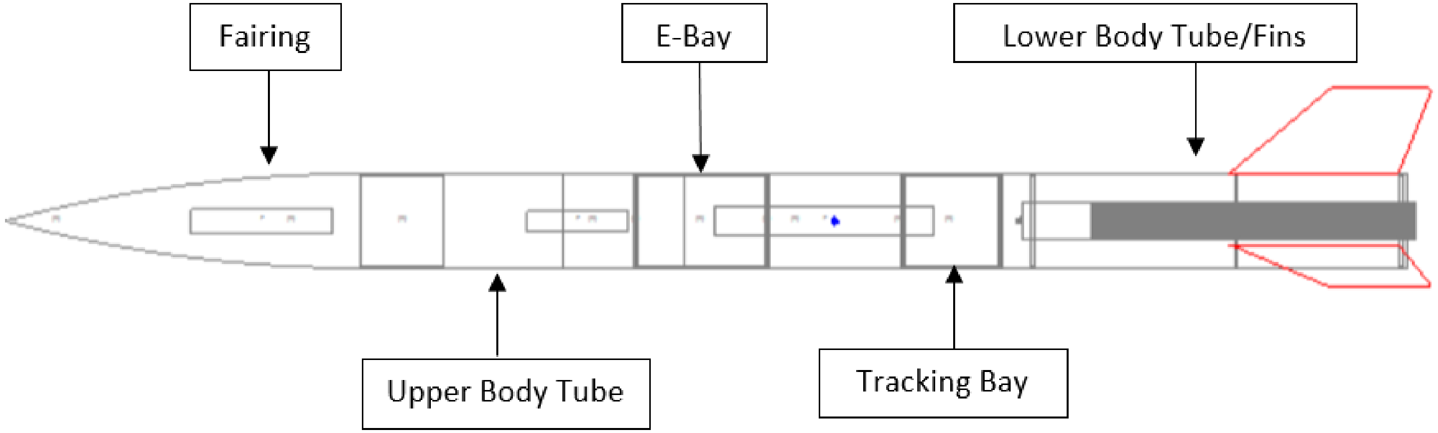
- The payload shall deploy at apogee
- The payload shall collect atmospheric measurements
- The payload shall take pictures
- The payload shall remain in orientation during descent and after landing
- The data from the payload shall be stored onboard and transmitted wirelessly to the ground station
- The payload will be reusable after the mission

Launch Vehicle Overview

- Design Overview
- Fairing Design
- Fin Design
- Motor Selection
- Tracking Bay Design
- Integration
- Mass Breakdown

Launch Vehicle Design

- Total length: 84.4 inches
- Airframe Diameter: 5.54”
- Fin count: 3
- Empty weight: ~12 lbs
- Loaded weight: ~19 lbs
- Center of Gravity: 46.79”
- Center of Pressure: 57.99”
- Stability Margin: 2.04
- Number of Subsections: 4

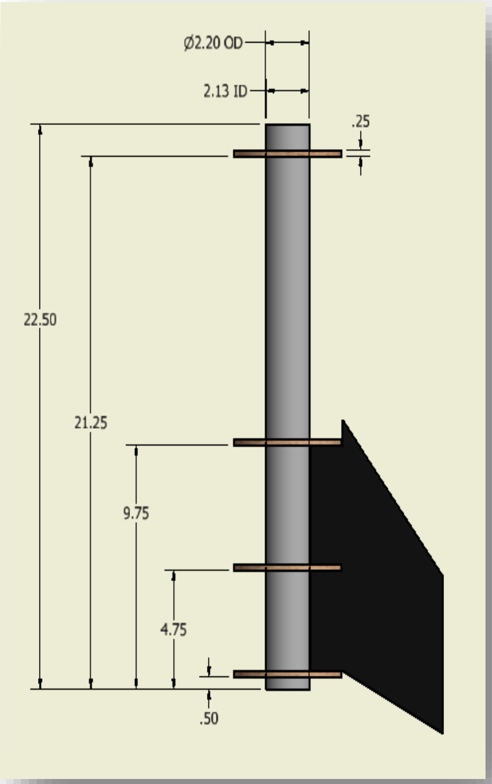


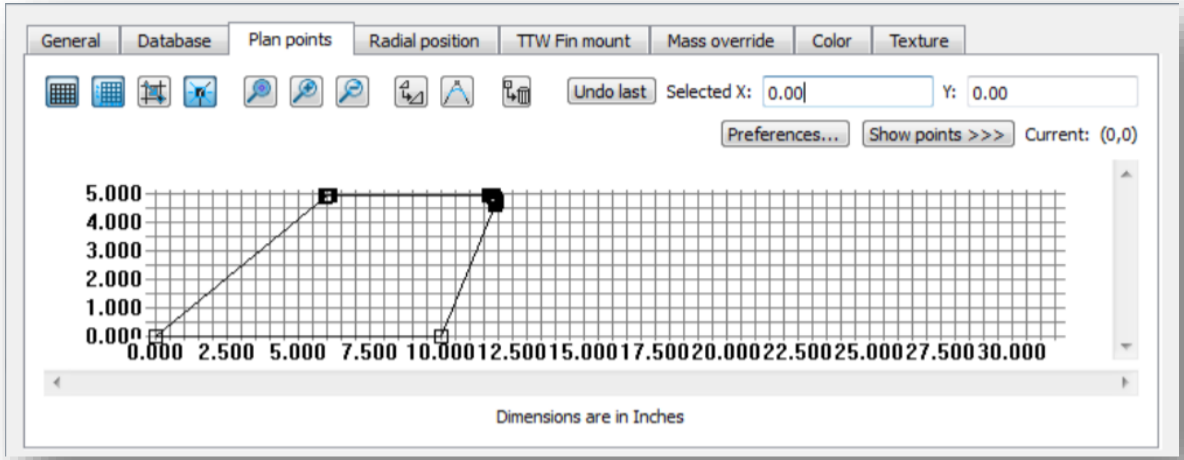
Fairing Design

- Mold made from standard 5.54” plastic nosecone
- Layers of 4 oz. and 6 oz. fiberglass and epoxy resin
- Interlocking machined polymer rib structure
- Overlapping tab to reduce airflow leakage
- Nylon shear screws to join pieces
- Tethered to P.I.L. parachute

Fin Design

- Fin Count: 3
- 1/16” G-10 Fiberglass plastic core
- 5lb. Divinycell foam shaped to airfoil
- 6oz. Fiberglass and epoxy shell
- Permanently attached to lower body tube





Motor Selection

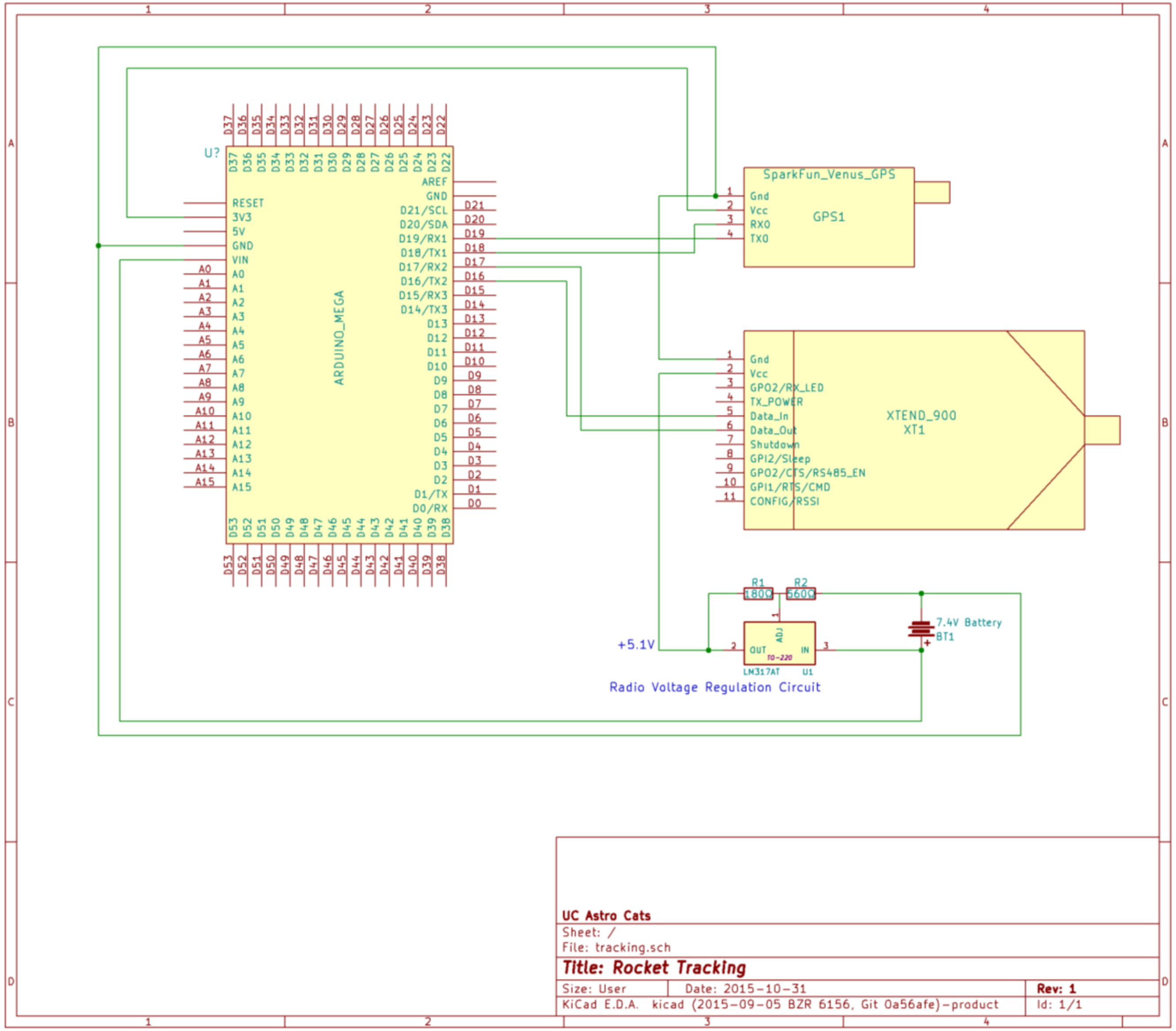
- Motor: Cesaroni – P54-5G Classic (K570)
- Size: 54 mm
- Burn time: 3.6 sec
- Total Impulse: 2062.9 Newton-Seconds
- Max Thrust: 892.7 Newtons
- Mass: 1685.0 grams
- Delay charge will be removed

Tracking Bay

- Components:
  - Arduino Mega
  - XTEND-900 radio transceiver
  - Venus GPS Module
  - Radio and GPS Antenna
  - Battery

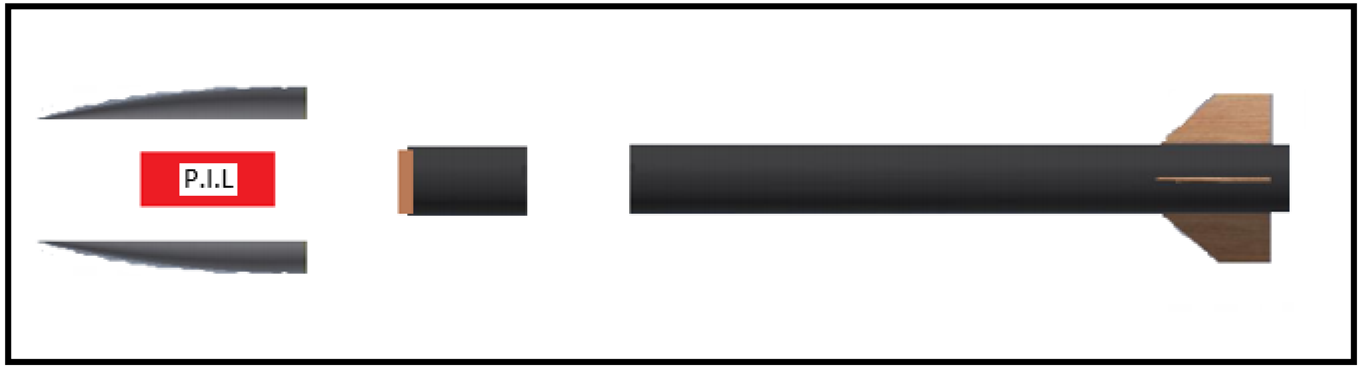
- Communicates vehicle position data back to ground station in real time.

Tracking Bay Electronic Schematic



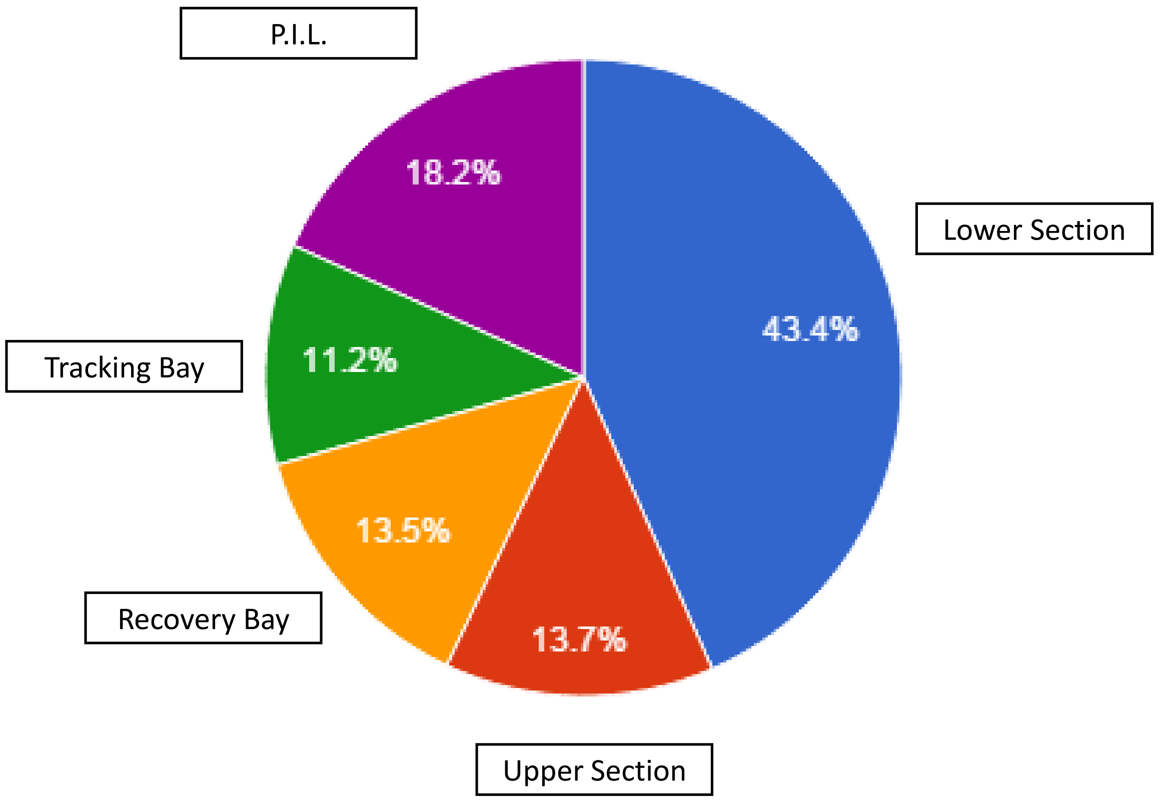
Integration

- 2 separation points – fairing and below recovery bay
- P.I.L. housed in fairing
- Drogue chute in upper section beneath the P.I.L.
- Main chute in lower section between Recovery and tracking bays

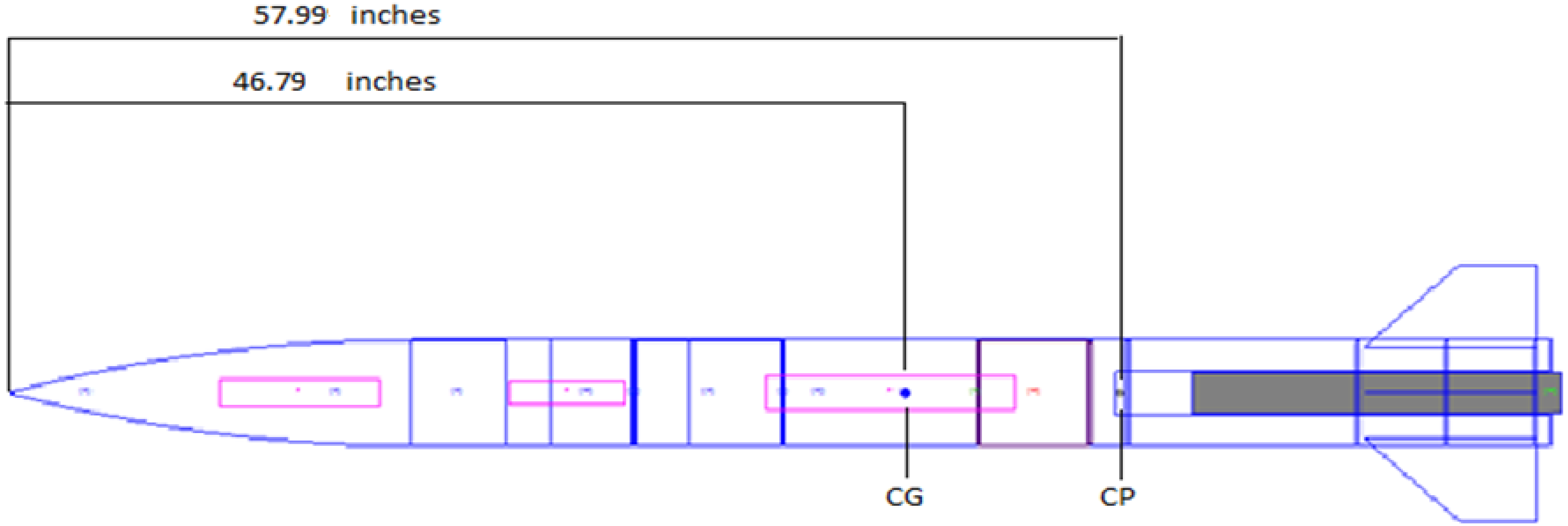


Mass Breakdown

Subsection	kilograms	lbs
Total Lower Section Mass	**3.61**	**7.97**
Total Upper Section Mass	**1.14**	**2.51**
Total Recovery Bay Mass	**1.13**	**2.48**
Total Tracking Bay Mass	**0.94**	**2.06**
Total P.I.L. Mass	**1.52**	**3.34**
Total Mass		18.36



Static Stability Margin



	On Launch Pad	After Burnout
CP (from tip)	57.99 in.	---
CG (from tip)	46.79 in.	43.15 in.
Static Margin	2.04	2.70

Motor Selection, thrust-to-weight ratio, exit rail velocity

- Currently we are using a Cesaroni K570 which has a total impulse of 2070.258 N-Sec and a 3.9 sec. burn time
    - Preliminary test show a total altitude of 5,740.30 feet.
    - Thrust-to-Weight Ratio: 6.77
    - Max velocity: 659.24 feet/second
    - Exit rail velocity: 64.22 feet/second
- Also considering using a Cesaroni K750-RL which has a total impulse of 2361.966 N-Sec and a 3.14 sec. burn time
    - Preliminary test show a total altitude of 6,638.85 feet.
    - Thrust-to-Weight Ratio of 8.53
    - Max velocity of 765 feet/second
    - Exit rail velocity: 41.4223 feet/second

Launch Vehicle Testing Plan

- Launch Vehicle
  - Subscale launch
  - Wind tunnel
  - Parachute drop tests
  - Full scale launch– simulated payload
  - Full scale launch – full integration

- Fairing
  - Pop tests
  - Impact and vibration testing

- Electronics
  - Radio communication tests
  - Altimeter vacuum test

Parachute Summary

SECTION	SURFACE AREA (FT^2)	DRAG COEFFICIENT	DESCENT RATE (FT/SEC)	KINETIC ENERGY AT IMPACT (FT-LBF)
MAIN PARACHUTE	57	1.26	14.2	35.3
DROGUE PARACHUTE	7.1	0.75	46	-
PIL PARACHUTE	12.6	0.75	22.5	44.6

Recovery Systems

- Parachute Summary
- PIL Recovery System
- Rocket Recovery System
- Ejection Charges
- Attachment Method & Durability

PIL Recovery System

- The PIL recovery will be a single parachute.

- The PIL will deploy its parachute at apogee.
  - PIL Parachute: Public Missiles PAR-60HD
  - Descent rate is approximately 22.5 (ft/sec)
    - Current mass calculation: 5.7 lbs.

Rocket Recovery System

- The rocket will be a two stage deployment after releasing the PIL.

- A drogue parachute will deploy five seconds after apogee.
  - Drogue Parachute: 36” LOC LHPC-36
  - Slows descent rate to approximately 46 (ft/sec)
    - Current mass calculations: 11.3 lbs.

- A main parachute will deploy at 600 feet (AGL).
  - Main Parachute: SkyAngle CERT-3 Large
  - Slows the rocket to an approximate final descent rate of 14.2 (ft/s)
    - Current mass calculations: 13.4 lbs.

Ejection Charges

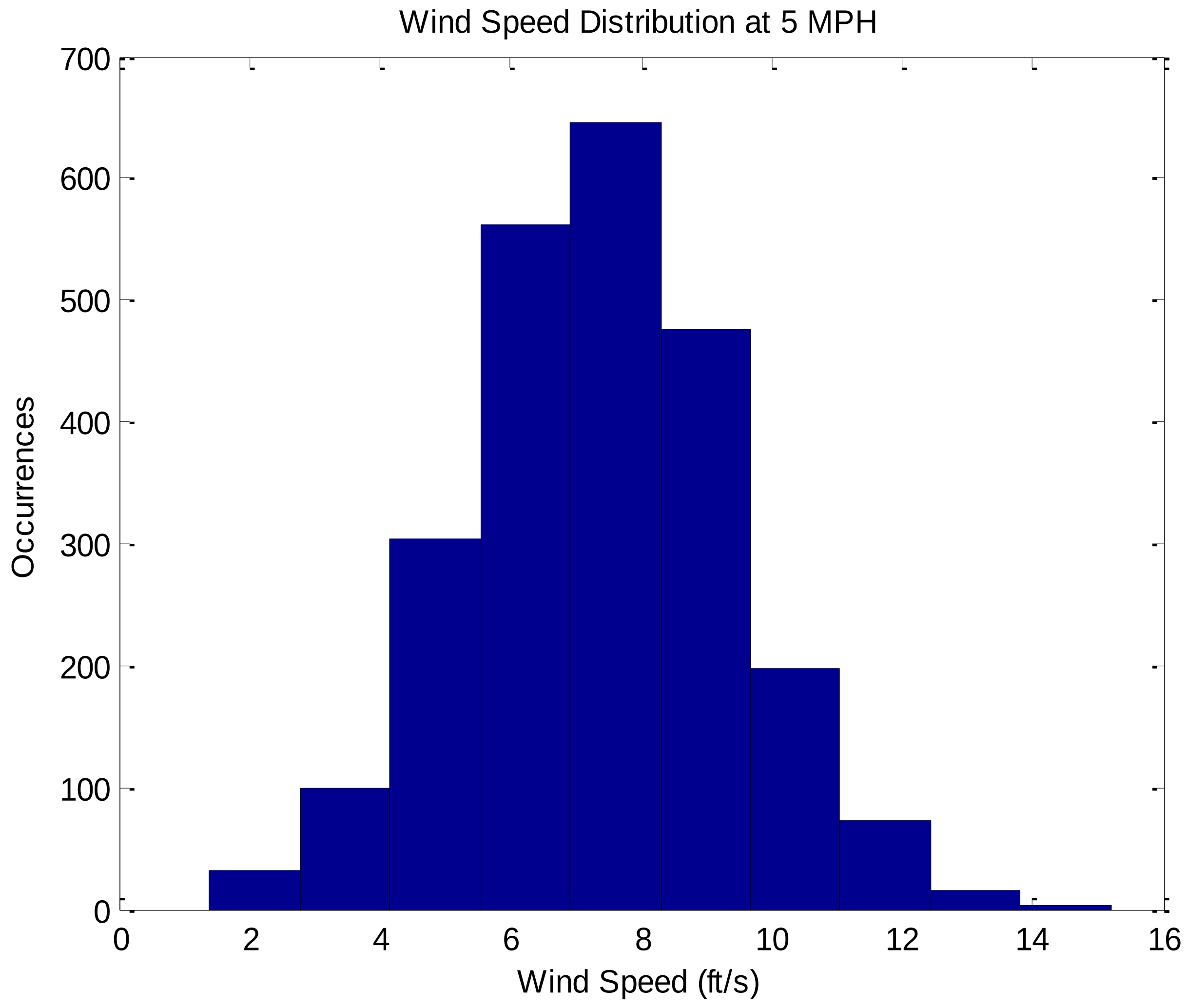
- Two black powder charges will be used for both the drogue and main parachute.
- Each parachute deployment will have a 1.5 gram main charge and a 2 gram redundant charge.
  - Pop-tests will refine these values.
- The Recovery Bay Sled will have three StratoLogger altimeters.
  - Strat 1 – Deploys main charge for faring and main parachute
  - Strat 2 – Deploys main charge for the drogue and back-up for main parachute
  - Strat 3 – Deploys back-up drogue charge

Attachment Method & Durability

- Attachment method for all parachutes will be the rip-stop nylon provided with each and additional nylon suspension supports.
- Rip-stop cords will be attached via eyebolts imbedded into the bulkheads of the Recovery Bay.
- The load capacity of each parachute is not exceeded per suppliers provided calculators.

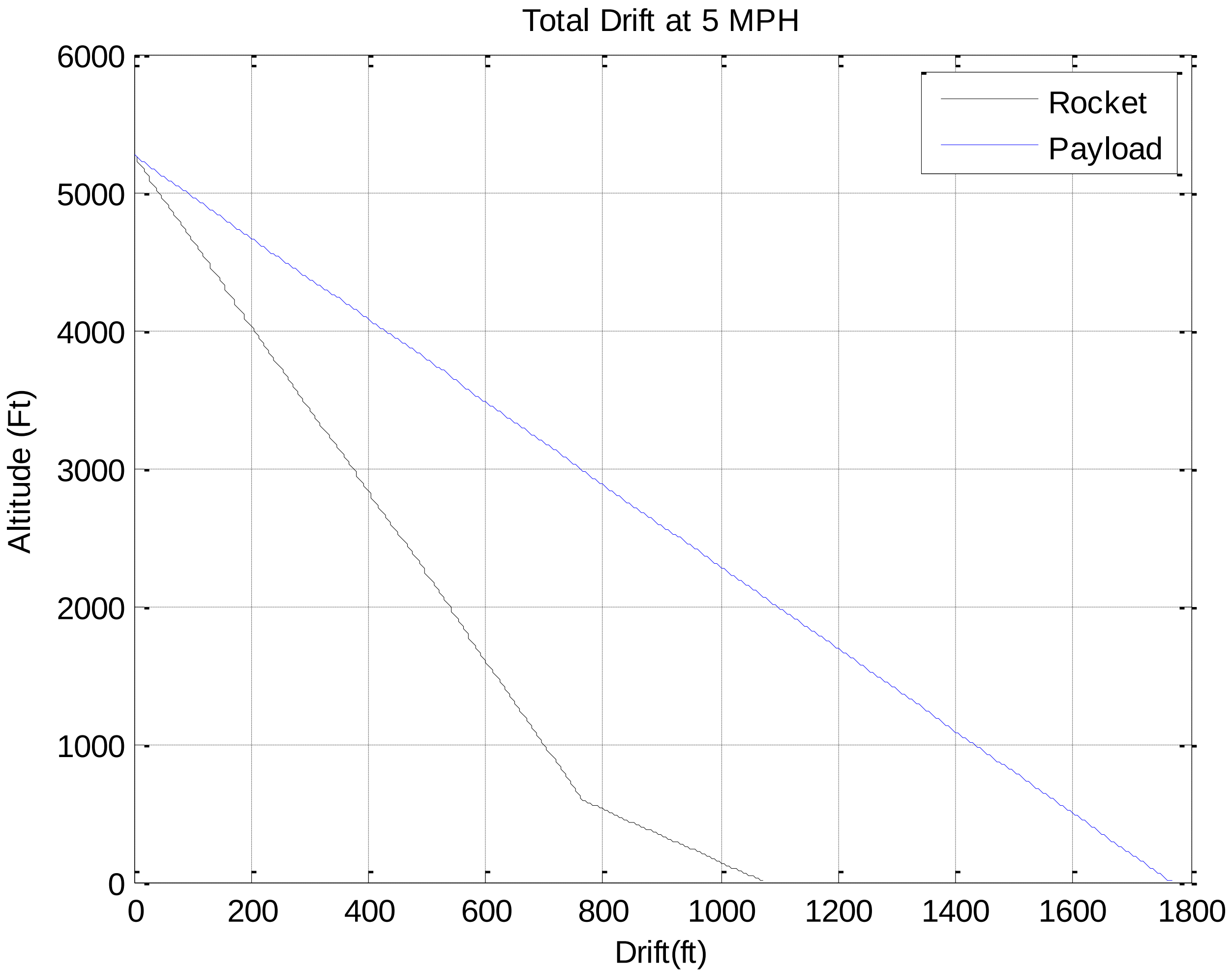
Drift-Wind Speed

- Assumptions
  - Sustained wind speeds change with a normal distribution
  - The standard deviation is 2 feet/sec
- Next steps
  - Research and gather experimental data either supporting the current wind behavior, or find data to model a more accurate distribution
- Graph to the right shows the wind speed distribution at a mean of 5 MPH (7.33 feet/sec). This was done for 0,5,10,15, and 20 MPH.



Drift-Single Run

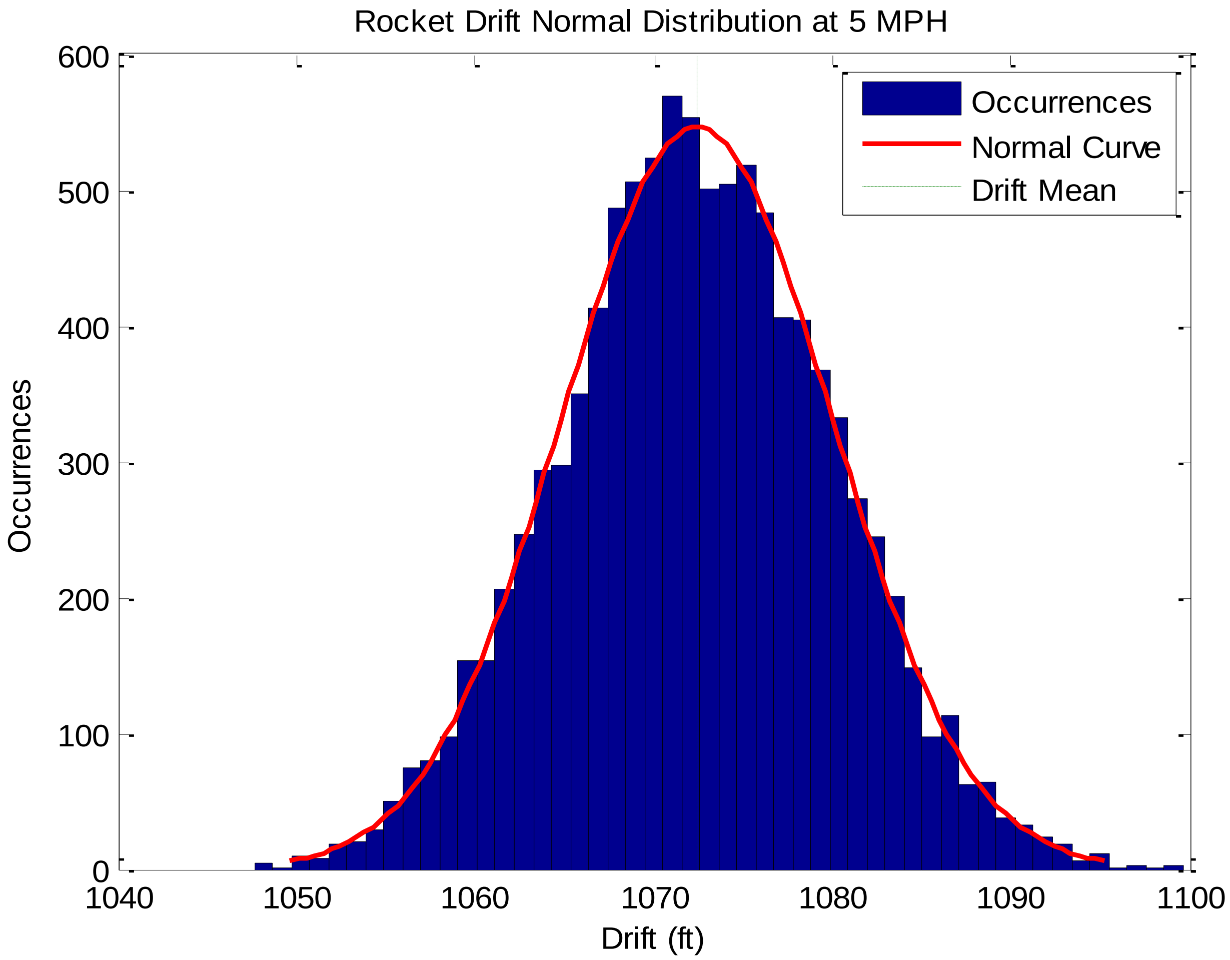
- Assumptions
  - Apogee is always 5,280 feet
  - Wind speed probability is a normal distribution
- On the right is a single drift estimate at 5 MPH
  - Payload descends at a constant rate.
  - The rockets main parachute is deployed at 600 feet



Drift-Multiple Runs

- Assumptions
  - 1 Degree-of-Freedom system
  - All assumptions stated above apply.

- The graph on the right shows a distribution of total drift at 5 MPH for the rocket.
  - This was done for both the rocket and the payload at 0, 5, 10, 15, 20 MPH
  - Can help us accurately predict landing zones



Drift Range

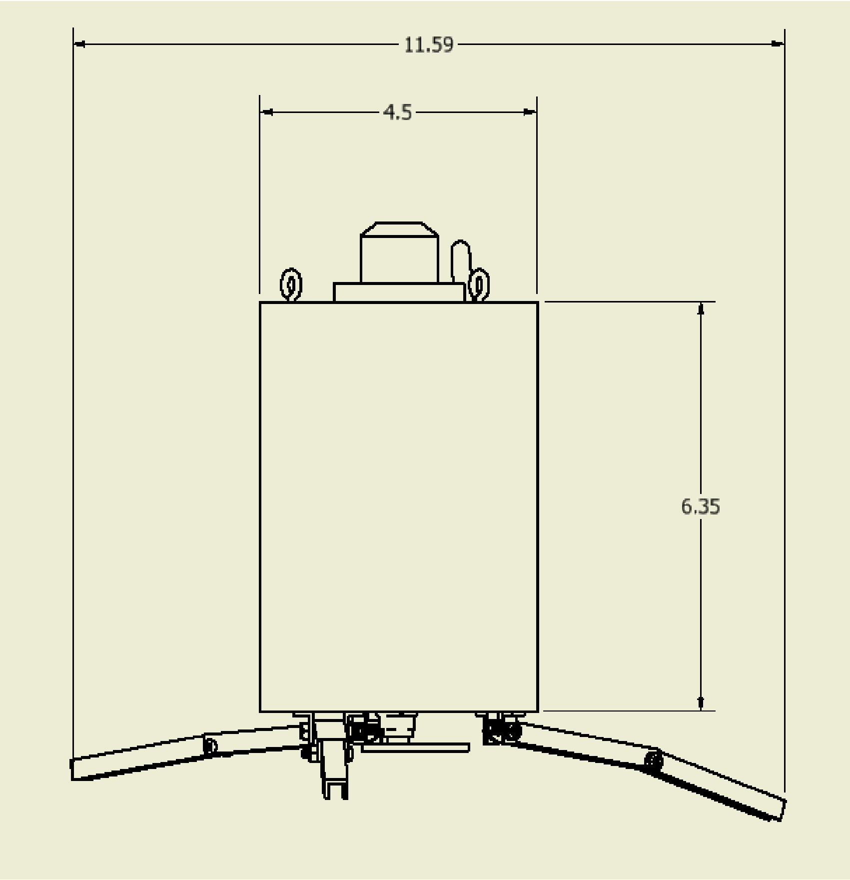
Wind Speed MPH	Rocket Drift Feet	Payload Drift Feet
0	0	0
5	1,049-1,095	1,733-1,791
10	2,123-2,169	3,498-3,557
15	3,195-3,241	5,260-5,320
20	4,268-4,313	7,024-7,083

Science Value

- Data taken will reinforce the scientific knowledge base
- Create plots of variables vs altitude
  - Use pressure sensor to find altitude
- Will analyze plots using MATLAB and other software
  - Look for points of interest and abnormalities
- Compare to known atmospheric models
  - Plot errors compared to our data
- Camera data will be analyzed visually for points of interest

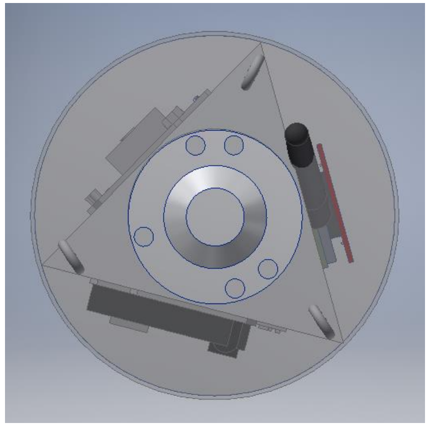
Payload Design Overview

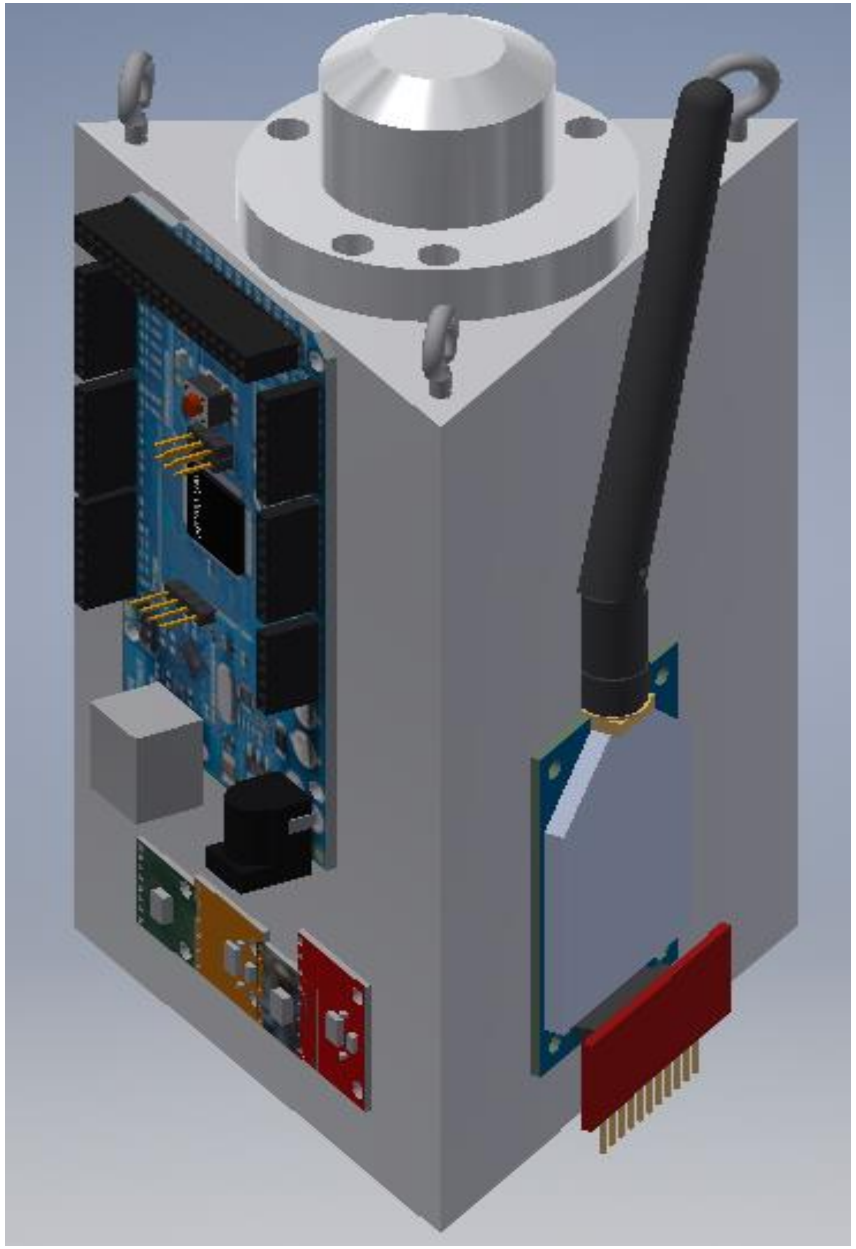
- Planetary Investigation Lander (PIL) Structure
- Landing Module
- PIL Hardware
- Ground Control
- Integration
- Mass Breakdown



PIL Structure

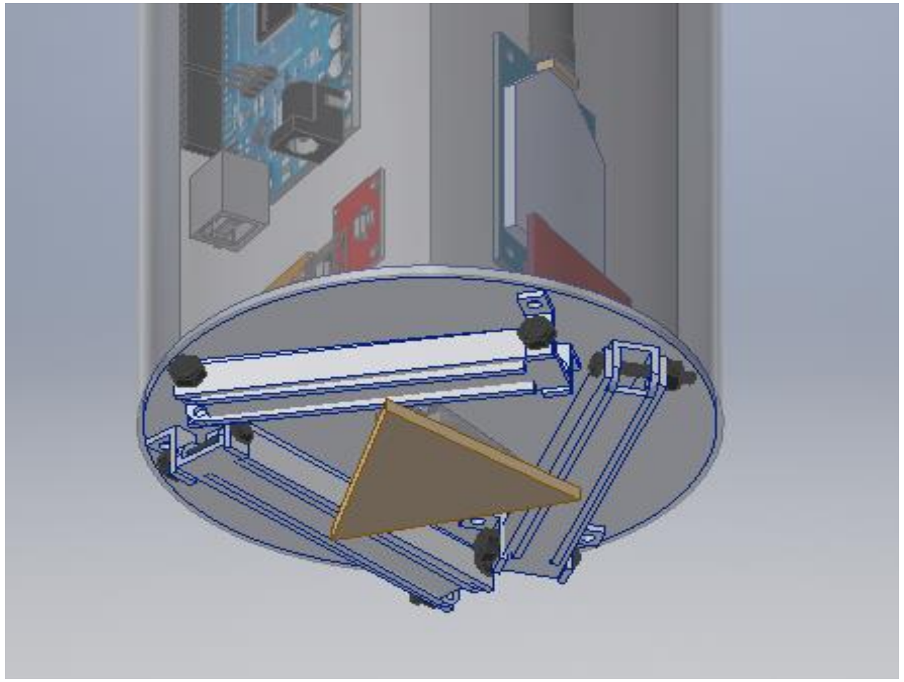
- Polymer Tri-structure for mounting
- Clear acrylic PIL housing
- Parachute connections mounted directly to main structure
- Aluminum Landing base plate

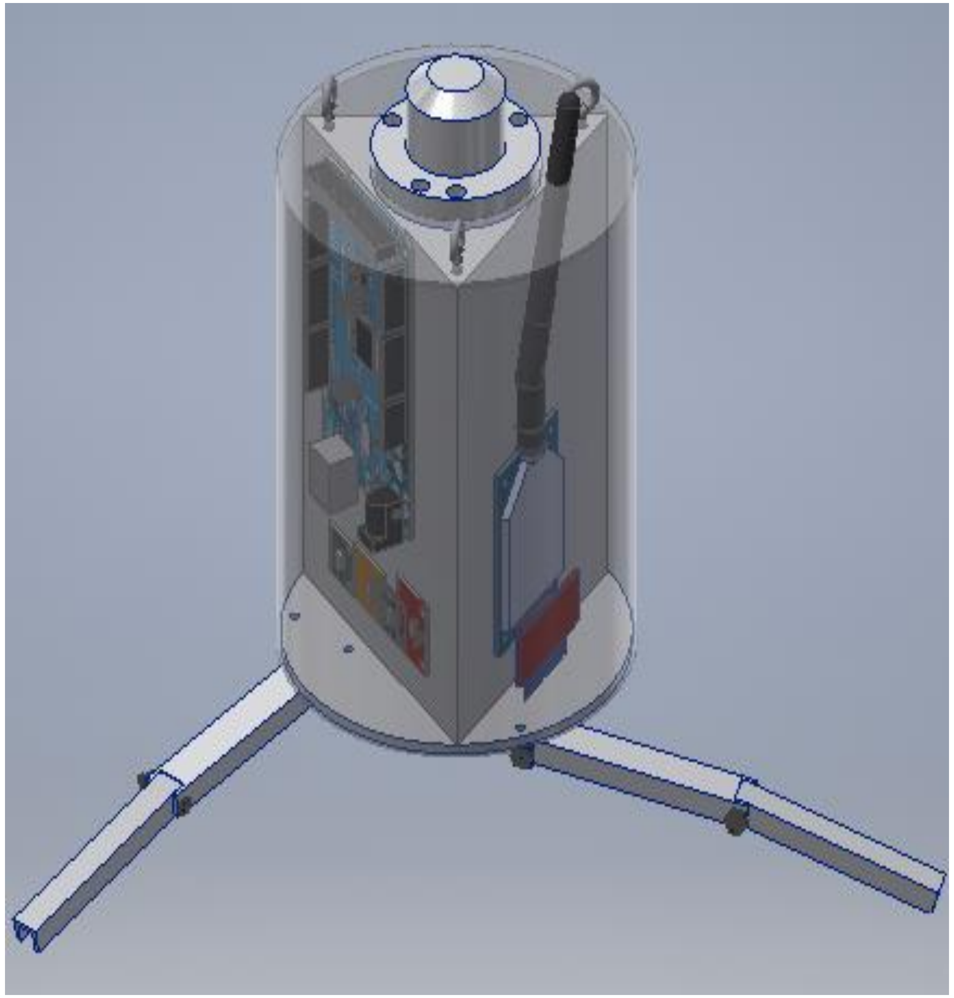




Landing Module

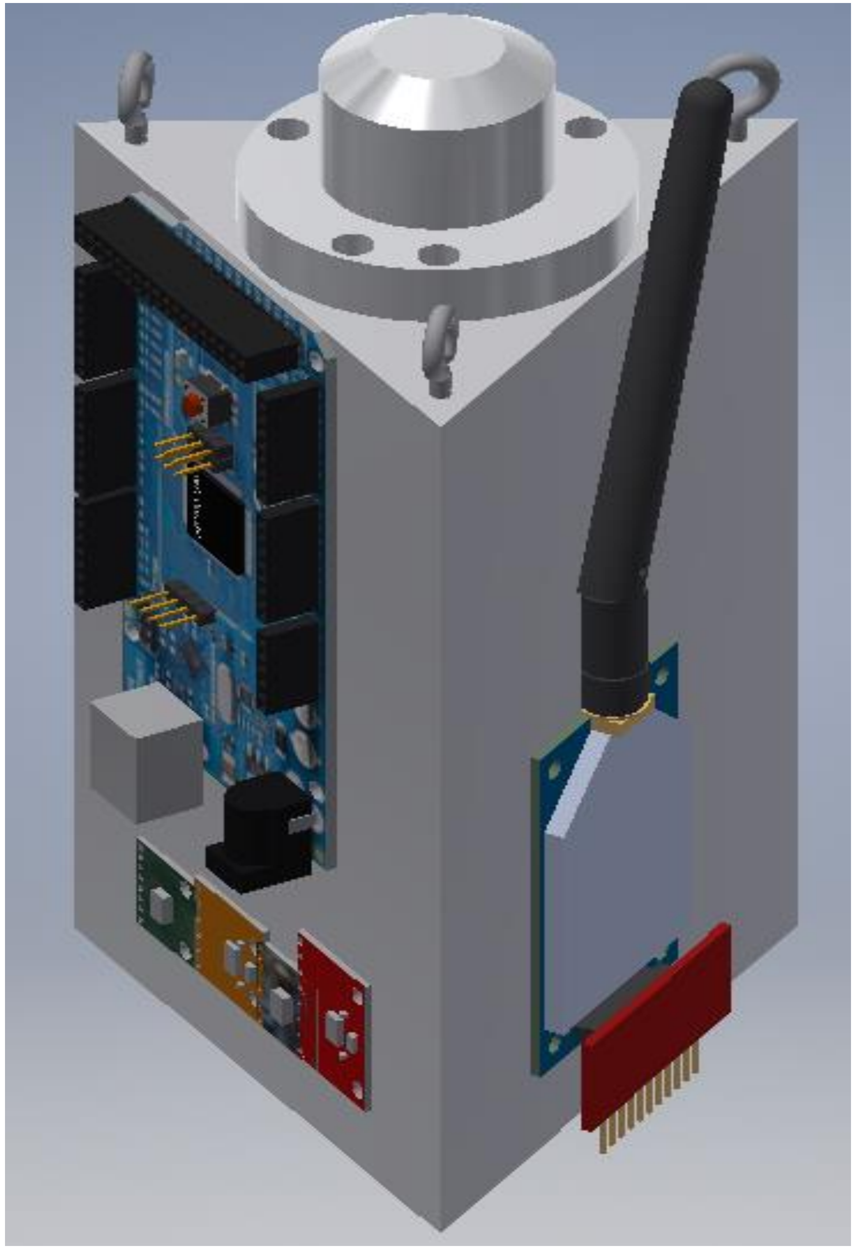
- Torsion spring leg deployment
- Servo-motor with triangle retaining plate





PIL Hardware

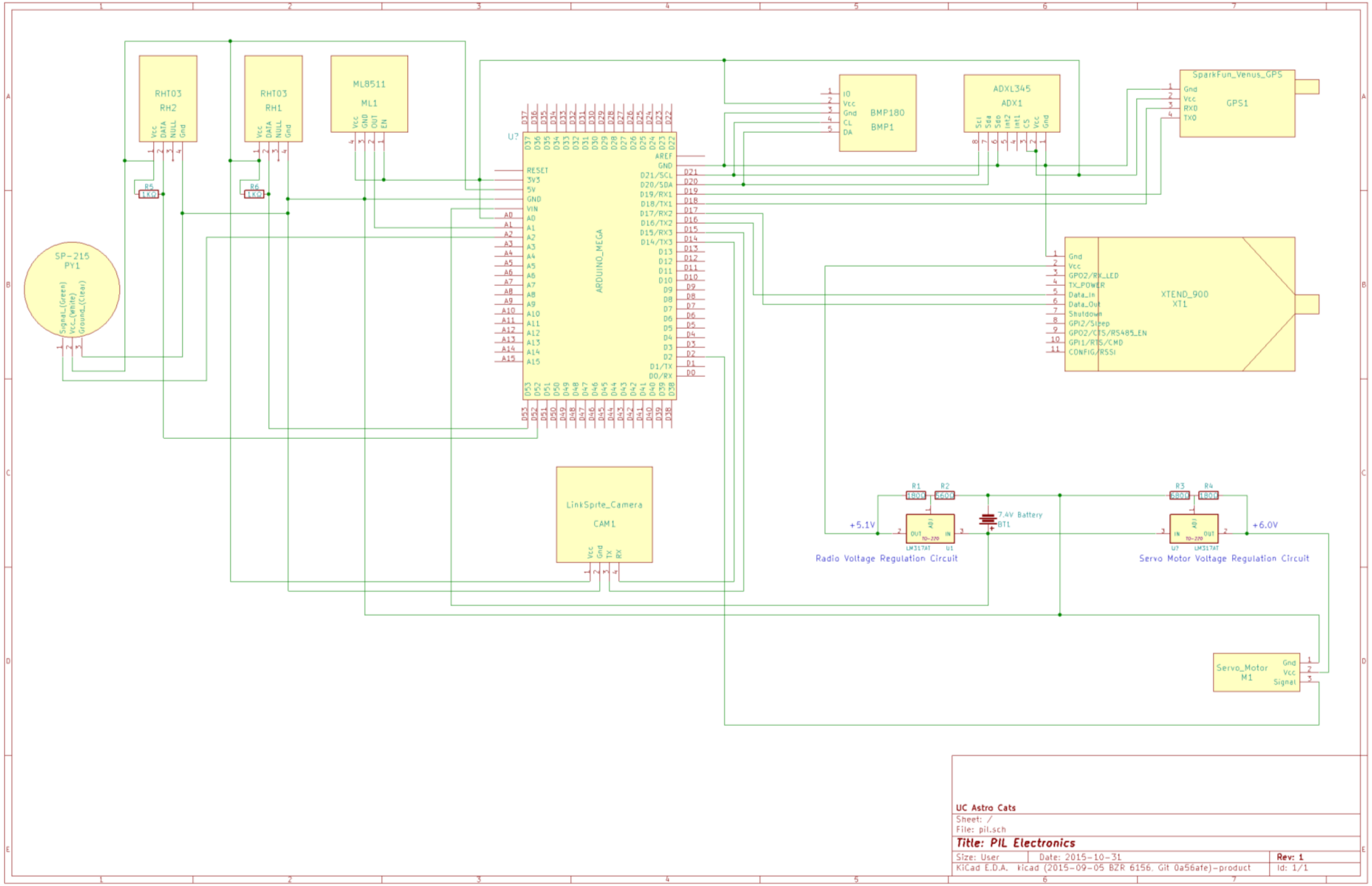
- Arduino Mega 2650 – Microcontroller
- XTEND 900 – 1 Watt 900 MHz radio
- SparkFun Venus GPS – GPS Module
- RHT03 – Temperature and Humidity sensor
    - Two used with alternating polling.
- BMP180 – Barometric sensor
- ML8511 – UV Sensor



PIL Hardware Continued

- Apogee Instruments SP-215 – Pyranometer
  - continuously outputting voltage relating to solar irradiance (W/m^2).
- ADXL345 – Accelerometer
- LS-Y201-2MP - JPEG Color camera
- SparkFun microSD Transflash
  - microSD Breakout board to write data to microSD
  - Backup data storage in case of radio failure

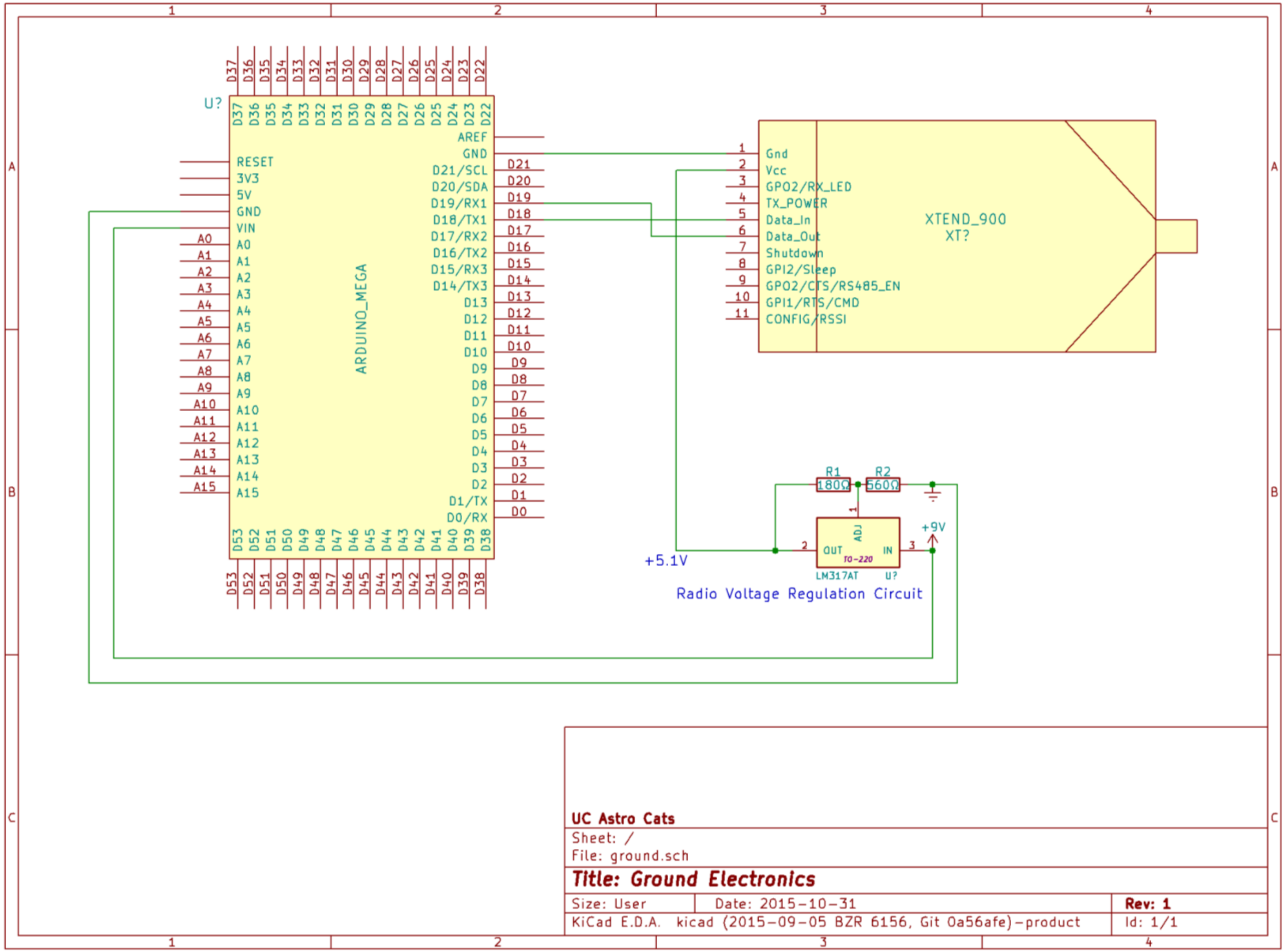
PIL Electronic Schematic



Ground Control Hardware

- Arduino Mega 2650
  - Microcontroller that interfaces the radio transceiver with the PC
  - Sends incoming radio data from the PIL and Tracking Bay to the PC
  - Sends outgoing commands to the radio, to transmit to the PIL
- XTEND-900 - Radio transceiver
- PC - A laptop used to interface with the Arduino
  - Collect and display gathered data using custom software

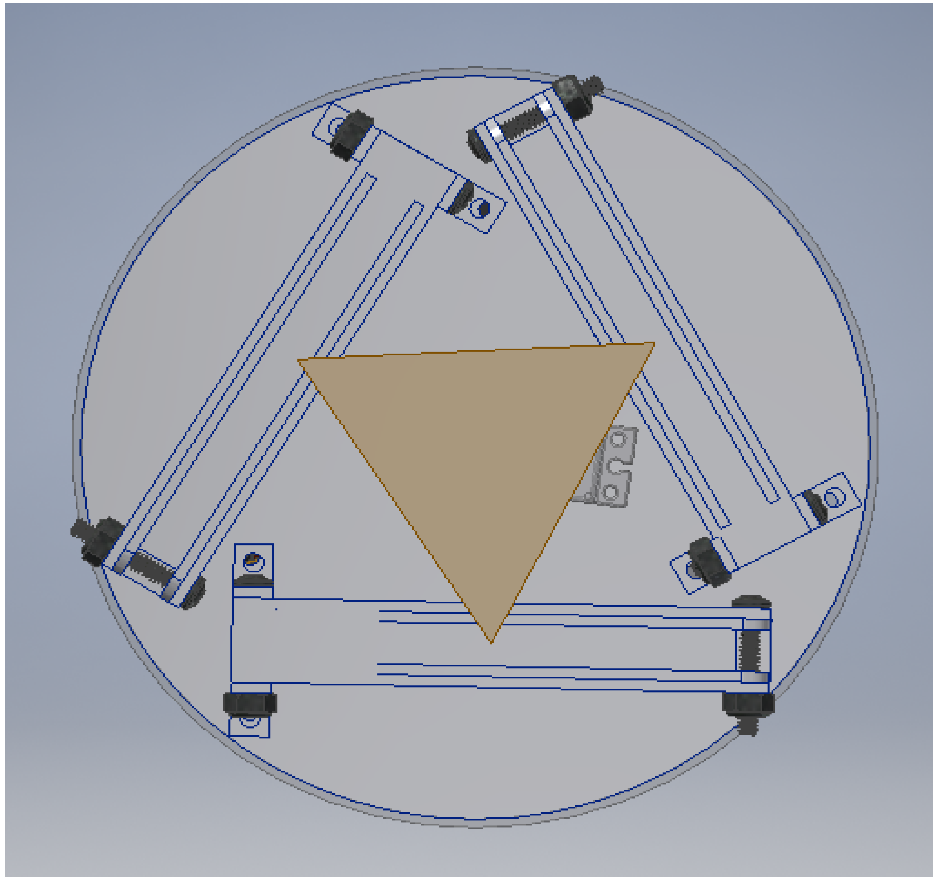
Ground Control Electronic Schematic

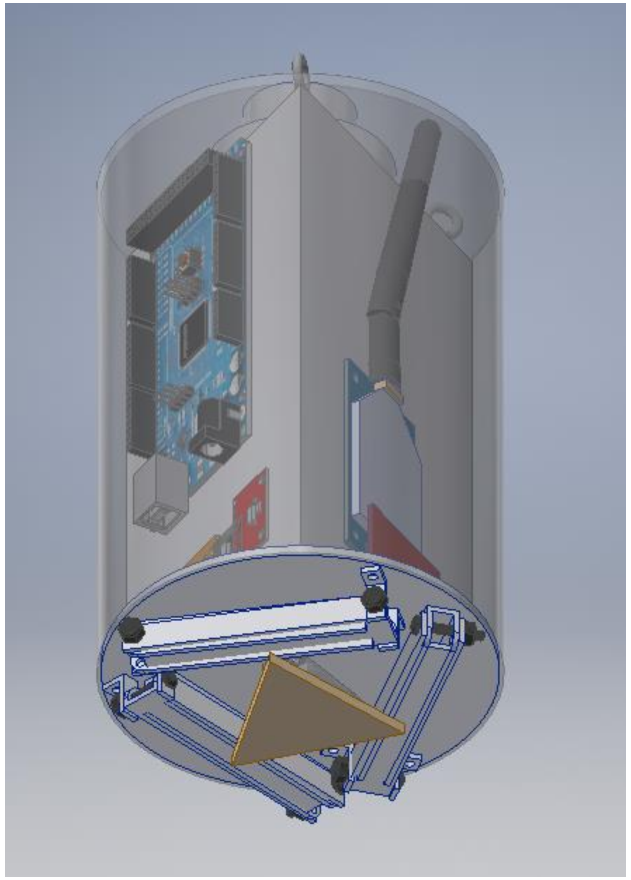


Ground Control Software

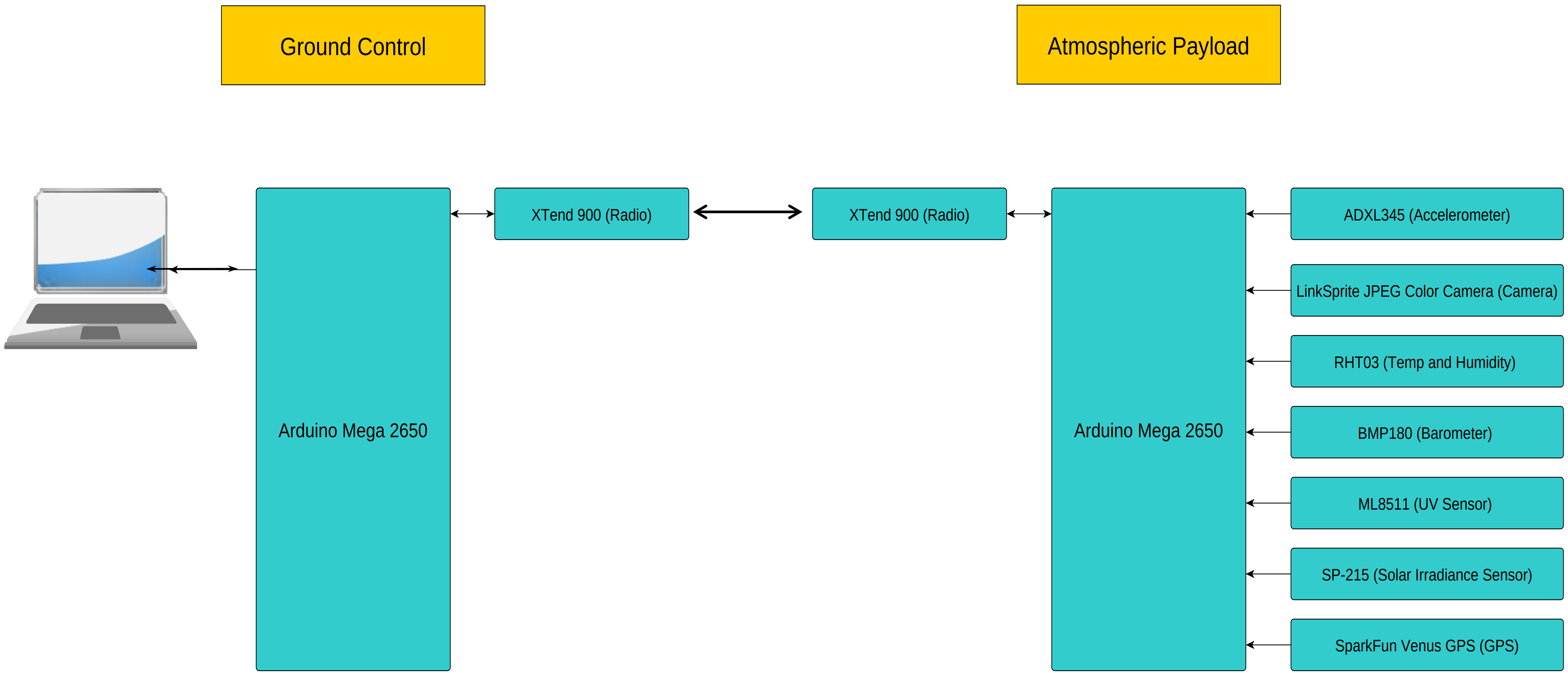
- Arduino will collect data from radio that has been received from PIL and Rocket Tracking Bay, and send it to the PC over serial connection.
- PC will utilize custom software that retrieves serial data sent from the Arduino.
- Data will be parsed and the user interface display will be updated in real time with new data.
- wxWidgets C++ GUI Library being used for GUI.

System Integration - PIL and landing module



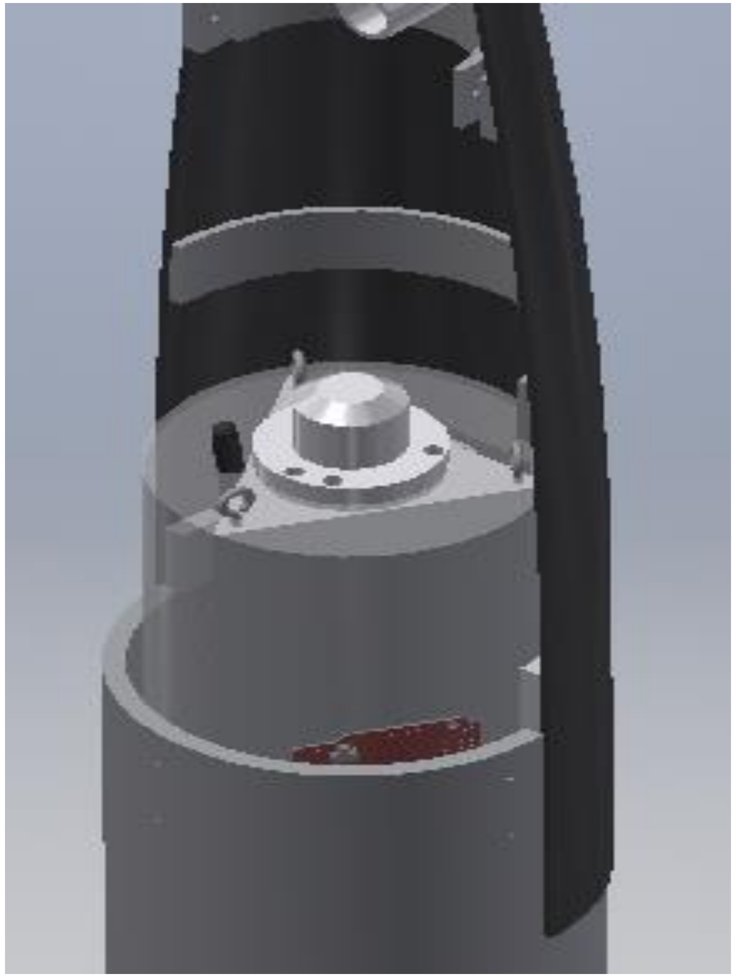


System Integration - PIL & Ground Ops

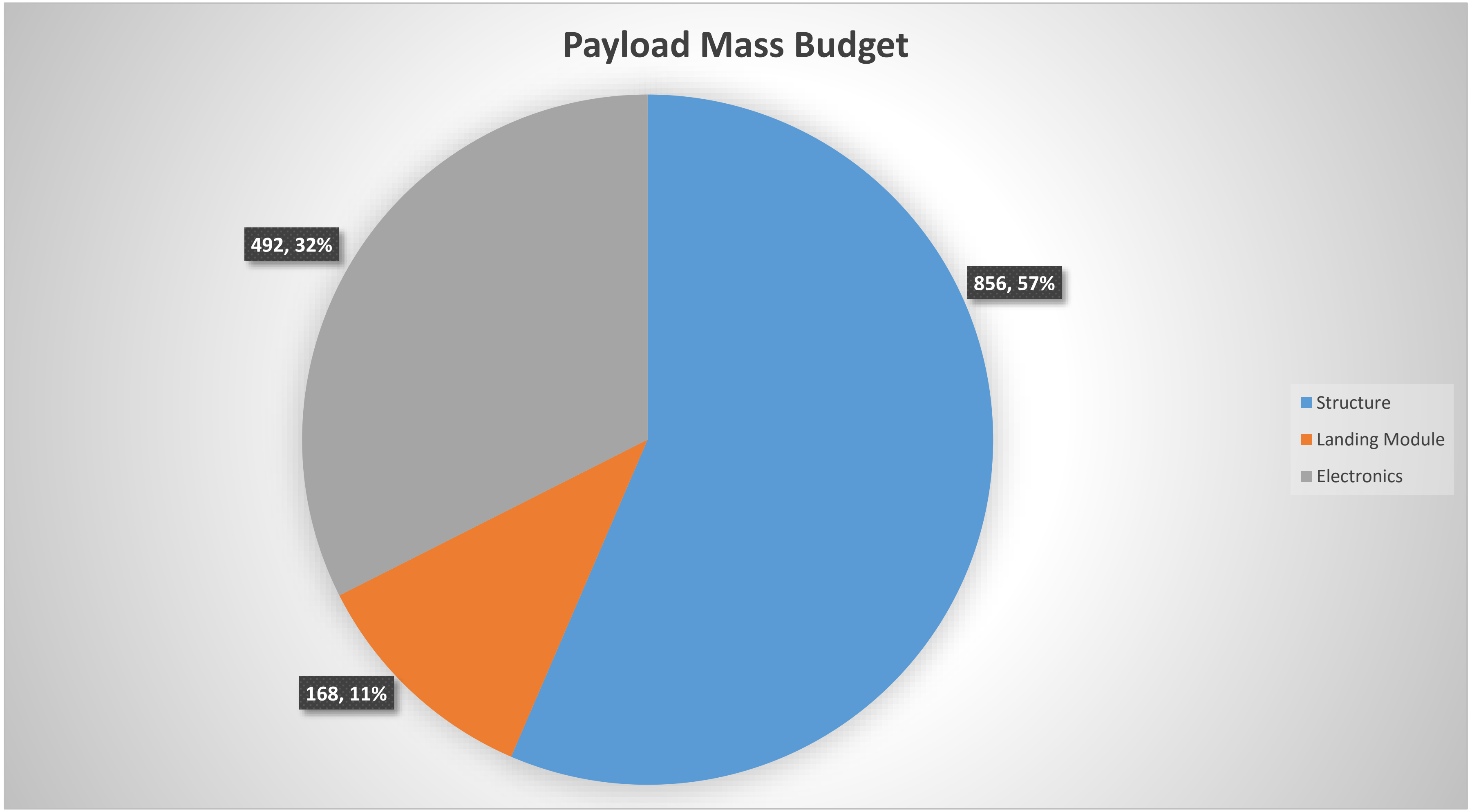


System Integration - PIL & Rocket

- PIL and Rocket integration
  - Payload adapter sleeve
  - PIL slides into Adapter Sleeve
  - Fairing Slides over Adapter Sleeve
  - Adapter Sleeve is fixed to rocket



PIL Mass Breakdown



Payload Testing Plan

Design Features to meet Requirement	Verification
The system is designed to be undamaged after launch with an easily replaceable motor.	This will be verified through testing.
The PIL system consists of all sensors necessary to record the atmospheric measurements at altitude and on the ground.	This will be verified through testing.
The PIL system is designed in a way to collect and transmit data at the required rate and for the required time.	This will be verified through inspection and testing.
The PIL system is design to hang in orientation under parachute at altitude and contains landing legs to remain in orientation on the ground.	This will be verified through testing.
The PIL system consists of onboard radios to transmit wirelessly to a ground station throughout the flight. Any missed packets of data will be retransmitted before end of operations on the ground.	This will be verified through testing.
The rocket contains a fairing and deployment mechanism.	This will be verified through analysis and testing.
The fairing system is tethered to PIL system, offering tracking and safe recovery of the fairing system.	This will be verified through inspection and testing.

Educational Engagement

- Completed on November 4 at Winton Woods High School
  - 200 high school students
- Water Bottle Rocketry
- Taught about thrust, stability, drag, and fin design
- Feedback forms to be sent to high school this week
- Documentation sent to NASA next week