University of Central Florida 2023-CDR-Presentation

Project Managers

Nathan Stahl
Aerostructures Manager

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Systems Manager

Emilio Pereira
Payloads Manager

Progress on Requirements

Section	Completed	In Progress	Incomplete
General Requirements	10	3	1
Vehicle Requirements	15	9	0
Recovery System Requirements	10	3	0
Payload Experiment Requirements	2	1	0
Safety Requirements	3	2	0
Final Flight Requirements	0	2	0

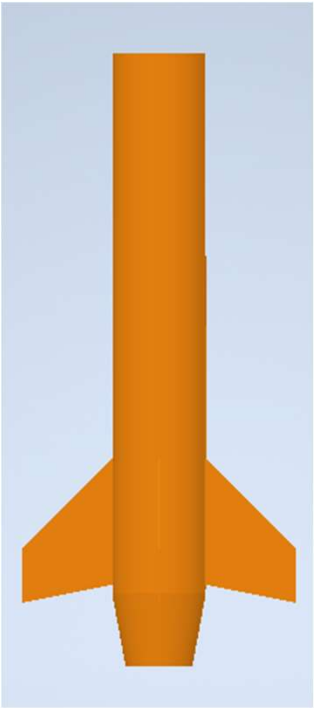
Vehicle Design

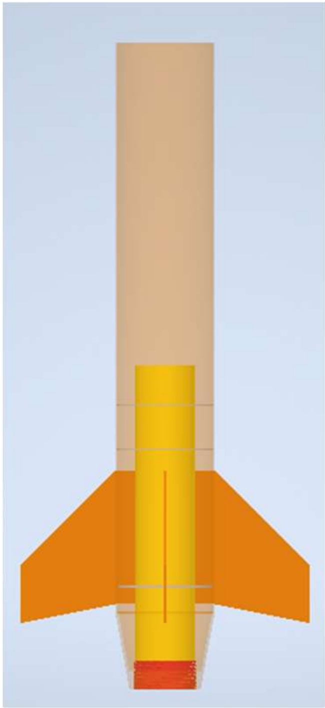
- Dual deployment with GPS tracking in the nosecone
- Tail cone to reduce base drag

Rail Exit Velocity	87.6 ft/s
Thrust-to-Weight Ratio	11:1
Maximum Velocity	684 ft/s
Maximum Acceleration	10.1G
Descent Time	72.38s
Highest Kinetic Energy Upon Landing	40.85 ft-lbs
Max Drift	2331'

Vehicle Name	Asclepius
Apogee	5507
Vehicle Length	87"
Expected Lift-off Weight	22.558 lb
Body Tube Outer Diameter	5.1"
Body Tube Inner Diameter	5.00"
Launch Pad Stability	2.74 cal
Launch Pad CoM	51.049" aft of tip
Launch Pad CoP	65.023" aft of tip

Booster Section





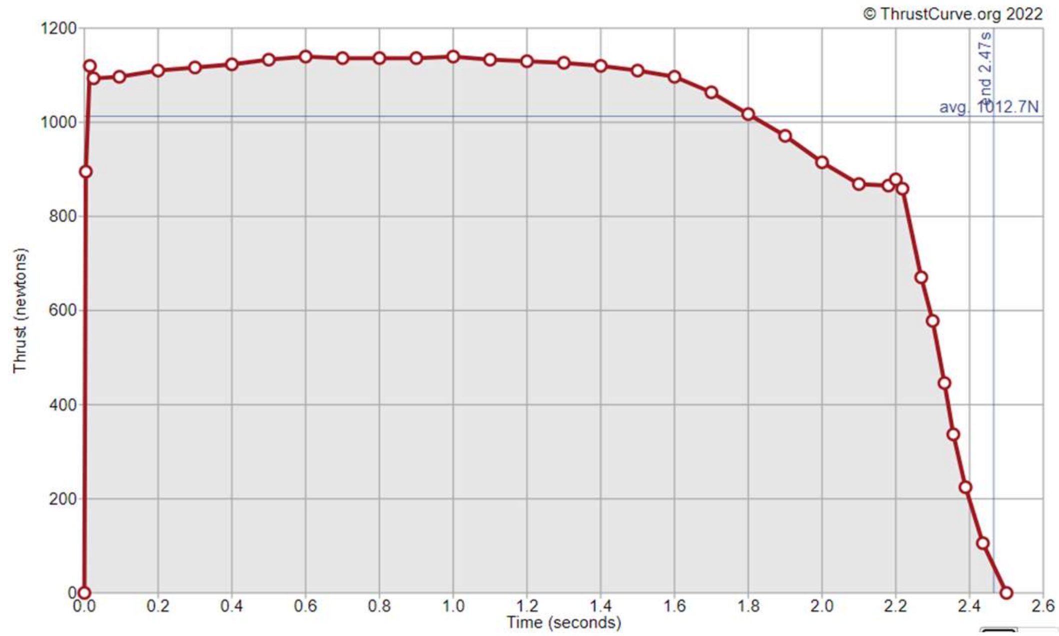
- Estimated Weight: 4 lbm
- Overall length of 34"
- Contains fins, motor tube, motor, centering rings, tail cone and motor retainer
- Booster tube made from Carbon Fiber

Fins

- 4 swept trapezoidal fins
- Dimensions
  - Height: 5.5"
  - Root Cord: 7"
  - Tip Cord: 3"
  - Sweep Length: 5"
- Epoxied in
- G10 Fiberglass Plates

Final Motor Choice – Aerotech K1000T

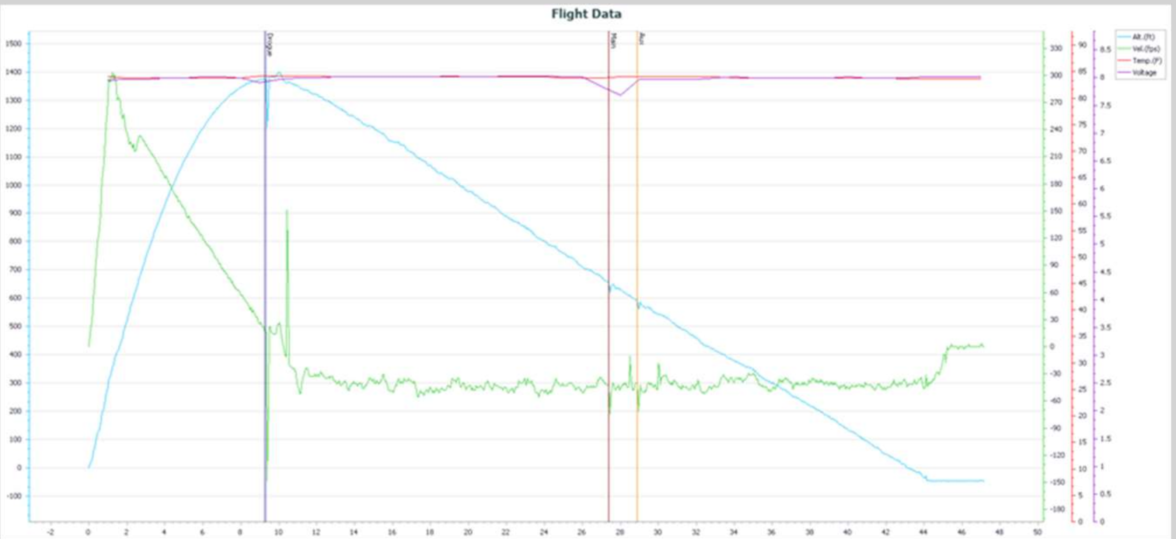
Motor Brand/Designation	**AeroTech K1000T**
Max/Average Thrust (lb)	1674N/1066N
Total Impulse (lbf-s)	2511.5Ns
Mass Before/After Burn (oz)	2602g/1392.5g
Liftoff Thrust (N)	1105N



Subscale Flight Data

Subscale Flight Data

- Altitude and velocity data recorded on a Missileworks RRC3
- GPS data recorded on a Featherweight GPS Tracker



Missileworks RRC3 Flight Data

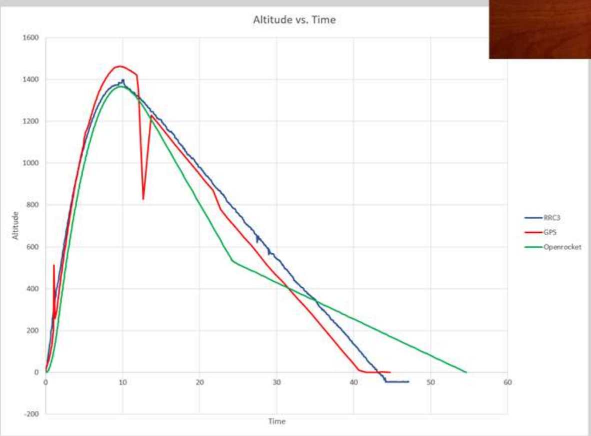
Featherweight GPS Tracker Data

Subscale Rocket Launch

Launch Date	December 17, 2022	
Launch location	Spaceport Rocketry Association at Palm Bay, FL	
Apogee	Expected: 1355	
	Actual: 1374	

Subscale Recovery Failure

- Main parachute caught on the upper body tube, likely due to inefficient parachute packing
- Altimeters fired all ejection charges and separating the upper body tube from the coupler
- Rocket impacted the ground at 40 ft/sec, only sustaining major damage on one fin
- Re-flight Jan 21 for our own enrichment and to validate updated parachute packing procedures



Upper left: Upper body tube separated from recovery coupler

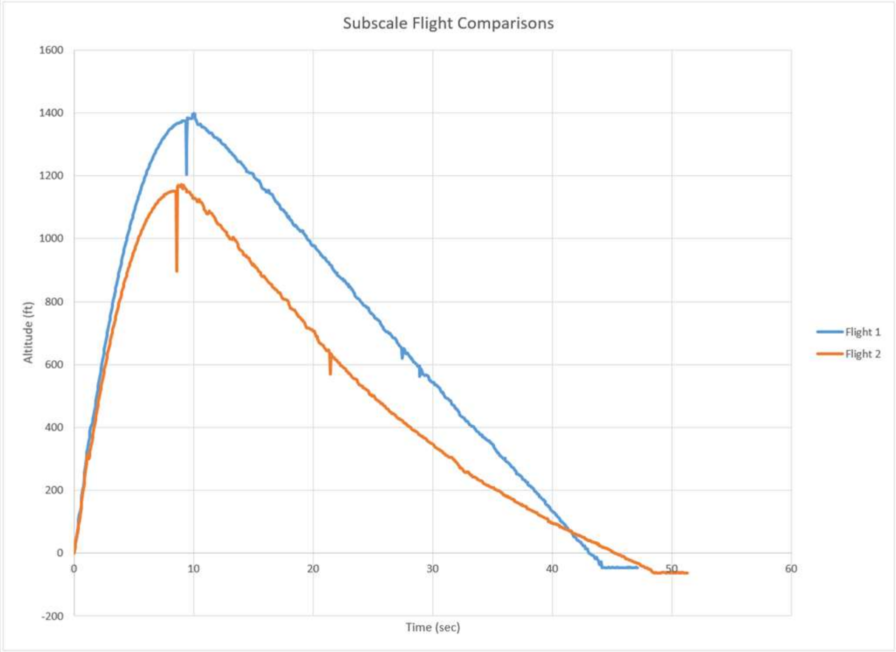
Lower left: Expected vs. Recorded flight data

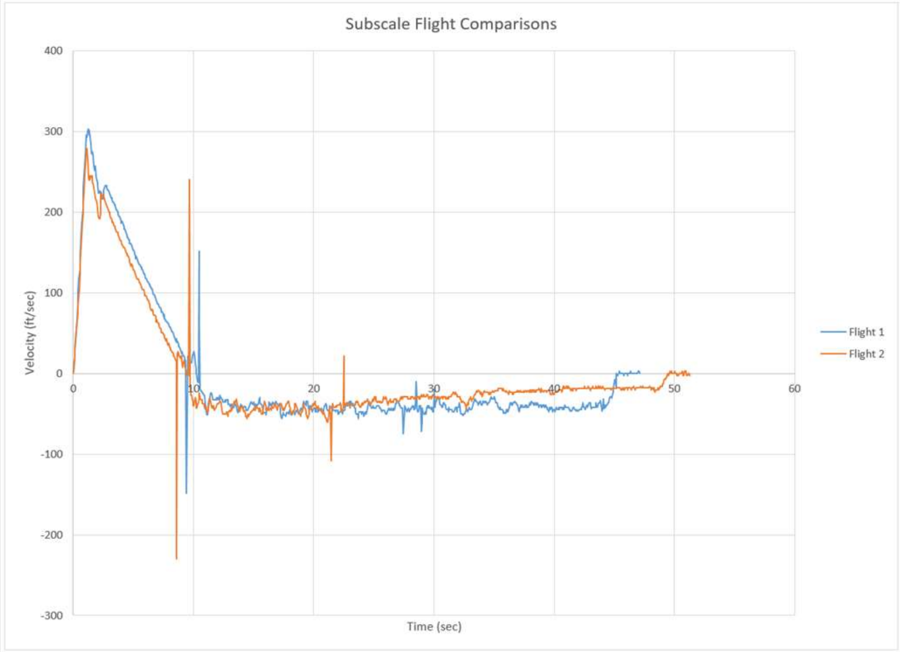
Right: Damage resulting from recovery failure

Subscale Rocket Relaunch

Launch Date	January 21, 2023	
Launch location	Spaceport Rocketry Association at Palm Bay, FL	
Apogee	Expected: 1258	
	Actual: 1171	

Subscale Reflight Data





Flight Data Comparison

Subscale Relaunch

- Fins were repaired and reinforced with tip-to-tip fiberglass
- Flight data shows main parachute deploying and slowing the rocket to 18 ft/sec for landing
- Lower apogee than flight 1, due to increased weight from fiberglass reinforcement

Upper left: Upper body tube separated from recovery coupler

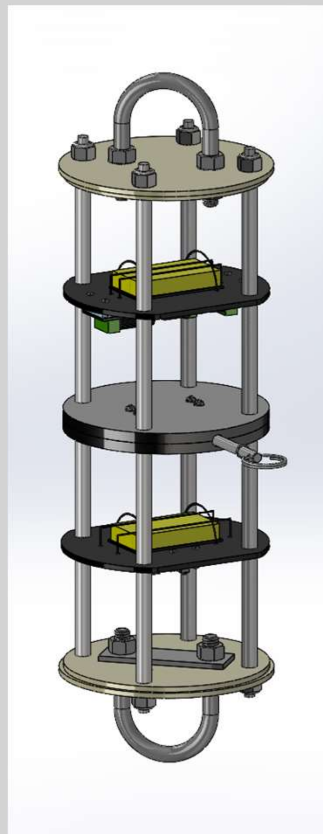
Lower left: Expected vs. Recorded flight data

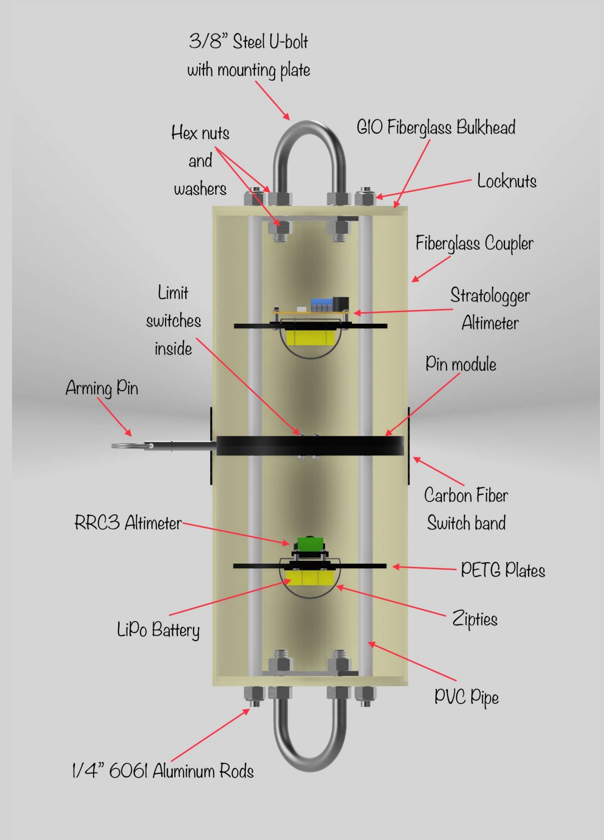
Right: Damage resulting from recovery failure

Recovery

Recovery

- Estimated weight: 3.81 lb
- Coupler Length: 12"
- Switch band: 2"
- Main chute located at top of upper tube
- Drogue chute in aft bay
- Shear pins attached to bottom of coupler and nose cone shoulder



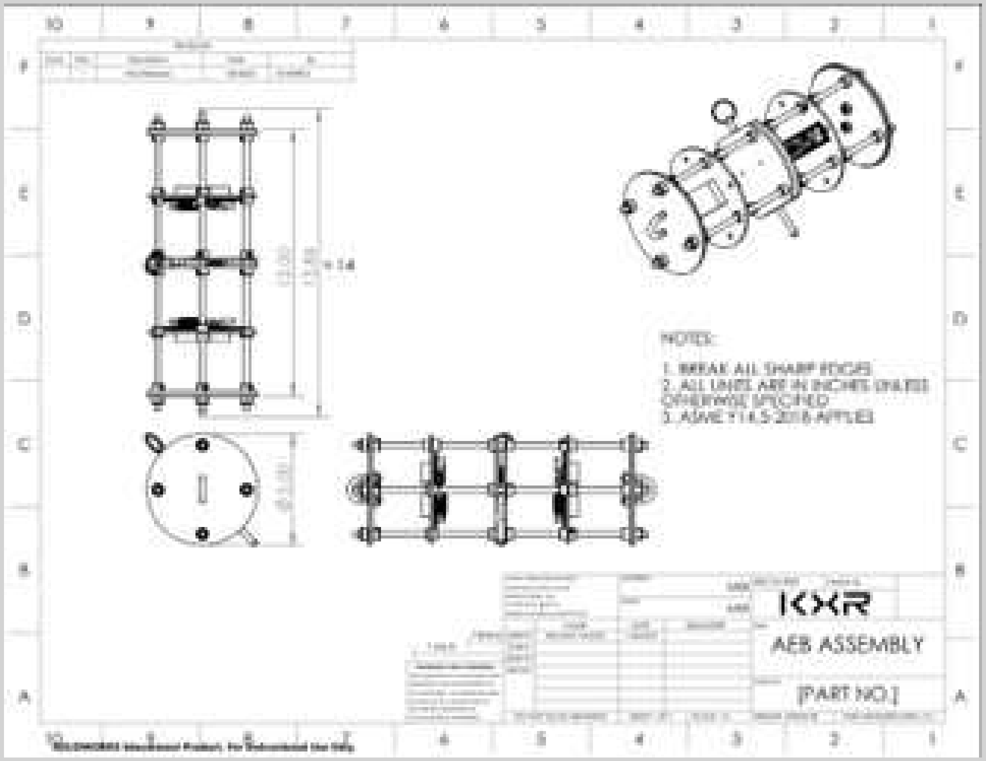


AZ0 change engineering drawing
Aleksandr Zhuchkan, 2023-01-08T21:46:36.255

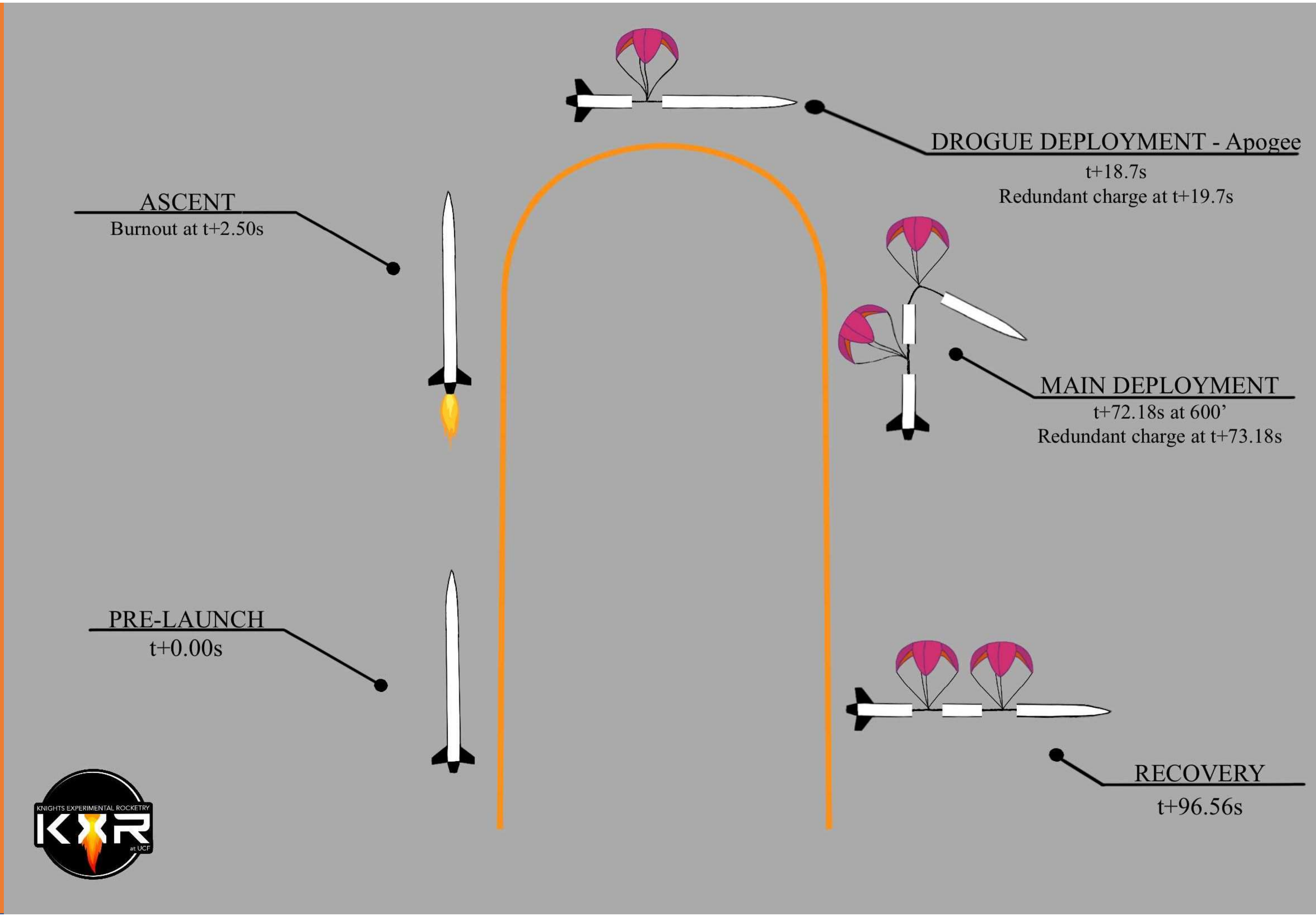
AZ1 engineering drawing
Aleksandr Zhuchkan, 2023-01-08T23:13:18.671

Recovery

- Fiberglass coupler
- Fiberglass Bulkheads
- Main and Redundant altimeter
- 3D-Printed electronics mount and support structures
- Free floating charges



JA0


DROGUE DEPLOYMENT - Apogee
t+18.7s
Redundant charge at t+19.7s
ASCENT
Burnout at t+2.50s
MAIN DEPLOYMENT
t+72.18s at 600’
Redundant charge at t+73.18s
PRE-LAUNCH
t+0.00s
RECOVERY
t+96.56s
KNIGHTS EXPERIMENTAL ROCKETRY
KXR
at UCF

Slide 18

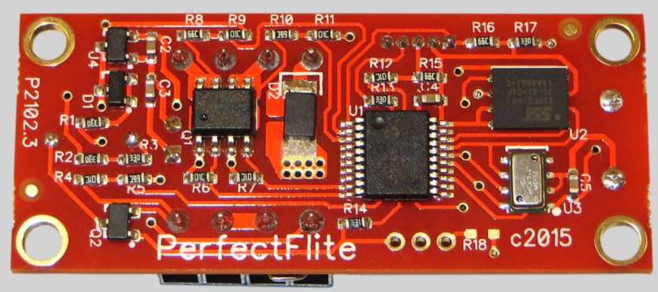
JA0 On this slide, simply state the main idea.
Main Idea: Flight diagram with time intervals taken from the Vertical Motion vs TIme graph plotted by OpenRocket.
Jericho Antoine, 2023-02-01T14:19:05.042

Primary Altimeter

- RRC3 Sport
  - 7.4V LiPo Battery
  - Large success with RRC2+ in past projects
  - Cohesive Flight Data
  - Easily Programmable

Redundant Altimeter

- StratoLoggerCF
  - 7.4V LiPo Battery
  - Redundant as it is new to us
  - Easily Programmable
  - Better for Flight Data
    - Battery, temp, velocity, altitude, etc.



JA1

Drogue Parachute

- **12" Standard Parachute**
  - **Rocketman**
  - CD: .97
  - Materials: 1.1 oz
  - Weight: 1 oz
  - Packing Volume: 5.3"^3

Main Parachute

- **84" Standard Parachute**
  - **Rocketman**
  - CD: .97
  - Materials: 1.1 oz
  - Weight: 8 oz
  - Packing Volume: 45.94"^3

Slide 20

AZ0 update to new chutes

Aleksandr Zhuchkan, 2023-01-08T22:25:45.625

JA1 Mention that the snatch force for main is 561.977 lbf at 100 ft/s

Jericho Antoine, 2023-02-01T17:42:31.403

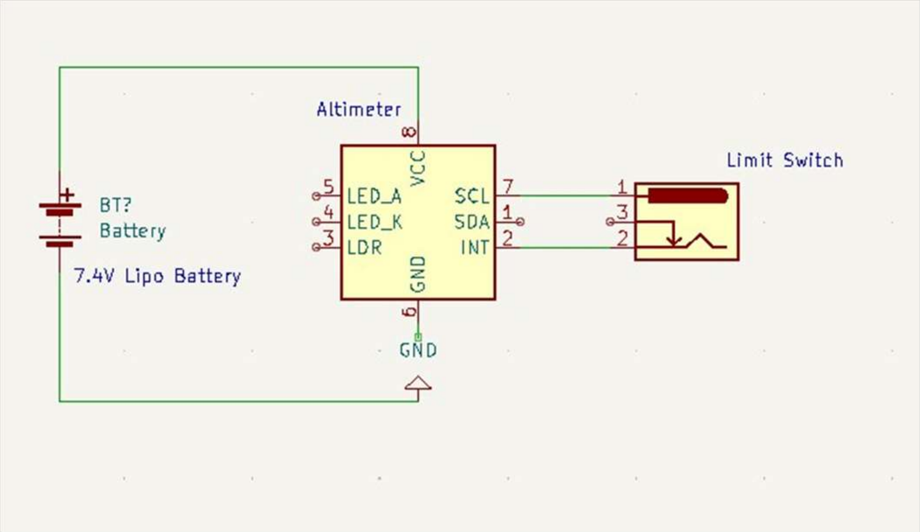
Heat Shielding

- **Nomex Blankets**
- **Heat-Resistant Epoxy Coating**

Shock Cord

- **Drogue Shock Cord**
  - Kevlar
  - 360 inches
- **Main Shock Cord**
  - Kevlar
  - 300 inches
- **PILL Shock Cord**
  - Kevlar
  - 48 inches
- **Harness/Airframe Interfaces**

Wiring Diagram



Ejection Charges

- **Ejection Charge Type**
  - FFFFg Black Powder
- **Ejection Charge Locations**
  - Forward AEB Bulkhead
  - Aft AEB Bulkhead
- **Drogue**
  - 1.5g
- **Main**
  - 3.9g

AZ0

Payload Deployment

- Payload (PILL) is attached to main shock cord by an extra 4ft
- Main parachute deploys
- Payload is pulled out with the main parachute
- Payload remains attached to the shock cord
- Payload and rocket reach touchdown
- Camera Exits Payload housing

Slide 23

AZ0 add an image possibly

Aleksandr Zhuchkan, 2023-01-09T05:20:00.861

Test Schedules

Test	Description	System Under Test	Status
Altimeter and Battery Drain Test	Altimeters are hooked up their respective batteries and are ran until the battery is dead to test the endurance of the system	RRC3 and Stratologger altimeters, 7.4V LiPo batteries	Incomplete
Parachute Drop Test	Both drogue and main parachutes are attached to a weight and dropped from a height to test parachute functionality	Drogue and main parachute	Incomplete
Altimeter Ejection Vacuum Test	Altimeters are tested for reliability and pass if they consistently ignite both ejection charges at the appropriate time	RRC3 and Stratologger altimeters	Incomplete
Black Powder Ejection Test	Black powder ejection systems are tested to fullfill the appropriate separation between stages	Drogue and main Parachute ejection system	Complete

JA1

Recovery Ground Test

- Objective
  - To ensure recovery components are functioning and determine the amount of black powder needed for appropriate body tube separation
- Success Criteria
  - Separation must occur while maintaining safety standards
- Methodology
  - Pour black powder into floating point charge, Connect e-match without battery to charge well, connect battery to e-match to light.

JA0 Objective Main Idea: Define the word appropriate for body tube separation.
Jericho Antoine, 2023-02-01T17:56:40.031

JA1 Success Criteria Main Idea: In order for our test to be deemed successful, an appropriate body tube separation must occur whilst following all safety protocols listed by our safety officer.
Jericho Antoine, 2023-02-01T18:00:05.930

Drogue Results

- Test 1
  - Incomplete due to e-match not wired correctly
- Test 2
  - Incomplete due to insufficient black powder for separation
- Test 3
  - Adequate separation with 0.5g. Decided on 0.55g to ensure separation

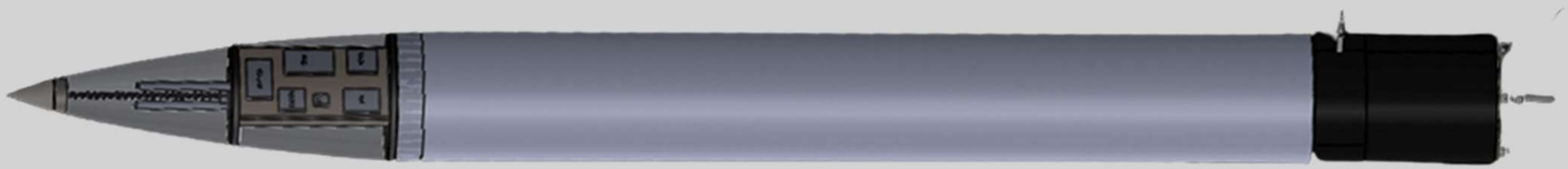
Main Results

- Test 1
  - Adequate separation with 0.5g. Decided on 0.55g to ensure separation

Payload Design

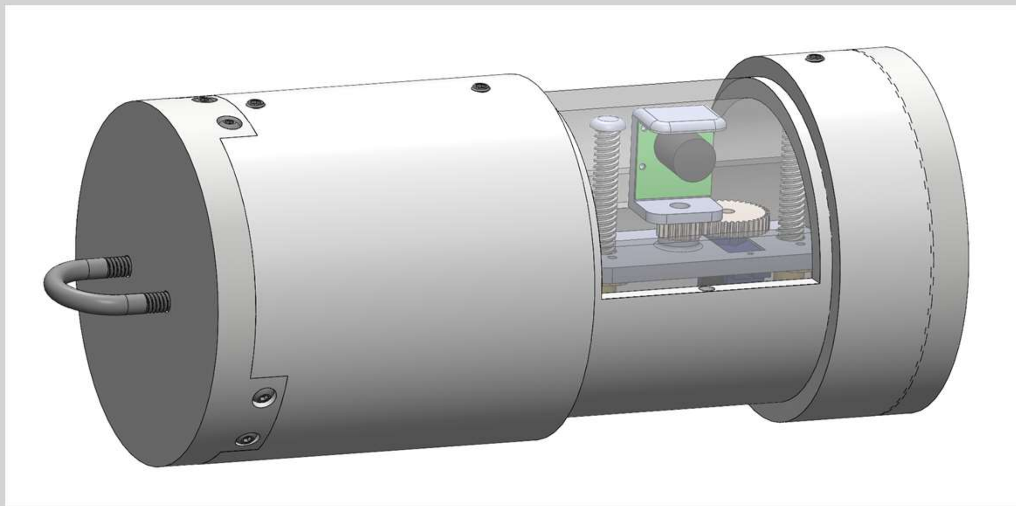
Payloads Section

- Overall Length: 58”
- Contains the Payload Integrated Launch Log (PILL), COTS GPS, and student-built flight computer
- Carbon fiber payload tube
- Fiberglass Nose Cone



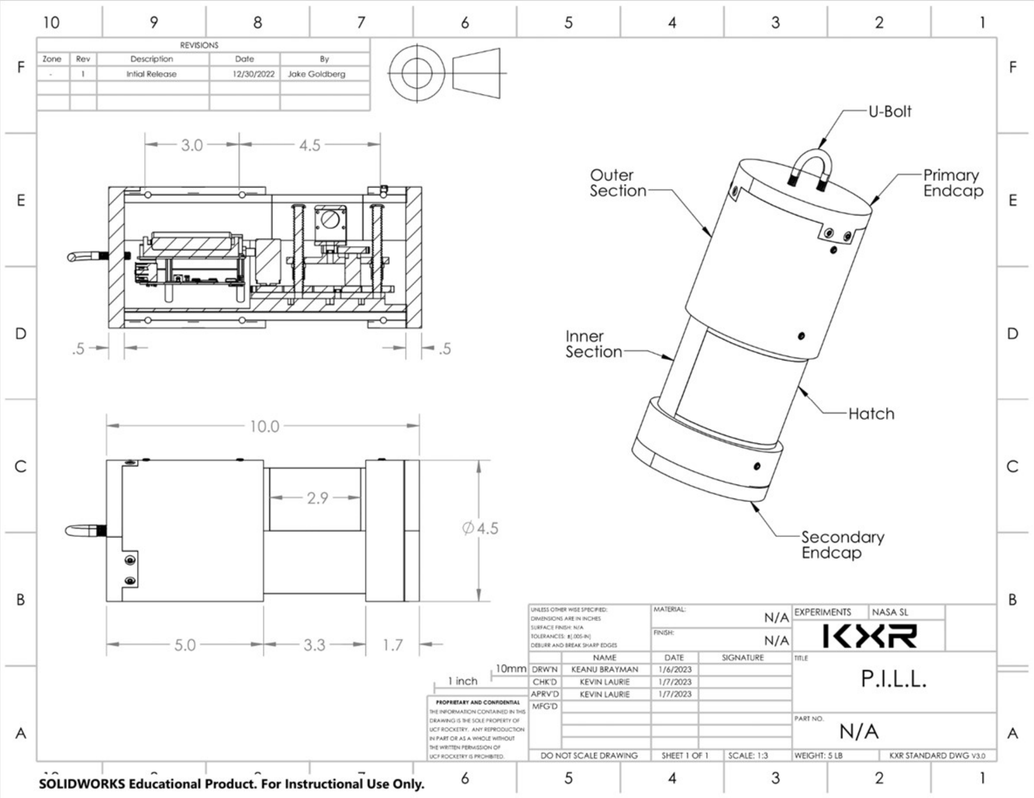
Payload Integrated Launch Log (P.I.L.L)

- PILL Mission Objectives:
    - House and deploy a camera capable of rotating 360° about the z-axis, whilst self-orienting itself parallel to the horizon
- Sub-system Breakdown
    - Experiments
    - Telemetry
    - Ground Station



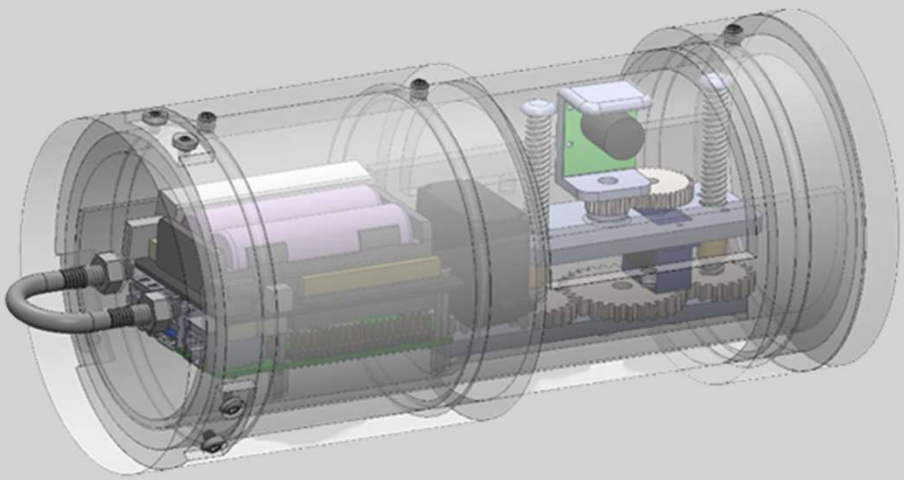
PILL Dimensions and Weight

- The PILL has a length of 10 inches and an OD of 4.5 inches
- The PILL is expected to weigh 3.8 pounds, with a maximum allowance of 5.0 pounds as an overhead.

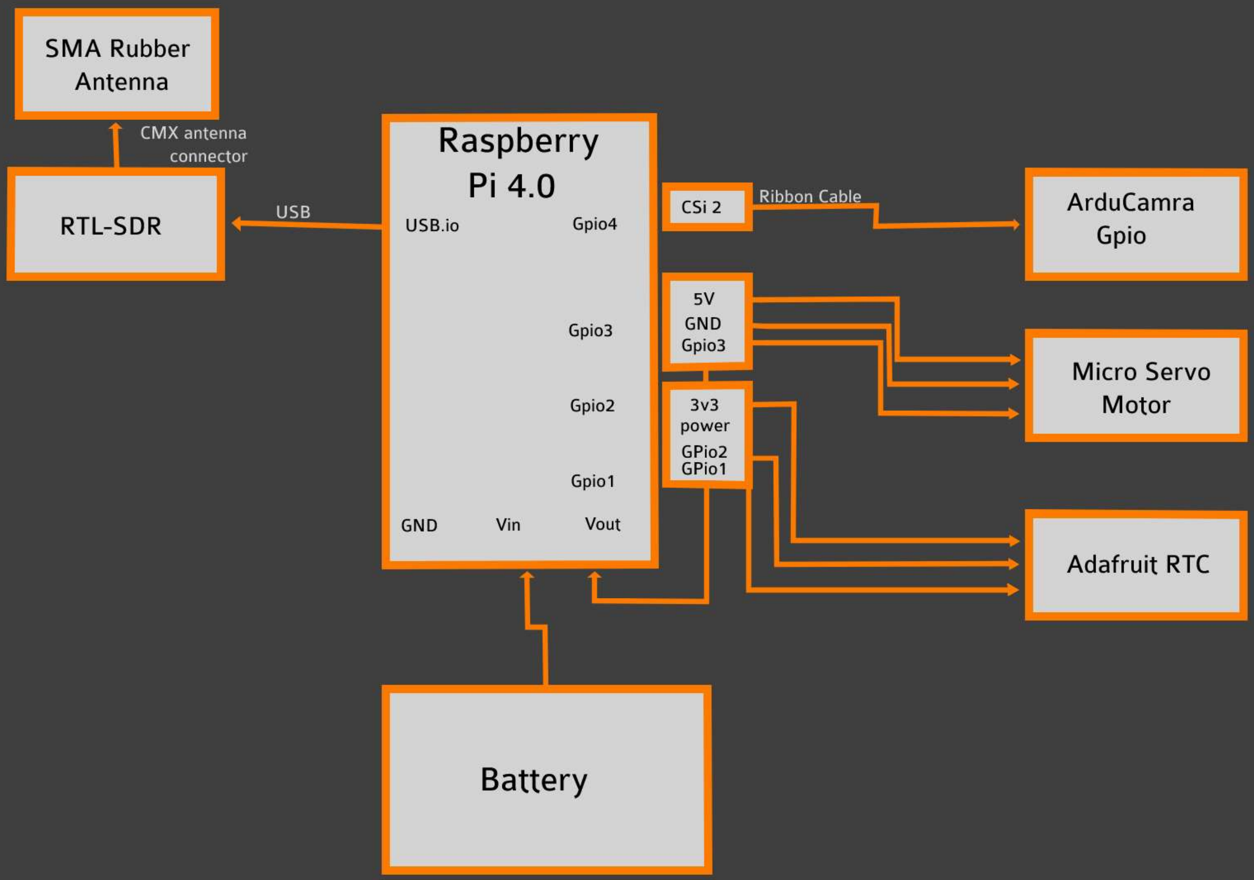


PILL Components

- Raspberry Pi Model 4B
- Linear Elevator Mechanism
- 1:2 Geared Servo Motor
- Continuous Servo
- Adafruit PiRTC Real-time Clock
- PETG Electronics Sled
- Polycarbonate Outer Case “PILL”
- SDR and Radio dongle
- Mini Short Walkie-talkie Antenna
- BNO055 IMU

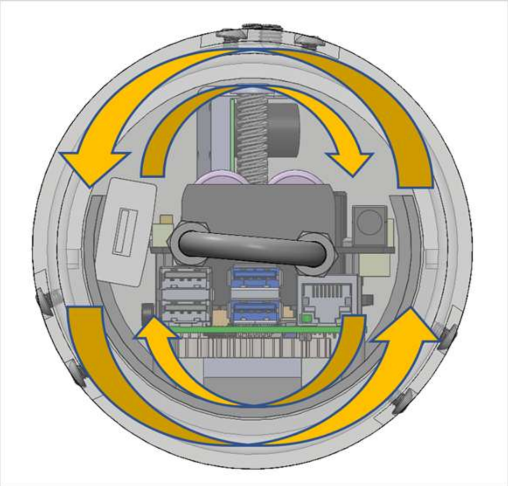


PILL Circuit Diagram



Self-Orientation

- Inner and outer sections are separated by ball bearing grooves.
- Inner section rotates independently from the outer sections
- Weight of components and low center of gravity causes camera to align upright with gravity



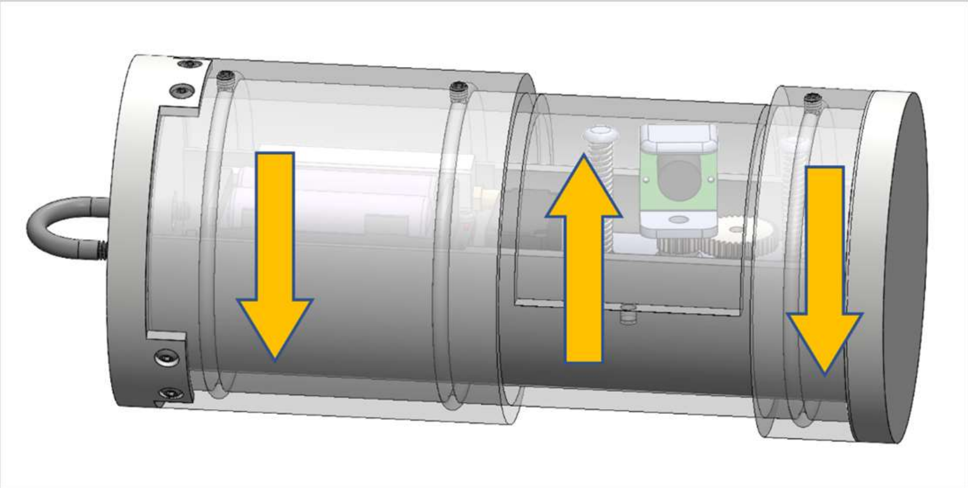


Image Processing

- The PILL will process images taken with the camera using OpenCV
- All code will be written in Python and run on the Raspberry Pi
- The system will be capable of executing all possible RAFCO commands

Epoxy Coating

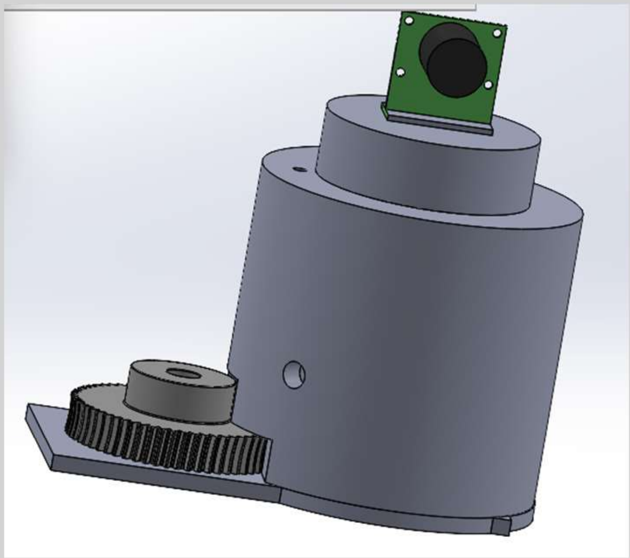
- Made at UCF Nano Technology Research Lab
- Heat resistant
- Impact resistant
- Optically clear for redundancy
- Made with polycarbonate
- Reinforced with
  - Rayon and/or
  - Fiberglass

Payload Iterations: COTS Linear Actuator

- Original PILL Design
- Hatch Above Camera
- Linear Actuator raises camera outside of PILL
- **Cons:**
  - Spacing Issues
  - Height Relative to space too low

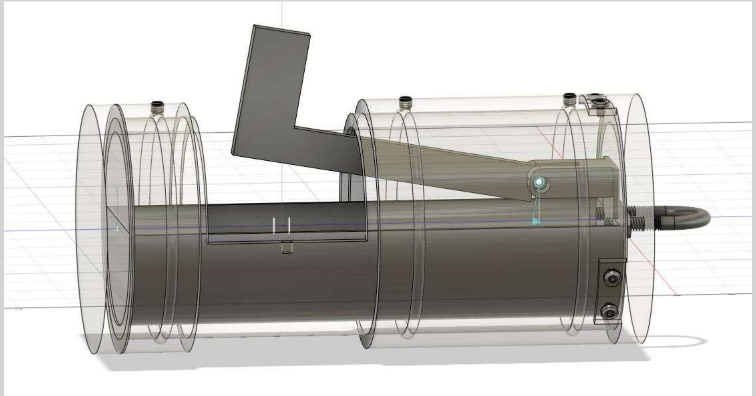
Payload Iterations: Spring Lock

- Similar function to a spring-loaded toilet paper holder
- Locked down by a servo with a pin
- Servo removes pin upon landing
- Camera 'ejects' out of hatch
- **Cons:**
  - Unpredictable, little to no control



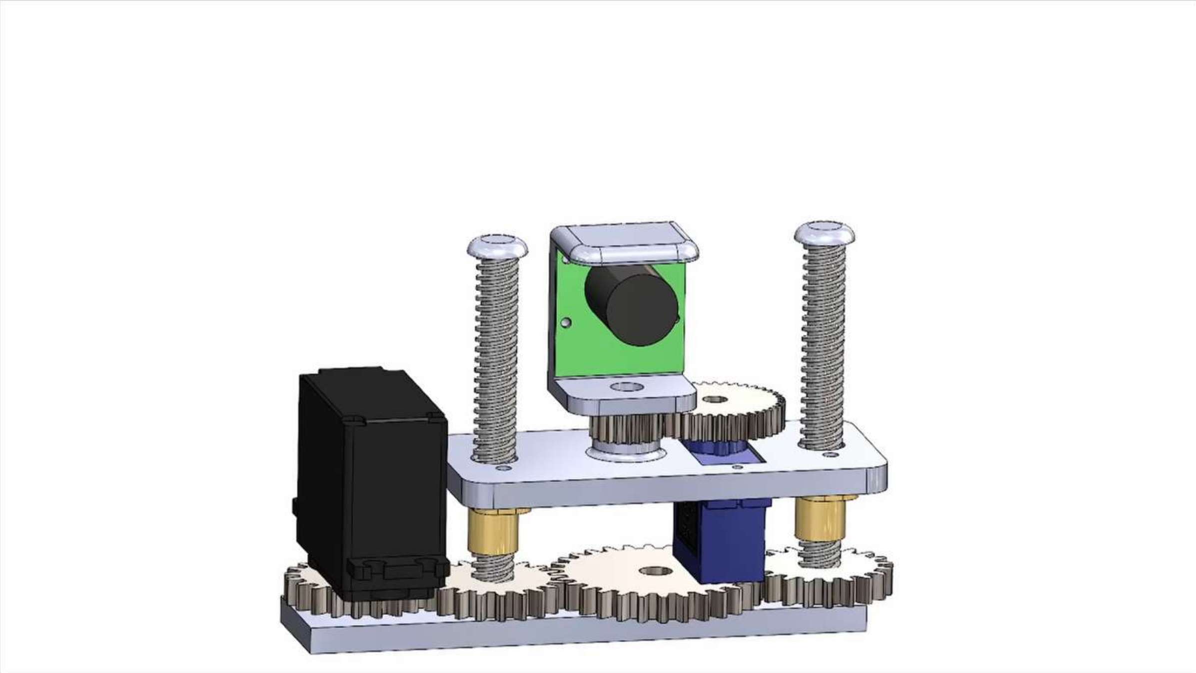
Payload Iterations: Boom Arm

- Inspired by firetruck boom arms
- Camera rotation possibly mitigated
- **Cons:**
  - Range of motion limited by hatch size
  - Took up large amount of space



Payload Iterations: Linear Elevator

- A dual lead screw-based lift
- Takes all strengths of COTS linear actuator
- More control, improved height and spacing



Decision Matrix

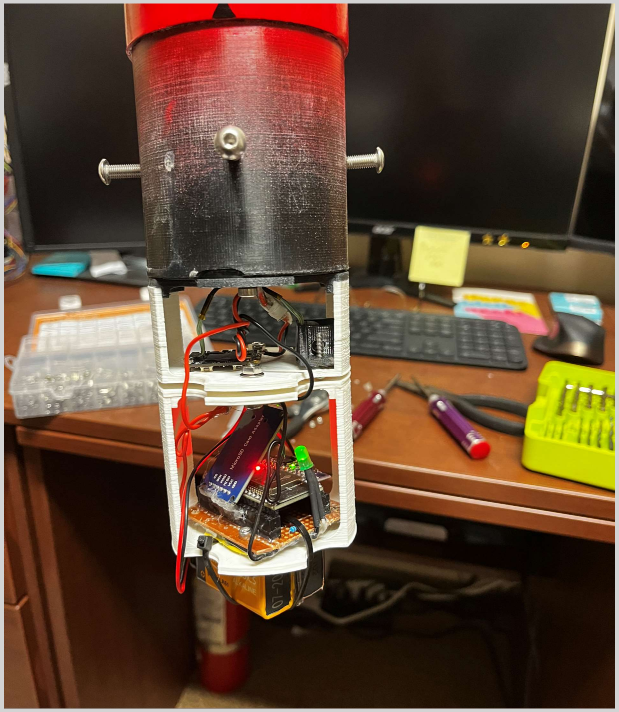
		RATINGS			
Criterion	Weight	COTS Linear Actuator	Spring Lock	Boom Arm	Linear Elevator
Y-axis Orientation	2	1	1	5	1
Reliability	5	5	1	5	5
Spacing	7	1	5	1	3
Distortion	7	5	5	5	5
Height	7	3	5	4	4
Manufacturability	3	5	2	4	4
Total		105	118	117	123

Major Design Flaws – Missing Axis

- Due to the implementation of the Linear Elevator, the camera can no longer self-orient about the y-axis due to the static hatch
- Because of the relatively flat terrain of the launch site, a single stabilization axis was deemed sufficient

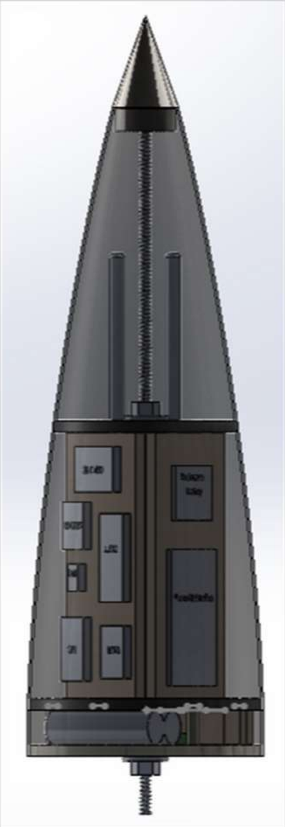
Subscale Flight Computer

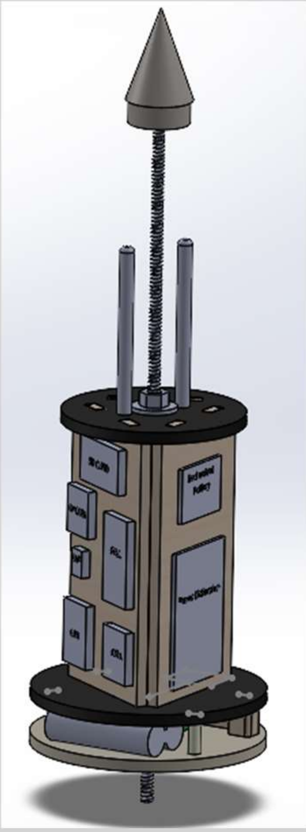
- PLA Structure
- SD-Card Data Logging
- Test Component efficacy
- Run Cam Footage
- Develop and Test Software



Avionics Bay

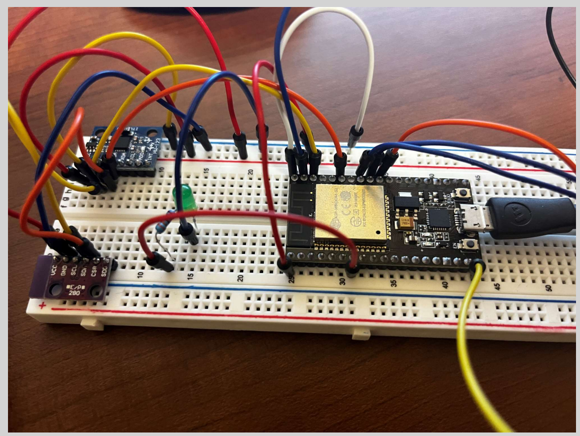
- Located in nose cone
- Threaded rod holding in metal nose cone tip
  - Possible source of interference
- PETG filament along threaded rod
- Triple Sled Design
  1. Featherweight GPS
  2. Flight computer
  3. LiPo Batteries
- Secondary camera located in shoulder

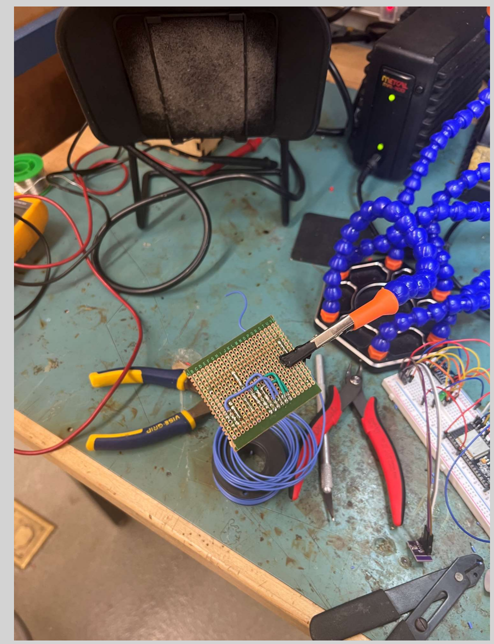


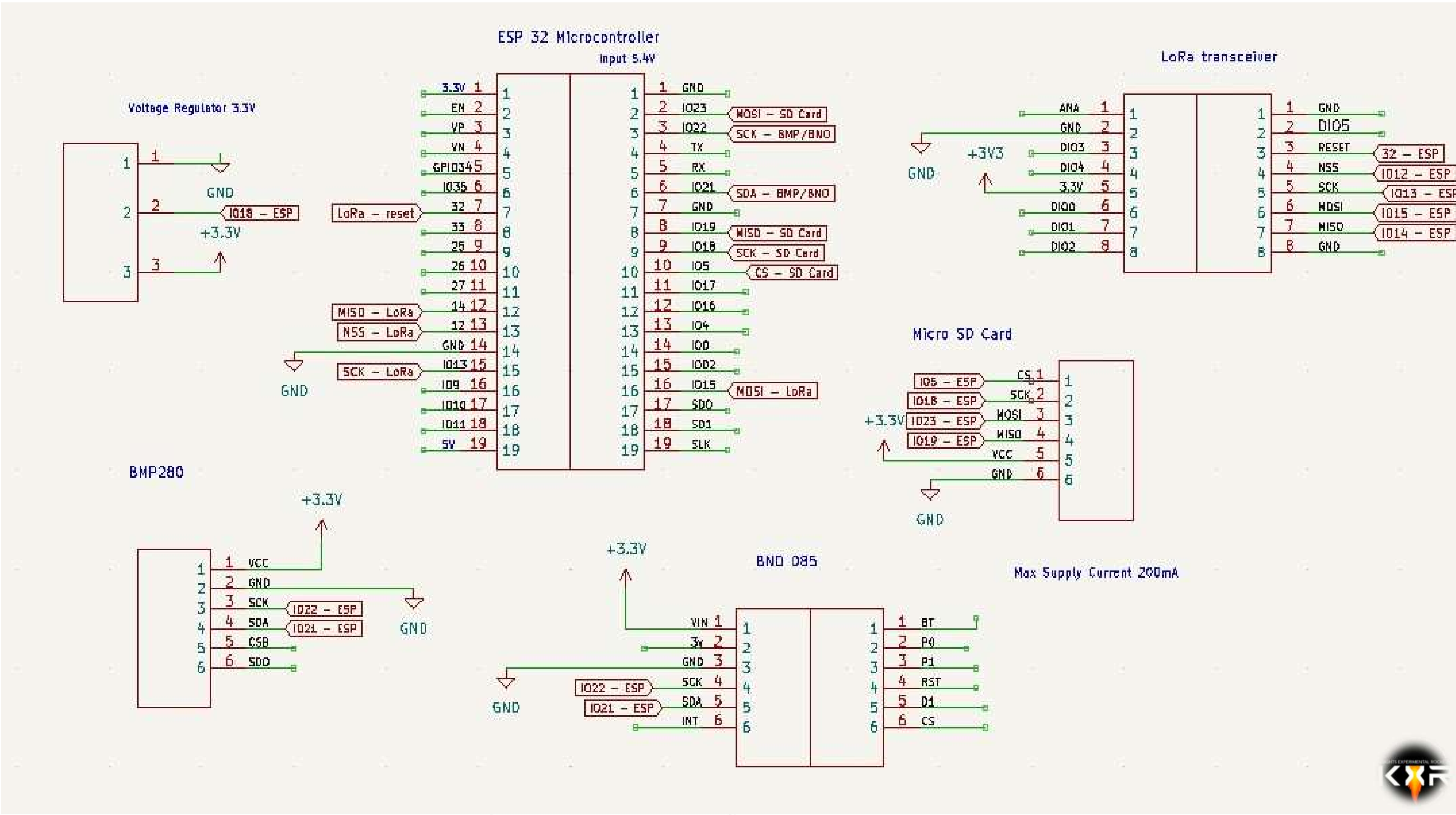


Flight Computer Components

- Custom PCB
- ESP-32
- BNO085
- BMP 280
- SD Card Reader
- 512MB Flash Storage
- Adafruit Ultimate GPS
- Adafruit LoRa Transceiver
- 18650 LiPo Batteries







ESP 32 Microcontroller
Input 5.4V
Voltage Regulator 3.3V
LoRa transceiver
Micro SD Card
BMP280
BNO 085
Max Supply Current 200mA

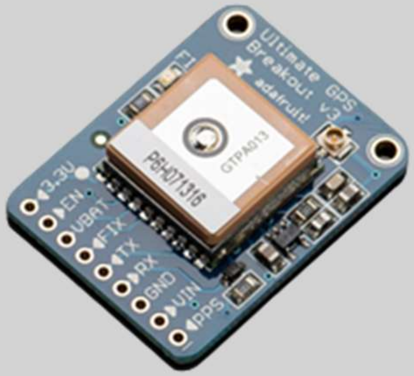
GPS Tracking

Featherweight GPS

- Independent of flight computer
- Low power draw
- Communicate up to 164,042 feet
- Connects to phone
- Advanced flight data

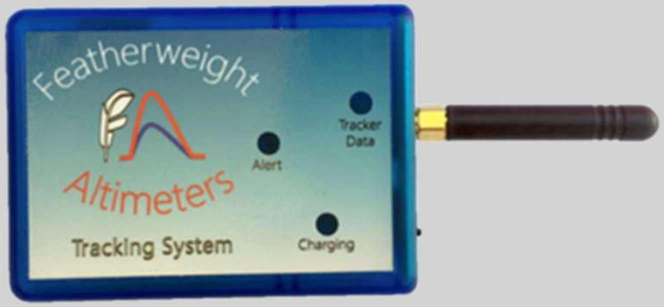
Adafruit Ultimate GPS

- Redundant GPS
- Compact
- Integrated with GPS
- High position/velocity accuracy
- Interfaced with custom ground station



Ground Station

- Primary - Featherweight comes with its own ground station
  - 164,042-foot range
- Redundant - LoRa Transceiver
  - Protective Case
  - Directional Antenna
  - Redundant Power supply
  - ESP-32
  - Laptop
  - About 2km range



Ground Station Flowchart

Secondary Experiments

Run Cam Split

- Located in nose cone shoulder
- Window drilled through shoulder and upper tube
- 165° FOV
- Requires an SD card and battery
- Can function independent of all other experiments/avionics

Safety

Risk Analysis Methodology

	Fatal – A	Critcal - B	Modera - C	Minimal - DF
Frequent – 5	5A	5B	5C	5D
Likely – 4	4A	4B	4C	4D
Occasional – 3	3A	3B	3C	3D
Rarely – 2	2A	2B	2C	2D
Improbable - 1	1A	1B	1C	1D

Launch Operations and Procedures

- Checklists
  - Mitigating risk by organizing conduct
  - Ensuring all components are properly assembled
  - Ensuring ability to proceed in absence of members
- Troubleshooting
  - Prioritizing prevention of injury
  - Avoid confusion and guarantee best case scenario should failure modes persist

Safety and Environment

- Personnel and Environment
  - Recognition of Hazards
  - Risk mitigations
- Materials Safety
  - Collection of Safety Data Sheets
  - Creation of product use guidelines

Timeline

Timeline

- **6 February** — Vehicle Design Manufacturing Ends
- **14 February** — All recovery tests complete
- **18 February** — Vehicle Demonstration Flight
- **6 March** — FRR
- **11 March** — Payload Testing Complete
- **15 March** — Flight Computer and Ground Station complete
- **18 March** — Payload Demonstration Flight
- **15 April** — Launch Day
- **1 May** — PLAR

Business

Business

Expected Costs	
Aerostructures	$ 2,300.53
Payload	$ 1,852.25
Propulsion	$ 1,201.35
General	$ 225.00
Total Rocket	$ 5,579.13
Rocket with 25% buffer	$ 6,973.92
Travel	$ 7,761.92
Travel with 25 % Buffer	$ 9,702.40
Total	$ 16,676.32

Funding Source	
FSGC / KXR	$ 3,000.00
SG FAO Bill	$ 3,000.00
SG CRT Bill	$ 3,000.00
Blue Origin	$ 3,000.00
Daytona 500	$ 2,000.00
Student Travel Fees	$ 5,100.00
Total	$ 19,100.00

Outreach

Outreach

STEM Engagement
Small Sat
Lockheed Martin Airshow
National Society of Black Engineers
STEM Day
UCF Club Fair
STEM Seminar
Intro to Engineering

Social Media
Instagram: ucf_rocketry
Website: https://kxrucf.com/index.html
LinkedIn: https://www.linkedin.com/company/knightsexperimentalrocketry/

Workshops
Arduino
Ansys
SolidWorks
OpenRocket
OpenMotor
Python
Composites
Manafacturing

Q&A

knightsrocketry@gmail.com