University of Central Florida 2023-PDR-Presentation

Executive Board

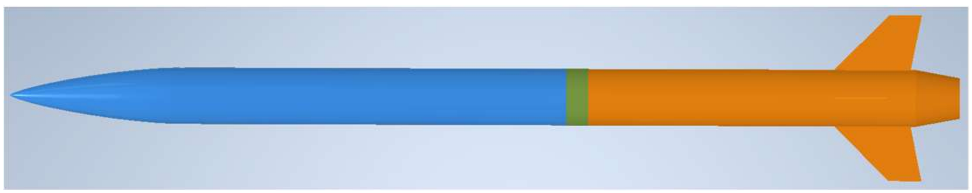
Nathan Stahl
Aerostructures Manager

Jonathan Perez
Systems Manager

Emilio Pereira
Payloads Manager

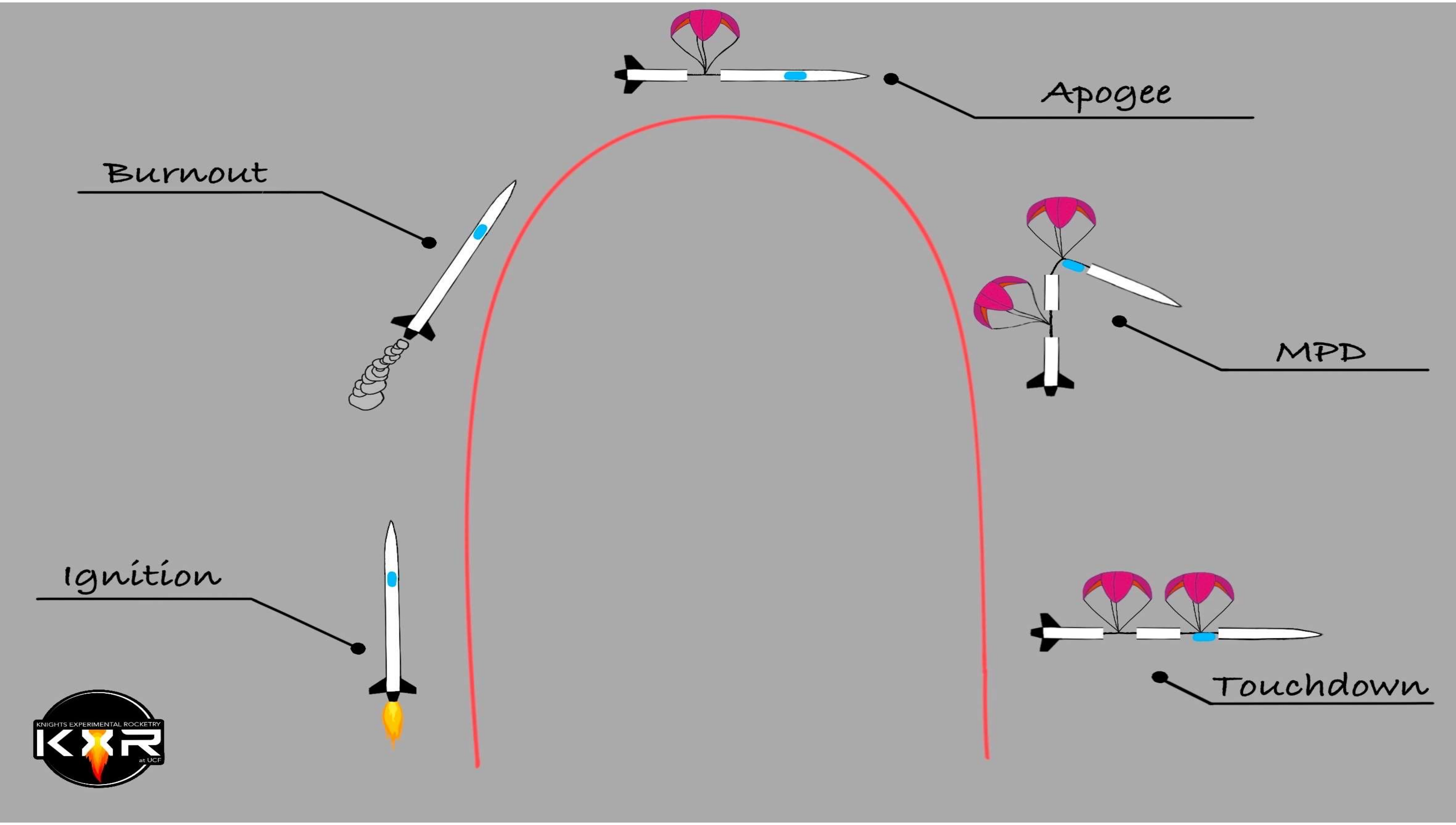
Vehicle Design

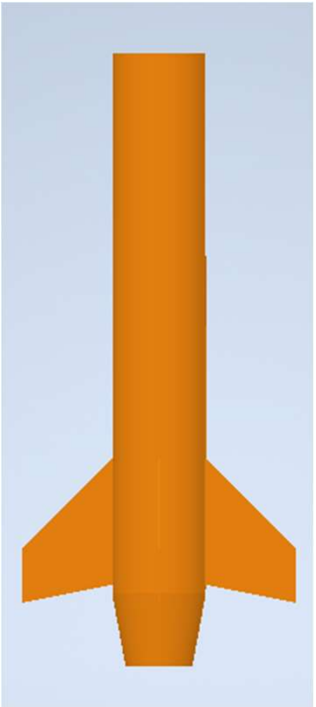
- Dual deployment with GPS tracking in the nosecone
- Tail cone to reduce base drag

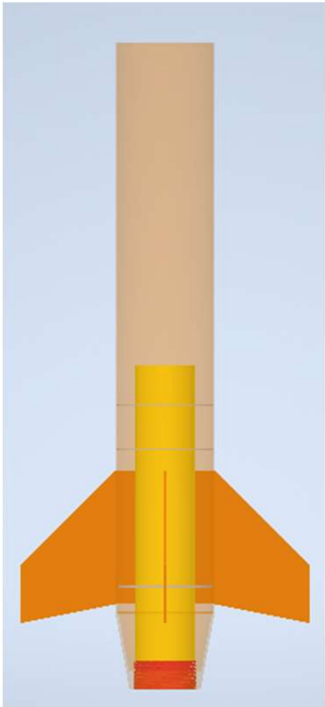


Rail Exit Velocity	63.4 ft/s
Thrust-to-Weight Ratio	12.6 ft/s
Maximum Velocity	691 ft/s
Maximum Acceleration	10.2G
Descent Time	52.87s
Highest Kinetic Energy Upon Landing	36.59 ft-lbs
Max Drift	2200'

Vehicle Name	Asclepius
Apogee	5507
Vehicle Length	87"
Expected Lift-off Weight	23.58 lb
Body Tube Outer Diameter	5.1"
Body Tube Inner Diameter	5.00"
Launch Pad Stability	2.31 cal
Launch Pad CoM	53.232" aft of tip
Launch Pad CoP	65.023" aft of tip


Apogee
Burnout
MPD
Ignition
Touchdown
KNIGHTS EXPERIMENTAL ROCKETRY
KXR
at UCF





- Estimated Weight: 3.5lbm
- Overall length of 34"
- Contains fins, motor tube, motor, centering rings, tail cone and motor retainer
- Booster tube made from Carbon Fiber

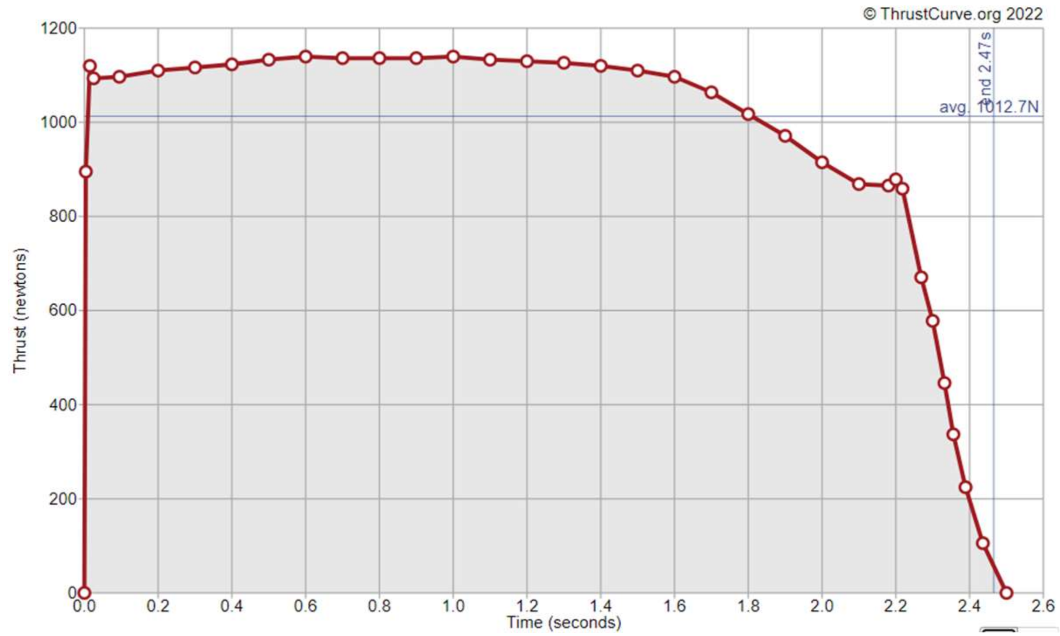
Booster Section

Fins

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

Preliminary Motor Choice – Aerotech K1000T

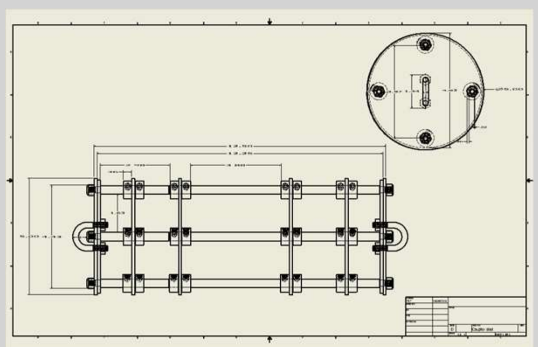
Motor Brand/Designation	**AeroTech K1000T**
Max/Average Thrust (lb)	1674N/1066N
Total Impulse (lbf-s)	2511.5Ns
Mass Before/After Burn (oz)	2602g/1392.5g
Liftoff Thrust (N)	1105N

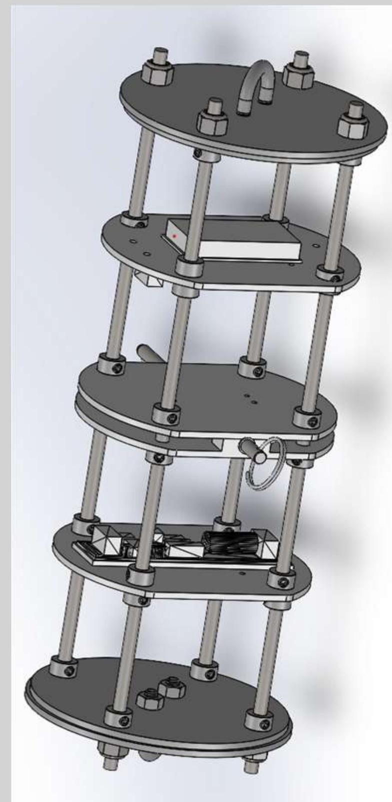


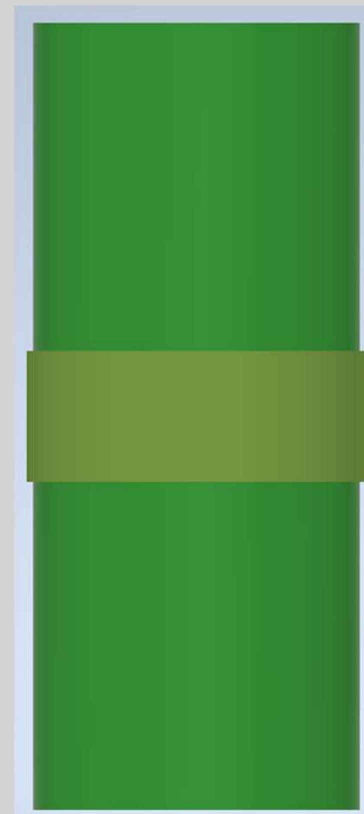
Recovery Section

- Estimated weight: 1.5lb
- 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
- Carbon fiber coupler

•Fiberglass Bulkheads
•Main and Redundant altimeter
•3D-Printed electronics mount and support structures
•Point charges







Altimeter Options

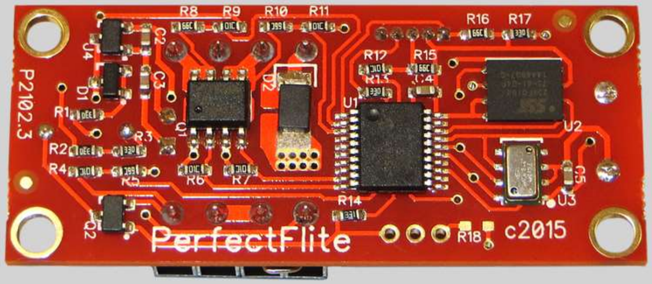
- Option 1: MissileWorks RRC2+
  - Pros: Cost-effective
  - Cons: lacks ability to interface with operating system
- Option 2: MissileWorks RRC3 Sport
  - Pros: configurable to WindowsOS;
  - Cons: large
- Option 3: Perfectflite StratologgerCF
  - Pros: configurable in WindowsOS
  - Cons: No prior experience with this altimeter

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.



Parachute Alternatives

- Drogue Parachute
  - Option 1: 12-inch Ultra-Light Parabolic Parachute
    - Lighter; Lower drag coefficient
  - Option 2: Fruity Chute 18-inch Elliptical Parachute
    - Heavier; Higher drag coefficient
- Main Parachute
  - Option 1: Rocketman's 96-inch Standard Parachute
    - Have previous experience with this parachute; Larger; Cheaper
  - Option 2: Iris Ultra 84-inch Standard Parachute
    - High quality; Expensive
  - Option 3: Rocketman's High Performance 84-inch CD 2.2
    - Smaller; High performance; Expensive

Drogue Parachute

- **12" Ultra-light Parabolic Parachute**
  - **Rocketman**
  - CD: 1.55
  - Materials: 1.1oz
  - Weight: .85oz
  - Packing Volume: 4.7"^3

Main Parachute

- **96 inch" Ultra-light Parabolic Parachute**
  - **Rocketman**
  - CD: .97
  - Materials: 1.1oz
  - Weight: 10oz
  - Packing Volume: 81.68"^3

Heat shielding

- **Nomex Blankets**

Attachment Hardware

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

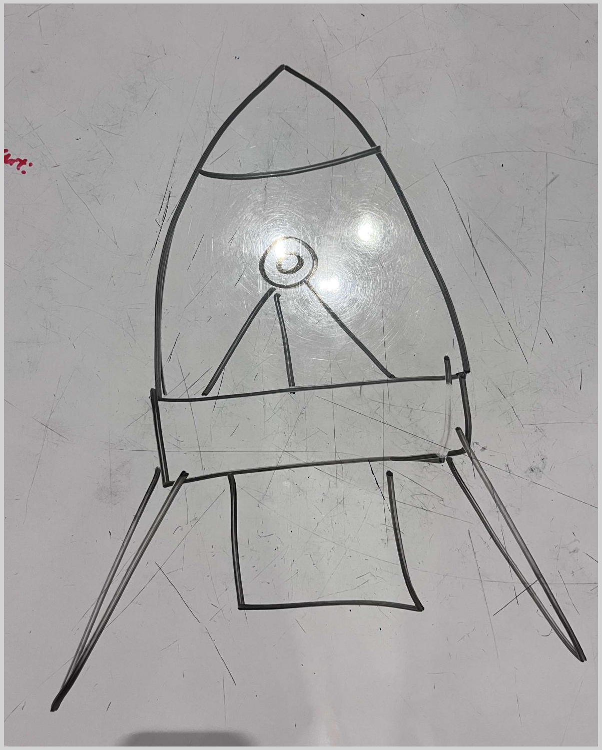
Payload Design

Payloads Section

- Estimated weight of Telemetry: 700g
- Overall Length: 58”
- Contains the Payload Integrated Launch Log (PILL), commercial GPS tracker, and student-made GPS tracker
- Carbon fiber payload tube

Payload Progression: Landing the Nose Cone

- Spring-locked legs flush with shoulder
- Payload located in nose cone
- Camera only need rotate about z-axis
- Easy to manufacture
- Extremely hard to implement

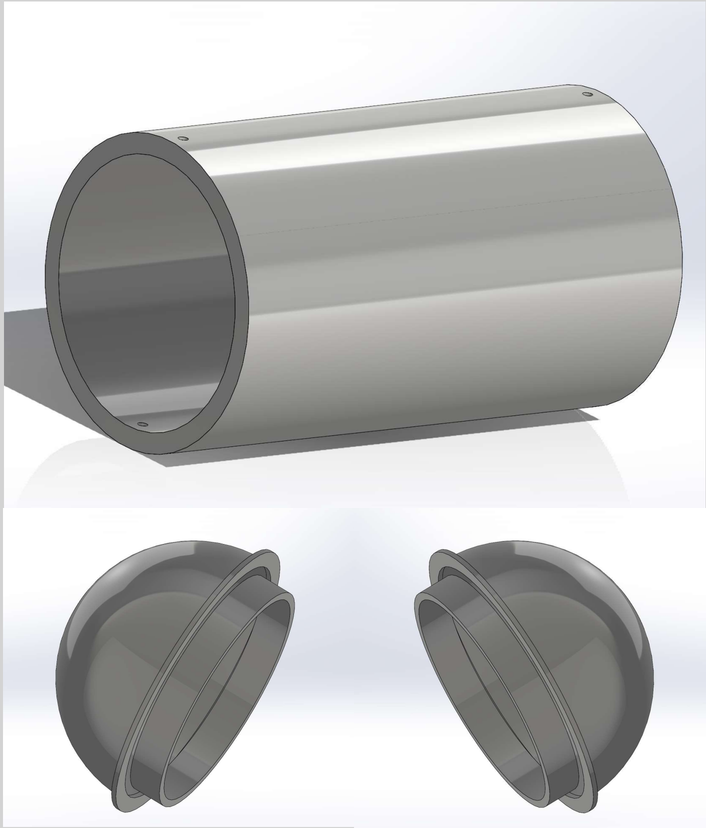


Payload Progression: Spherical Gimble (Hamster Ball)

- Polycarbonate Sphere
- Gimble on all axis
- Hard to manufacture
- Less spacing for internal components
- Low structural integrity

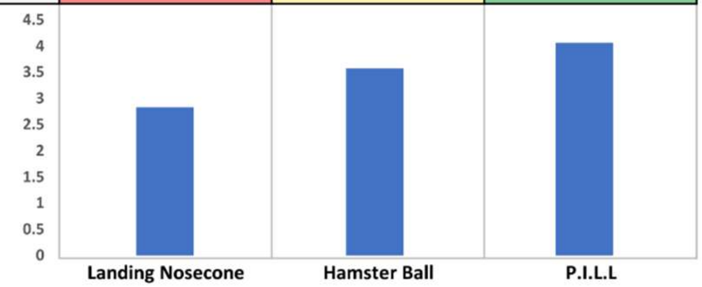
Payload Progression: PILL

- Polycarbonate rolling cage
- Easy to manufacture
- Easy to implement
- Less effective
- Dome ends may be hard to manufacture
- Deployment method may be difficult



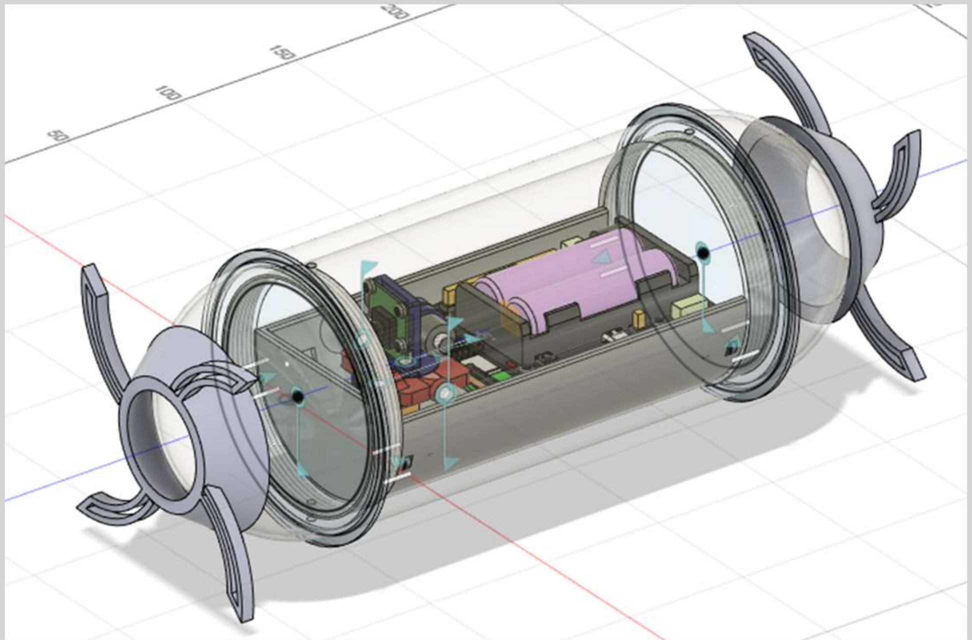
Choice Decision Matrix

		RATINGS		
Criterion	**Weight**	**Landing Nosecone**	**Hamster Ball**	**P.I.L.L**
Overall Payload Effectiveness	6	6	5	5
Satisfies NASA Requirements	5	5	5	5
Design Simplicity	5	1	3	5
Manufacturing Simplicity	4	2	4	3
Low Manufacturing Cost	4	2	3	3
Adequate Space Requirements	3	2	1	3
Adequate Weight Requirements	3	2	3	3
Low Failure Potential	5	1	3	4
Total	**35**	**2.83**	**3.57**	**4.06**



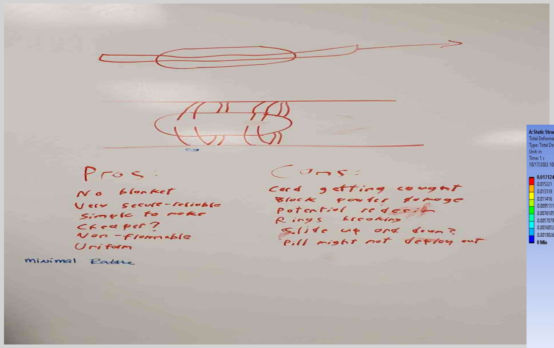
Payload Integrated Launch Log Overview

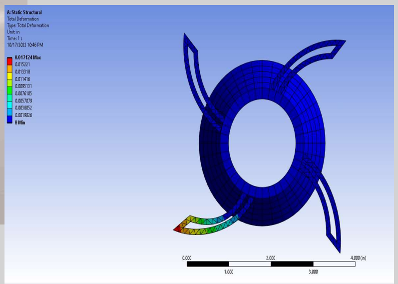
- PILL Mission:
  - House and deliver a camera capable of rotating 360° about the z-axis, whilst self-orienting itself parallel to the horizon
- Sub-system Breakdown
  - Experiments
  - Telemetry
    - Ground Station

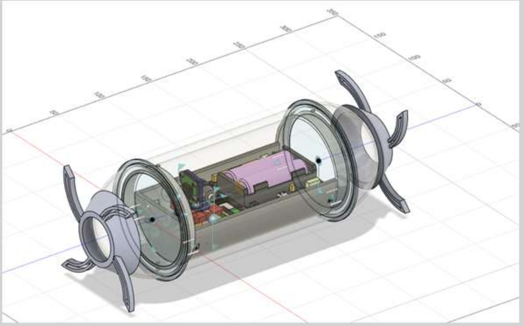


PILL Concepts and Design:

- Out of the many proposals that were presented, our team had decided on using silicone-based shock absorbers with 4 ‘wings’ that would mitigate the shock felt by the payload.
- To reduce the friction of the silicone against the body, the payload will be wrapped in a fire-resilient blanket. With this, the black soot will not stain the polycarbonate and damage it.
- Finally, our current design for our payload system contains all design elements that had been considered and compiled together to make the current payload design seen below.

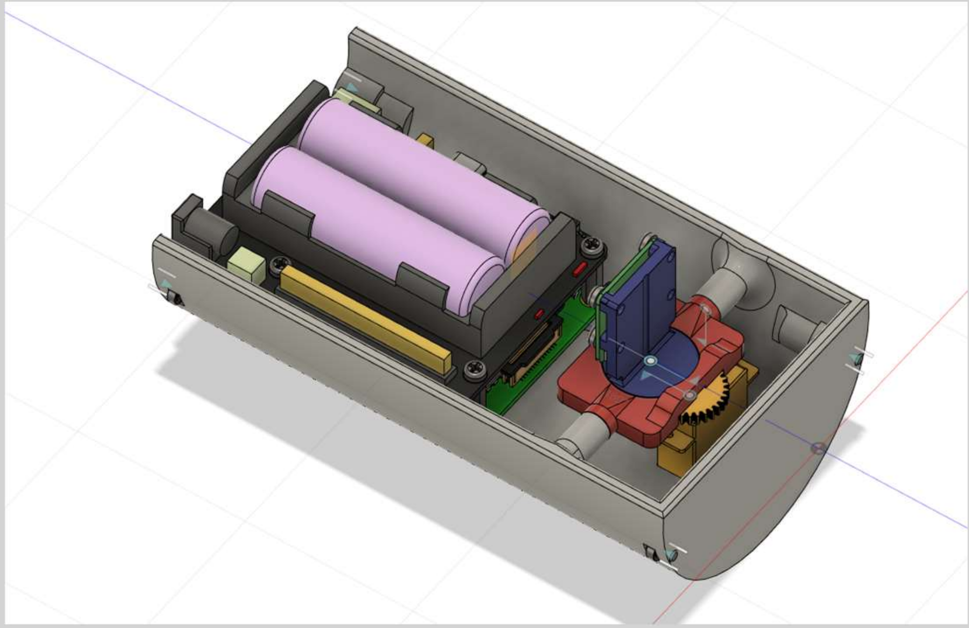




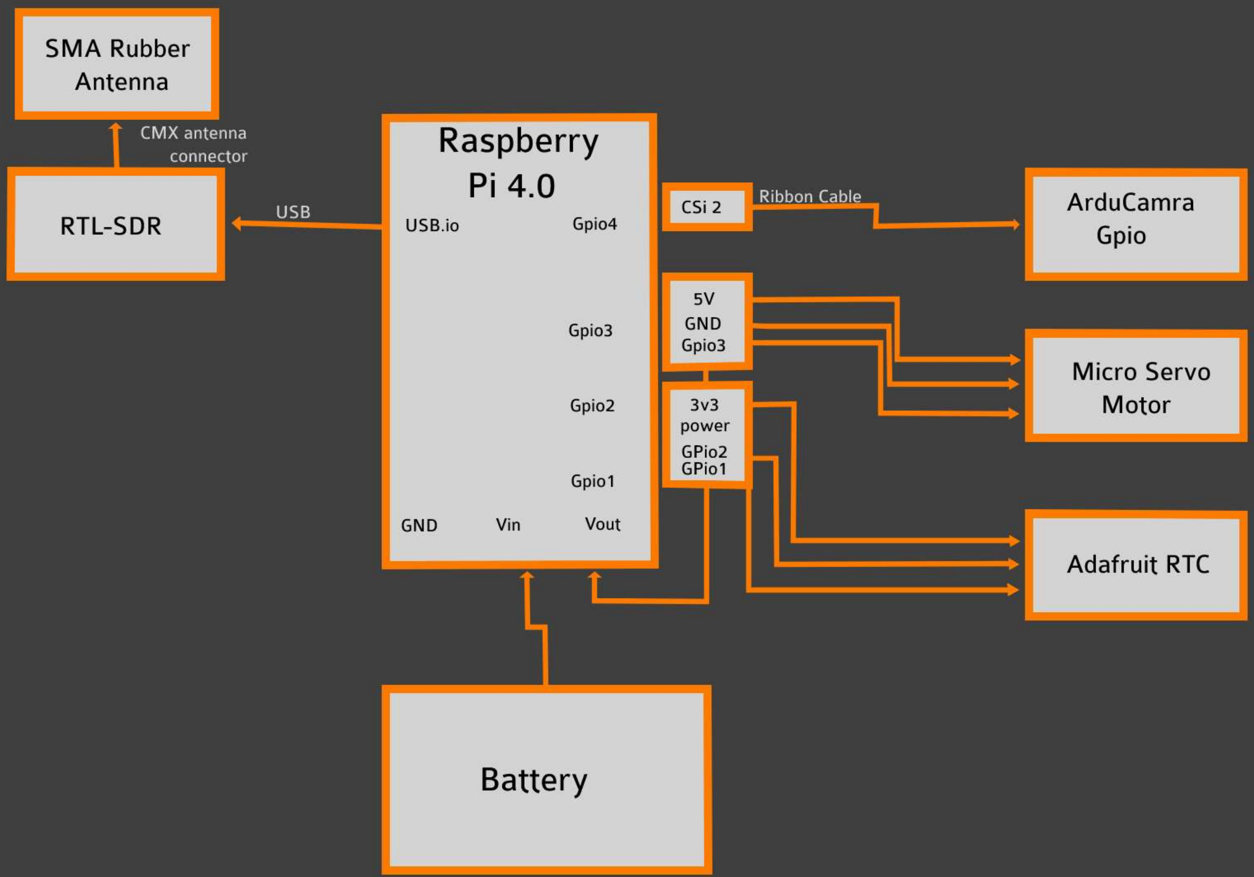


PILL Components

- Raspberry Pi Model 4B
- 1:3 Geared Servo Motor
- Adafruit PiRTC Real-time Clock
- PETG Electronics Sled
- Polycarbonate Outer Case "PILL"
- SDR and Radio dongle
- Mini Short Walkie-talkie Antenna

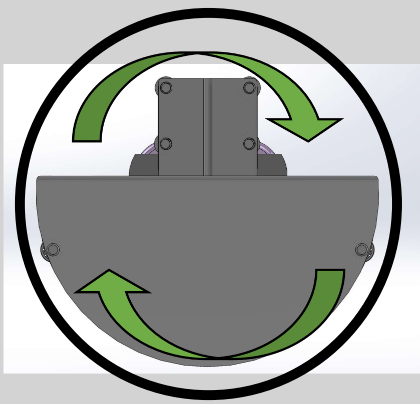


PILL Circuit Diagram



Self-Orientation

- Inner casing is held down by a Polycarbonate “lip” protruding from inside of polycarbonate
- Lower center of gravity allows Polycarbonate Outer Case to act as a “rolling cage” account for orientation about x-axis
- Sled mounted on ball bearings allows gravity to account for orientation about y-axis



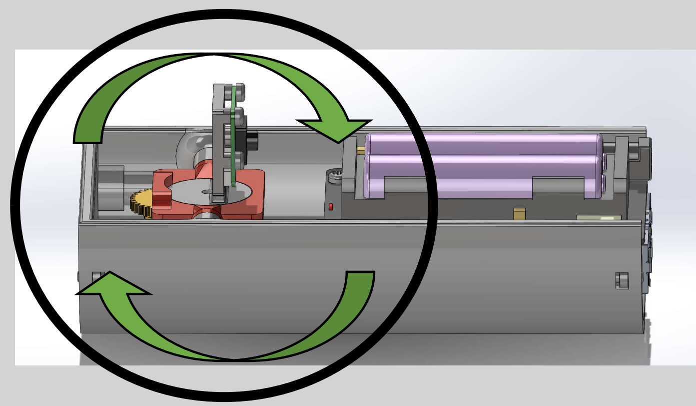


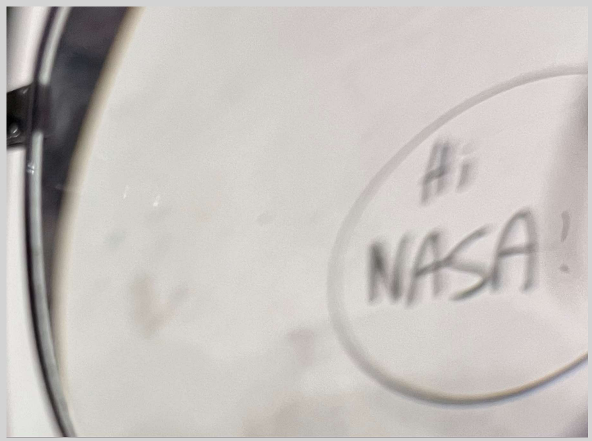
Image Processing

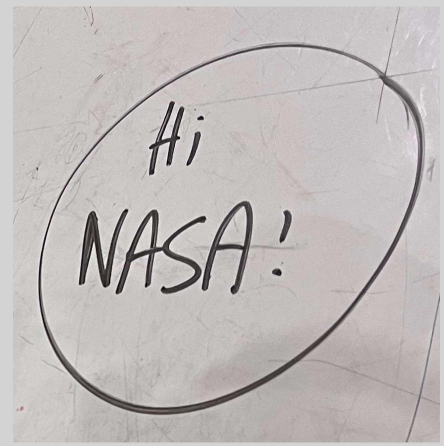
- The PILL will process images taken with the camera using OpenCV
- All code will be written in Python and run on the Raspberry Pi
- The system will be capable of executing all possible RF commands, including rotating the camera, taking time-stamped images, rotating the image, and applying filters.

Major Design Flaws

Distortion

- PILL is a polycarbonate cylinder
- Polycarbonate has a refraction index of 1.59
- Cylindrical shape could cause extreme distortion
- Alternative
  - Domes
  - Sphere Gimble



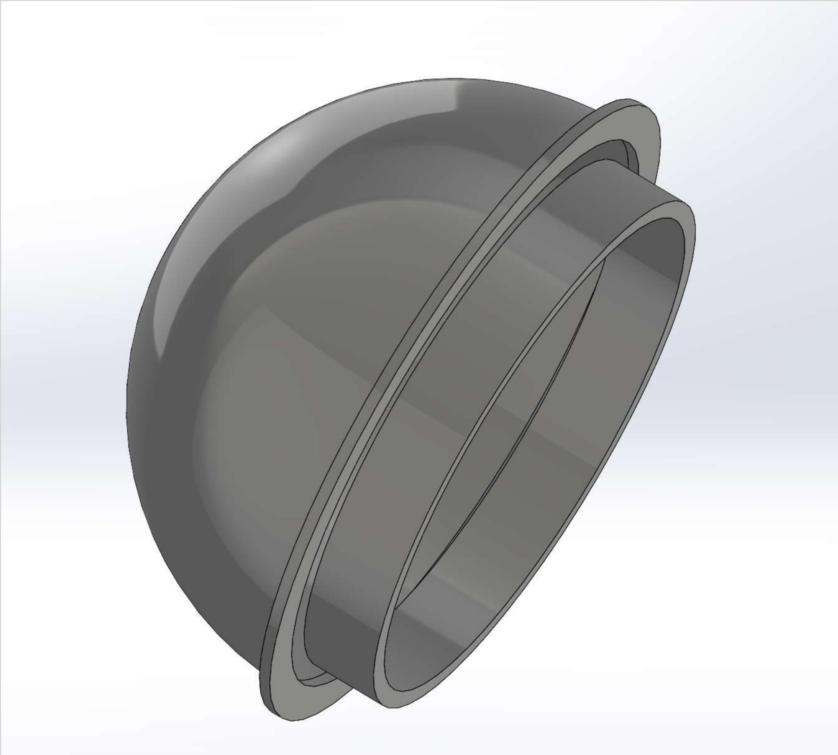


Side by side comparison of distortion through a polycarbonate lens

Major Design Flaws - Cont

Eyebolt Location

- Current design has eye bolts on side of PILL
- Centering rings reduces clearance to ½”
- Space for eye bolts limited
- Eyebolts on side as alternative
- Would imply flat edges in leu of domes
- Less Space due to rods connecting plates

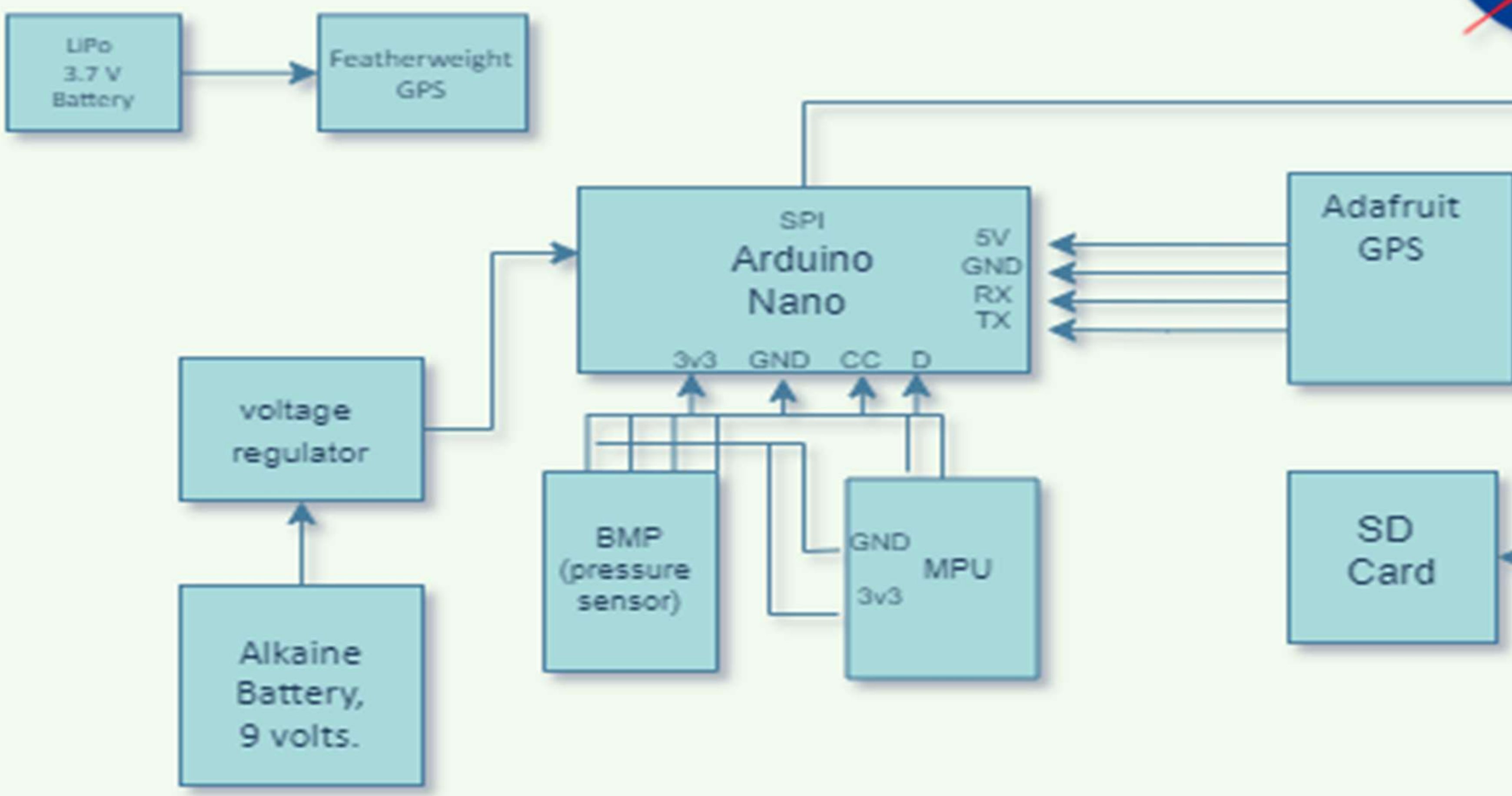


Avionics Bay

- Located in nose cone
- Threaded rod holding in metal nose cone tip
- PETG filament along threaded rod
- Featherweight GPS located at tip
- Flight computer located at base of nose cone
- Secondary camera located in shoulder

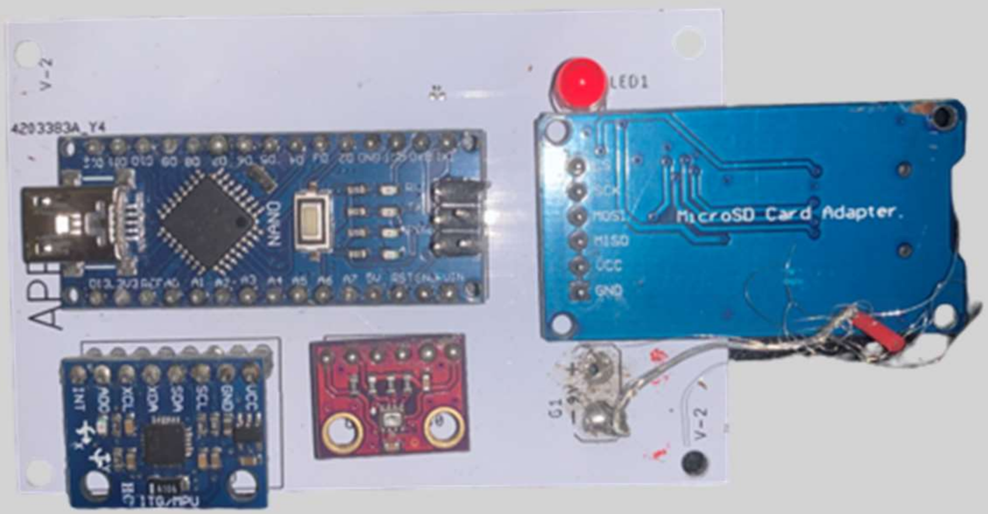
Telemetry Electrical Diagram:

Electrical diagram shown is the avionics system that is located within the Nosecone.



Flight Computer

- Custom PCB
- Arduino Nano
- MPU 6050
- BMP 280
- SD Card Reader
- Adafruit Ultimate GPS
- 3.7V Lipo Battery



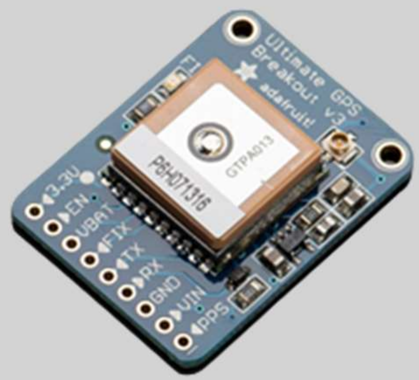
GPS Tracking

Featherweight GPS

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

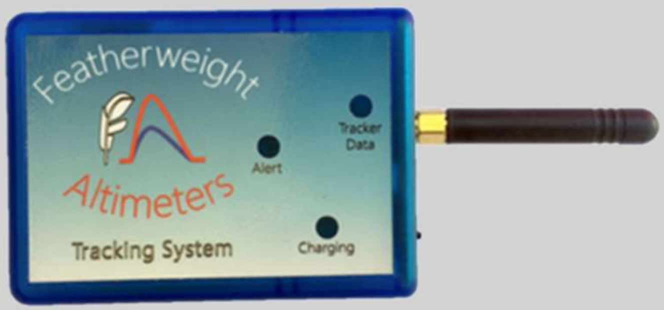
Adafruit Ultimate GPS

- Redundant GPS
- Compact
- Integrated with GPS
- High position/velocity accuracy
- Past experience with Adafruit



Ground Station

- Featherweight comes with own ground station
- 164,042 foot range
- Redundant GPS requires a separate ground station
- Second ground station remains in design phase
  - Telemetry will be in charge of ground-system as design progress



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	Critical - B	Moderate - C	Minimal - D
Frequent - 5	5A	5B	5C	5D
Likely - 4	4A	4B	4C	4D
Occasional - 3	3A	3B	3C	3D
Rarely - 2	2A	2B	2C	2D
Unprobeable - 1	1A	1B	1C	1D

Timeline

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- 11/3/22 PDR Video Conference
- 11/19/22 Sub-scale Flight
- 12/10/22 Design Finalized
- 12/30/22 Final RF Workshops
- 1/19/23 CDR
- 2/20/23 Manufacturing Finalized
- 3/6/23 FRR
- 4/15/23 Launch
- 5/1/23 PLAR

Business

Business

Expected Costs	
Vehicle Design	$ 2,477.04
Payload	$ 1,909.65
Propulsion	$ 1,020.95
General	$ 225.00
Total Rocket	$ 5,632.64
Rocket with 25% buffer	$ 7,040.80
Travel	$ 5,875.00
Travel with 25 % Buffer	$ 7,343.75
Total	$ 14,384.55

Funding Plan

- Student Government: $3,000
- Florida Space Grant Consortium: $3,330
- CRT Bill: $2,500
- Remainder
  - Club Dues
  - Donations
  - Fundraisers

Outreach

Outreach

Stem Engagement

- SmallSAT Convention
- Lockheed Martin Airshow
- Girls in Aviation

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