FAMU-FSU College of Engineering

2025 NASA Student Launch

Team 509: Payload

Design Review Four

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Nathan Hardie, Kyle Mahoney, Neil Maldonado

Team Introductions

Matthew Archibald
ME – Fabrication Engineer

Donovan Dwight
ME - Test Engineer

Nathan Hardie
CE - Communications Systems Engineer

Kyle Mahoney
ME – Structural Engineer

Neil Maldonado
EE - Data Systems Engineer

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Faculty Sponsor and Advisor

<u>Sponsor</u>
Shayne McConomy, Ph.D.
ME – Teaching Faculty II

<u>Advisor</u>
Taylor Higgins
Ph.D.
ME – Assistant Professor

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Project Objective

The objective of this project is to design and integrate a payload into a high-powered rocket for the 2025 NASA Student Launch Competition.

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Background and Scope

2025 NASA Student Launch:

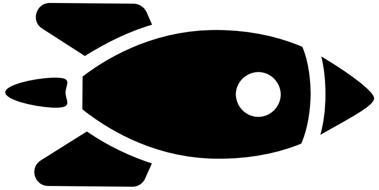
- Annual competition for universities nationwide
- Design, build, test, and fly and high-powered rocket
- New payload experiment every year

Payload Experiment Goals

- Collect a variety of flight data
- Transmit data via radio signals
- Safely transport four “STEMnauts”

Assumptions:

- Average weather conditions
- Rocket functionality
- FTM-300DR transceiver



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Project Targets

Target
Acceptable
Unacceptable

STEMnaut Safety

Structural Damage
(Degree of Damage)

1 2 3 5

STEMnaut Acceleration
(g)

0 9 12

STEMnaut Displacement
(in)

0 0.09

Payload Fastener
(lbf Pull Out Load)

0 103.66

Data Measurement

Number of Data Metrics
(Quantity)

1 3 8

Data Precision
(Log Normalized Error)

0 -3 -2

Measurable Acceleration
(g)

0 9 12

Measurable Altitude
(ft)

4500 5500

Data Transmission

Selectable Frequencies
(MHz)

144 148

Transmission Power
(W)

0 0.5 2 5

Receivable Distance
(ft)

0 2500 5000

Number of Transmissions
(Quantity)

0 1 12

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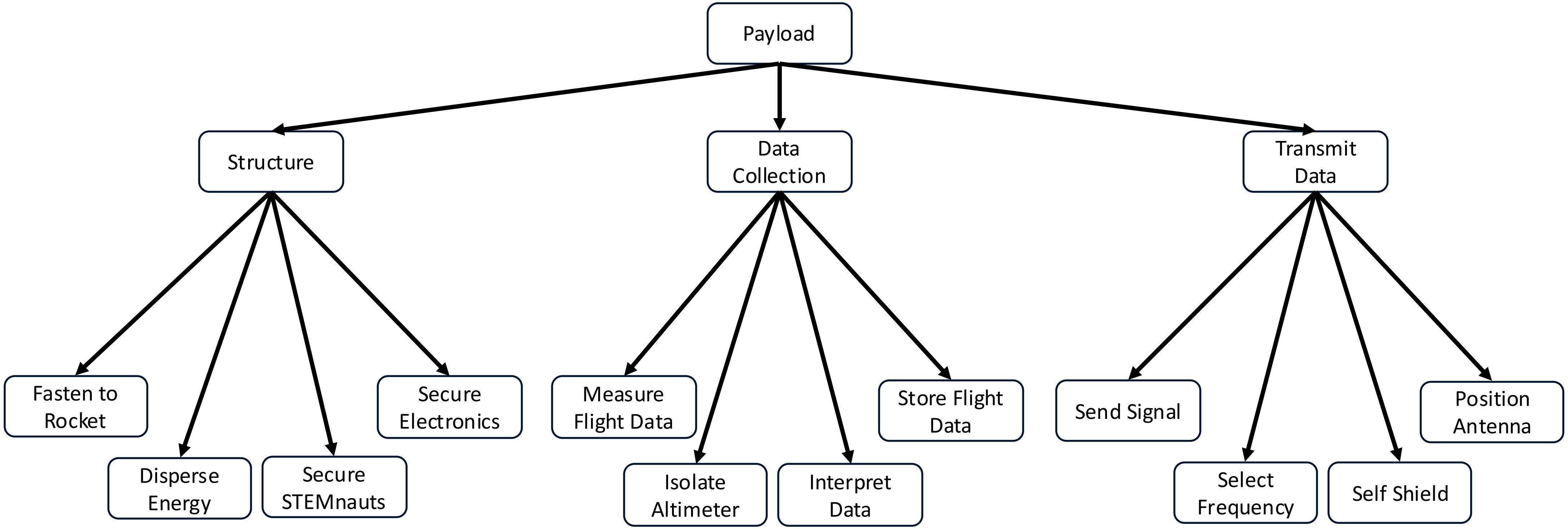
Functional Decomposition



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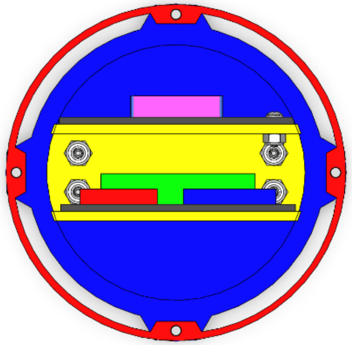
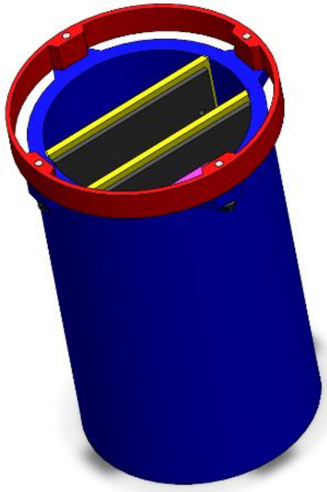
Initial Design Overview:

<u>**Structural Design Overview**</u>

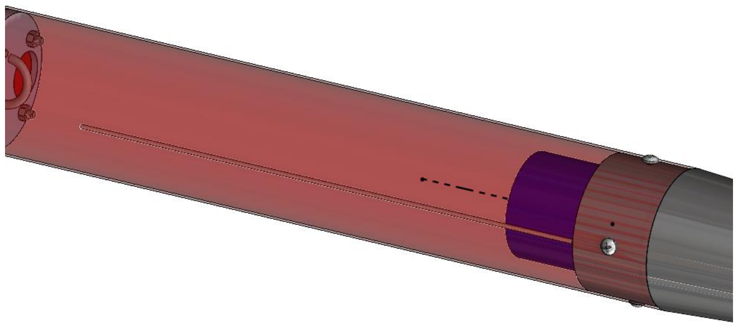
- **Structural Body -** SLS-printed Nylon-12
- **Mounting Method -** AL6061 bracket, secured in rocket's nosecone with high-strength epoxy
- **Chambers –** Data collection, Transmission, and STEMnaut
- **Electronics –** Stored on trays inside capsule





<u>**Electrical Design Overview**</u>

- **Electronics Trays -** RF, Sensor, STEMnaut
- **Sensors –** Payload IMU, Altimeter, 4xSTEMnaut IMU's connected via I2C
- **Transmitter –** LightAPRS: 1 W @ 144.39 MHz
- **Antenna –** Quarter wave (50cm) copper wire



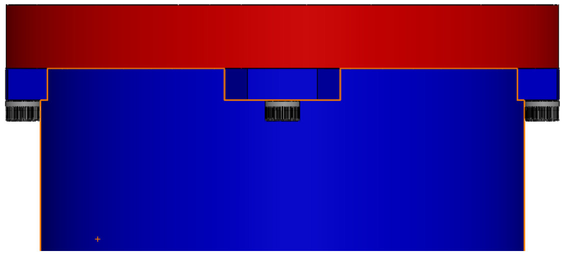
Initial Design Concerns

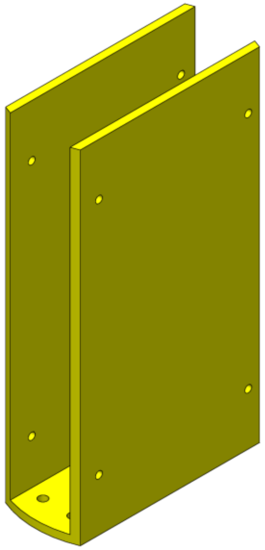
Major concerns:

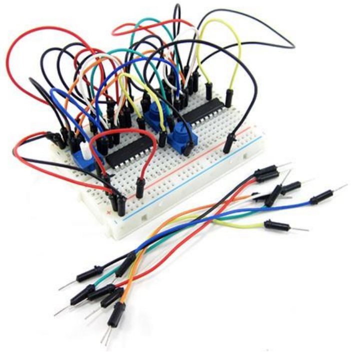
1. Uncertainties with mounting method
2. Excessive vibration
3. No clear STEMnaut securement method
4. Sprawling wires for electrical connections

Additional concerns:

1. Difficult assembly process
2. Excessive manufacturing costs
3. Unreliable tracking method for rocket-payload system
4. Lack of software state indicators







Kyle Mahoney

Subscale Flights

Intact heat inserts post launch

Subscale Flights 1 & 2

- Recovery system failure resulted in destruction of the nosecone and payload
- Heat inserts in nylon-12 parts performed remarkably well despite energetic landings
- Demonstrated flight stability of the rocket with payload mass simulator

Adversarial terrain

Successful recovery of payload mass simulator

Subscale Flight 3

- Demonstrated successful recovery of the payload mass simulator
- Locating the rocket took several hours due to auditory locator failure and adversarial terrain

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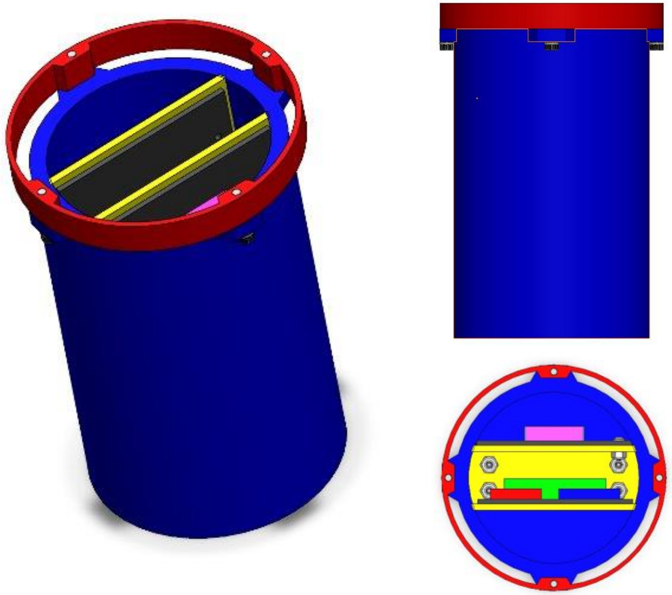
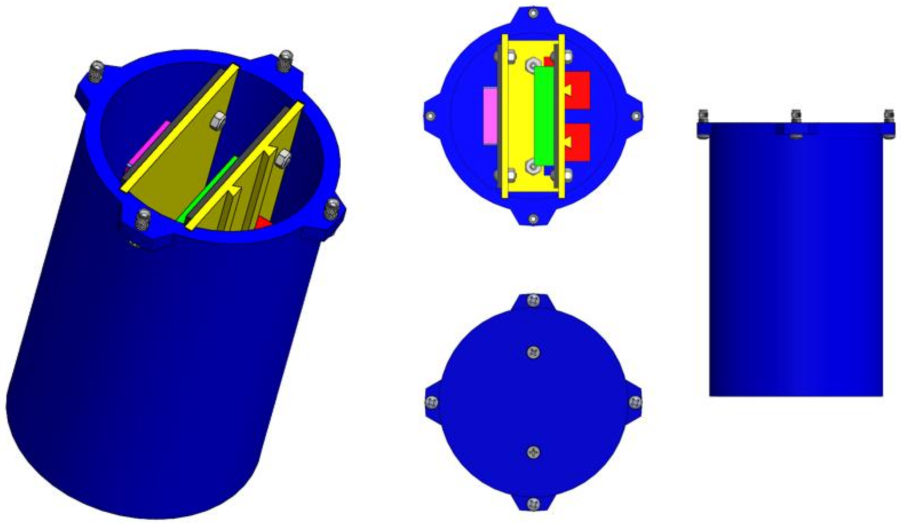
Revised Structural Design

Initial Design



Revised Design



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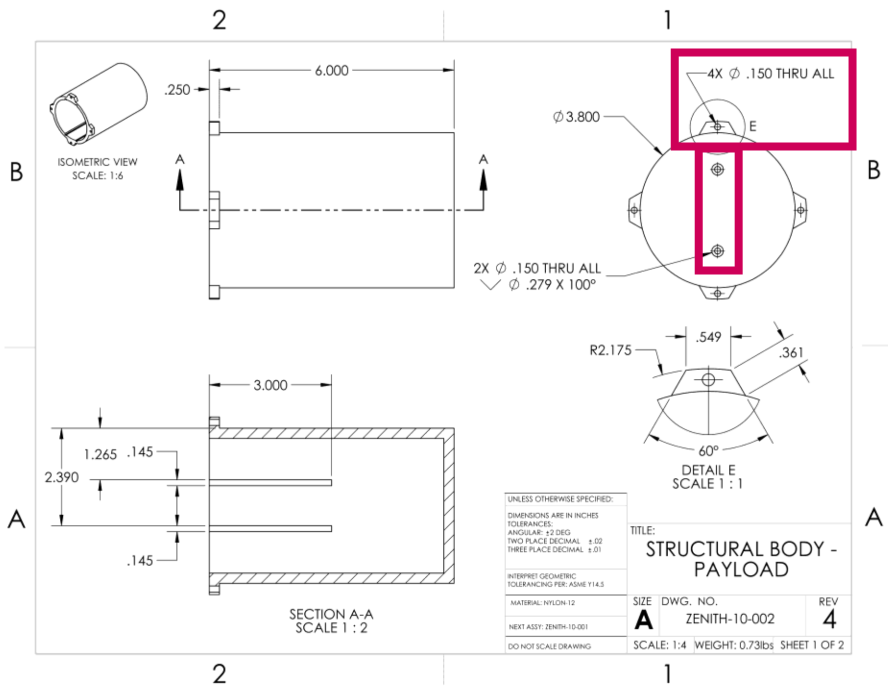
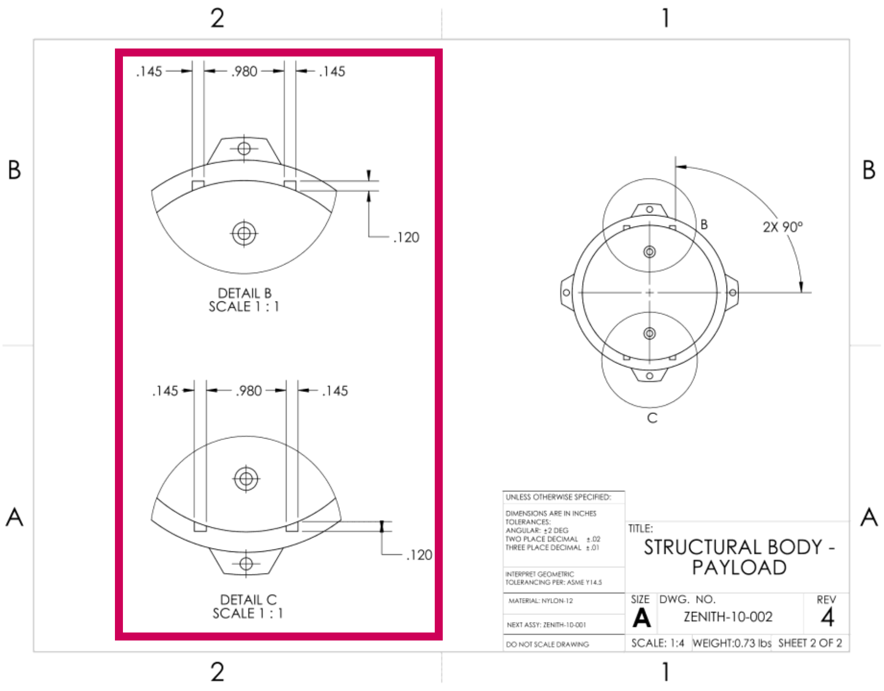
Structural Body Changes

Change #1: Reduction in amount of Chamber Divider mounting screws.
Change #2: Reduction in Payload mounting screw size.
Change #3: Addition of tracks for Chamber Divider securement.





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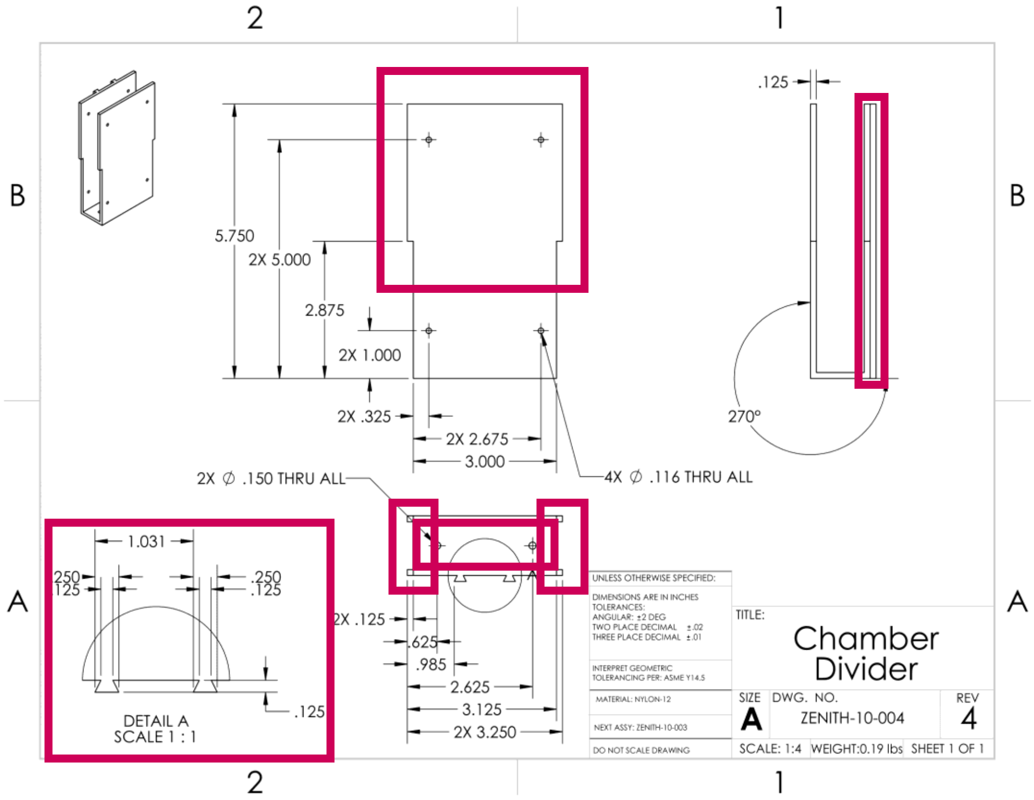
Chamber Divider Changes

<u>Change #1:</u> Addition of tabs to prevent vibration.
<u>Change #2:</u> Reduction in amount of mounting screw holes.
<u>Change #3:</u> Material change (AL6061 ➔ Nylon-12)
<u>Change #4:</u> Removed of edge filets.
<u>Change #5:</u> Addition of tapered tracks for STEMnaut mounting.



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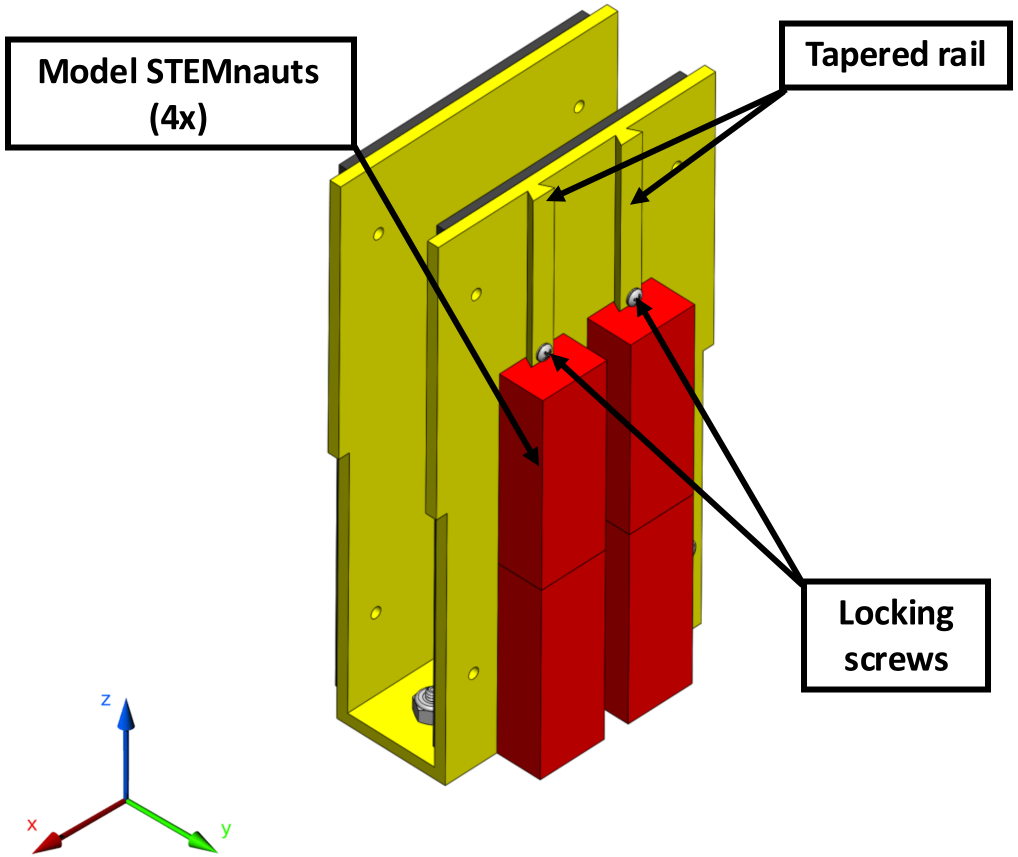
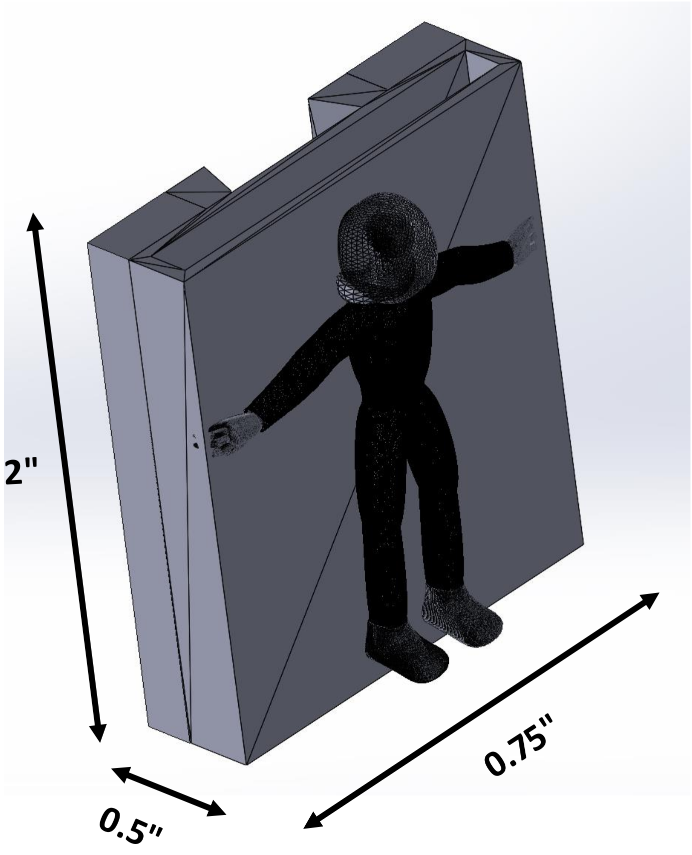
STEMnaut Fastening





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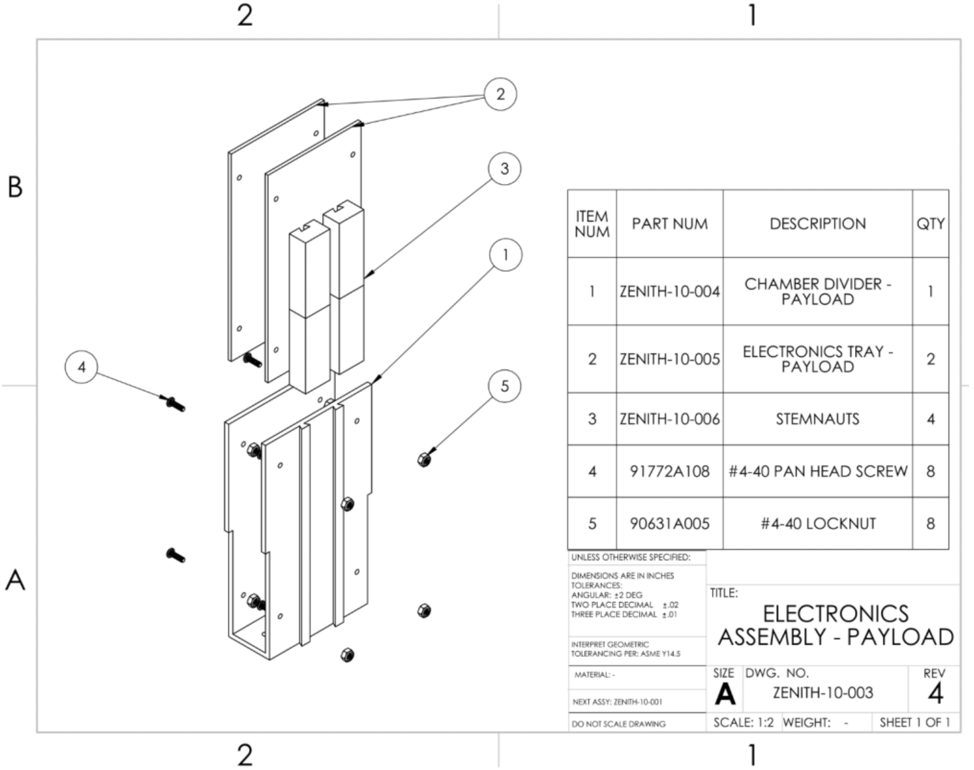
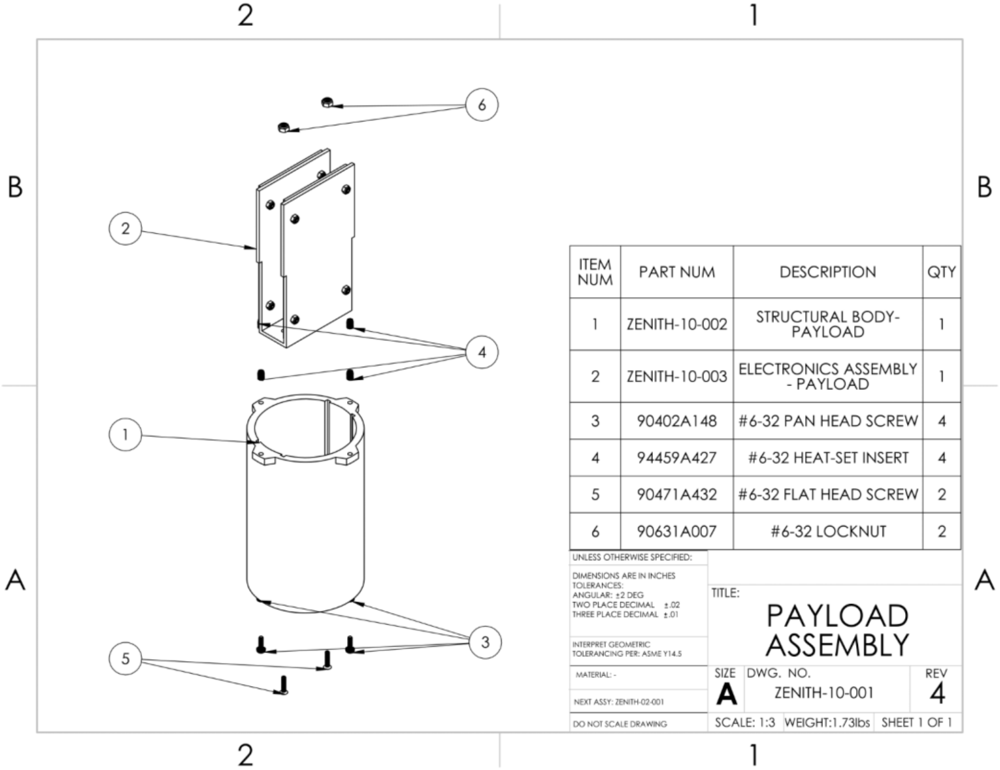
Final Structural Assembly

Electronics Assembly – Payload



ITEM NUM	PART NUM	DESCRIPTION	QTY
1	ZENITH-10-004	CHAMBER DIVIDER - PAYLOAD	1
2	ZENITH-10-005	ELECTRONICS TRAY - PAYLOAD	2
3	ZENITH-10-006	STEMNAUTS	4
4	91772A108	#4-40 PAN HEAD SCREW	8
5	90631A005	#4-40 LOCKNUT	8

Payload System Assembly



ITEM NUM	PART NUM	DESCRIPTION	QTY
1	ZENITH-10-002	STRUCTURAL BODY-PAYLOAD	1
2	ZENITH-10-003	ELECTRONICS ASSEMBLY - PAYLOAD	1
3	90402A148	#6-32 PAN HEAD SCREW	4
4	94459A427	#6-32 HEAT-SET INSERT	4
5	90471A432	#6-32 FLAT HEAD SCREW	2
6	90631A007	#6-32 LOCKNUT	2

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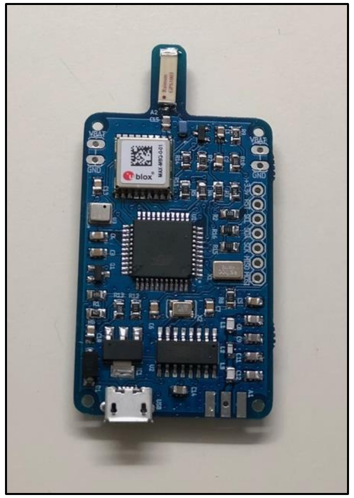
Electronics Design

<u>Electronics Modules</u>

- **RF Module & Microcontroller** – LightAPRS: Specifically designed for 2-Meter band
- **Alitmeter –** Paralax MS5607 Barometric Altimeter
- **Payload IMU –** BNO085: Accelerometer, Orientation, Sensor Fusion
- **STEMnaut IMU –** FSM300: Small size to fit onto the STEMnauts

<u>Electrical Connections</u>

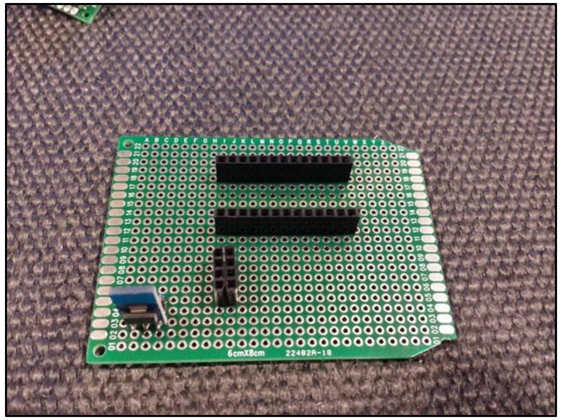
- **Intra-Tray Connections –** Perfboards with soldered connections, pin headers for breakout boards
- **Inter-Tray Connections –** 4-pin Molex KK cables to connect the trays to one another
- **Switches and Indicators –** Screw switches and LEDs



<u>LightAPRS</u> – Contains the Microcontroller and RF modules for the payload.

<u>Screw Switch</u> – Used as a secure switch to power on and arm the payload.

<u>Molex KK Cable</u> – Connector will be soldered each tray's perfboard (left) and cables connect the trays (right).



<u>Perfboard</u> – Used to make permanent connections between pins. Pin headers are used to securely fasten breakout boards.

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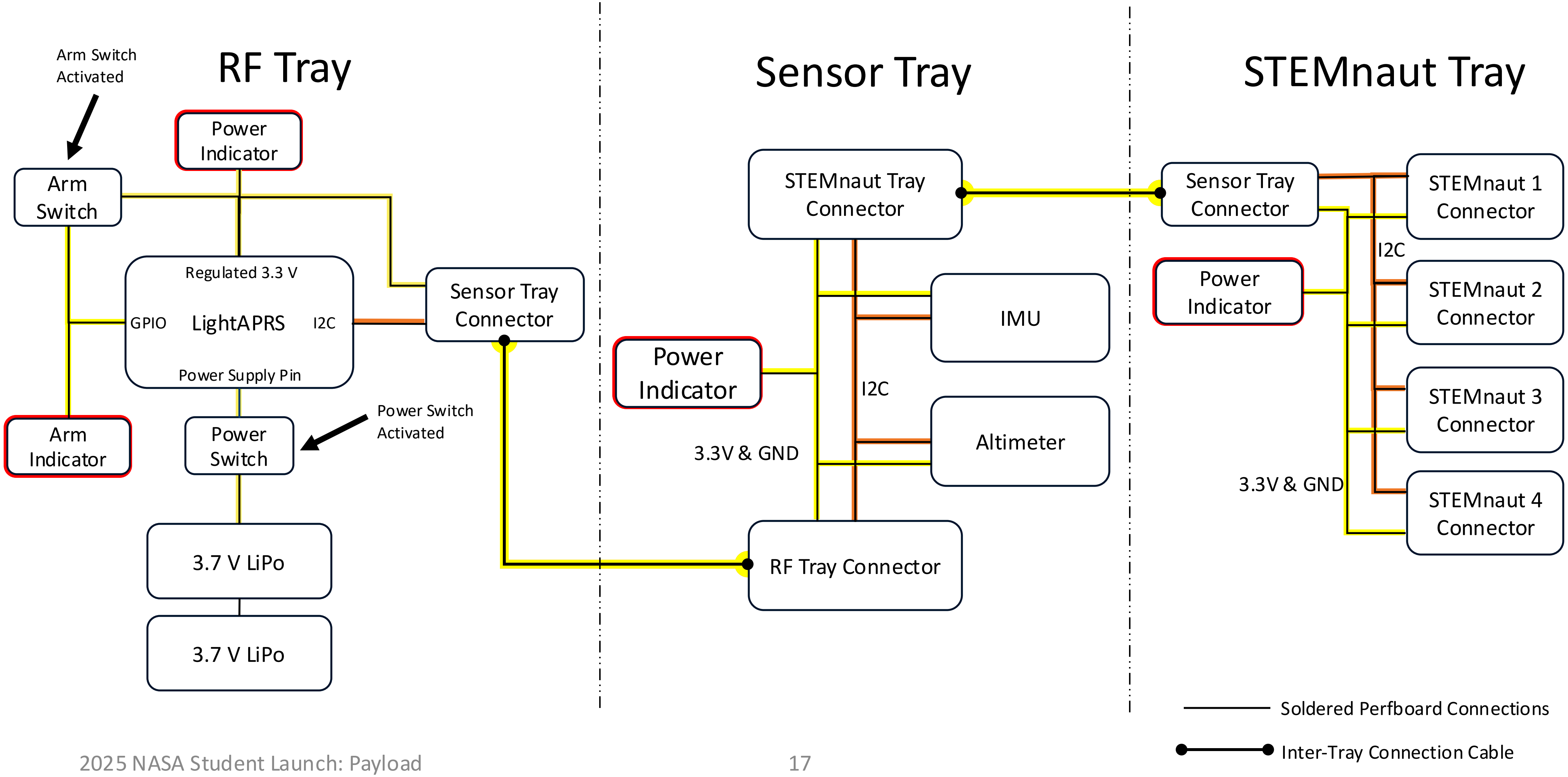
Electronics Block Diagram



Data Collection Design

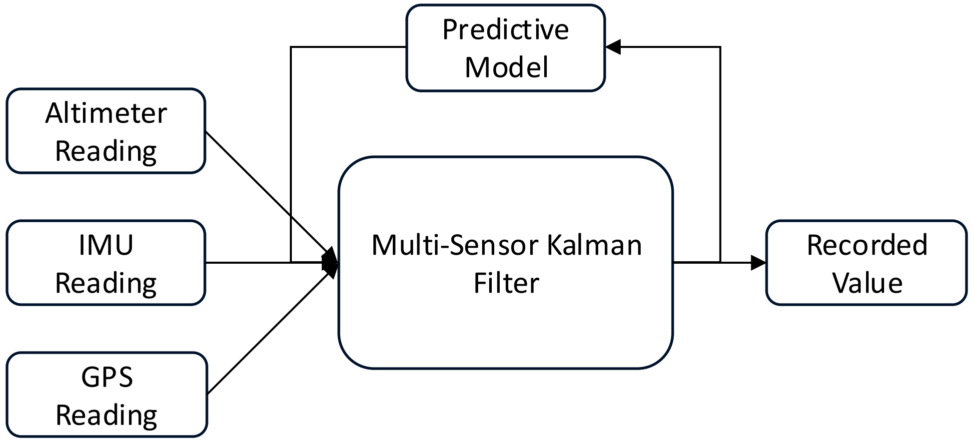
Sensor Fusion by Multi-Sensor Kalman Filter

- **IMU Readings –** Accurate dead-reckoning navigation
- **Altimeter Readings –** Frequent vertical positioning
- **GPS Readings –** Provides infrequent absolute positioning

Single Sensor Data

- **Temperature Readings –** Temperature sensor on the Altimeter
- **Power Readings –** Power supply connected to ADC
- **Time –** Hardware timer on the microcontroller

Sensor Fusion Block Diagram



Eight Pieces of Required Data	
STEMnaut Survivability	Temperature of landing site
Apogee Reached	Orientation of on-board STEMnauts
Landing velocity, G-forces sustained	Time of landing
Maximum velocity	Battery check/power status

Data that uses Sensor Fusion (left column)

Data with a single source (right column)

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Software Design

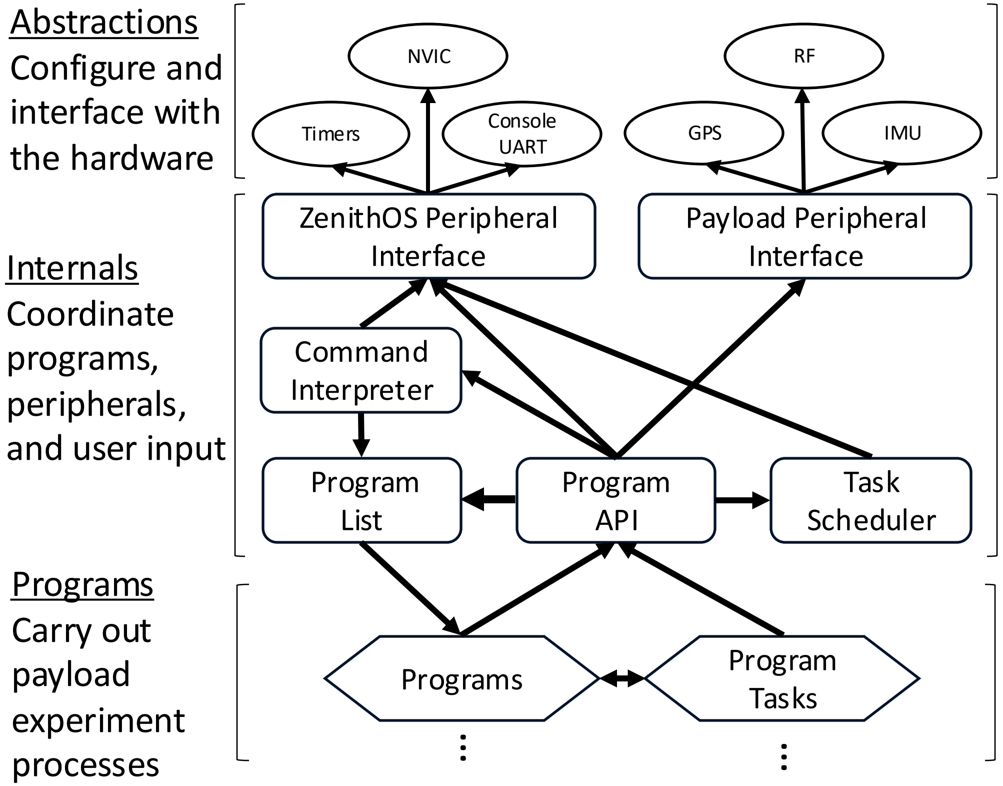
LightAPRS with Atmega1284P-AU Microcontroller

- **Timers –** 2x 16-bit hardware timers (one dedicated to time of landing)
- **I2C Pins –** 1x set available on LightAPRS
- **Core –** 1x Low-Power 8-bit AVR Microcontroller

Payload Software Requirements

- **Time Sensitive –** Sensor readings, Sensor Fusion, Data Loging
- **I2C Sensors –** 5xIMU, Altimeter
- **Simultaneous –** Flight Monitoring, Sensor Fusion, Data Interpretation, Logging

ZenithOS BlockDiagram



ZenithOS Framework

- **Multitasking –** Allows for multiple independent programs: Flight monitor, Data logger, Sensor fusion, Data interpreter
- **Resource Allocation –** Manages tasks, logging, CPU time, and peripheral requests for multiple programs
- **User Interface –** Terminal interface allows the user to start/stop programs, run diagnostics, and send commands at runtime
- **Hardware Abstraction –** A single implementation can be thoroughly tested and used by all programs

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Rocket Recovery Subsystem (RRS)

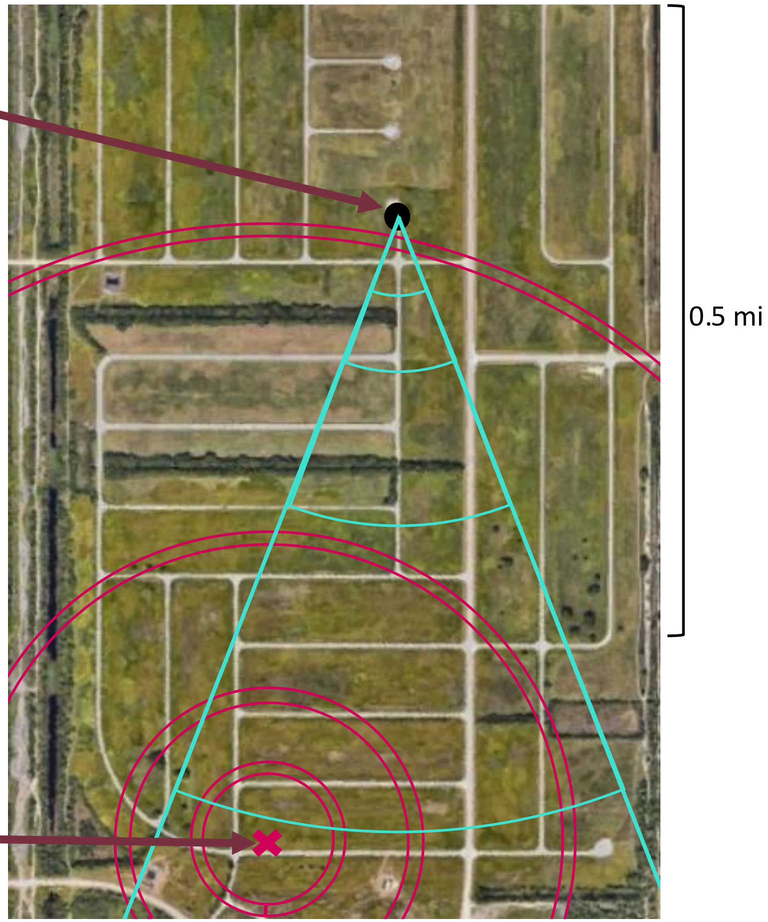
Situation

- Subscale Flight 3 was nearly a loss of vehicle because of adverse search conditions in Palm Bay
- The payload already has GPS and high-power RF hardware which could be used to aid recovery efforts

Solution

- The RRS program will be started after landing and periodically transmit the rocket's GPS location
- If GPS satellites are invisible, chirps are transmitted so that a directional antenna can be used to locate the payload

Launch Site:
Single & multi-directional antenna



Landing Site:
Payload sends GPS or chirp transmissions

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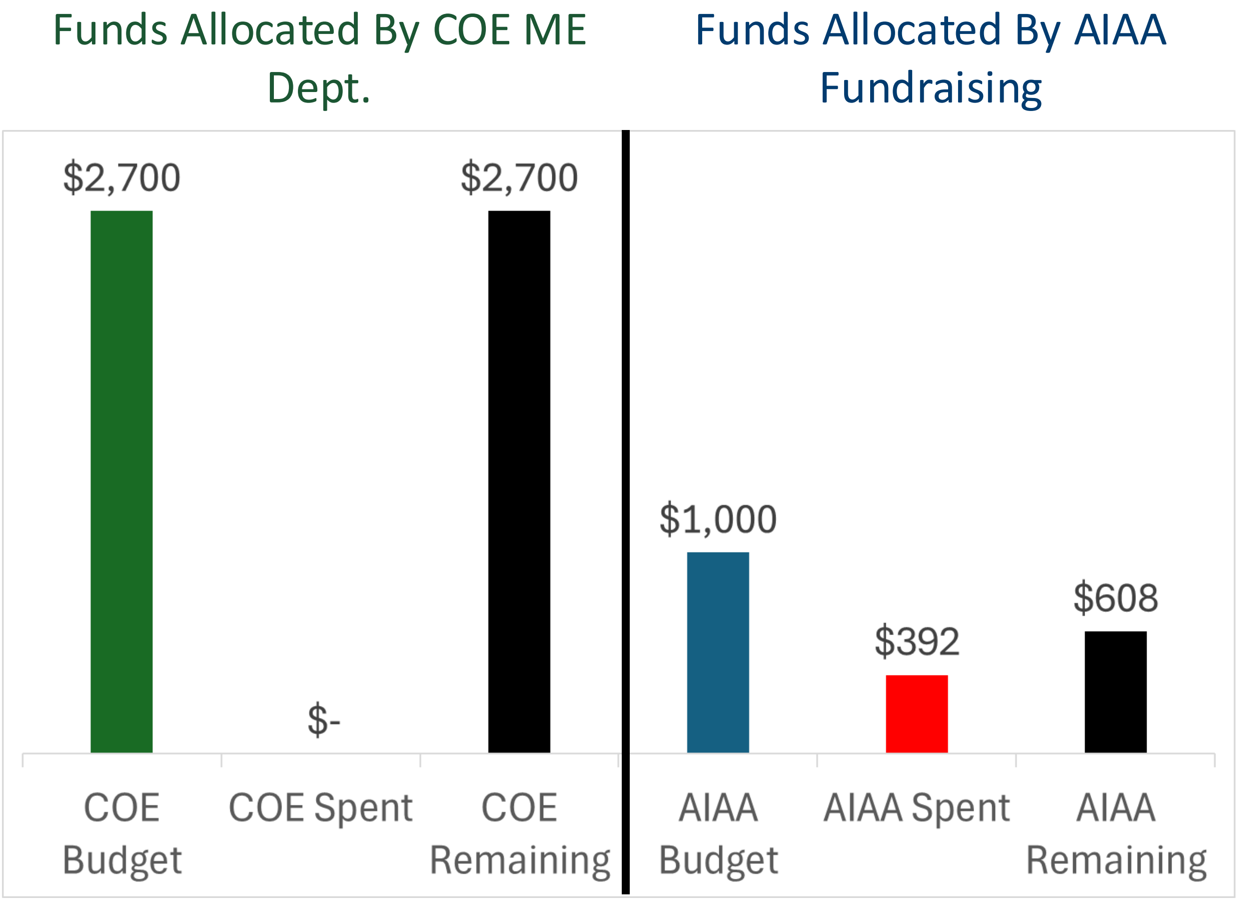
Budget Updates

AIAA Budget:

- Source of funds for all purchases thus far
- Remaining funds will be re-allocated to Team 508

COE Budget:

- Plans to use for testing
- Expecting to have funds left over
- Remaining funds will be re-allocated to Team 508



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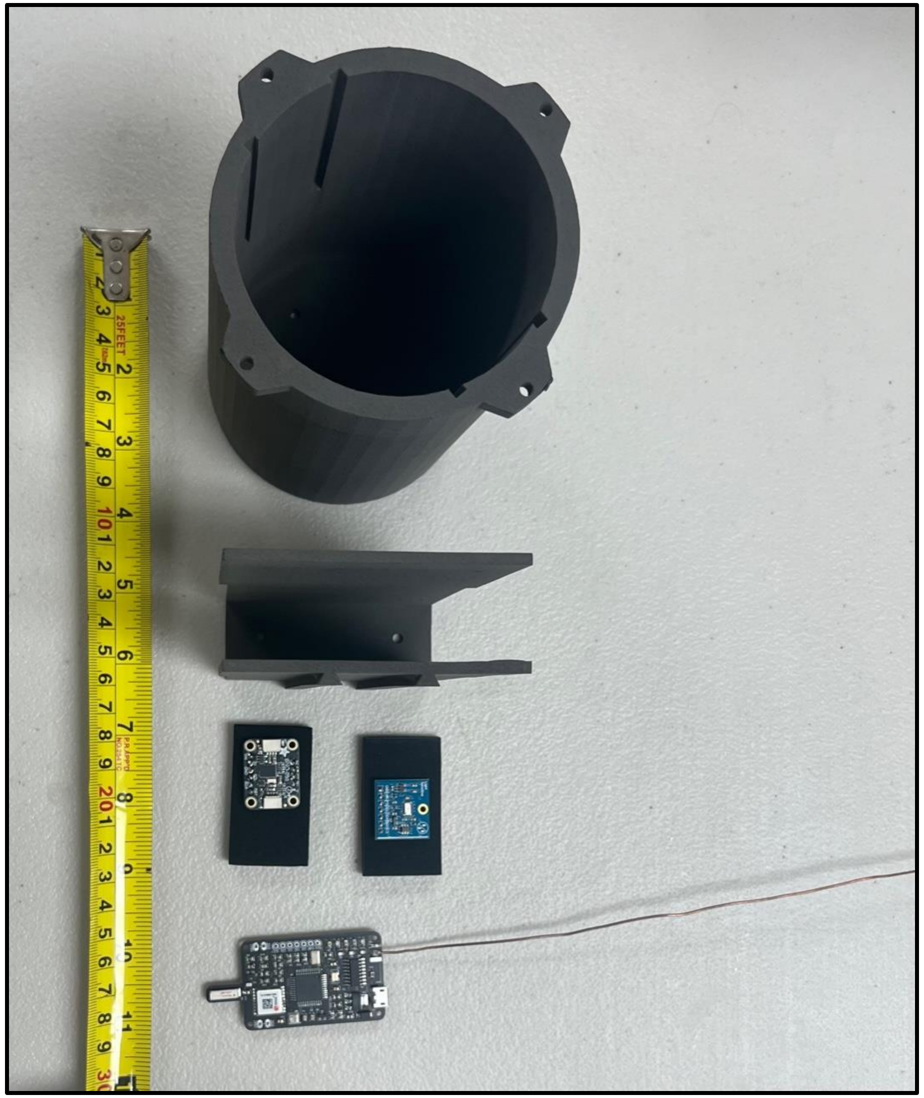
Future Work

- Fabricate remaining components (Electronic Trays)
- Component and sub-system testing:
  1. Load barring testing for mounting screw/inserts
  2. Impact testing
  3. Vibrational testing
  4. RF module distance/attenuation testing
  5. IMU/Altimeter verification
  6. Rocket Recovery System (RRS) testing
- Critical Design Review (CDR) presentation – January 29th
- Flight Readiness Review (FRR) report – March 17th



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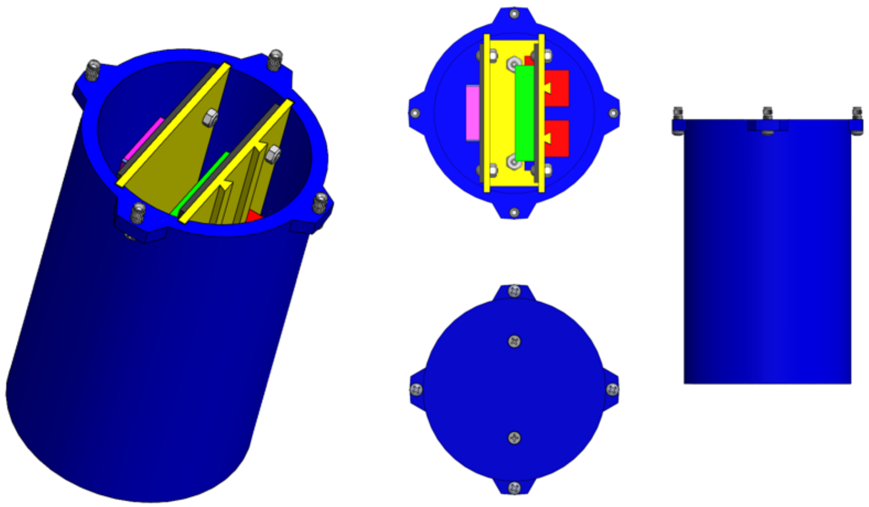
Thank you for listening!



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