FAMU-FSU College of Engineering

2025 NASA Student Launch

Team 509: Payload

Design Review 5

Authors: Matthew Archibald, Donovan Dwight,
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

Sponsor
Shayne McConomy, Ph.D.
ME – Teaching Faculty II

Advisor
Taylor Higgins Ph.D.
ME – Assistant Professor

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Donovan Dwight

Project Objective

Design and Integrate a payload into a high-powered rocket for the 2025 NASA Student Launch Competition.

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Presentation Outline

- Project Overview
  - Critical Design Attributes
- Initial Design Overview
  - Design Concerns
  - Subscale Testing
- Final Design Overview
  - Structural
  - Electronics and Software
- Testing
- Budget and Future Work

Donovan Dwight

Project Overview

2025 NASA Student Launch

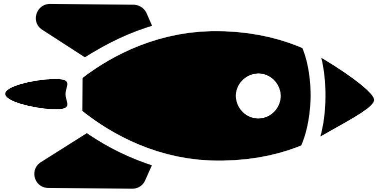
- Annual competition for universities nationwide
- Design, build, test, and fly and high-powered rocket
- New payload experiment every year

Payload Experiment Goals

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

Assumptions

- Fair weather conditions
  - Wind speed: <12mph
  - No precipitation
  - 40 – 90 ˚ F
- Rocket functionality
- FTM-300DR Transceiver



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Critical Design Attributes

- STEMnauts subjected to no more than 12 G’s
- Minimum pullout load of 104 lbf
- Minimum of 3 flight parameters collected
- Transmission frequency range between 144 MHz to 148 MHz

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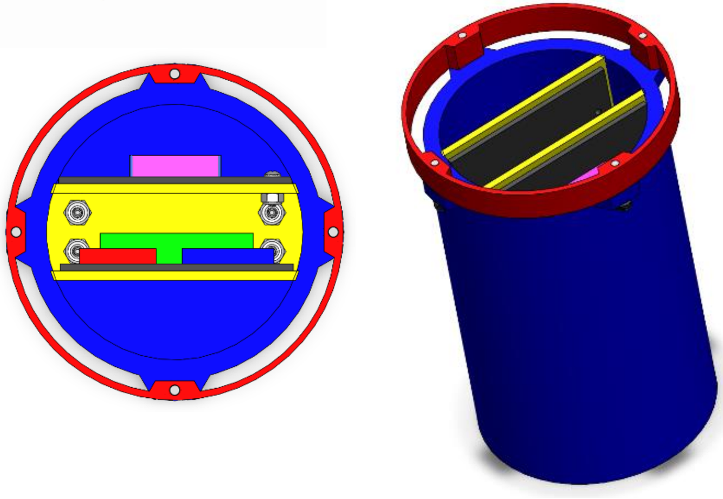
Initial Design Overview

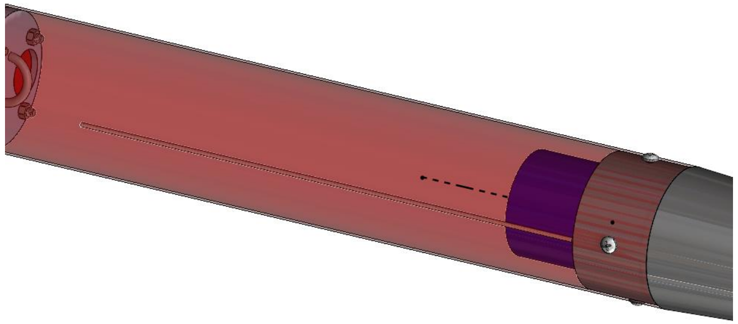
Structural Design Overview

- Structural Body
- Mounting Method
- Chambers
- Electronics



Electrical Design Overview

- Electronics Trays
- Sensors
- Transmitter
- Antenna



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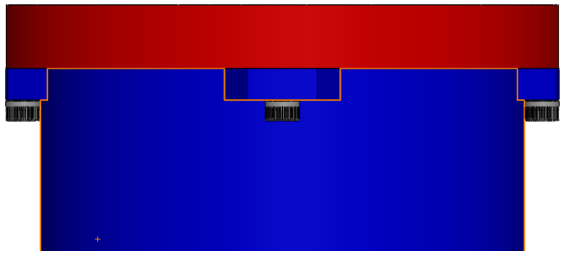
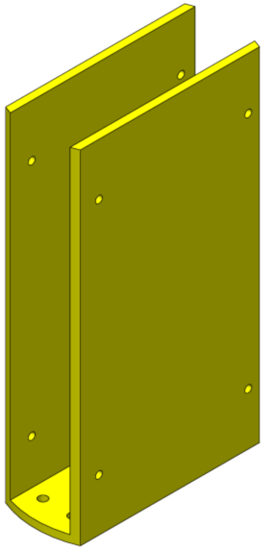
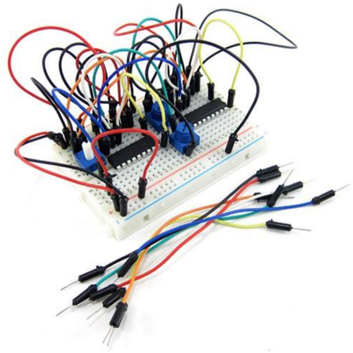
Initial Design Concerns

Concerns

- Uncertainty with fastening method
- Excessive vibration
- STEMnauts not secure
- Messy wires
- Long assembly time







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Subscale Flights

Subscale Flights 1 & 2

- Recovery System Failure
- Heat inserts in Nylon – 12 parts performed remarkably
- Demonstrated flight stability

Subscale Fight 3

- Demonstrated successful recovery
- Adversarial terrain

Intact heat inserts post launch

Adversarial terrain

Successful recovery of payload mass simulator

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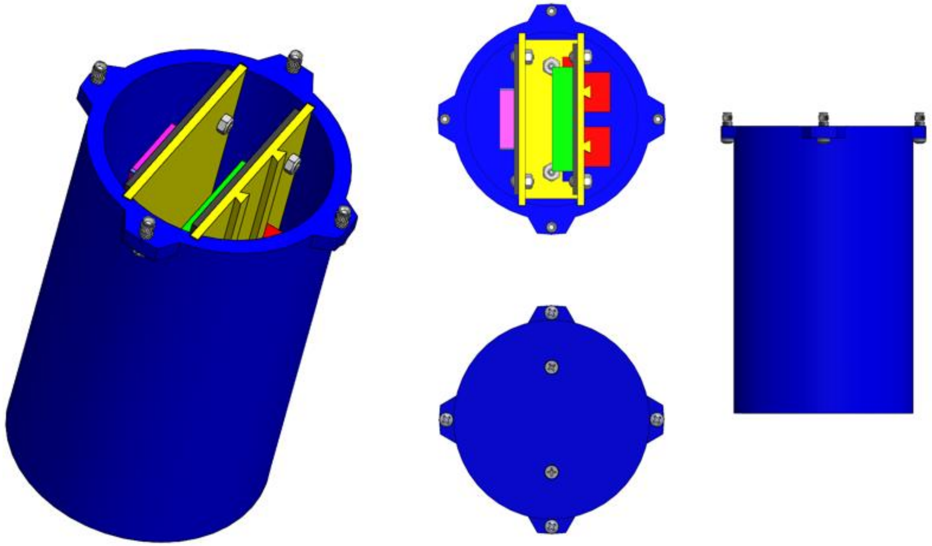
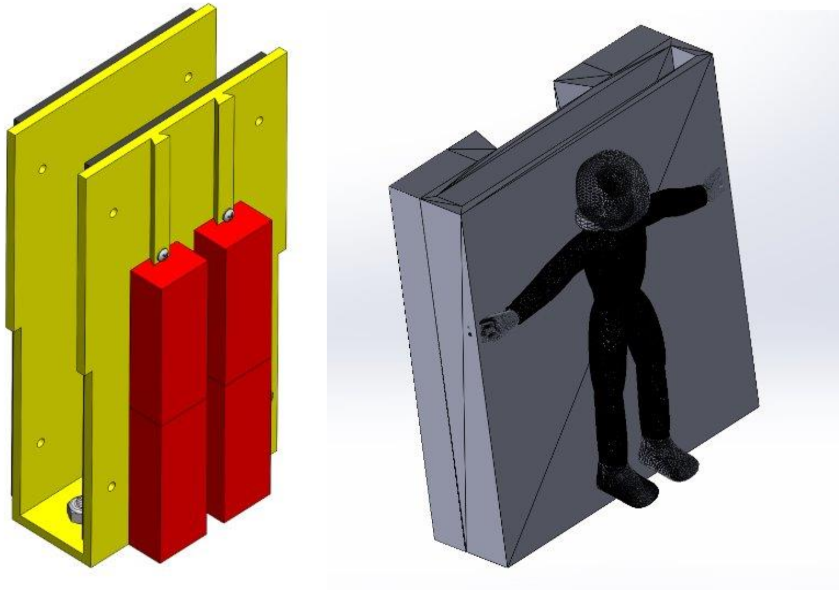
Revised Structural Design

Payload Structure



- Removed mounting bracket
- Reduction in screw amount & size
- Chamber divider tracks
- Vibration proof tabs & slots

STEMnaut Structure



- STEMnauts (4x) containing IMU's
- Tapered rail
- Locking screws

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Electronics & Sensor Overview

RF Module & Microcontroller

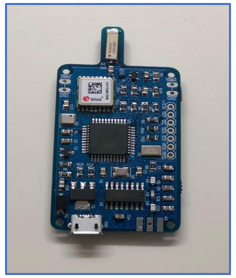
- LightAPRS

Sensors

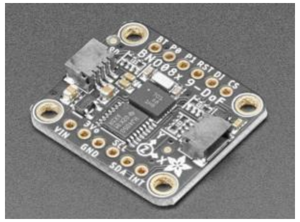
- Paralax M55607 Barometric Altimeter
- Payload IMU – BNO085
- STEMnaut IMU - FSM300

Electrical Connections

- Intra-Tray Connections: Pin headers solder to Perfboards
- Inter-Tray Connections: 4-pin Molex KK cables for cross tray connections
- Screw Switches
- LED Indicators



LightAPRS



Inertial Measurement Unit

Molex KK Cables

Screw Switch

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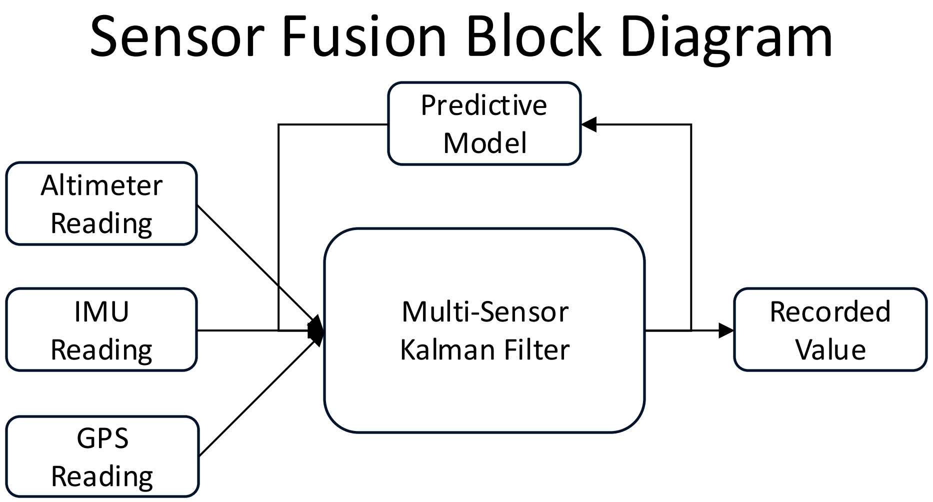
Sensor Fusion

Sensor Fusion

- Kalman Filter
- IMU
- Altimeter
- GPS

Single Sensor Data

- Temperature
- Power
- Time



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Software

```
>sensorCheck altimeter

>zeroAltimeter

>simulateFlight

>readyForLaunch
```

Example Payload Commands

User Interface

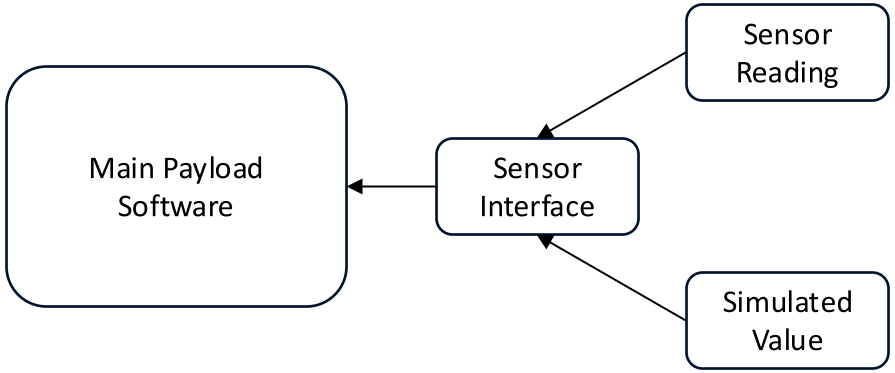
- Command Line Interface
- Diagnostics and pre-flight checks

Hardware In the Loop Testing

- Simulate mock-flights on the ground
- Backdoors on peripheral readings

Logging

- Data logging on a micro-SD card
- Analysis of rocket flight profile
- History of payload software milestones for debugging



Backdoor System for Simulation

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Rocket Recovery Subsystem (RRS)

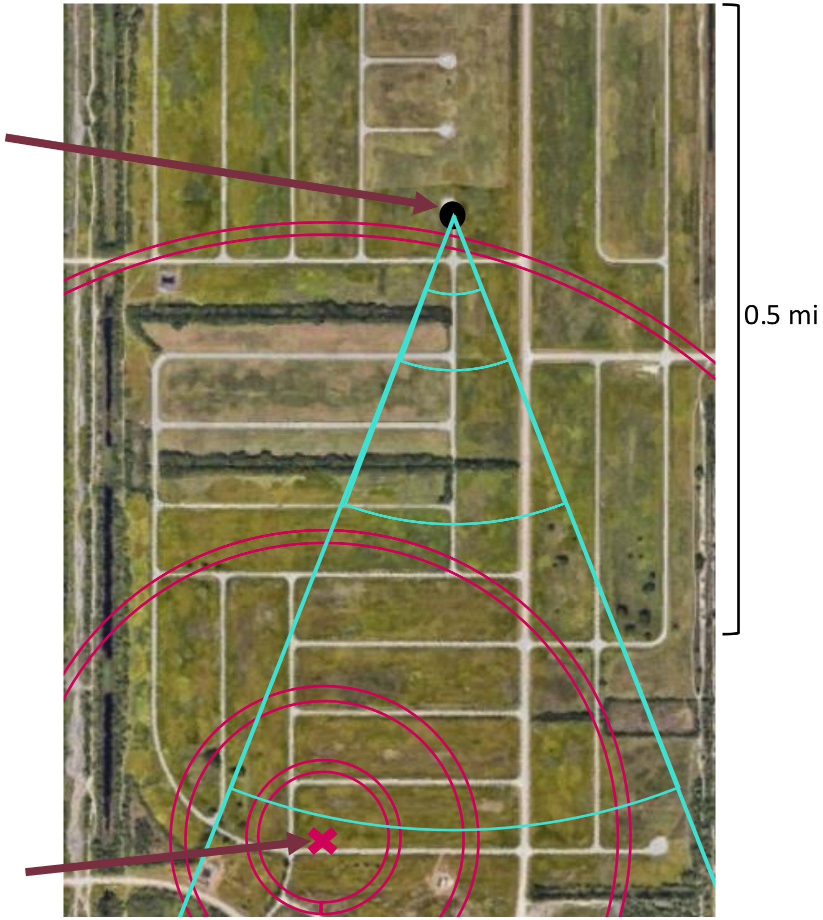
Situation

- Subscale Flight 3 near loss of vehicle
- GPS and high-power RF hardware on board to aid recovery efforts

Solution

- The RRS program upon landing transmits GPS
- Low GPS visibility will transmit, chirps to the directional antenna

Launch Site
Single & multi-directional antenna



Landing Site
Payload sends GPS or chirp transmissions

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Dwight

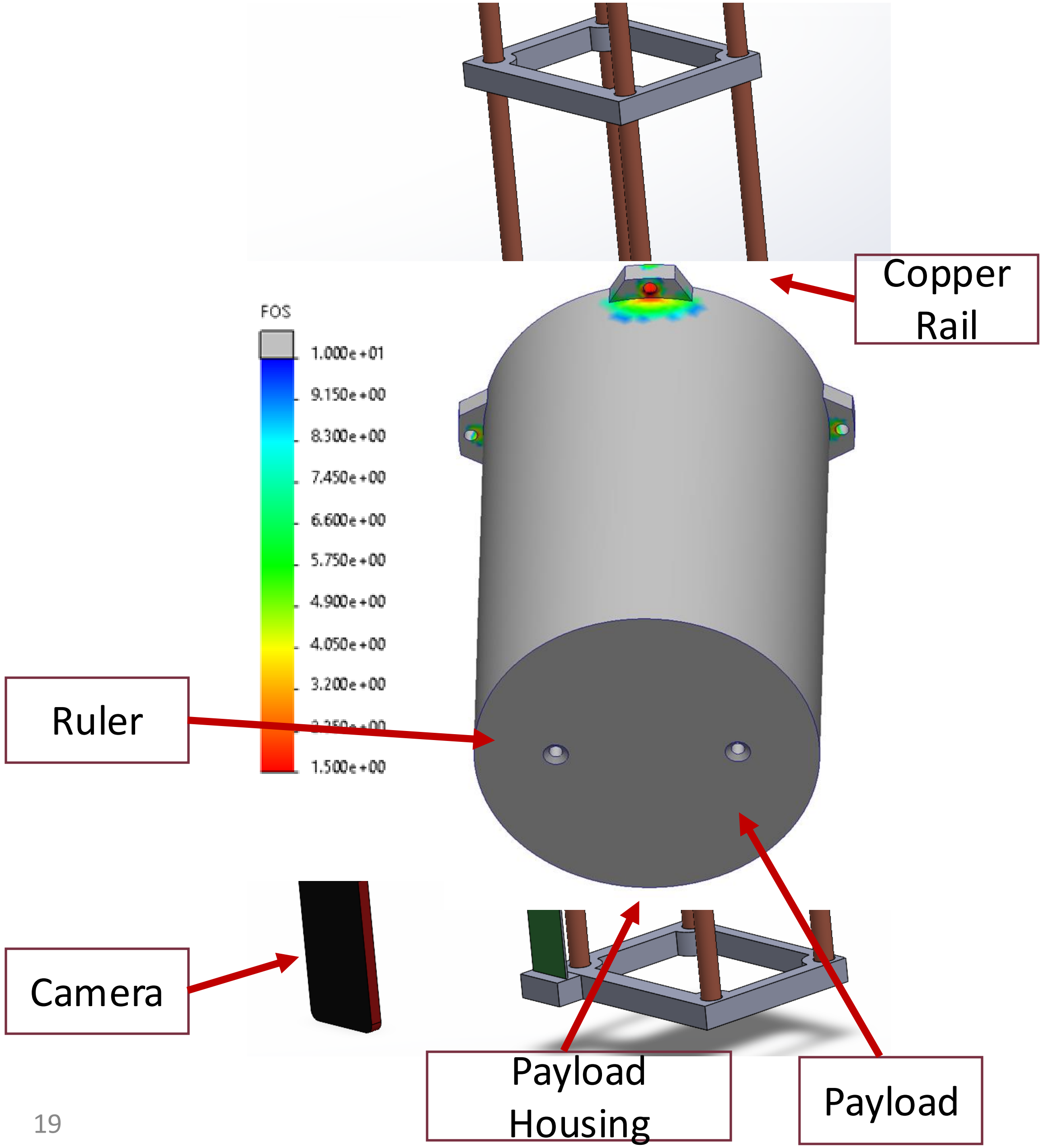
Testing

<u>FEA Testing</u>

- Structural integrity of the flanges
- Analyzed worst case landing condition

<u>Horizontal Displacement Testing</u>

- Displacement of Separators
- Integrity of electronic boards



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Budget Updates

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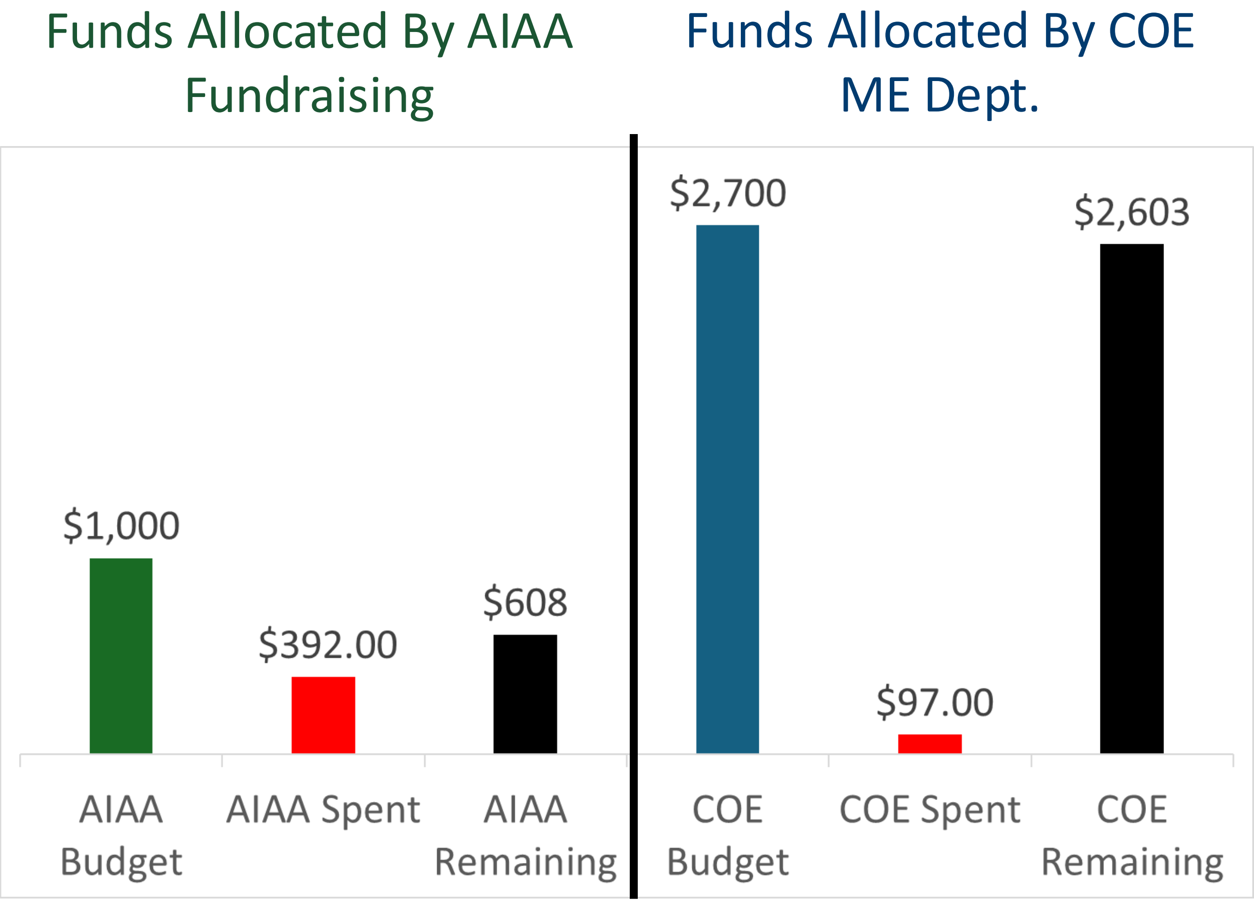
AIAA Budget

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

COE Budget

- Plans to use for testing
- More than $500 to be spent on Nylon-12 for backup payload parts
- Remaining funds will be re-allocated to Team 508



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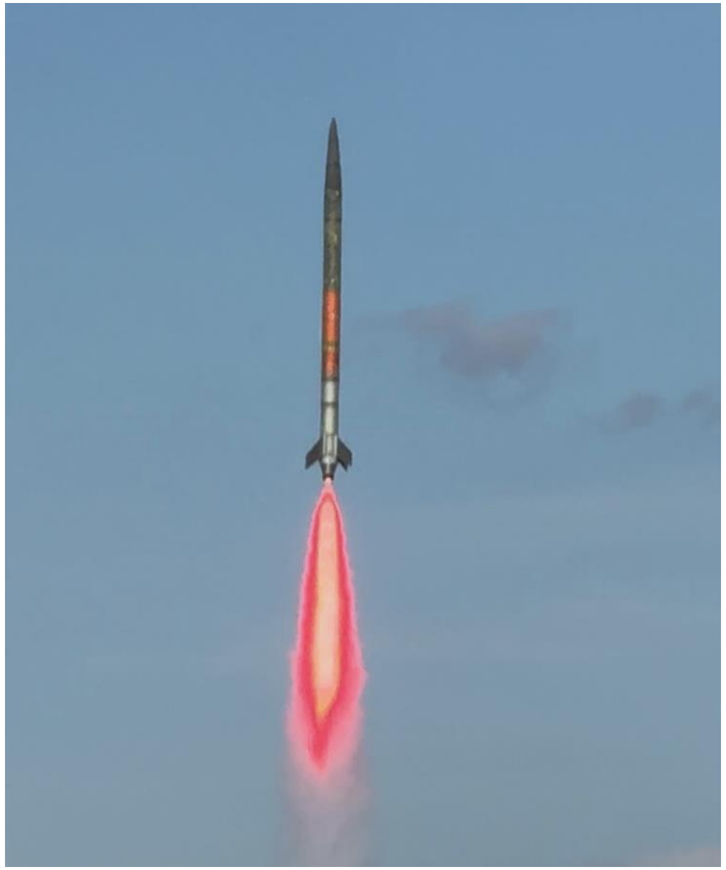
Future Work

- Flight Readiness Review (FRR) report – March 17
- Continued Testing
    1. IMU/Altimeter verification
    2. Rocket Recovery System (RRS testing)
    3. Impact Testing
    4. Vibrational Testing
- First Launch TBD



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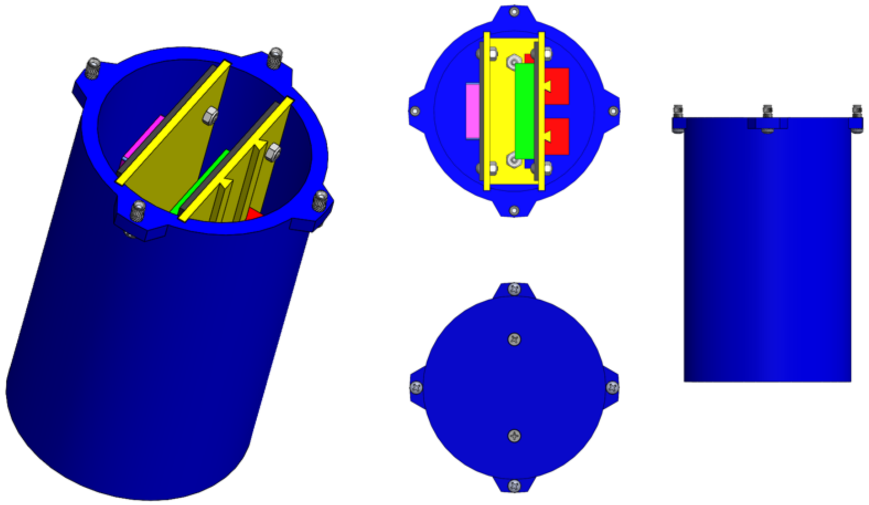
Thank you for listening!



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Scope

Design a payload with a built-in factor of safety for the STEMnauts

Transmit flight data after landing which ensures the success of the flight

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Kyle Mahoney

Subscale Flights

Intact heat inserts post launch

Subscale Flights 1 & 2

- Recovery system failure
- Heat inserts in nylon-12 parts performed **remarkably**
- Demonstrated flight stability of the rocket with payload mass simulator

Adversarial terrain

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

Successful recovery of payload mass simulator

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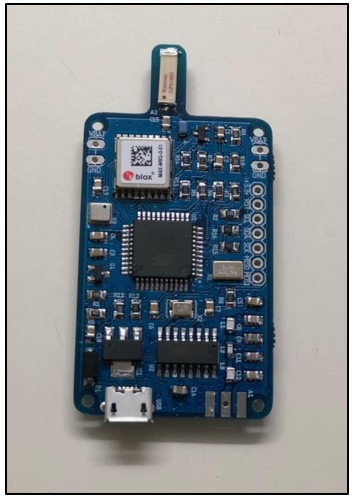
Electronics Design

Electronics Modules

- **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

Electrical Connections

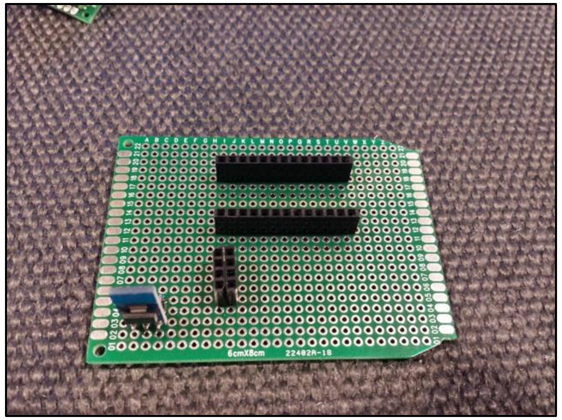
- **Intra-Tray Connections –** Perfboards with soldered connections, pin headers for breakout boards
- **Inter-Tray Connections –** 4-pin Molex KK cables to connect the trays to one another
- **Switches and Indicators –** Screw switches and LEDs



LightAPRS – Contains the Microcontroller and RF modules for the payload.

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

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



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

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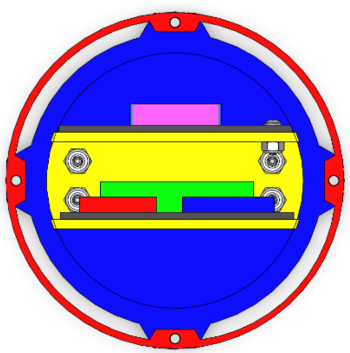
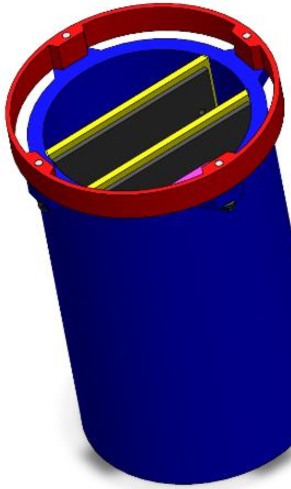
Initial Design Overview:

Structural Design Overview

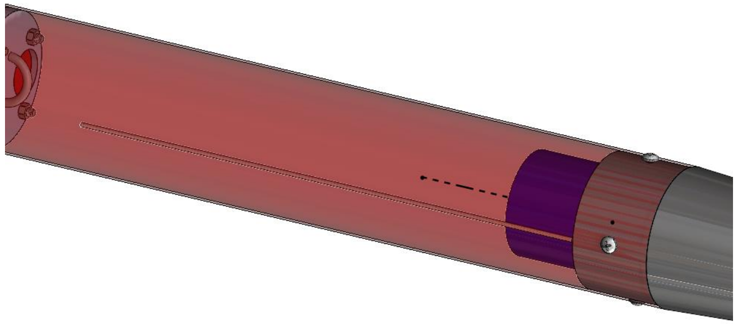
- **Structural Body -** SLS-printed Nylon-12
- **Mounting Method -** AL6061 bracket, epoxied to nosecone
- **Chambers –** Three separate areas for Data collection, Transmission, and STEMnauts
- **Electronics –** Stored on trays inside the capsule





Electrical Design Overview

- **Electronics Trays -** RF, Sensor, STEMnauts
- **Sensors –** Payload IMU, Altimeter and STEMnaut IMU's connected via I2C
- **Transmitter –** APRS tracker
- **Antenna –** 50cm copper wire



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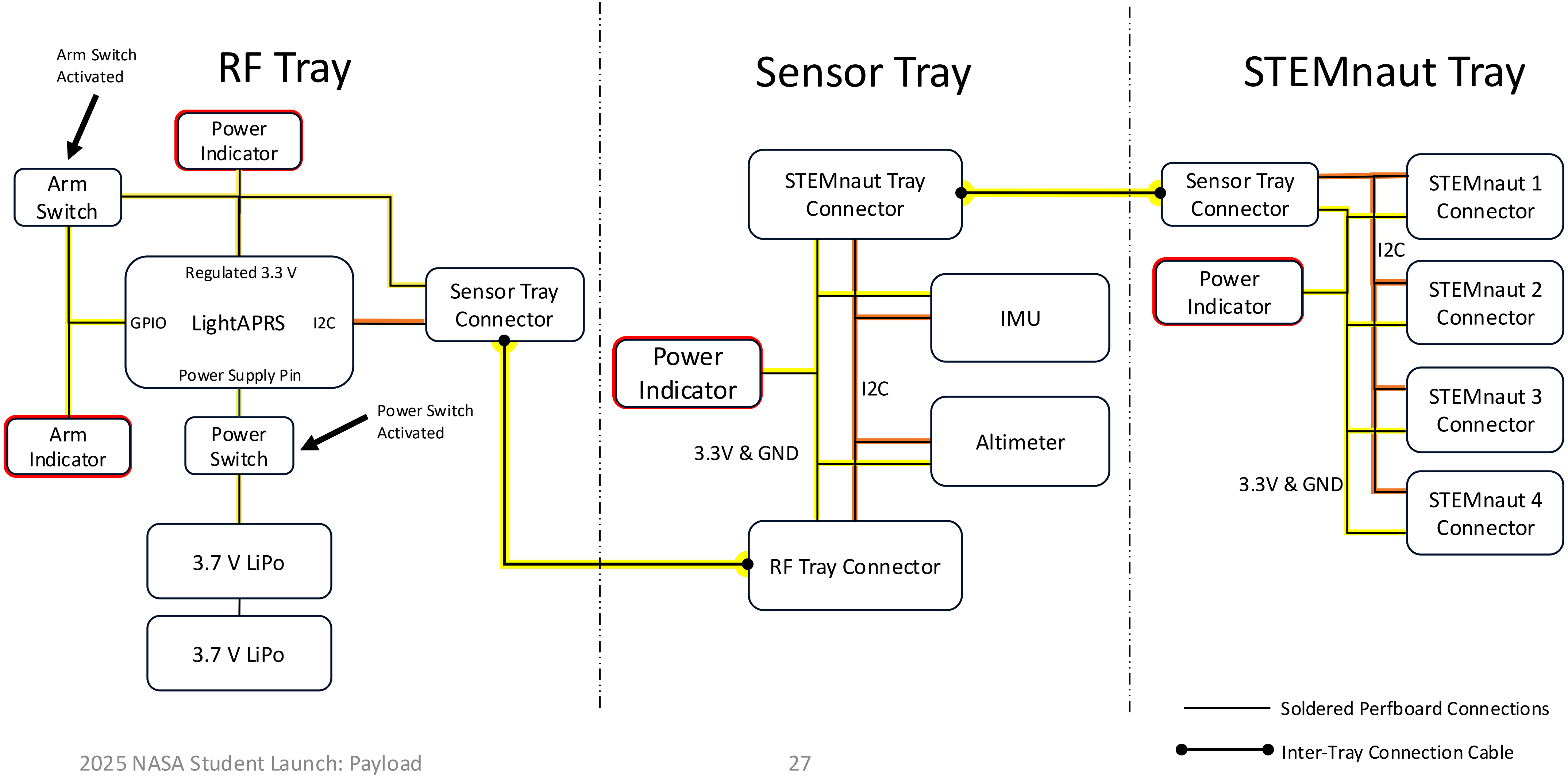
Electronics Block Diagram



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Data Collection Design

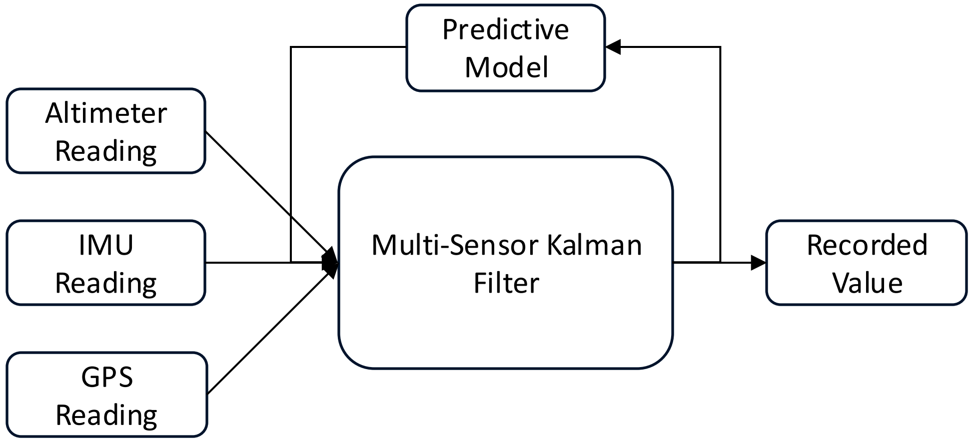
Sensor Fusion by Multi-Sensor Kalman Filter

- **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

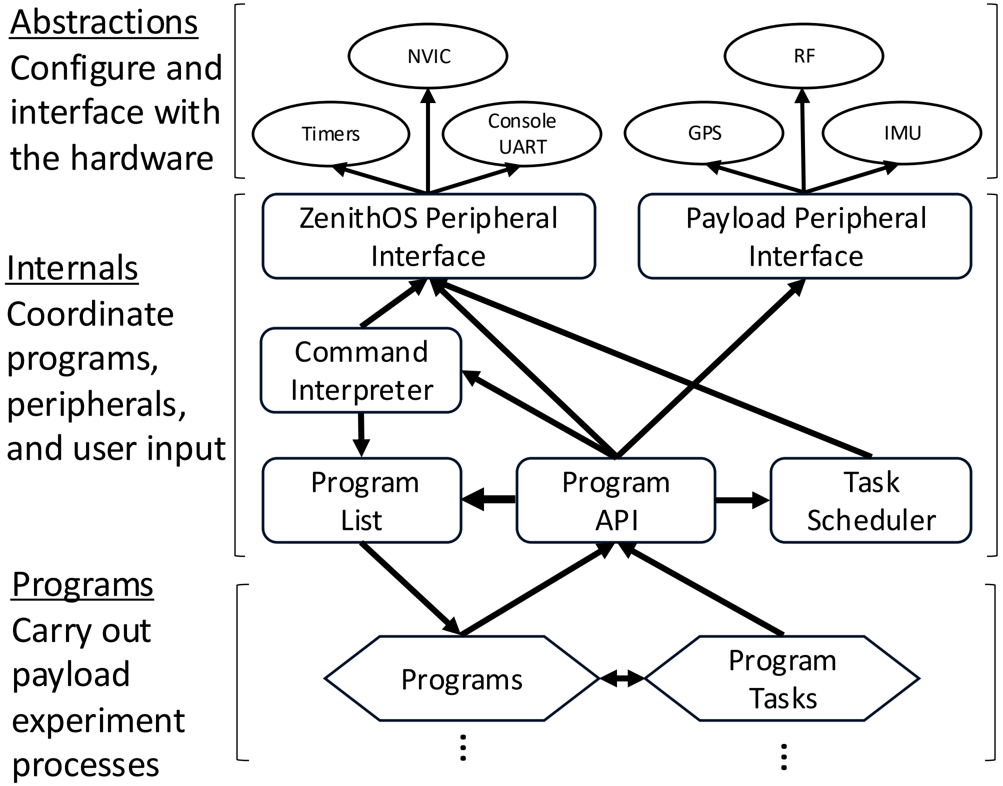
Payload Software Requirements

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

ZenithOS 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

ZenithOS Block Diagram



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Target
Acceptable
Unacceptable

Project Targets

STEMnaut Safety

Structural Damage
(Degree of Damage)

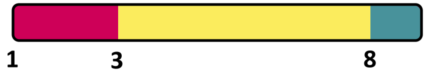
STEMnaut Acceleration
(g)

STEMnaut Displacement
(in)

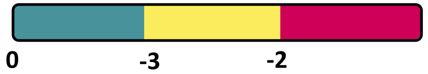
Payload Fastener
(lbf Pull Out Load)

Data Measurement

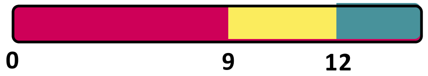
Number of Data Metrics
(Quantity)



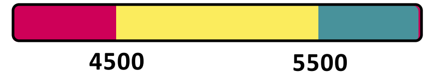
Data Precision
(Log Normalized Error)



Measurable Acceleration
(g)

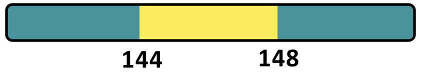


Measurable Altitude
(ft)

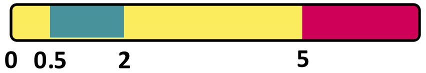


Data Transmission

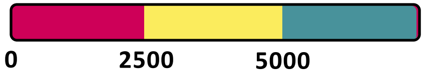
Selectable Frequencies
(MHz)



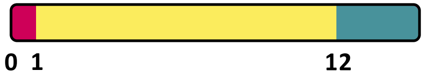
Transmission Power
(W)



Receivable Distance
(ft)



Number of Transmissions
(Quantity)



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