2025 NASA Student Launch

Team 509: Payload

Virtual Design Review Two

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Team Introductions

Matthew Archibald
ME - Structural Engineer

Donovan Dwight
ME - Test Engineer

Nathan Hardie
CE - Communications Systems Engineer

Kyle Mahoney
ME - Fabrication 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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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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Project Association

<u>University Association</u>
FAMU-FSU College of Engineering
ME Department

<u>Government Association</u>
National Aeronautics and Space Admiration (NASA)

<u>Club Association</u>
American Institute of Aeronautics and Astronautics (AIAA)

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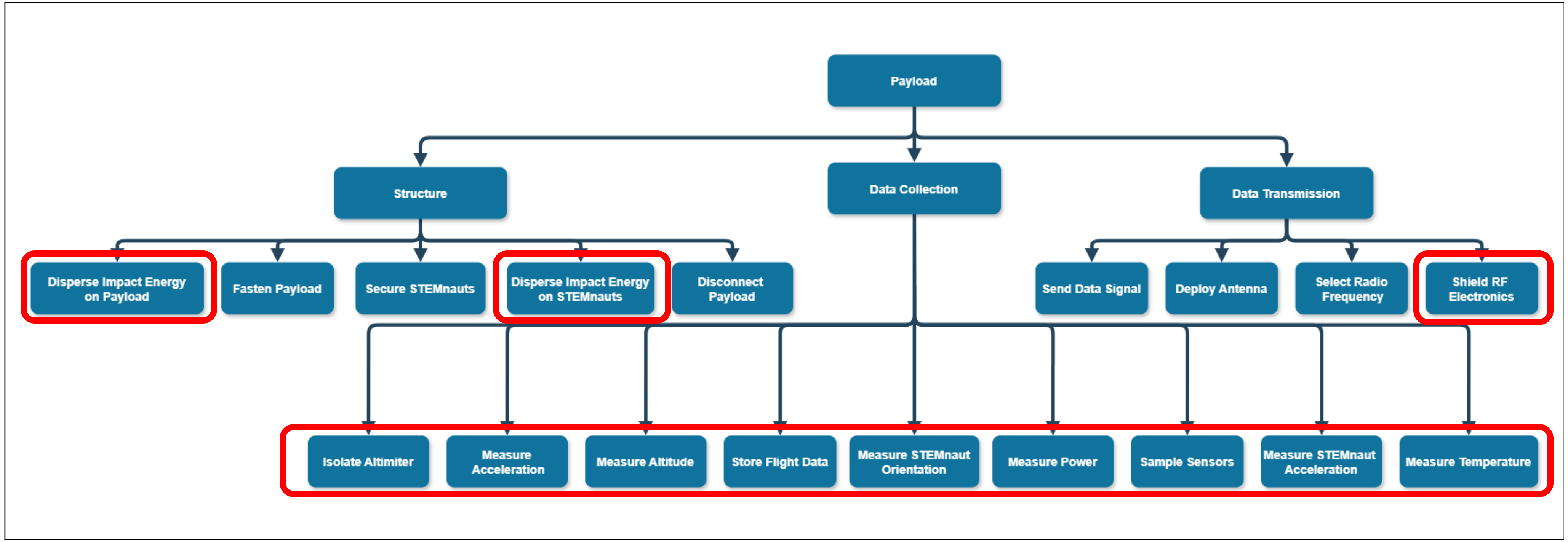
Updated Functional Decomposition



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Targets and Metrics

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Function	Target	Metric
Fasten Payload	41.02 lbf	Pull out load
Secure STEMnauts	0.09 in	Physical Displacement
Disperse Impact Energy on STEMnauts	9 G	Acceleration
Disperse Impact Energy on Payload Body	2	Degree of Damage
Measure Altitude	0-5500 ft	Measure Range
Measure Acceleration	0-10 g	Measure Range
Measure Temperature	0-38 Celsius	Measure Range
Measure STEMnaut Acceleration	0-10 G	Measure Range
Select Radio Frequency	144-148 MHz	Frequencies of Operation
Sample Sensors	20 Hz	Sample Frequency
Send Data Signal	5W	Transmission Power

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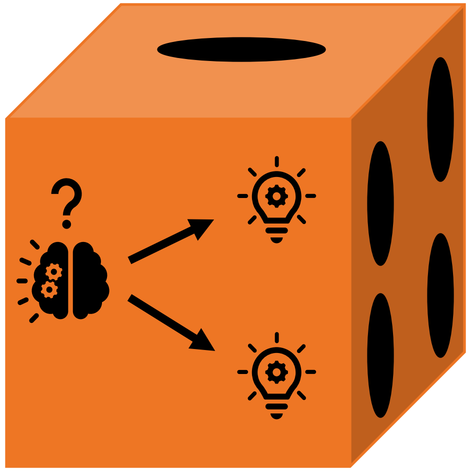
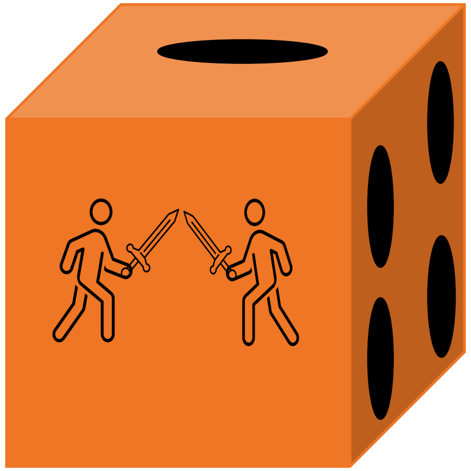
Concept Generation

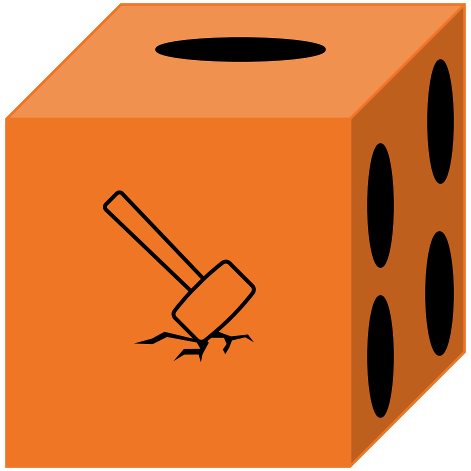
Crapshoot



Morphological Chart



Battle of Perspectives



Forced Analogy

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Concept Generation – Medium Fidelity

1. Adding a compartment to the payload using the outer openings in the CAD design will create more space for sensors and STEMnauts, allowing for separation of components and reducing interference.
2. Integrating all electronic modules into a single custom PCB within the payload will minimize space, creating room for more STEMnauts or a smaller capsule.
3. Design where all electronic modules are integrated into a single custom PCB, optimizing space for more STEMnauts or a smaller capsule.
4. In this concept, the payload's structure is the rocket's nosecone, with data collection systems mounted on trays that slide into slots, secured by external bolts, and a permanently deployed radio antenna at the tip.
5. This concept uses airbags in smaller compartments to cushion the payload’s fall, ensuring STEMnauts’ safety, with sensors to activate the airbags upon impact, based on the crap shoot method.

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Concept Generation – High Fidelity

1

The first concept features a small cylindrical capsule mounted below the rocket's nosecone, housing the payload's electronics, with a separator for electronic trays and a permanently deployed radio antenna, secured with screws and epoxy.

2

Includes a deployable antenna extending through the nosecone, with a linear motor to extend it and the radio module mounted at the top-center of the capsule, requiring coordination with the rocket team for deployment.

3

This payload design builds on Concept 1, using the same attachment flanges and sliding electronic trays, while adding motors and flaps to reorient the payload for antenna clearance, with the final antenna configuration pending coordination with the rocket team.

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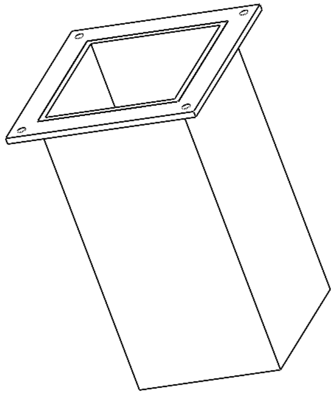
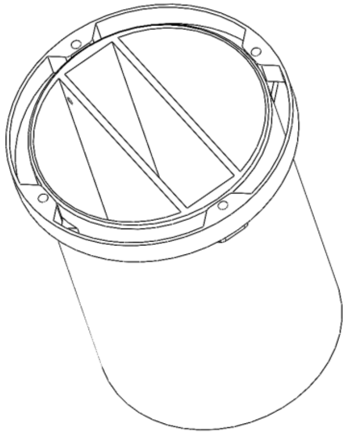
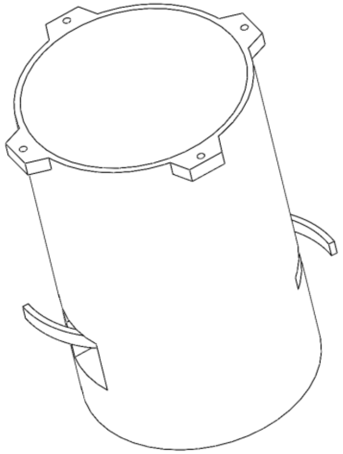
Important Design Features



- Rectangular body
- Welded Flange
- Components mount to inner wall



- Mounting bracket
- 3D printed body
- Components mount to divider inside body



- Flaps installed to reorientate capsule
- Motors fixed to 3D printed body
- No mounting bracket

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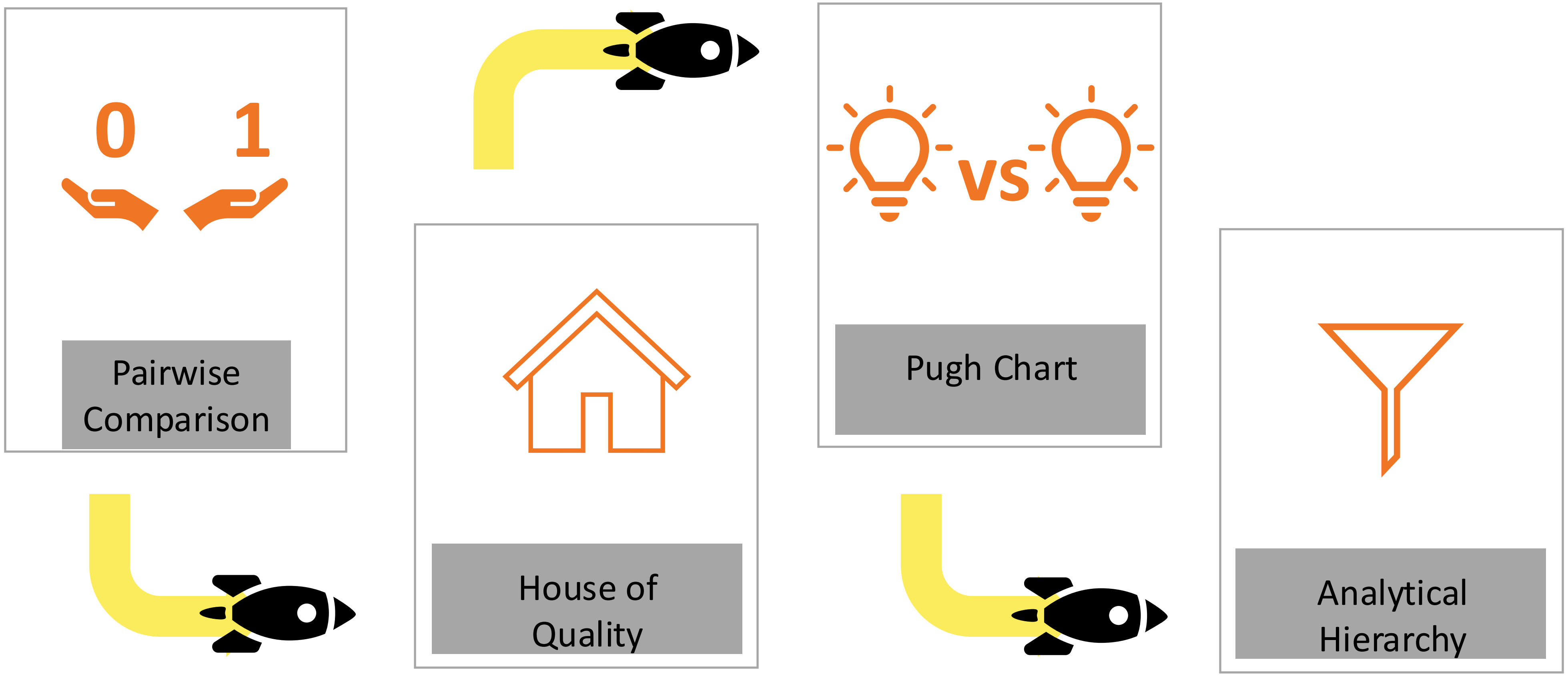
Concept Selection Process



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Pairwise Comparison

Pairwise Comparison	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	Total
1. STEMnauts must be creative representations	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. The payload must transmit on a 2m-band	1	-	1	1	0	1	1	1	0	1	1	0	1	1	0	10
3. Payload must transmit at specific frequencies	1	0	-	0	0	1	1	0	0	0	0	0	1	1	0	5
4. Payload must be compatible with an FTM-300DR	1	0	1	-	0	1	1	1	0	1	1	0	1	1	0	9
5. Payload must abide by all NAR and FAA regulations	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1	14
6. Payload must not protrude more than 0.25" from the rocket	1	0	0	0	0	-	1	1	0	1	1	0	1	1	0	7
7. Transmission of radio signal must be controlled by the operator	1	0	0	0	0	0	-	0	0	1	0	0	1	1	0	4
8. Payload must transmit at or below 5W of power	1	0	1	0	0	0	1	-	0	1	1	0	1	1	0	7
9. Payload must structurally withstand rocket's landing conditions	1	1	1	1	0	1	1	1	-	1	1	1	1	1	1	13
10. Payload must transmitt a variety of data	1	0	1	0	0	0	0	0	0	-	0	0	0	0	0	2
11. Payload must have an independent power source	1	0	1	0	0	0	1	0	0	1	-	0	1	1	0	6
12. Payload's electronics must be independent from rocket's	1	1	1	1	0	1	1	1	0	1	1	-	1	1	0	11
13. Location of payload must not negatively impact rocket's flight	1	0	0	0	0	0	0	0	0	1	0	0	-	0	0	2
14. Payload must not pull above the multitude of gravitational accelaration that a human can survive	1	0	0	0	0	0	0	0	0	1	0	0	1	-	0	3
15. Payload can withstand flight stresses	1	1	1	1	0	1	1	1	0	1	1	1	1	1	-	12
	14	4	9	5	0	7	10	7	1	12	8	3	12	11	2	n-1 = 14
Check	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	

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House of Quality

Improvement Direction		↑	↓	↓	↓	↑	↑	↑	↑	-	↑	↓
Units		lbf	in	G	-	ft	G	°C	G	MHz	Hz	W
Customer Needs	Importance Weight Factor	Fasten Payload	Secure STEMnauts	Disperse Impact Energy on STEMnauts	Disperse Impact Energy on Payload Body	Measure Altitude	Measure Accelaration	Measure Temperature	Measure STEMnaut Accelaration	Select Radio Frequency	Sample Sensors	Send Data Signal
1. STEMnauts must be creative representations	0	1	7	7	1	1	1	1	5	1	1	1
2. The payload must transmit on a 2m-band	10	1	1	1	1	5	5	5	5	9	5	9
3. Payload must transmit at specific frequencies	5	1	1	1	1	5	5	5	5	9	5	9
4. Payload must be compatible with an FTM-300DR	9	1	1	1	1	5	5	5	5	9	3	9
5. Payload must abide by all NAR and FAA regulations	14	7	3	5	5	3	3	3	7	3	3	5
6. Payload must not protrude more than 0.25" from the rocket	7	5	3	3	3	1	1	1	1	1	1	9
7. Transmission of radio signal must be controlled by the operator	4	1	1	1	1	3	3	3	3	7	3	3
8. Payload must transmit at or below 5W of power	7	1	1	1	1	3	3	3	3	5	5	9
9. Payload must structurally withstand rocket's landing conditions	13	9	9	9	9	1	1	1	1	1	1	1
10. Payload must transmitt a variety of data	2	1	1	1	1	9	9	9	9	1	9	7
11. Payload must have an independent power source	6	3	1	1	1	5	5	5	5	3	3	7
12. Payload's electronics must be independent from rocket's	11	3	1	1	1	9	9	9	9	5	9	3
13. Location of payload must not negatively impact rocket's flight	2	7	3	1	3	1	1	1	1	1	1	1
14. Payload must not pull above the multitude of gravitational accelaration that a human can survive	3	3	9	9	7	1	1	1	1	1	3	1
15. Payload can withstand flight stresses	12	7	5	5	9	1	1	1	1	1	1	1
Raw Score	3092	445	327	351	397	379	379	379	435	433	369	543
Relative Weight Percent (%)		14.39	10.58	11.35	12.84	12.26	12.26	12.26	14.07	14.00	11.93	17.56
Rank Order		2	11	10	5	6	6	6	3	4	9	1

Shows us customer needs compared to engineering characteristics

Rank all the characteristics to the customer's needs

Top 5: Send Data Signal, Fasten Payload, STEMnaut Acceleration, Select Radio Frequency, Disperse Impact Energy of Payload Body

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Pugh Chart 1

Selection Criteria	Criteria Weight	Zenith 1 Rectangular Prism Design	Concepts							
			Cylindrical capsule below nosecone, electronic trays to house sensors, fixed antena, single custom PCB	Cylindrical capsule, electronic trays to house sensors, deployable antenna out top of rocket	Cylindrical capsule below nosecone, electronic trays to house sensors, flaps on payload to reorientate payload while on the ground	Cylindrical capsule, an extra tray to house the stemnauts and sensors independently, mounts to nosecone	Shock absorbing foam, storing velocity, acceleration, apogee, antenna sticking out the top of rocket	Cylindrical capsule , electronic modules all separate	Data collection and transmission mounted onto trays that slide into nosecone of the rocket, bolts would mount the trays, antenna permantly deployed from the noseconse	Airbag cushion structure , compartments for the sensors and STEMnauts, and a fixed antenna
Send Data Signal	17.56%	Datum	S	+	S	S	S	S	S	S
Fasten Payload	14.39%		+	+	S	S	S	S	-	-
Measure STEMnaut Acceleration	14.08%		+	S	S	-	S	+	S	-
Select Radio Frequency	14.00%		S	S	S	S	S	+	S	S
Disperse Impact Energy on Payload Body	12.84%		+	+	-	+	+	S	-	+
Number of (+)			3	3	0	1	1	2	0	1
Number of (-)			0	0	1	1	0	0	2	2

Process Overview

- Compare generated concepts to selected datum based on selection criteria
- Concepts ranked based on amounts of plus and minus signs
- Results in four concepts with no minuses moving on to the next stage of Pugh, and another datum being established

Top Concepts

1) Cylindrical capsule below nosecone, electronic trays for sensors, fixed antenna, custom PCB
2) Cylindrical capsule, electronic trays for sensors, deployable antenna out top of rocket
3) Shock absorbing foam, storing velocity, acceleration, apogee, antenna protruding from cone
4) Cylindrical capsule, electronic modules all separate

Pugh Chart 2

Selection Criteria	Criteria Weight	Cylindrical capsule, an extra tray to house the stemnauts and sensors independently , mounts to nosecone	Concepts			
			Cylindrical capsule below nosecone, electronic trays to house sensors, fixed antenna, single custom PCB	Cylindrical capsule, electronic trays to house sensors, deployable antenna out top of rocket	Shock absorbing foam, storing velocity, acceleration, apogee, antenna sticking out the top of rocket	Cylindrical capsule , electronic modules all separate
Send Data Signal	17.56%	Datum	S	+	S	S
Fasten Payload	14.39%		+	S	-	S
Measure STEMnaut Acceleration	14.08%		S	S	S	+
Select Radio Frequenecy	14.00%		S	S	S	S
Disperse Impact Energy on Payload Body	12.84%		+	S	+	S
Number of (+)			2	1	1	1
Number of (-)			0	0	1	0

Process Overview

- New datum established from previous Pugh chart
- Compare top concepts to new datum based on selection criteria
- Results in 3 concepts which proceed to the analytical hierarchy stage
- Elimination of one concept occurs

Top Concepts

1) Cylindrical capsule below nosecone, electronic trays for sensors, fixed antenna, custom PCB
2) Cylindrical capsule, electronic trays for sensors, deployable antenna out top of rocket
3) Cylindrical capsule, electronic modules all separate

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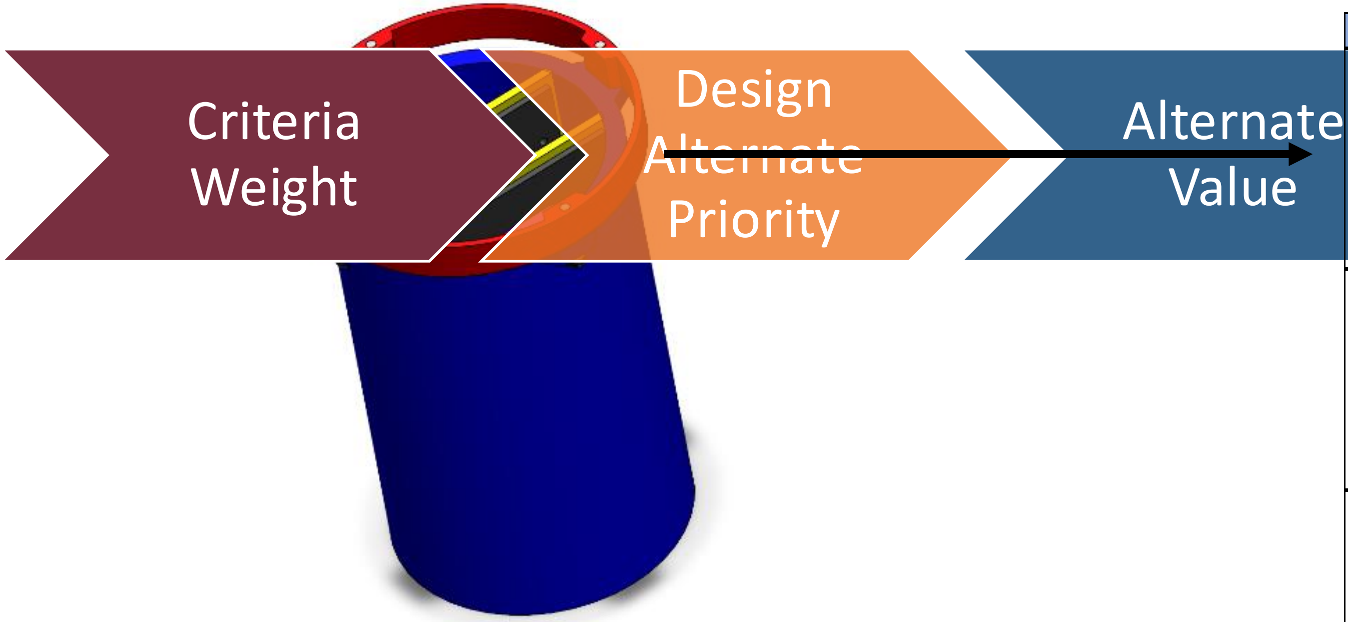
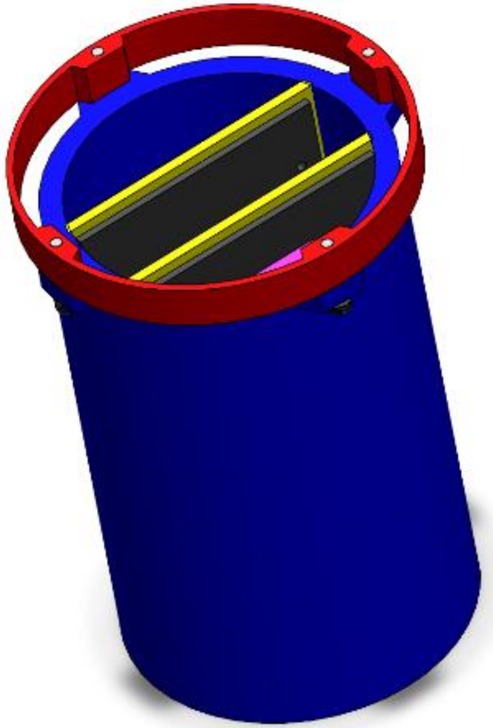
Analytical Hierarchy



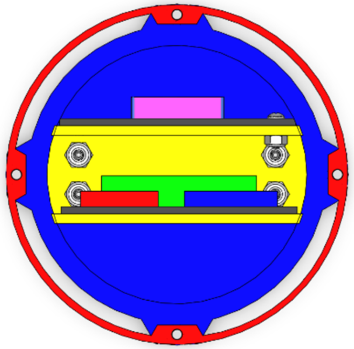
Concept	Alternate Value
Cylindrical capsule below nosecone, electronc trays to house sensors, fixed antena, single custom PCB	0.475
Cylindrical capsule, electronic trays to house sensors, deployable antenna out top of rocket	0.404
Cylindrical capsule , electronic modules all separate	0.121

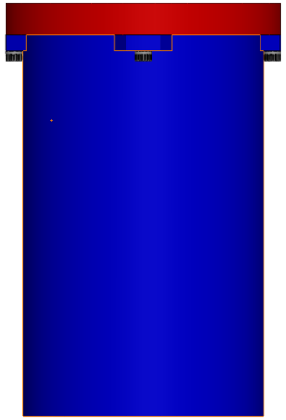
Final Selected Concept



Design Overview

- **Nylon-12 Capsule -** 3D-printed, FSU Innovation Hub (blue)
- **Mounting -** AL6061 bracket, secured in rocket's nosecone with high-strength epoxy
- **Chambers –** Three chambers separated by AL6061 divider (yellow)
- **Electronics –** Stored on trays inside capsule (black)
- **STEMnauts –** Housed in a single chamber of the payload





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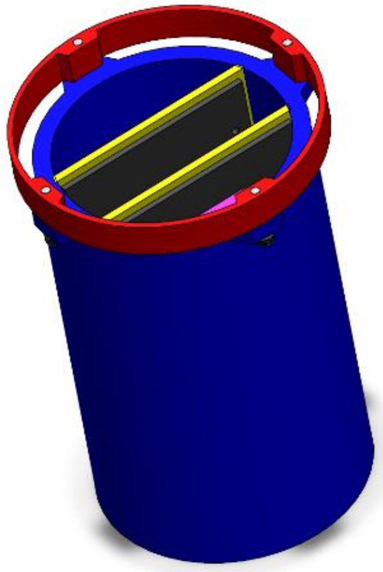
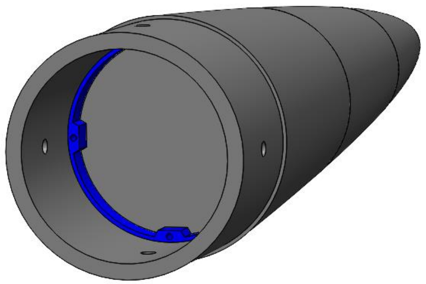
Structural Design

- <u>Mounting System:</u>
  - Payload mounting at base of nosecone
  - AL6061 mounting bracket (red)
  - #8-32 x ¾” mounting fasteners (4x)
- <u>Housing:</u>
  - 3D printed Nylon-12
- <u>Chambers:</u>
  - AL6061 chamber divider (yellow)
  - Three chambers: transmission, data collection, STEMnaut chambers





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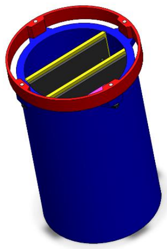
Payload Housing



Data Transmission Chamber

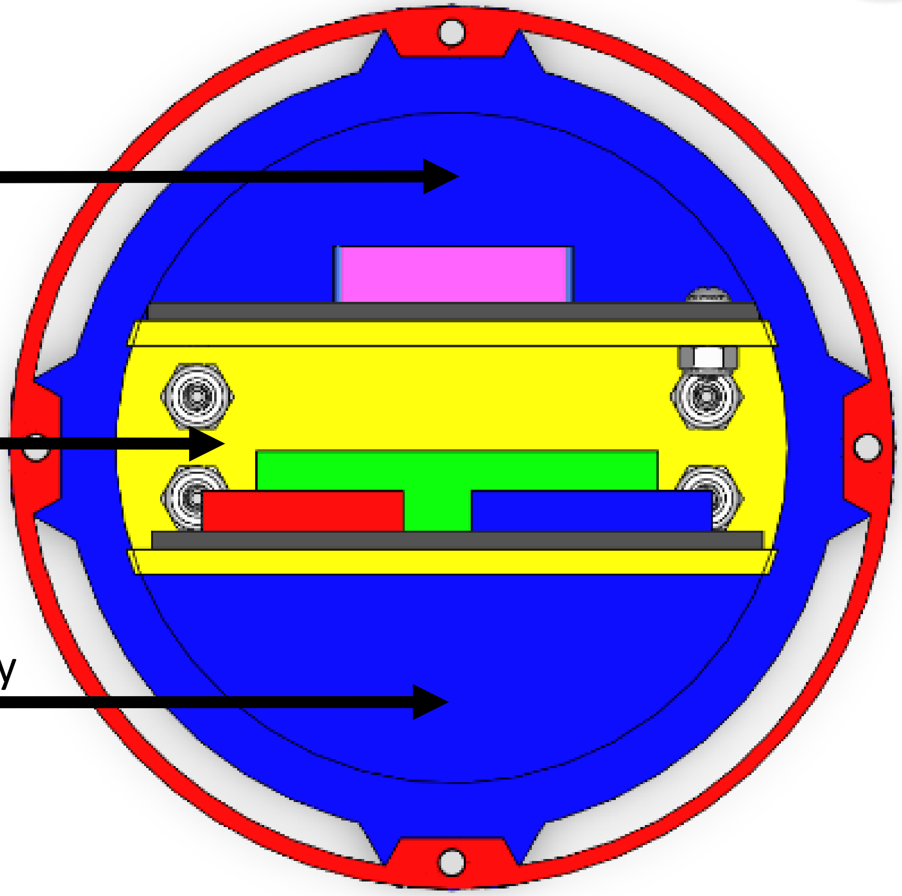
- Contains RF module
- Communicates with radio transceiver

Data Collection Chamber

- Contains sensors and power supply
- Stores and collects data from flight

STEMnaut Housing Chamber

- Contains the STEMnauts
- Updates STEMnaut orientation and survivability



Payload Top View

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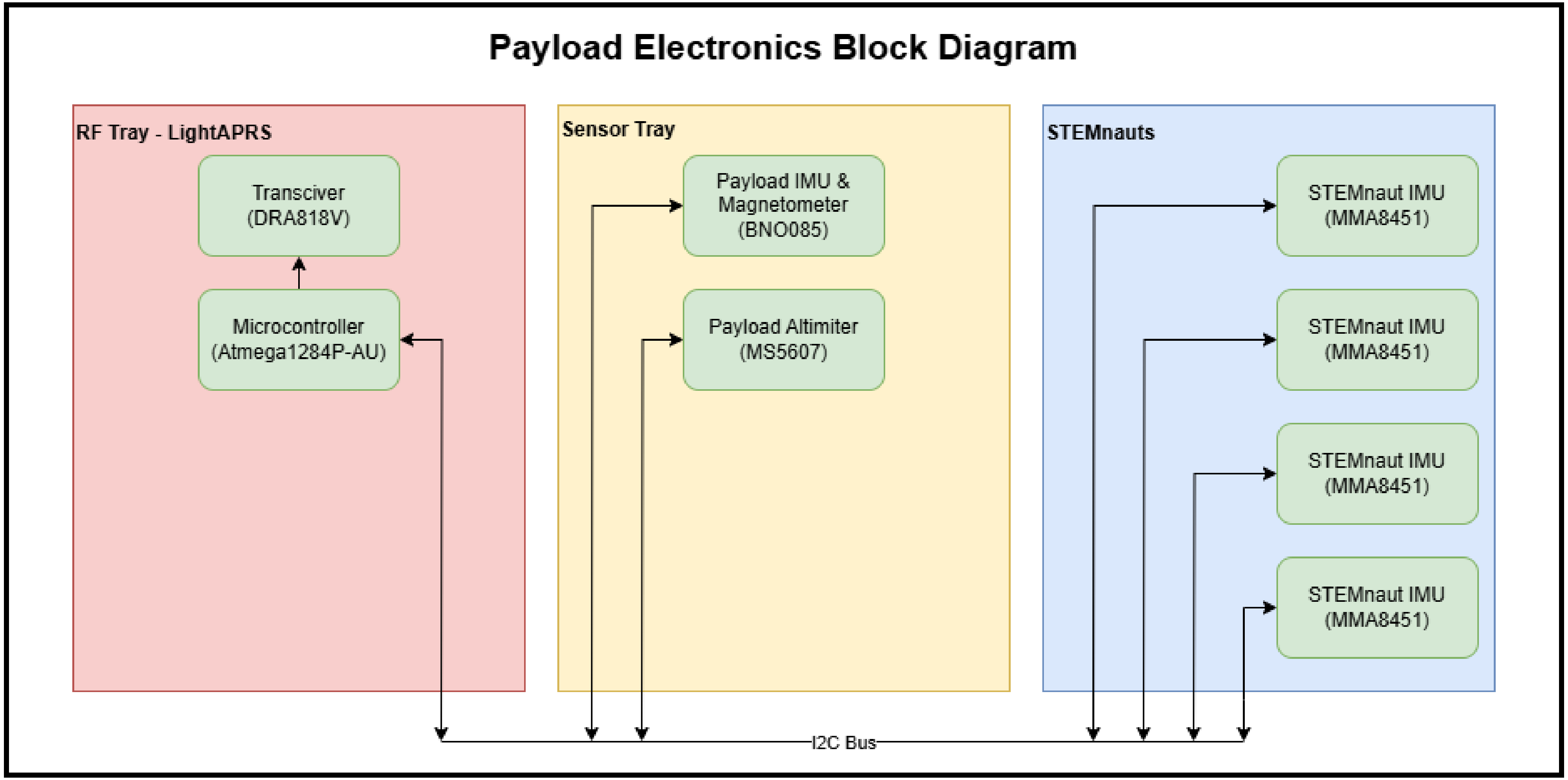
Electronics Design



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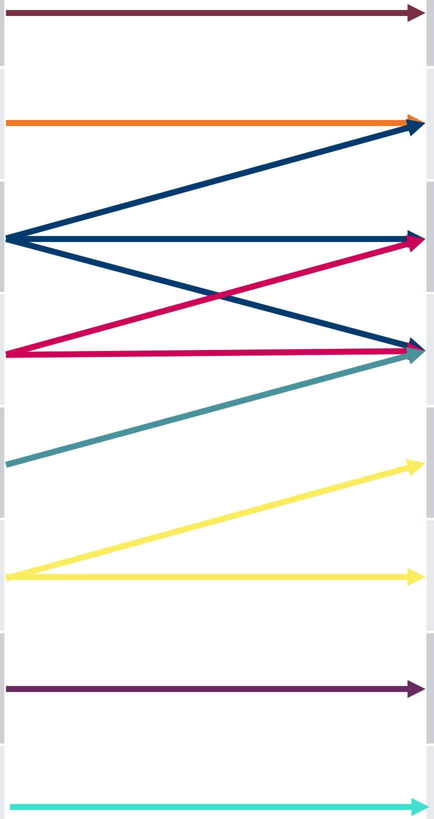
Sensor Assignments

Piece of Data
Temperature of landing site
STEMnaut survivability
Landing velocity, G-forces sustained
Maximum velocity
Apogee reached
Orientation of on-board STEMnauts
Time of landing
Battery check/power status



Sensor
Thermometer
STEMnaut Accelerometer
Payload Accelerometer
Altimeter
Payload Gyroscope
STEMnaut Gyroscope
Digital Timer
Analog to Digital Converter (ADC)

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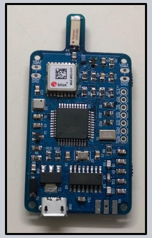
Component Selection

Module	Location	Leading Product	Function
Altimeter Module	Tray 1	MS5607 	Thermometer Altimiter
STEMnaut IMU Module	On STEMnaut flight suits (x4)	MMA8451 	STEMnaut Gyroscope STEMnaut Accelerometer
Payload IMU Module	Tray 1	BNO085 	Payload Gyroscope Payload Accelerometer
RF Transceiver & Microcontroller	Tray 2	LightAPRS 	Digital Timer Analog to Digital Converter (ADC) Transciver

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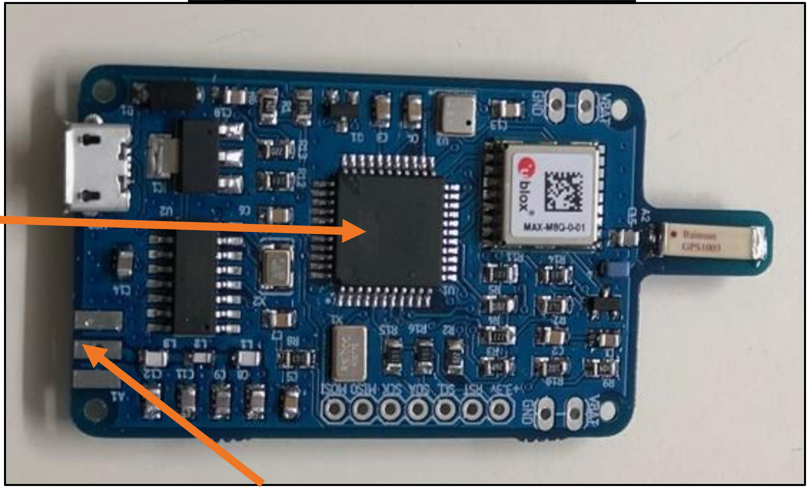
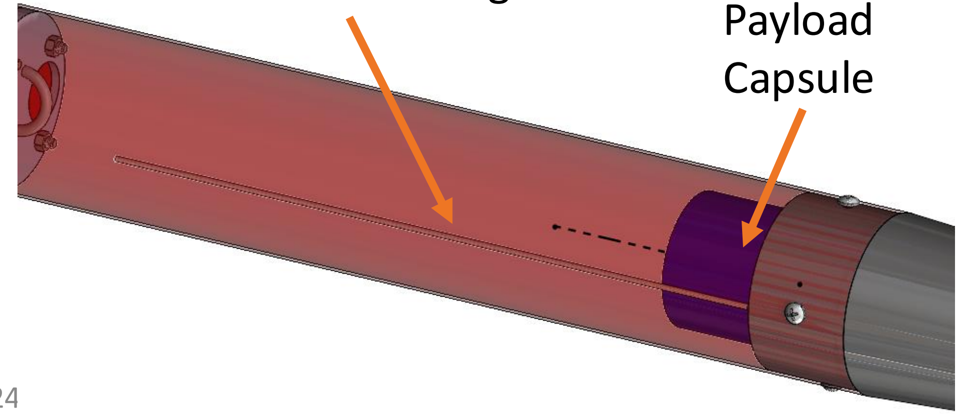
Transmitter Design

- Fixed Antenna:
  - 50 cm copper wire
  - Mounted coincident to the inside of the fuselage
  - Connected to RF module
- Projected Attenuation:
  - Must transmit through Nylon-12 and G12 Fiberglass
  - 2.2% loss at worst case orientation
- Transmission Protocol:
  - APRS packets
  - Telemetry format

LightAPRS – RF module





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Future Work

- Prototyping and Testing
- Spring Project Plan
- Full Scale Fabrication and Testing
- Subscale Mass Simulant
- Critical Design Review (CDR)

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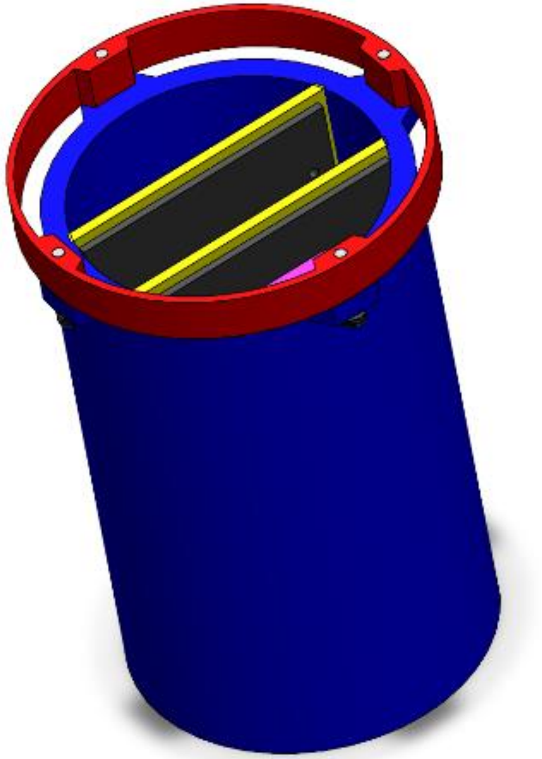
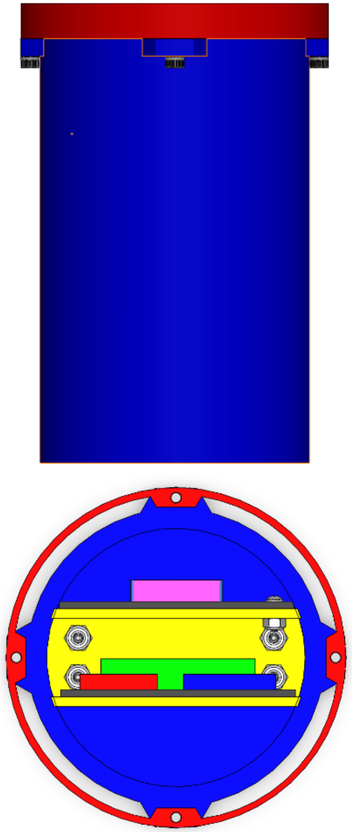
Thank you for listening!





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