Project Wolf

Critical Design Review

PSP-SL 2025

Purdue University Executive Board

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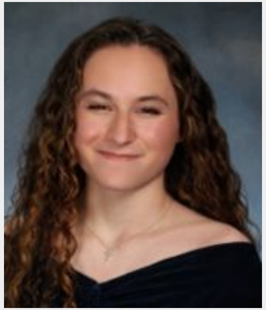

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Avionics Lead
Payton Gross

Payload Lead
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R&D Lead
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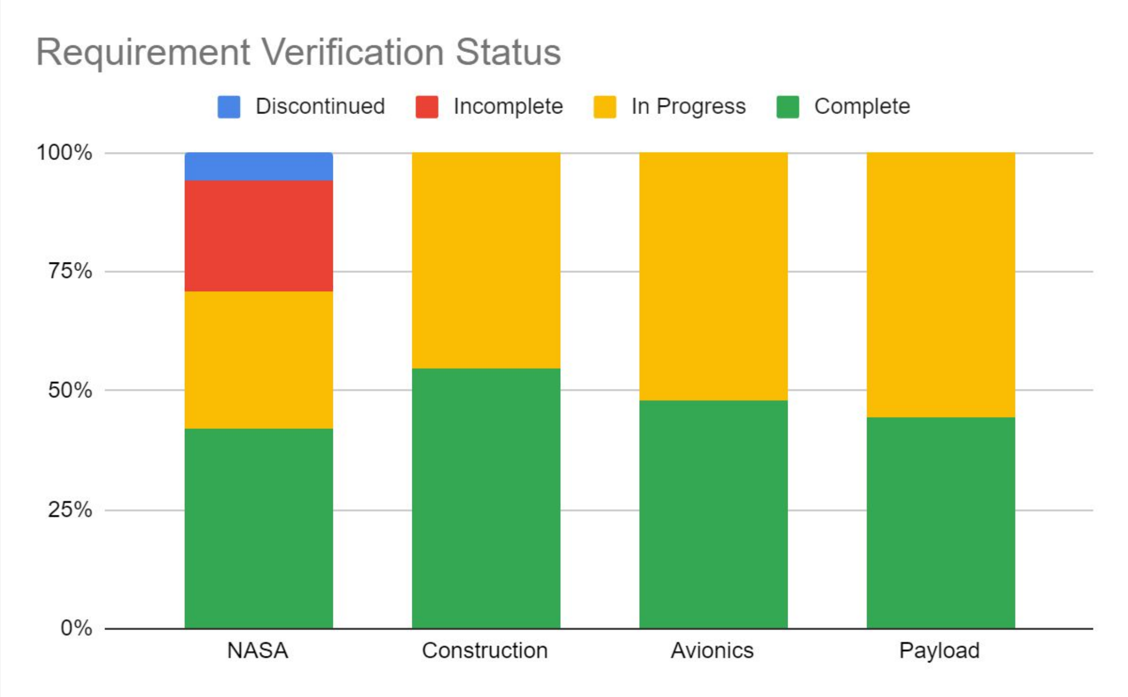
Changes Since PDR

- Length of Booster and Lower Recovery Airframe
- Fin Design
- Payload design

R&VP Plan

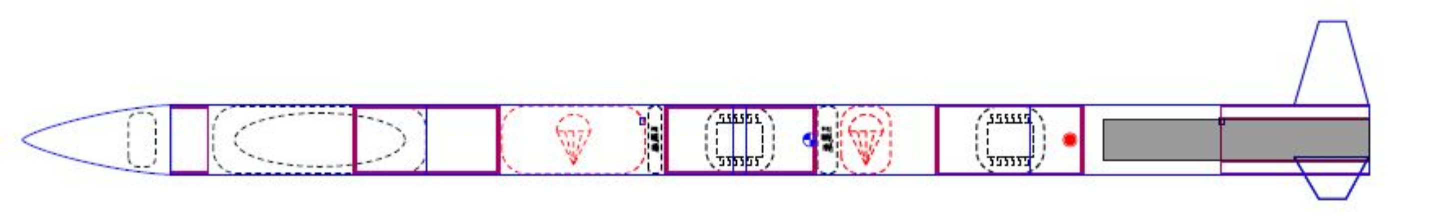
Requirement Verification Progress



Construction

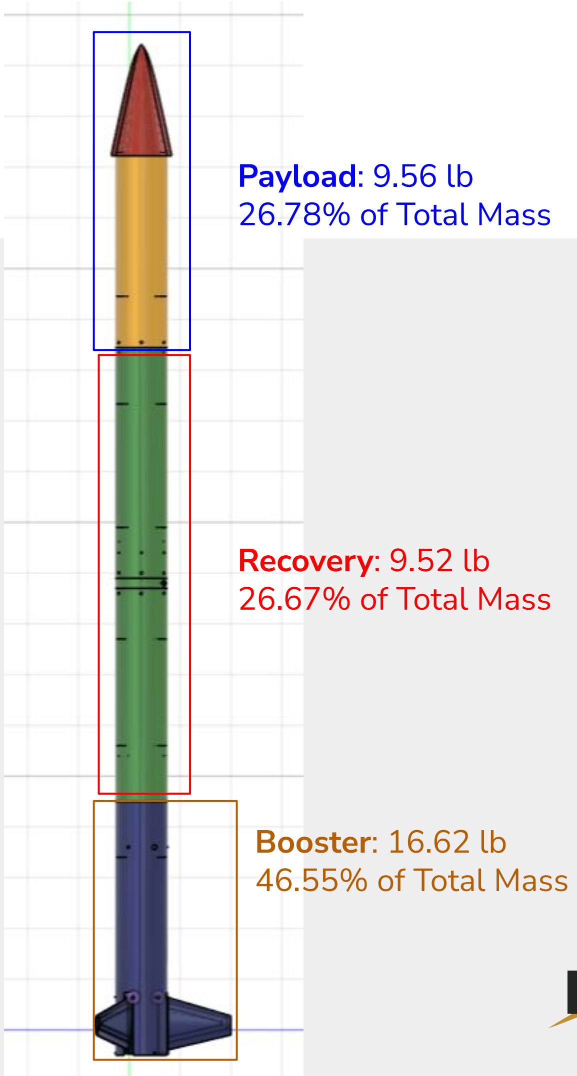
Launch Vehicle Dimensions

Vehicle Predicted Mass	35.7 lbs	**Number of Fins**	3
Vehicle Outer Diameter	5.15”	**Lower Airframe Section Length**	25”
Vehicle Length	99.6”	**Avionics and Recovery Section Length**	44.7”
Vehicle Independent Sections	3	**Payload Section Length**	29.9”



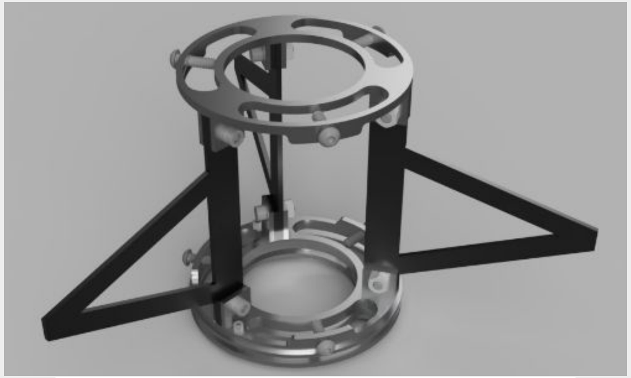
Mass Margin

Component(s)	Mass (lb)
Nose Cone	2.33
Camera Bay	1
Payload	6.22
Upper Recovery (w/ main parachute)	5.22
Avionics	2.68
Lower Recovery (w/ drogue parachute)	1.62
Booster (w/o fins, MFSS, motor, RnD Payload)	3.53
RnD Payload	2.66
Motor Fin Support Structure	0.97
Fins	1.63
Motor (w/ propellant)	7.9
Propellant	4.2
Estimated Total	**35.7**



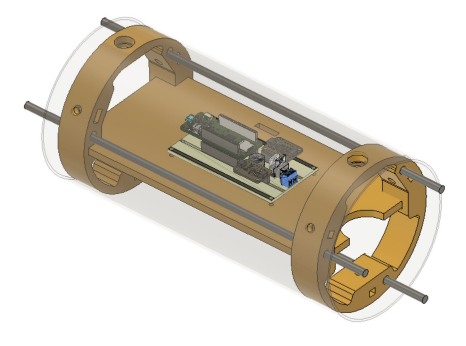
Booster Key Design Feature

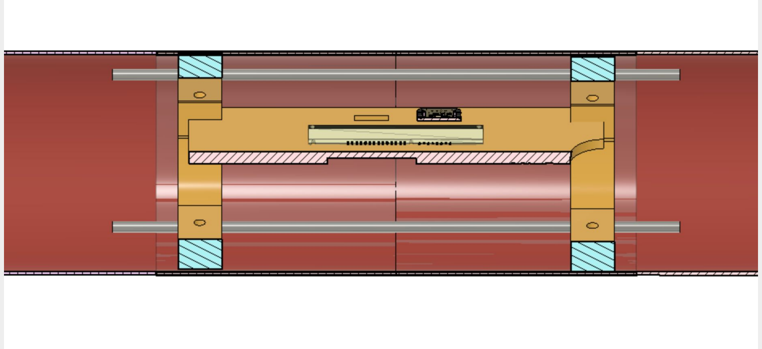
- Motor Fin Support Structure
  - Milled Al-6061
  - Easy assembly and disassembly
  - Keeps both boosters and fins aligned
- Fins
  - Resin casted fin design
  - Improved manufacturing process
    - SLA print and new box design
  - NACA 0012 Airfoil Design
  - G10 Fiberglass Insert for rigidity



R&D Key Design Feature

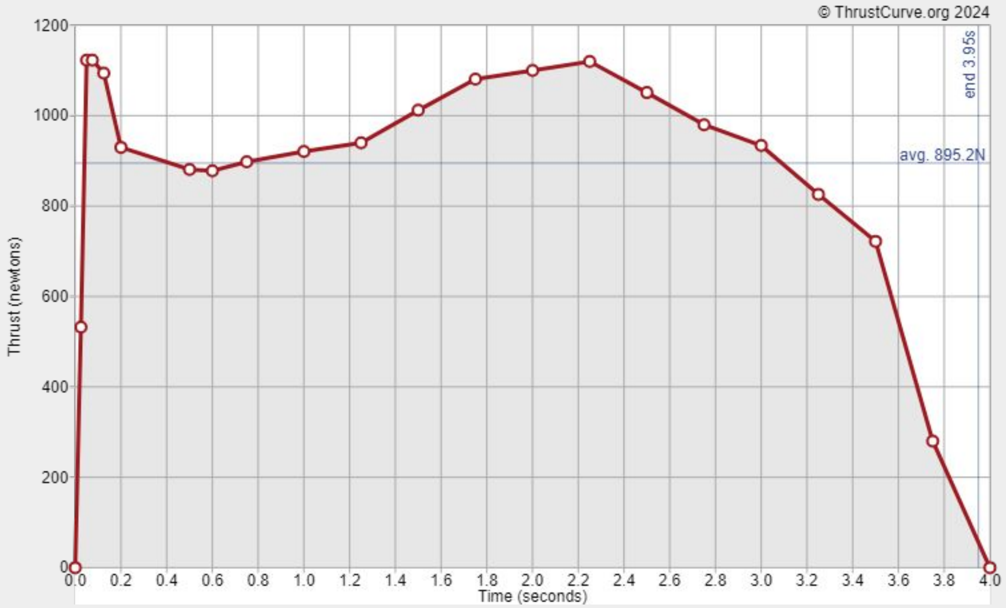
- Secondary payload located above booster
- 3D printed sled design
- 11” coupler above the booster section
- Purpose
    - Completely passive
    - Gather data for research projects
    - Developing air brakes system





Final Motor Choice

- Main motor L930
  - 3587 Ns Total Impulse
  - Liftoff thrust: 252.5 lbf
  - Avg thrust: 209 lbf
  - Max thrust: 252.5 lbf
  - Burn time: 3.8 sec
  - Thrust to weight: 5.76
  - Rail exit velocity: 61.3 ft/s
- Secondary L1482, L1400



Motor Selection and Target Altitude

- Motor L930
  - 3587 Ns Total Impulse
  - Liftoff thrust: 252.5 lbf
  - Avg thrust: 209 lbf
  - Max thrust: 252.5 lbf
  - Burn time: 3.8 sec
  - Thrust to weight: 5.76
  - Rail exit velocity: 61.3 ft/s
- Official Target Altitude: 4,772’ AGL

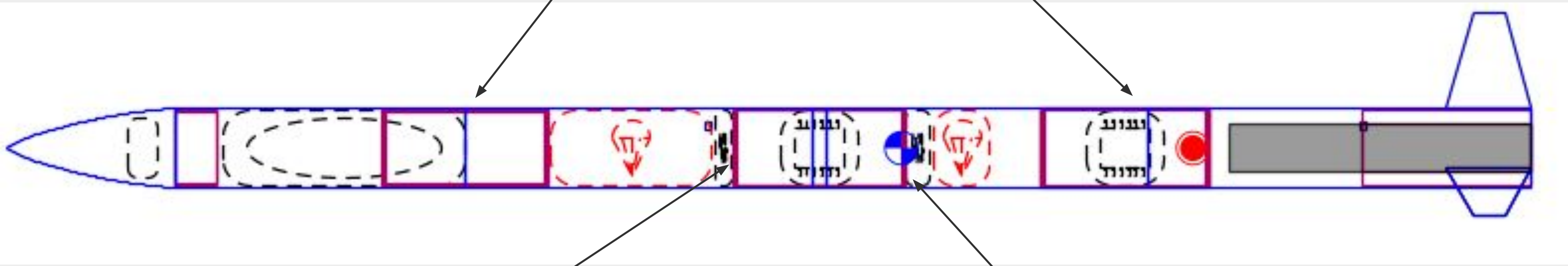
Launch Parameters	Apogee from OpenRocket (ft)	Apogee from RocketPy (ft)	Average (ft)
0 mph wind, 5° launch angle	5018	5028	5023
5 mph wind, 5° launch angle	4925	4932	4929
10 mph wind, 7.5° launch angle	4668	4657	4663
15 mph wind, 7.5° launch angle	4503	4455	4478
20 mph wind, 10° launch angle	4155	4037	4096

Points of Separation

- Two points of Separation

Separation for main parachute

Separation for drogue parachute



Energetics for main parachute

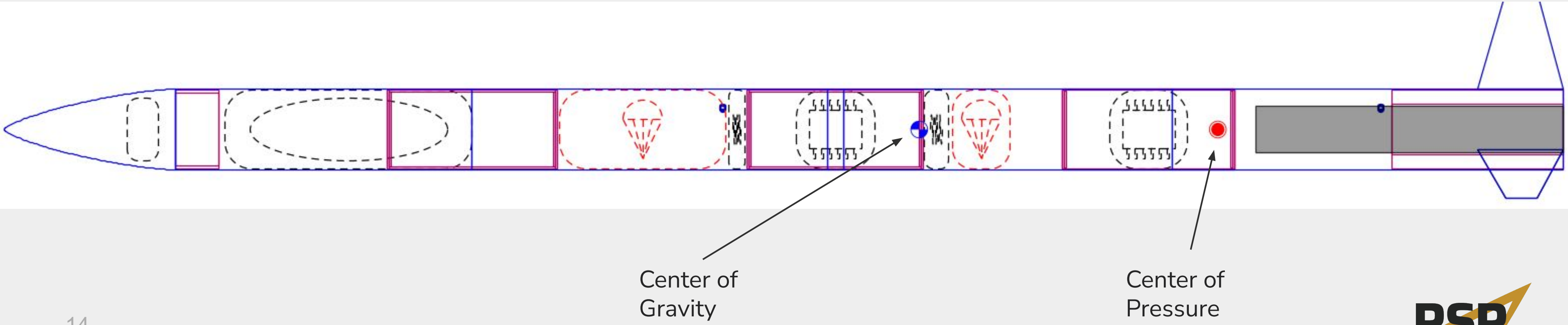
Energetics for drogue parachute

Flight Stability

- Stability Margin: 3.7 cal

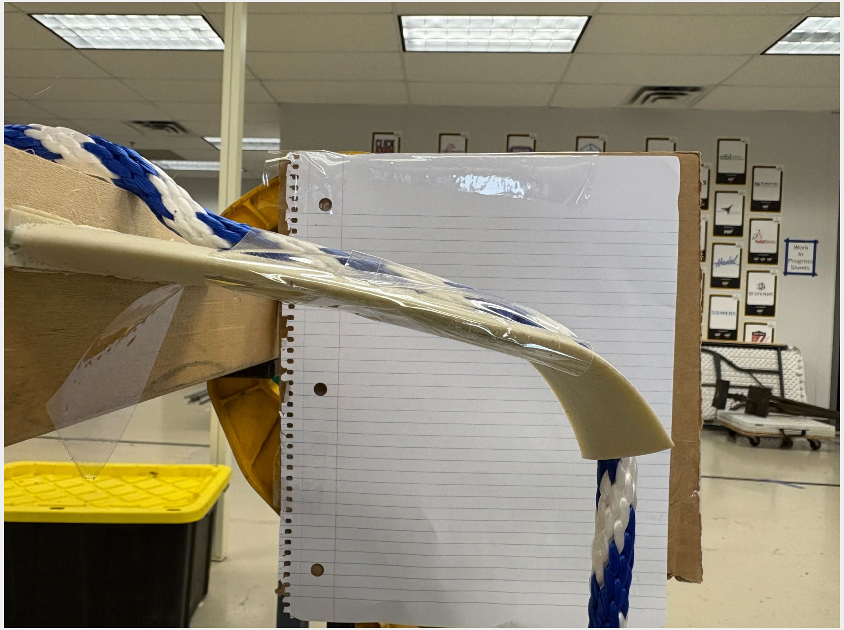
$$SM = \frac{x_{cp} - x_{cg}}{D_{max}} = 3.7\,\text{cal}$$

Center of Gravity (from Nosecone)	58.45”
Center of Pressure (from Nosecone)	77.51”



Composite Fin Testing

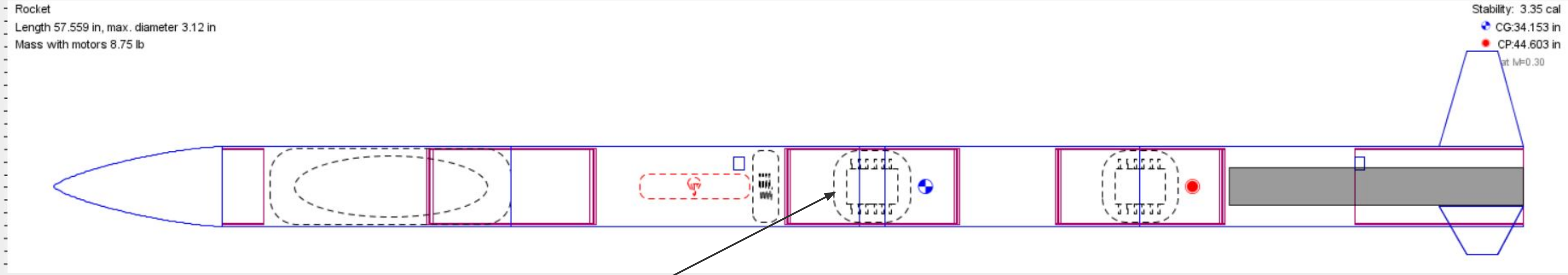
- Tip loading test
  - Did fin deflection test using a bucket tied to a rope taped to a fin
  - Loaded the fins in increments of 1 lb of sand
- Conclusions
  - Improved manufacturing process
  - Failure at 14 lbs
  - Fin Redesign to NACA 0012 from NACA 0008



Subscale Launch

Subscale Launch Vehicle

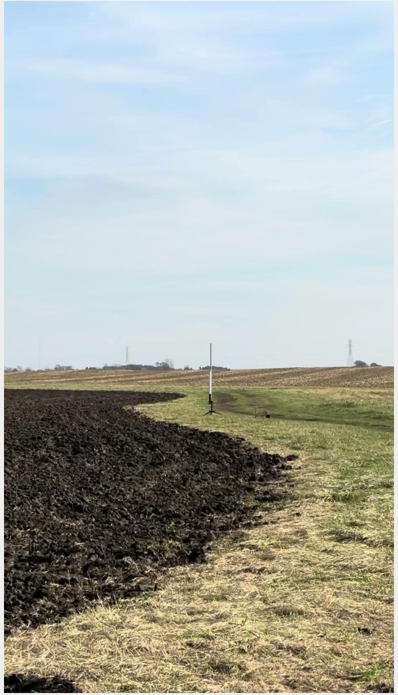
- 60% Scaling Factor
- Length: 57.6”
- Diameter: 3”
- 1 Separation Points



Separation Point

Subscale Launch Conditions

Launch Date	November 17th, 2024
Weather	Sunny
Temperature	54° Fahrenheit
Pressure	14.39 psi
Wind Speed	7.4 mph
Location	Purdue Dairy Farm



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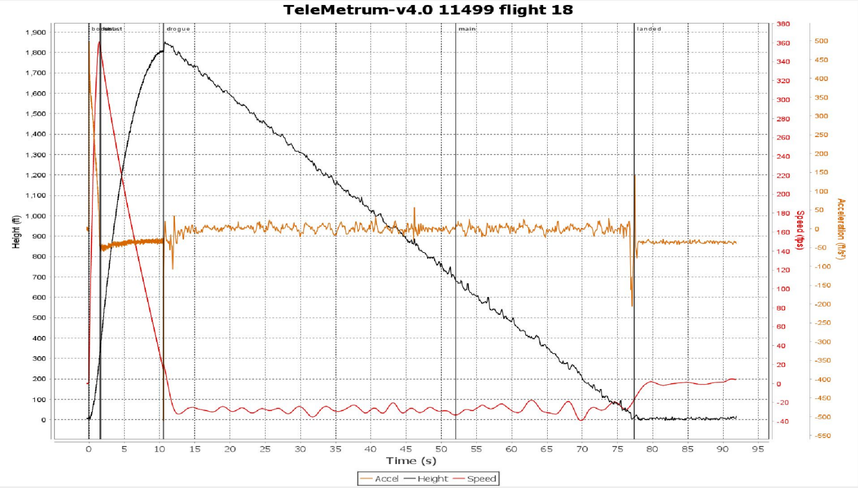
Subscale Launch Data

	RocketPy	OpenRocket	Actual
Apogee (ft)	1857	1858	1851
Descent Time (seconds)	48.2	47.6	41.5
Maximum Velocity (ft/s)	345	347	361
Maximum Acceleration (ft/s^2)	456	457	497



Subscale Landing Configuration

Upper Section

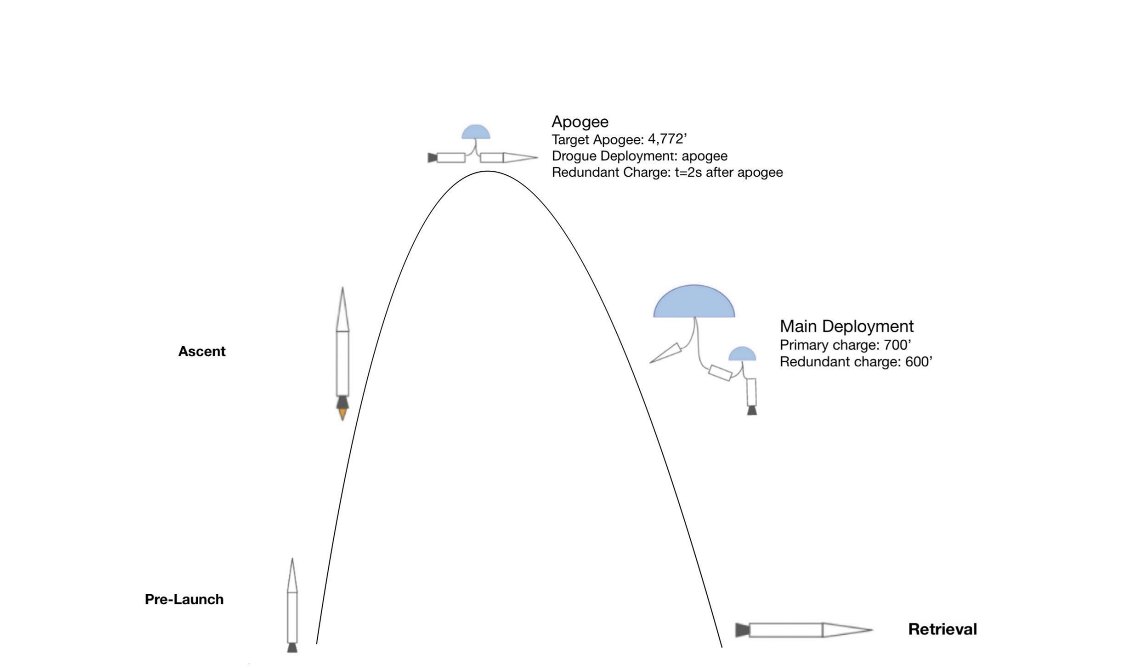
Lower Section

Parachute

Avionics

Recovery System Concept of Operations

- Preparation
- Initiation
- Flight
- Retrieval



Parachutes

Parachute	Main: 120” Rocketman High Performance Parachute	Drogue: 24” Rocketman High Performance Parachute
Material	Ripstop Nylon	Ripstop Nylon
Harnesses	250 lb nylon shroud lines 3000 lb swivel	250 lb nylon shroud lines 1500 lb swivel
Descent Rate	14.7 ft/s	131 ft/s

Parachute Attachment

Hardware	Material	Working Load
Main Shock Cord	⅜” tubular Kevlar, 60’ long	3600 lb
Drogue Shock Cord	⅜” tubular Kevlar, 40’ long	3600 lb
Quick Links	¼” stainless steel	880 lb
Eye Bolts	¼” stainless steel	500 lb

Kinetic Energy

Vehicle Section	Weight (lbs.)	Maximum Kinetic Energy at Landing (ft-lbf)
Payload	9.56	0
Recovery	7.93	2727
Booster	14.0	6296

Main Deployment Kinetic Energy

Vehicle Section	Weight (lbs.)	Maximum Kinetic Energy at Landing (ft-lbf)
Payload	9.56	31.24
Recovery	7.93	25.91
Booster	14.0	45.74

Landing Kinetic Energy

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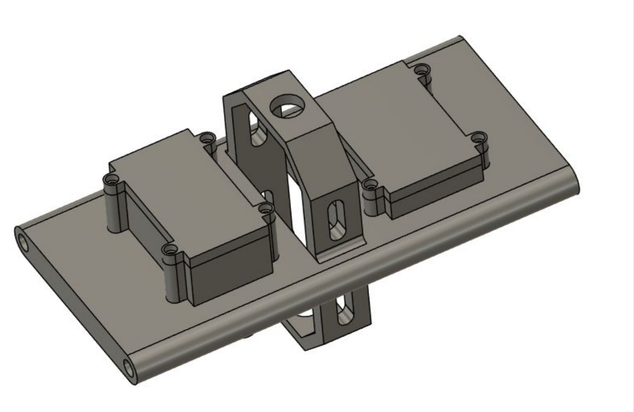
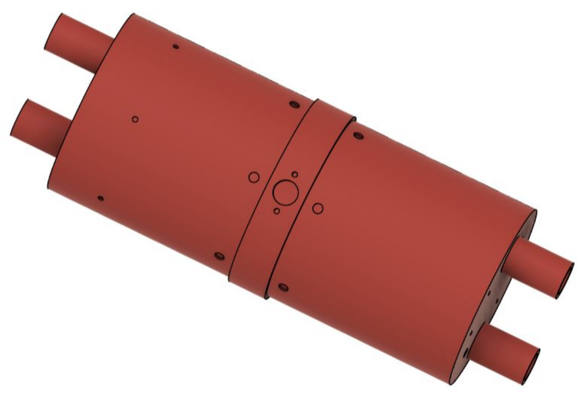
Predict Drift Distance

Wind speed and Launch Angle	Distance from OpenRocket Simulated Trajectory (ft)	Distance from OpenRocket Descent time and wind speed (ft)	Distance from RocketPy Simulated Trajectory (ft)	Distance from RocketPy Descent time and wind speed (ft)
0 mph 5°	299	0	613	0
5 mph 5°	49	491	425	524
10 mph 7.5°	347	967	375	1025
15 mph 7.5°	759	1450	85	1511
20 mph 10°	999	1789	69	1933

Avionics Sled Design

- Coupler Length: 11”
- Integrated Sled Design
- Ejection Charge Configuration:
  - Primary Charge: 2.5g
  - Primary Charge Redundant: 3g
  - Drogue Charge: 1g
  - Drogue Charge Redundant: 1.5g





Mission Performance Predictions

Parameter	Value	Requirement	Pass/Fail
Predicted Apogee	4925’	C.2.1	Pass
Ascent Time	18.4 s	-	-
Drogue Descent Velocity	124.6 ft/s	S.A.10	Pass
Landing Velocity	14.3 ft/s	-	-
Descent Time	69.1 s	A.3.12	Pass
Drift Distance	49 ft	A.3.11	Pass
Rail Exit Velocity	62.5 ft/s	C.2.17	Pass
Landing Kinetic Energy of Heaviest Section	45.1 ft-lbf	A.3.3	Pass

Note: Predicted values were based off 5 miles per hour wind speeds and launch angle of 5 degrees using OpenRocket

Avionics and Recovery Testing

Test	Goal/Description	Requirement(s)	Status
Altimeter Continuity and Battery Drain Test	Verifies continuity over different temperatures and voltage is supplied over expected duration	G.2.6, S.A.1, S.A.2, S.A.3	In Progress
Altimeter Ejection Vacuum Test	Verifies altimeters consistently ignite at required stages in flight	S.A.25	In Progress
Black Powder Ejection Test	Verifies black powder charges separate the airframe sections and no components receive heat damage	S.A.13, S.A.14	Incomplete
Parachute Drop Test	Verifies parachute deploys within an appropriate distance range	S.A.14	In Progress
Force Drop Test	Verifies key switch and other avionics components can withstand the forces of flight and landing	S.A.6, S.A.11	Incomplete

Payload

Payload Design Overview

After careful deliberation, designs for each major payload subsystem have been selected from the options in the Preliminary Design Review.

Subsystem	Name	Function
STEMCRaFT	4.1.2 Radio Transmission System	Transmit relevant landing site data to a NASA-owned receiver
STEMCRaFT	4.1.3 STEMnaut Capsule	Transport 4 STEMnauts from Earth to the launch vehicle's destination
STEMCRaFT	4.1.4 Sensor Package	Collect relevant landing site data
Integration and Retention	4.1.5 Integration and Retention System	Interface between the STEMcRAFT and the rest of the launch vehicle

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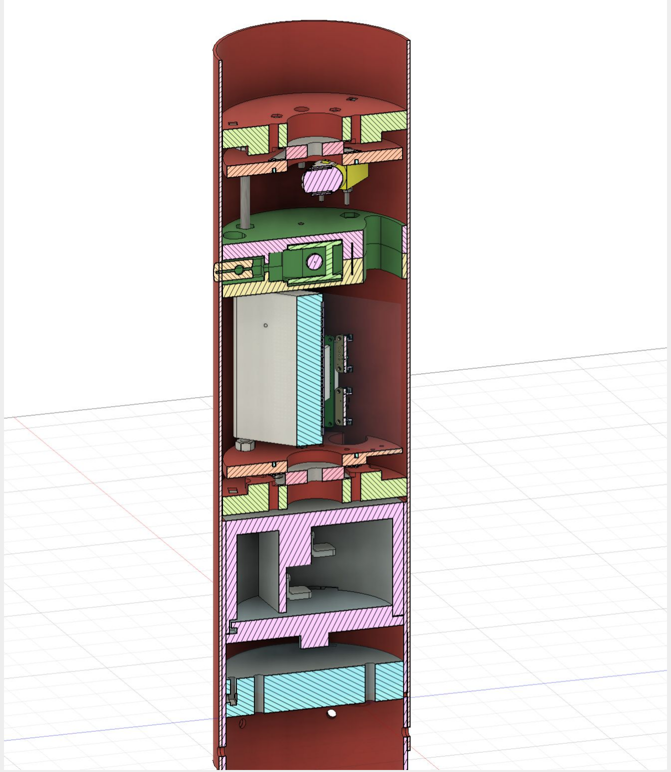
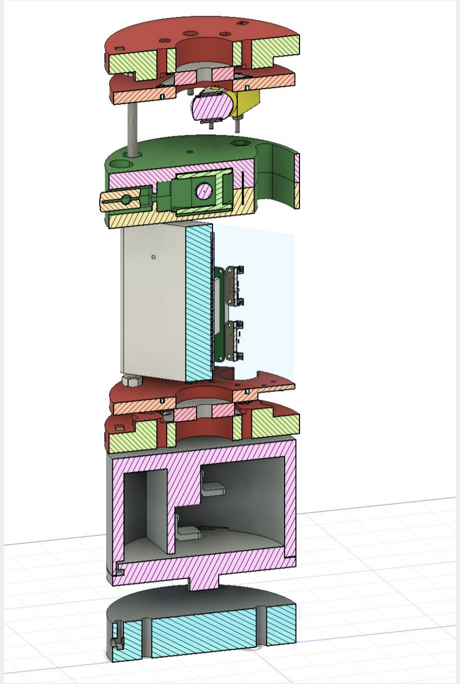
Final Design Assemblies

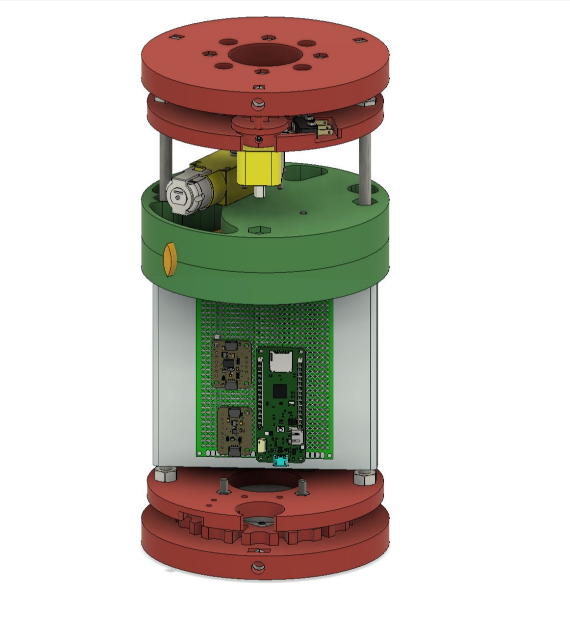


Payload Top Level Assembly

Final Design Assemblies



STEMCRaFT



Transmission Arm Rotating System (TARS)

Subscale Results

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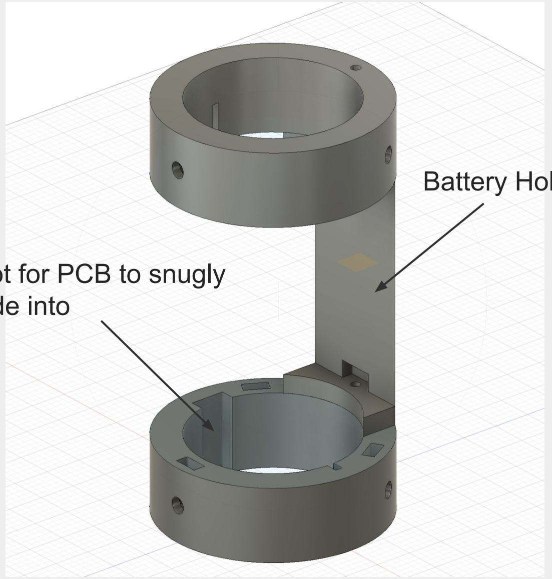
POST FLIGHT DATA
maxAltitude = 582.86 m
Temp. of landing site = 13.33 *C

Time elapsed: 00:37:27
```

Subscale Post-Flight Data

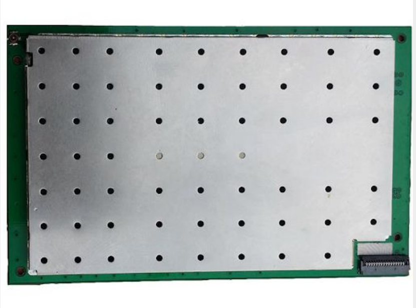
	Apogee (ft)	Temperature (*C)	Time Elapsed
Sensor Package	1912.27	13.33	00:37:27
Validation Data	1851	13.78	N/A
Percent Error	3.31%	3.27%	N/A

Subscale Sensor Package Data compared to Validation Data

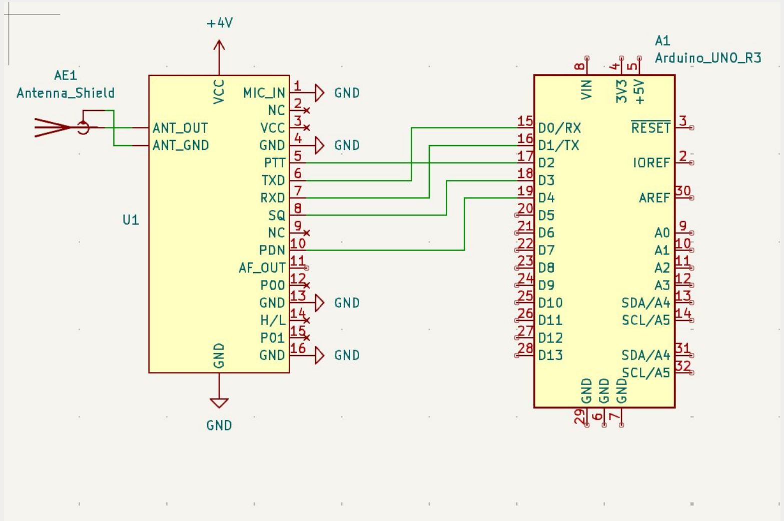


Integration and Retention System for Subscale

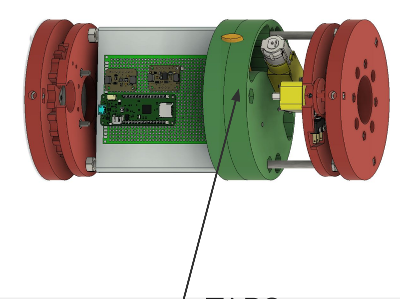
Radio Transmission System



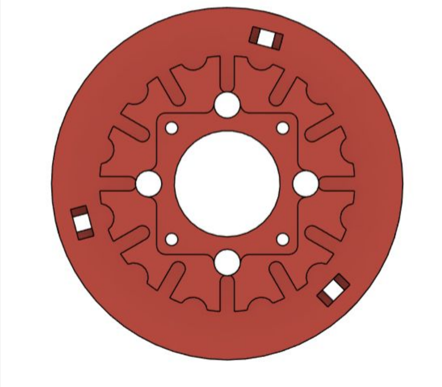
The SR_FRS_4WV VHF Transmitter



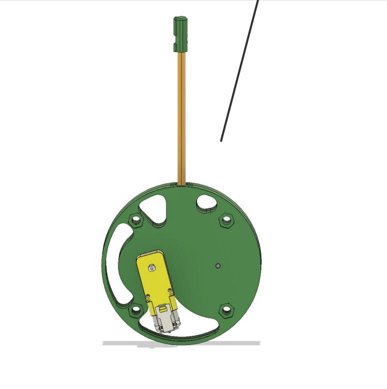
Connections from the SR_FRS_4WV to the Arduino Uno



TARS



Geneva Driver



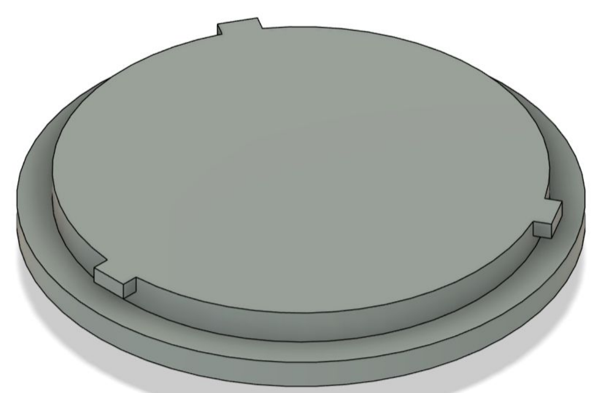
Antenna Extension Assembly

STEMnaut Capsule

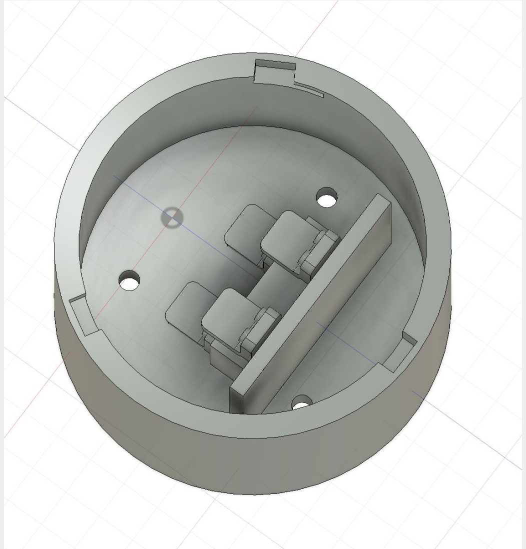
STEMnauts:

- Janice Voss
- David Wolf
- Purdue Pete
- Neil Armstrong

STEMnauts as LEGO® Minifigures

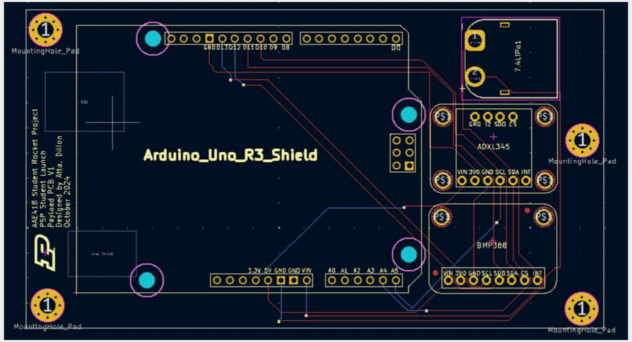


STEMnaut Capsule Lid

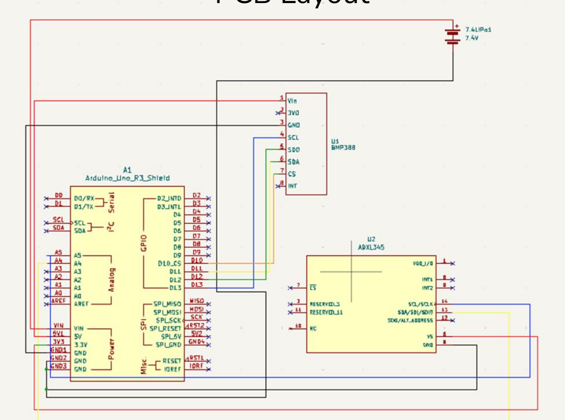


Internal View of STEMnaut Capsule

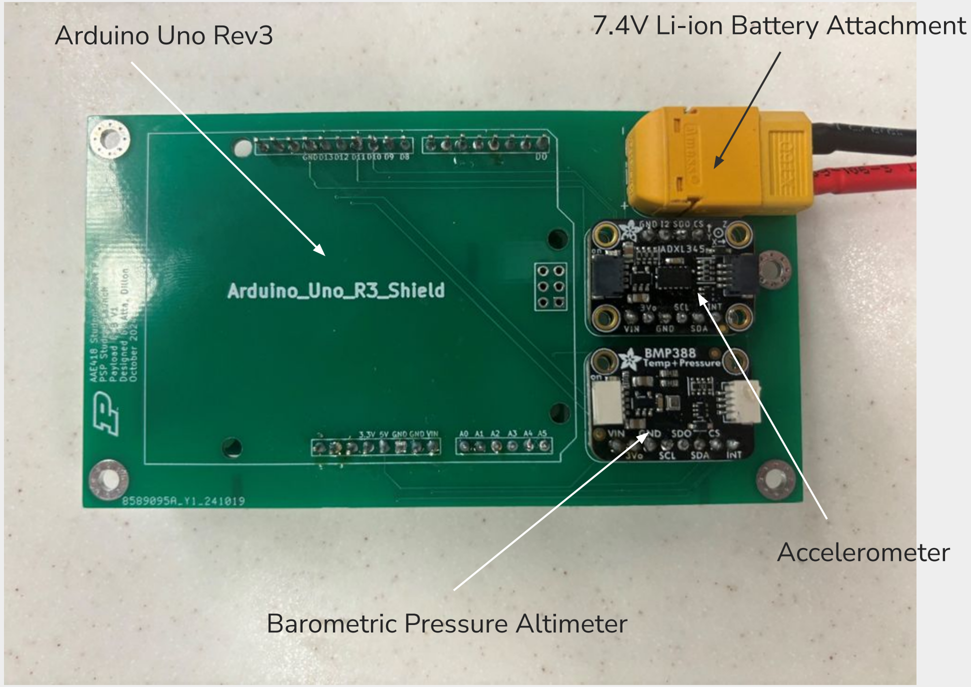
Sensor Package



PCB Layout



Sensor package schematic from KiCad

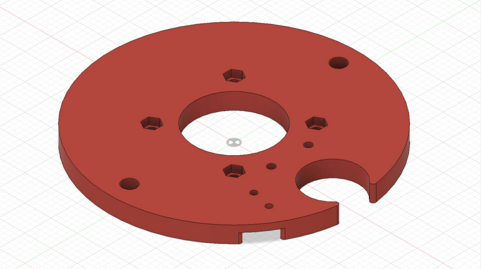


Soldered Components on the PCB

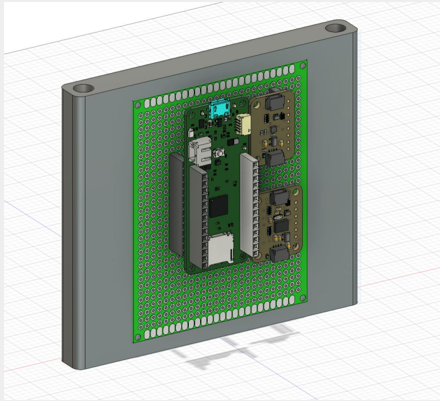
Integration and Retention

Retention Plan

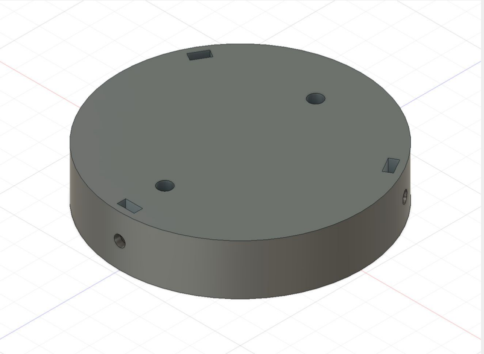
- TARS -> Fixed Rings
- Capsule -> Bolted Directly
- Threaded rods -> Threaded Rod Mount



Fixed Ring



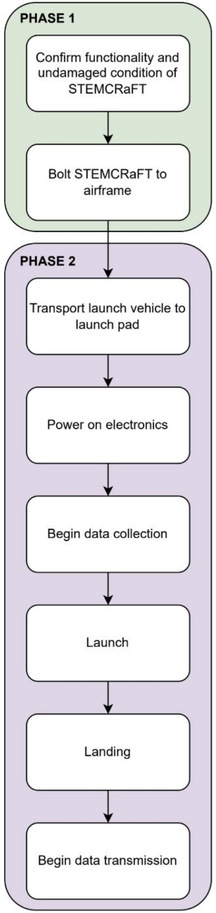
Electronics Mount



Threaded Rod Mount

Payload Integration Plans

1. Ensure connection of the batteries to their respective systems
2. Fasten capsule into the coupler and wire through the bulk plate
3. Position the rotating apparatus so that the transmission arm is set between discrete holes
4. Fasten the rotating apparatus in place and connect to capsule
5. Connect payload bay and payload coupler



Payload Testing

Test	Goal/Description	Requirement(s)	Status
Transmitter Range Verification Test	Ensures that the landing site data can be clearly transmitted to the transceiver.	P.4.1, S.P.4	Incomplete
Sensor Package Test	Ensures that the STEMcRAFT and its contents remain in operating condition during and after flight.	P.4.1, P.4.2, S.P.5	Incomplete
Temperature Test	Determines if the deployment system can properly function within temperatures up to 115 degrees Fahrenheit.	S.P.8	Incomplete
Battery Life Test	Ensures that the sensor package system will be able to operate for an extended period of time.	G.2.6, S.P.9	Incomplete

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Questions?