Project Imua
Mission 10

Full Mission Simulation Review

University of Hawai‘i Community Colleges

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Presentation Outline

- Section 1: Mission Concept and Interfaces
- Section 2: Design Overview
- Section 3: Subsystem Integration and Test Status
- Section 4: Full Mission Simulation Results
- Section 5: Project Schedule
- Section 6: June Operations
- Section 7: Conclusion

1.0 Mission Concept and Interfaces

Frank

Mission Statement (Summary)

1. Project Imua
   a. Collaboration of Honolulu Community College (HonCC) & Windward Community College (WinCC) with Assets High School
   b. Promote STEM education & careers
2. Research
   a. Launch a small scale sublimation rocket
   b. Determine specific impulse I_{sp} of sublimate (camphor)
   c. Electronic Payload
      i. Student Development & Understanding
      ii. Proof of Concept test of the 1U Artemis CubeSat

Mission Statement

Project Imua Mission 10's goals are:

- To encourage UHCC students to explore and enter STEM-based careers by engaging in team-oriented, problem-solving activities that emphasize the integration process involved in the design, fabrication, testing and documentation of launch-ready, space-bound payloads supporting scientific and/or engineering experiments.
- To conduct research on the feasibility of using a sublimation–fueled motor for providing low-power venier thrust. The specific impulse of the sublimate camphor will be determined by a static ground test and by deploying the rocket from a sounding rocket at apogee. On board cameras will record the sublimation rocket's flight parameters. This data will be supplemented by an IMU and a multi-axis accelerometer that will provide a baseline for the payload's flight trajectory. In addition, a proof of concept test will be performed on a 1U Artemis CubeSat.

Mission Objectives

Mission: Our mission is to design a payload that supports two primary and two secondary experiments while fostering intercampus collaboration.

1. **Objective 1: Student Engagement (STEM)**
   a. Facilitate cross campus collaboration (HonCC +WinCC)
   b. Foster interest in aerospace education of high school students (Assets)
   c. Project-based internship in aerospace engineering
2. **Objective 2: Primary Experimental Payload**
   a. Deploy sublimation rocket (**ScubeR**) and determine specific impulse of camphor
   b. Record flight parameters of sublimation rocket
3. **Objective 3: Secondary Experimental Payload**
   a. Measure flight parameters of flight deck with multi-axis IMU and Accelerometer
   b. Proof of Concept of a 1U Artemis CubeSat

Minimum Success Criteria: Primary Objectives

Primary Objectives	Minimum Success Criteria
Engage students in design, fabrication and aerospace engineering.	5 students awarded scholarship per semester; 5 students & 2 faculty mentors attend RockSat-X 2022 test & launch at WFF with fully integrated, flight certified payload.
Deploy sublimation rocket from payload bay near apogee.	Achieve sublimation thrust sufficient for rocket to fully clear CarRoLL.
Capture imagery by Mobius ActionCam.	Record deployment of sublimation rocket with visual cues determining acceleration. Record a minimum of three images at three different times.

Minimum Success Criteria: Secondary Objectives

Secondary Objectives	Minimum Success Criteria
Demonstrate operation of 9-axis motion tracking device.	Save data to SD card on deck plate.
Demonstrate operation of 3-axis accelerometer.	Save data to SD card on deck plate.
Proof of Concept flight for modified Artemis CubeSat Kit.	Demonstrate Artemis CubeSat onboard utilities

Desirable Success Criteria: Primary Objectives

Primary Objectives	Minimum Success Criteria
Engage students in design, fabrication and aerospace engineering.	10 scholarships awarded per semester; 8 students and 3 faculty mentors to attend RockSat-X 2022's test and launch events at WFF with a fully integrated, flight certified payload.
Deploy sublimation rocket from payload bay near apogee.	Achieve sublimation thrust sufficient for rocket to fully clear the CarRoLL and with a greater than initial release velocity.
Capture imagery by Mobius ActionCam.	Record deployment of sublimation rocket with visual cues determining acceleration. Obtain a video recording of ScubeR's flight for approximately 2 minutes.

Desirable Success Criteria: Secondary Objectives

Secondary Objectives	Minimum Success Criteria
Demonstrate operation of 9-axis motion tracking device.	Save data to SD card on deck plate.
Demonstrate operation of 3-axis accelerometer.	Save data to SD card on deck plate.
Proof of Concept flight for modified Artemis CubeSat Kit.	Demonstrate Artemis CubeSat onboard utilities (same as minimum success criteria)

ScubeR Expectations

$$F = \dot{m}v_{ex} + A_{th}P_{vap}$$

Thermodynamic Considerations: The payload compartment radiates heat (on ascent) lowering the temperature by less then 2K at the time of ScubeR deployment. The exhaust speed, v_{ex}, is essentially the thermal velocity of the reaction mass particles. The vapor pressure, P_{vap}, can be related (to first order) to the rate of sublimation of the reaction mass, $\dot{R}$.

$$P = \frac{Nk_BT_K}{V} = \left(\dot{R}\,\frac{N_A}{\mathfrak{M}}\Delta t\right)\left(\frac{k_BT_K}{V}\right)$$

Where $\mathfrak{M}$ is the molar mass of the sublimating material, N_A is Avogadro's number, R_u is the universal gas constant, and Δt is the elapsed time from the on-set of sublimation. The rate of mass loss is the ratio of the throat area A_{th}, to the total surface area that sublimation can occur over $\dot{m} = \left(\frac{A_{th}}{A}\right)\dot{R}$.

$$F = \dot{R}A_{th}\left\{\frac{1}{A}\sqrt{\frac{3R_uT_K}{\mathfrak{M}}} + \left(\frac{N_Ak_BT_k}{\mathfrak{M}V}\right)\Delta t\right\}$$

Since not all the volume holding the reaction mass is available for the sublimating material to expand to, we need to include a volume coefficient ϵ indicating the percentage of the volume that is available for the sublimating material to expand into.

ScubeR Thrust Equation

$$F = A_{th}\dot{R}\left\{\frac{1}{A}\sqrt{\frac{3R_uT_K}{\mathfrak{M}}} + \left(\frac{N_Ak_BT_K}{\mathfrak{M}\epsilon V}\right)\Delta t\right\}$$

F is the thrust of ScubeR measured in Newtons

$\dot{R}$ is the sublimation rate of Camphor measured in grams per second

A_{th} is the area of the throat measured in square meters

A is the cross-sectional area of the sublimation chamber measured in meters

R_u is the Universal Gas Constant 8.31 J/mol K

N_a is Avogadro's number 6.02 X 10^{23}

k_B is Boltzmann's constant 1.38 X 10^{-23} J/K

T_K is the temperature of ScubeR, taken to be 299 K

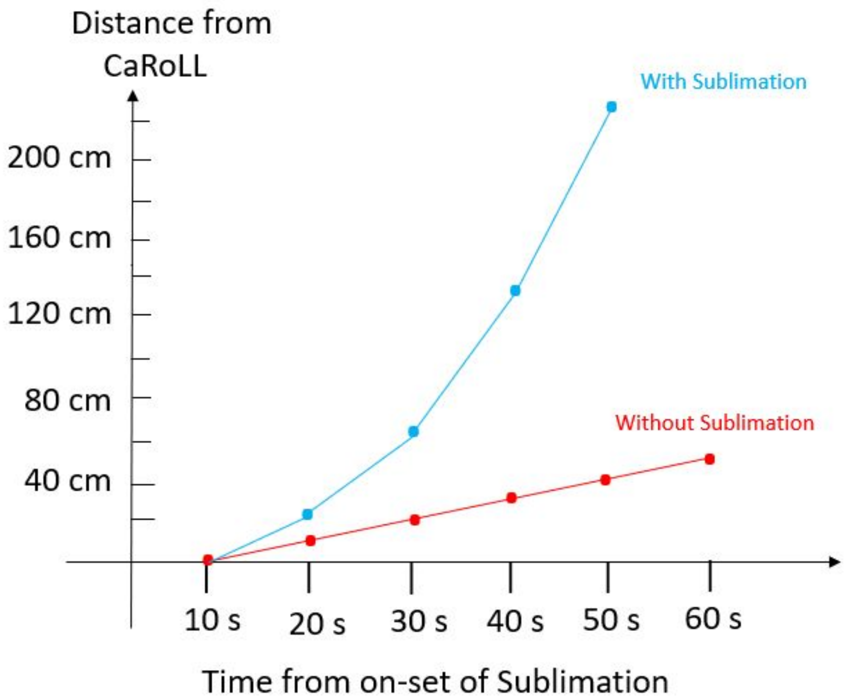
$\mathfrak{M}$ is the molar mass of Camphor, 0.152 kg/mol

Δt is the time interval from the onset of sublimation measured in seconds

ϵ is the percentage of the ScubeR volume that the sublimating material can expand into

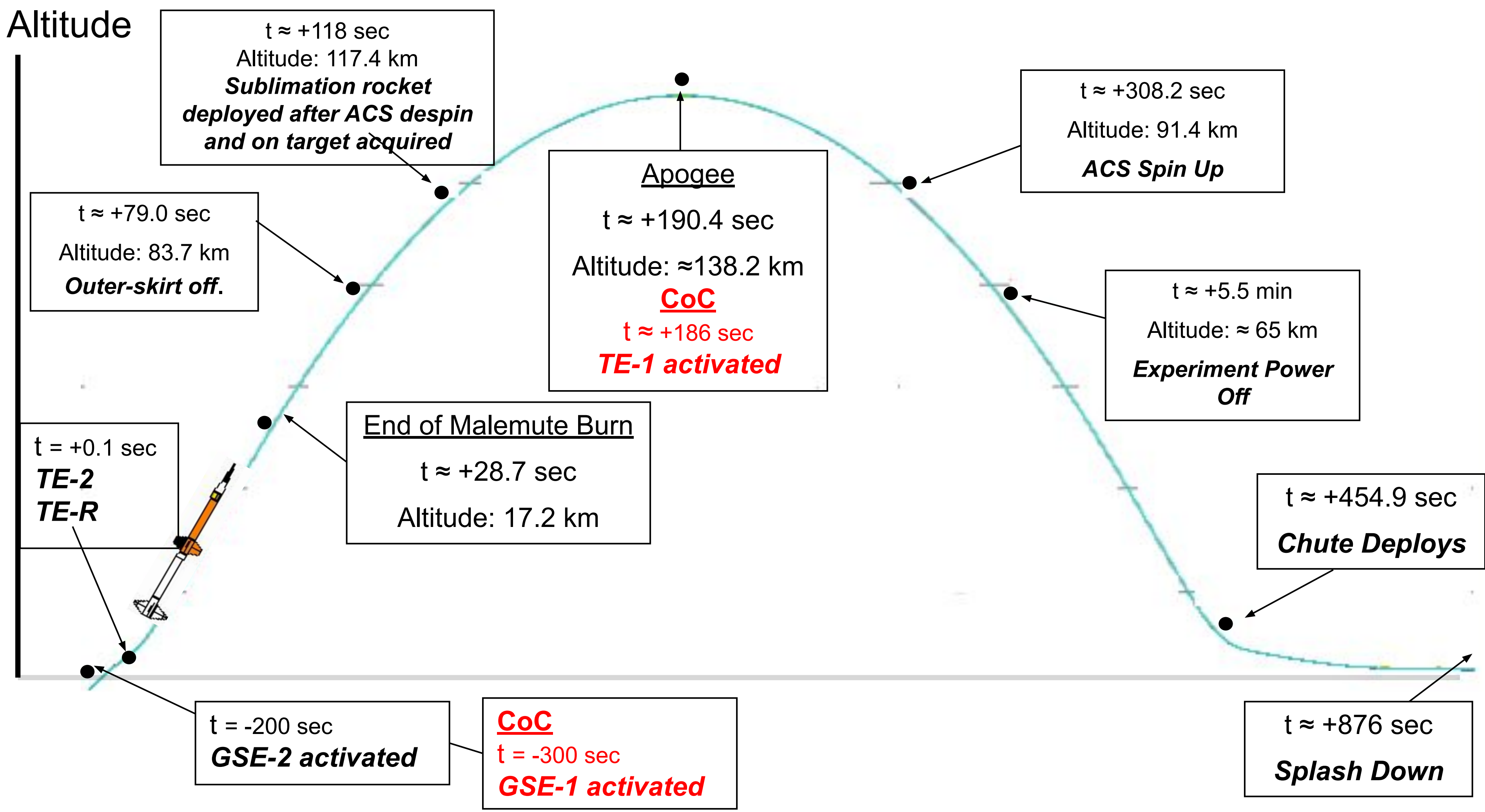
V is the volume of the ScubeR sublimation chamber in cubic meters

ScubeR Expectations



The maximum thrust, given the current dimensions of ScubeR, is estimated to be 0.69 mN. ScubeR reaches this maximum thrust 2 s after on-set of sublimation, while still on the stepper motor thread. With an estimated ScubeR mass of 0.30 kg, ScubeR will have a constant acceleration of 2.3 mm/s^2 , along with an initial speed of 10 mm/s, at the time of deployment.

Concept of Operations



Concept of Operations [Cont.]

Event	Time On	Dwell	Event Description
GSE 1	N/A	N/A	N/A
GSE 2	T-200 sec	Flight	Powers on Artemis Raspberry Pi.
TE-1	N/A	N/A	N/A
TE-2	T+0.1 sec	Flight	Supply Power to Power Distribution Board.
TE-3	N/A	N/A	N/A
TE-R	T+0.1 sec	Flight	Ensures that power is supplied to the Power Distribution Board.

Concept of Operations: ScubeR

Jared

ScubeR Deployment Timeline	Event
T = -200s	Artemis powered on via GSE
T = +0.1s	ScubeR Controller to give H bridge command to power motor, level shifter turned on via TE-2 and TE-R through PDB.
T = +103s	ScubeR Controller to start full backwards turn step command towards puncturing sublimate chamber for experiment start
T = +107s	ScubeR Controller to start full forwards rotation command (after ACS)
T = +118s	ScubeR is released from the shaft (deployed)
T = +123s	ScubeR Controller to complete command cycle and cease all commands

Concept of Operations: Data Controller

Data Controller Deployment Timeline	Event
T = +0.1s	Power Distribution Board (PDB) supplies power to data controller and turns on. One accelerometer at ±2g & the other at ±16g. The gyroscope will be set to ±245 dps Magnetometer set to ±4 gauss (0.4mT) Saving Data to MicroSD card
T = +336s	Power off.

Concept of Operations: On-board Video Camera

Caleb

On-board Cameras Deployment Timeline	Event
T = +0.1s	Power Distribution Board (PDB) supplies power to Mobius Action Cameras and turn on. Video Camera starts recording video of the ScubeR deployment. Recorded video will be stored onto MicroSD card.
T = +300s	Video recording has ended the 1st video clip and data is stored on MicroSD. 2nd video clip now recording (Internal event to the camera. Nothing is needed)
T = +336s	Power off and video will end.

Concept of Operations: On-board Photo Camera

Caleb

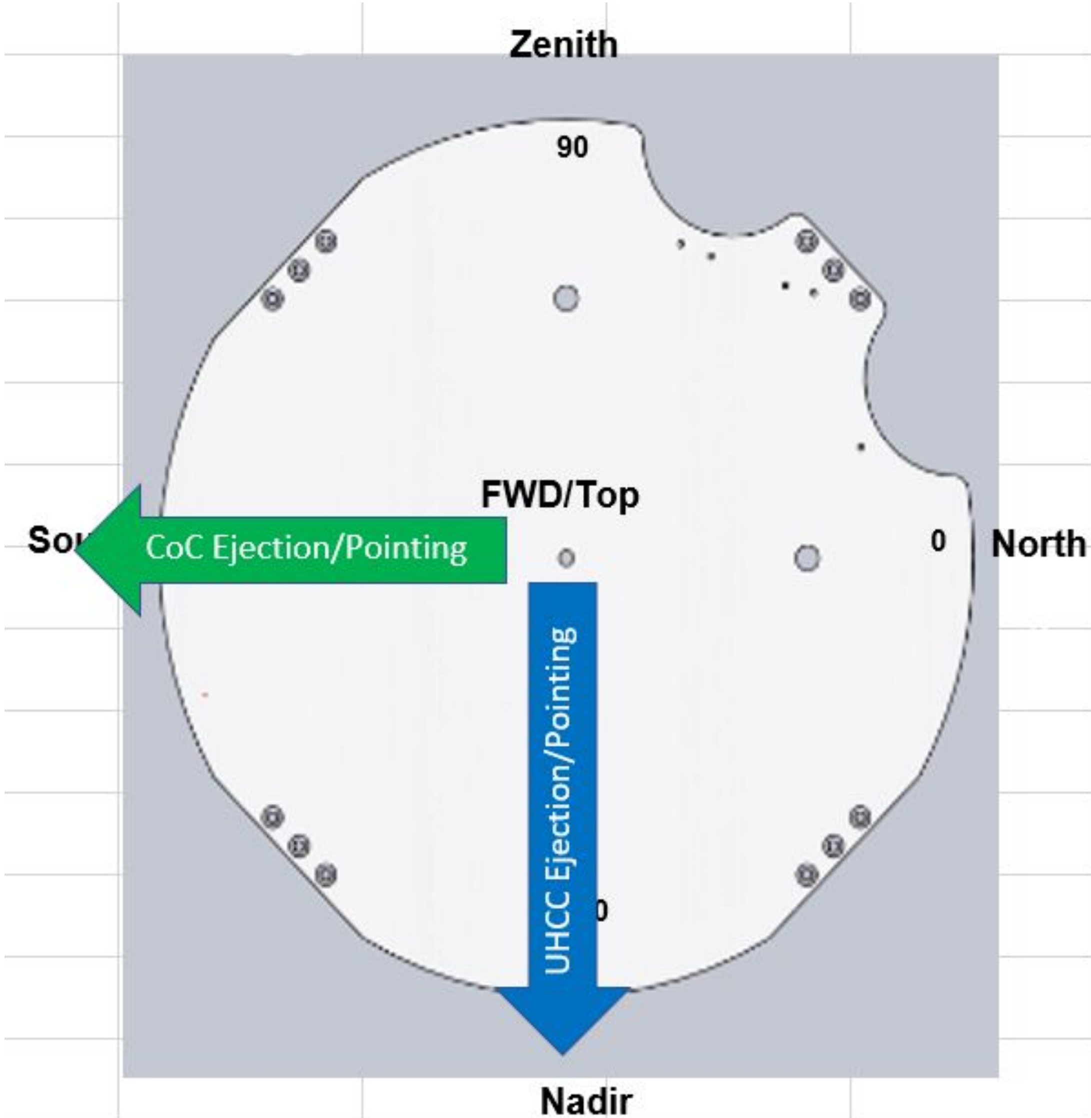
On-board Cameras Deployment Timeline	Event
T = +0.1s	Power Distribution Board (PDB) supplies power to Mobius Action Cameras and turn on. Photo Camera constantly takes a photo every 2 seconds throughout the deployment and stores data onto a MicroSD card.
T = +336s	Power off and picture taking will stop.

Caleb

Payload Location

Caleb

Pointing



Timer Event Matrix

Team Name: UHCC
Date: 4/30/22

Event	Time On	Units	Dwell Time	Units	Event Description
GSE 1		(T-X) (sec)	Flight	(sec)	
GSE 2	T = -200 sec	(T-X) sec)		(sec)	Powers on Artemis Raspberry Pi.
TE-R	T = +0.1 sec	(T+X) (sec)	Flight	(sec)	Supply power to Power Distribution Board.
TE-1		(T+X) (sec)		(sec)	
TE-2	T = +0.1 sec	(T+X) (sec)	Flight	(sec)	Supply power to Power Distribution Board.
TE-3		(T+X) (sec)		(sec)	

Jared

Activation Sequence: CoC and UHCC

	School	Start (sec only)	Dwell (sec)	End (sec only)	Comments
GSE 1	CoC	T-300s	Flight	Flight	Main Power for experiment computers
GSE 2	UHCC	T-200s	Flight	Flight	Power on Artemis raspberry pi.
TE-R	UHCC	T+0.1s	Flight	Flight	Ensures that power is supplied to the distribution board.
TE-1	CoC	T+200s	Flight	T+205s	Launch Suborbital Reentry Payload at apogee, WVU antenna deploy
TE-2	UHCC	T+0.1s	Flight	Flight	Supply power to power distribution board.
TE-3	N/A	N/A	N/A	N/A	N/A

Power Pin Assignment

RS-X 2022 Pin Assignments

	Team:	UHCC
	Date:	4/30/22

Power Pin	Function	Intended Use
1	GSE 1	N/C
2	Timer Event Redundant (TE-RA)	Failsafe for turning on Power Distribution Board
3	Timer Event Redundant (TE-RB)	N/C
4	Timer Event 1 (TE-1)	N/C
5	GND	GSE 2
6	GND	TE-2
7	GND	TE-RA
8	GND	N/C
9	GSE 2	Turn on Artemis Raspberry Pi at T = -200 sec
10	Timer Event 2 (TE-2)	Turn on Power Distribution Board at T = 0.1 sec
11	Timer Event 3 (TE-3)	N/C
12	GND	N/C
13	GND	N/C
14	GND	N/C
15	GND	N/C

Telemetry Pin Assignment

RS-X 2022 Pin Assignments		
Telemetry	**Function**	**Intended Use**
1	Analog 1	N/C
2	Analog 2	N/C
3	Analog 3	N/C
4	Analog 4	N/C
5	Analog 5	N/C
6	Analog 6	N/C
7	Analog 7	N/C
8	Analog 8	N/C
9	Analog 9	N/C
10	Analog 10	N/C
11	Parallel Bit 1 (MSB)	N/C
12	Parallel Bit 2	N/C
13	Parallel Bit 3	N/C
14	Parallel Bit 4	N/C
15	Parallel Bit 5	N/C
16	Parallel Bit 6	N/C
17	N/C	N/C
18	Ground	N/C
19	Ground	N/C
20	Parallel Bit 7	N/C
21	Parallel Bit 8	N/C
22	Parallel Bit 9	N/C
23	Parallel Bit 10	N/C
24	Parallel Bit 11	N/C
25	Parallel Bit 12	N/C
26	Parallel Bit 13	N/C
27	Parallel Bit 14	N/C
28	Parallel Bit 15	N/C
29	Parallel Bit 16 (LSB)	N/C
30	Parallel Read Strobe	N/C
31	N/C	N/C
32	RS-232 Data (TP1)	Status Update for controllers
33	RS-232 GND (TP2)	Status Update for controllers
34	N/C	N/C
35	N/C	N/C
36	Ground	N/C
37	Ground	N/C

Jared

Power Budget Deliverable

UHCC - Power Budget							
Date: 4/30/22							
Wallops Power Line	**Subsystem**	**Voltage (V)**	**Max Current (A)**	**Start Time (min)**	**Time On (min)**	**Watts**	**Ah**
GSE1/2	PDB (Artemis)	5.0	1.00	t = -3.3 min	8.9	5.00	0.15
						0.00	0.00
TE1/2/3/R	PDB (Cameras - 2)	5.0	1.60	t = +0.01 min	5.6	8.00	0.15
	PDB (Data and ScubeR Controllers)	9.0	0.16	t = +0.01 min	5.6	1.43	0.01
	PDB (Stepper)	3.3	0.29	t = +0.01 min	5.6	0.96	0.03
						0.00	0.00
		GSE 1/2 Total	1				
		TE1/2/3/R Total	2.05				
		Total	3.05			15.39	0.34
		Total Power Capacity					0.50
		Over/Under					0.16
					# of Flights Margin		**2.9**

Jared

Mechanical Design Weight Budget Part I

UHCC - Weight Budget (Individual Subsystems)	
Date: 4/30/22	
Subsystem	Total Weight (lbs)
ScubeR	0.55
Artemis	1.31
Data Controller	0.11
Mobius Cameras (2)	0.13
Hammond Box	0.99
Payload Deck	3.425
Total	6.52
Over/Under (15 lbs)	Under by 8.48

Mechanical Design Weight Budget Part II

UHCC - Weight Budget (Integrated Subsystems)	
Date: 4/30/22	
Subsystem	Total Weight (lbs)
ScubeR (and Guide Rail)	0.8
Artemis	0.78125
Lead Block (Dead Weight)	6.093715
Hammond Box with Cameras	1.54375
Screws and Washers (Dead weight)	~1.356
Total	~15
Over/Under (15 lbs)	~0 +/- 0.5

User Guide Compliance: Summary

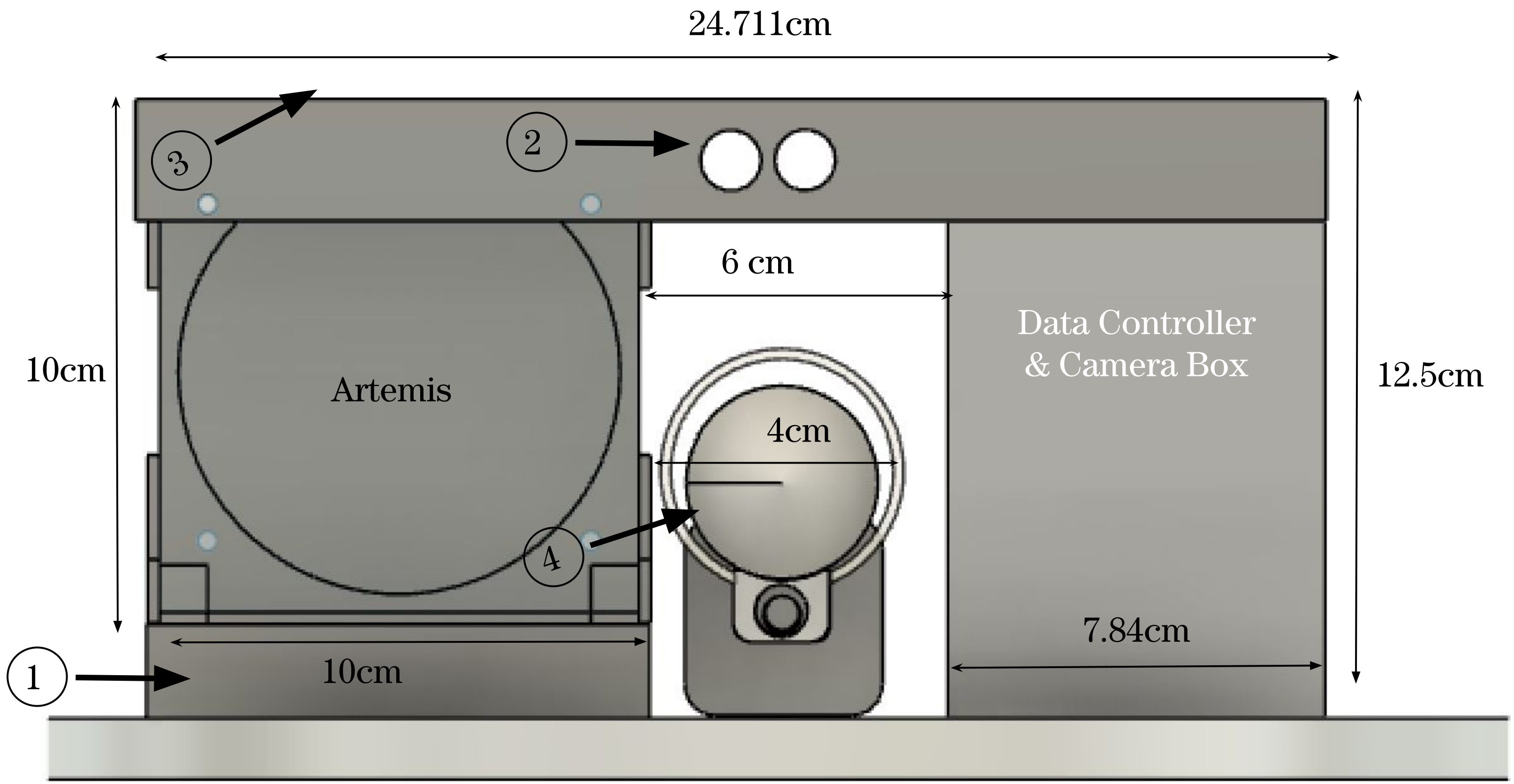
	Assets	Honolulu	Windward	Total
Weight?	~1.31 lbs	~ 1.14 lbs	~ 0.77 lbs.	~6.64 lbs excluding mounting hardware and including the payload deck
Dimensions?	Height = 110 mm Area 100 x 100 mm	4.92” x 4.49” X 3.11”	Height = 40mm Base = 250 x 40mm	Within space
Within 1 inch keep out zone?	yes	yes	yes	yes
Deployments?	No	No	Yes	Yes, speed is under 1 inch/sec
ADC Lines?	No	No	No	0
Async/Parallel?	No/No	No/No	Yes/No	Yes/No
GSE Lines?	No	No	Yes	1
Power/Timer Events?	Yes, GSE-2 @ T= -200	TE-2 @ T= 0.1+	TE-2 @ T= 0.1+ TE-R @ T=0.1 +	TE-2 @ T= 0.1+ TE-R @ T=0.1+ GSE-2 @ T = -200
Understand CG Requirement?	Yes	Yes	Yes	Yes
High Voltage?	No	No	No	No
Using < 0.5 Ah	Yes	Yes	Yes	Yes
Hazardous Procedures?	No	No	No	No
RF?	No	No	No	None
Bottom of Deck Plate Flush?	Yes	Yes	Yes	Yes
US Persons for whole team?	Yes	Yes	Yes	Yes
ITAR? Export Control Hardware?	Compliant,none	Compliant, none	Compliant, none	Compliant, none

2.0 Design Overview

Updates Since ISTR

- We have recorded our inhibition of ScubeR.
- We have completed all individual and integrated subsystem testing.
- No major changes have been made to the payload.

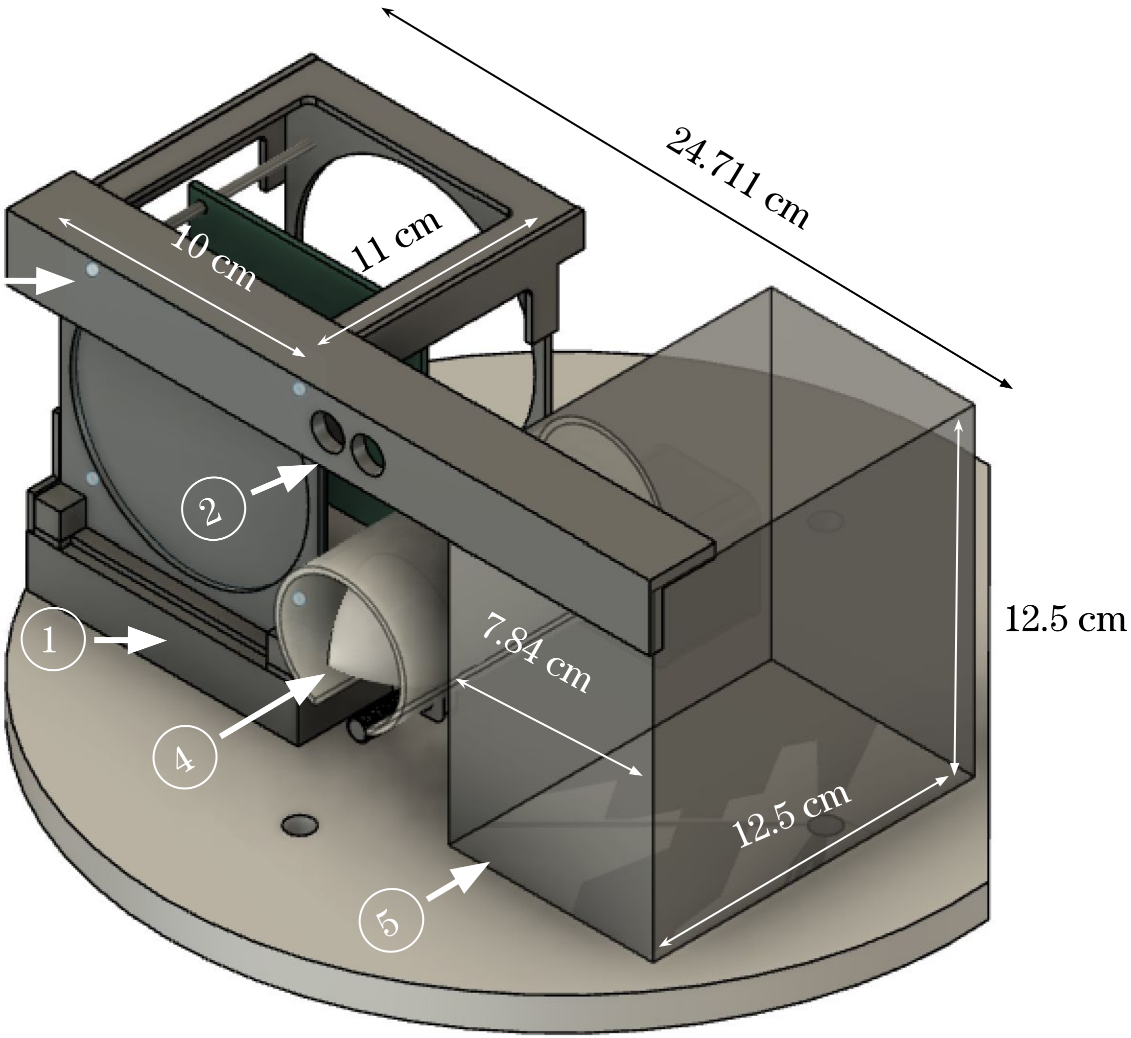
Design Overview Front View



1. Dead Mass Base Plate
2. Camera Lensed
3. Lens Bridge
4. ScubeR Assembly

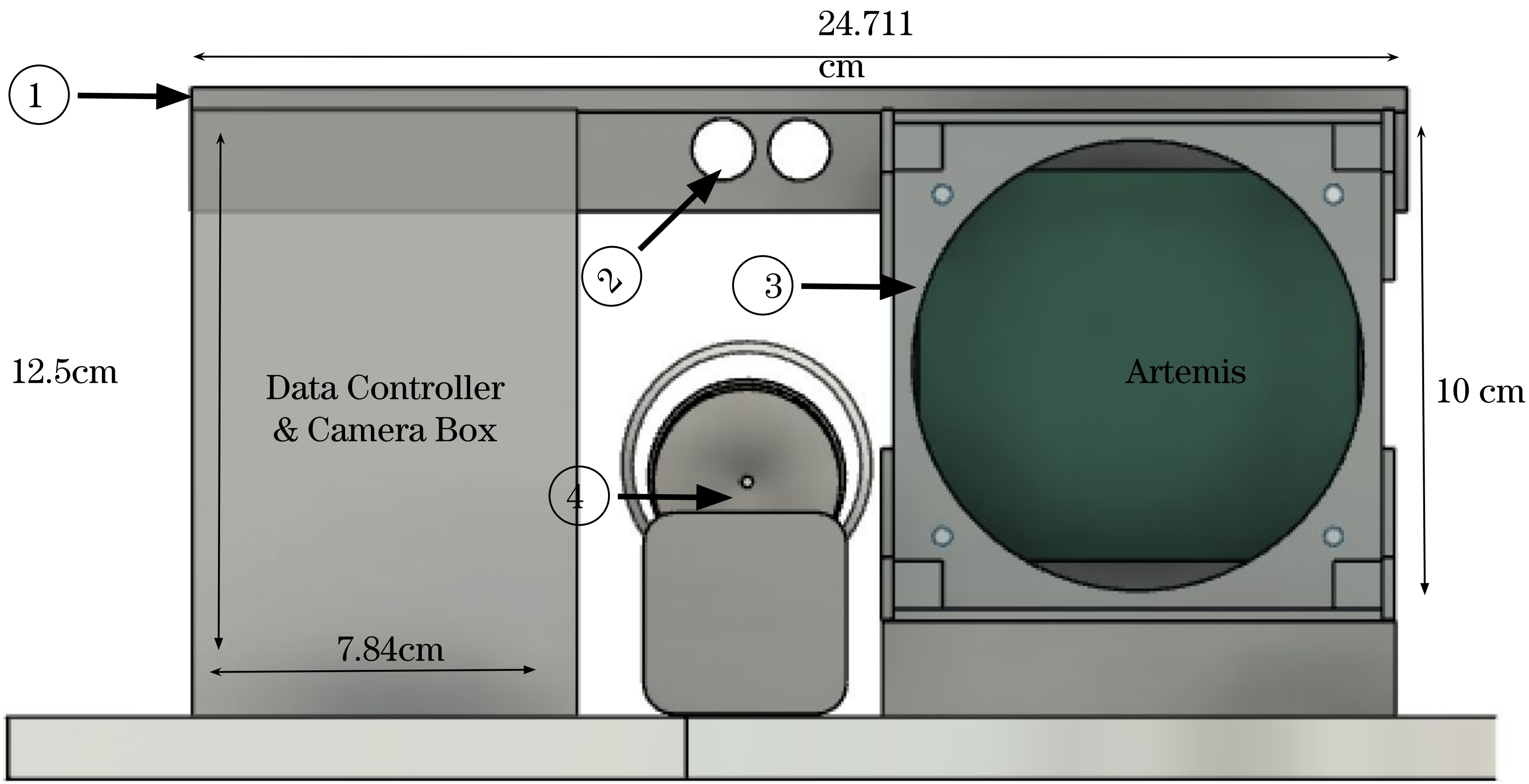
Note: ScubeR is a deployable sublimation rocket. Total deployment time is an estimated 14 seconds.

Design Overview Angled View



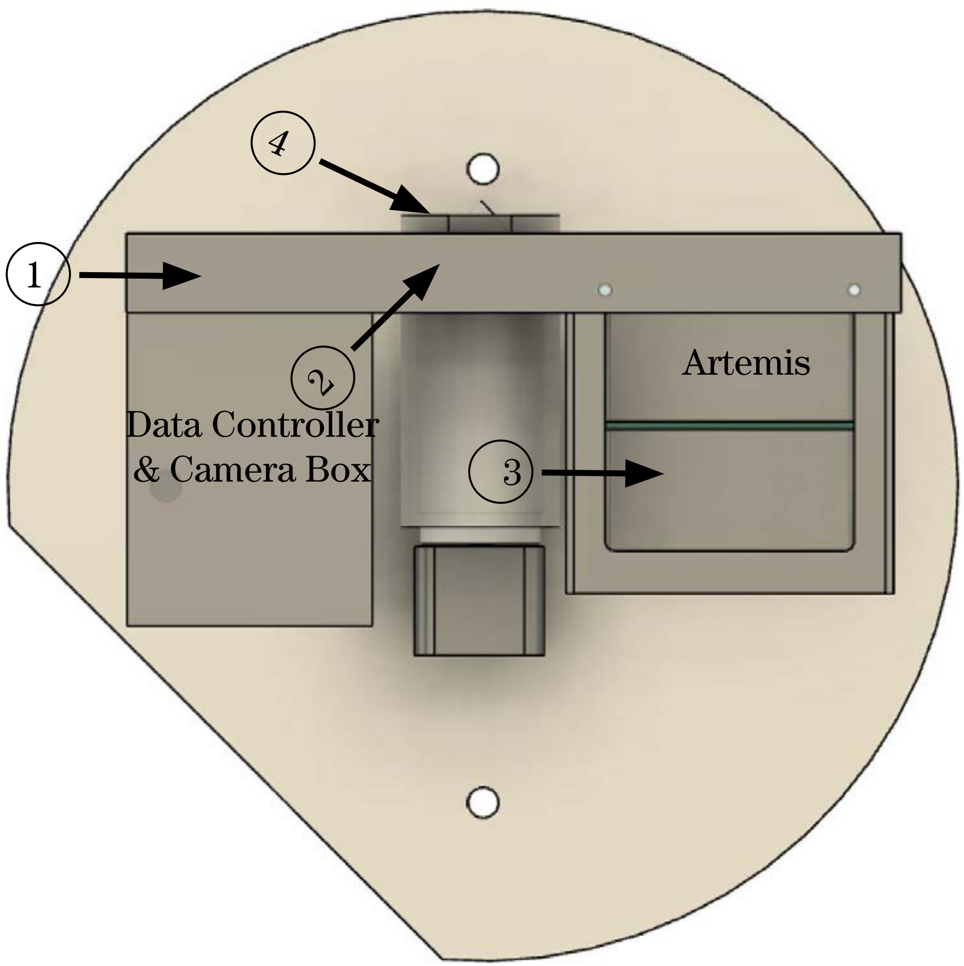
1. Dead Mass Base Plate
2. Camera Lenses
3. Lens Bridge
4. ScubeR Assembly
5. Data Controller & Camera Housing

Design Overview Back View



1. Lens Bridge
2. Camera Lenses
3. Artemis
4. ScubeR Assembly

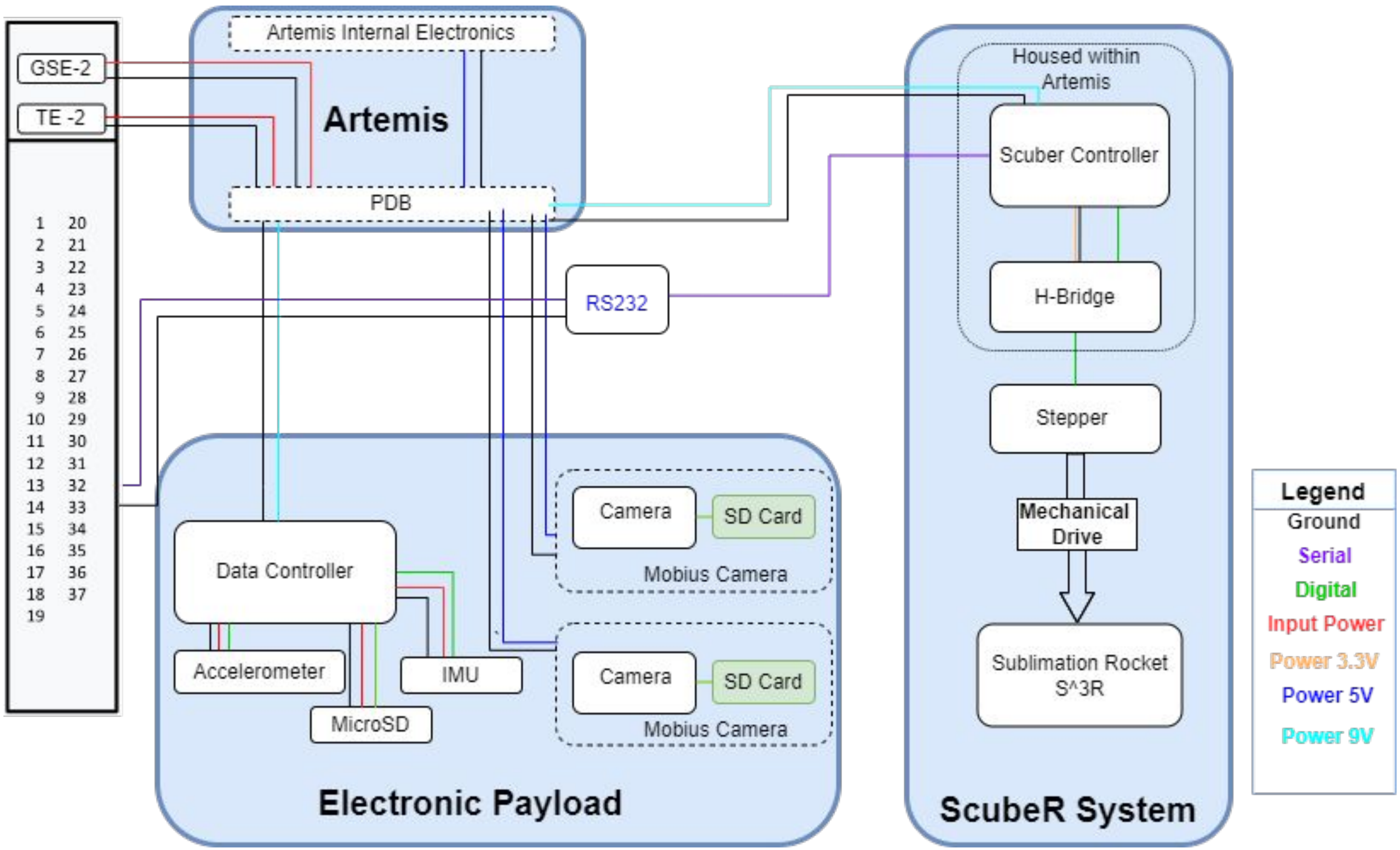
Design Overview Top View



1. Lens Bridge
2. Camera Lenses
3. Artemis
4. ScubeR Assembly

*Note: This image does not include the 1" keep out zone.

Functional Block Diagram



Hazardous Mechanical and Electrical Materials

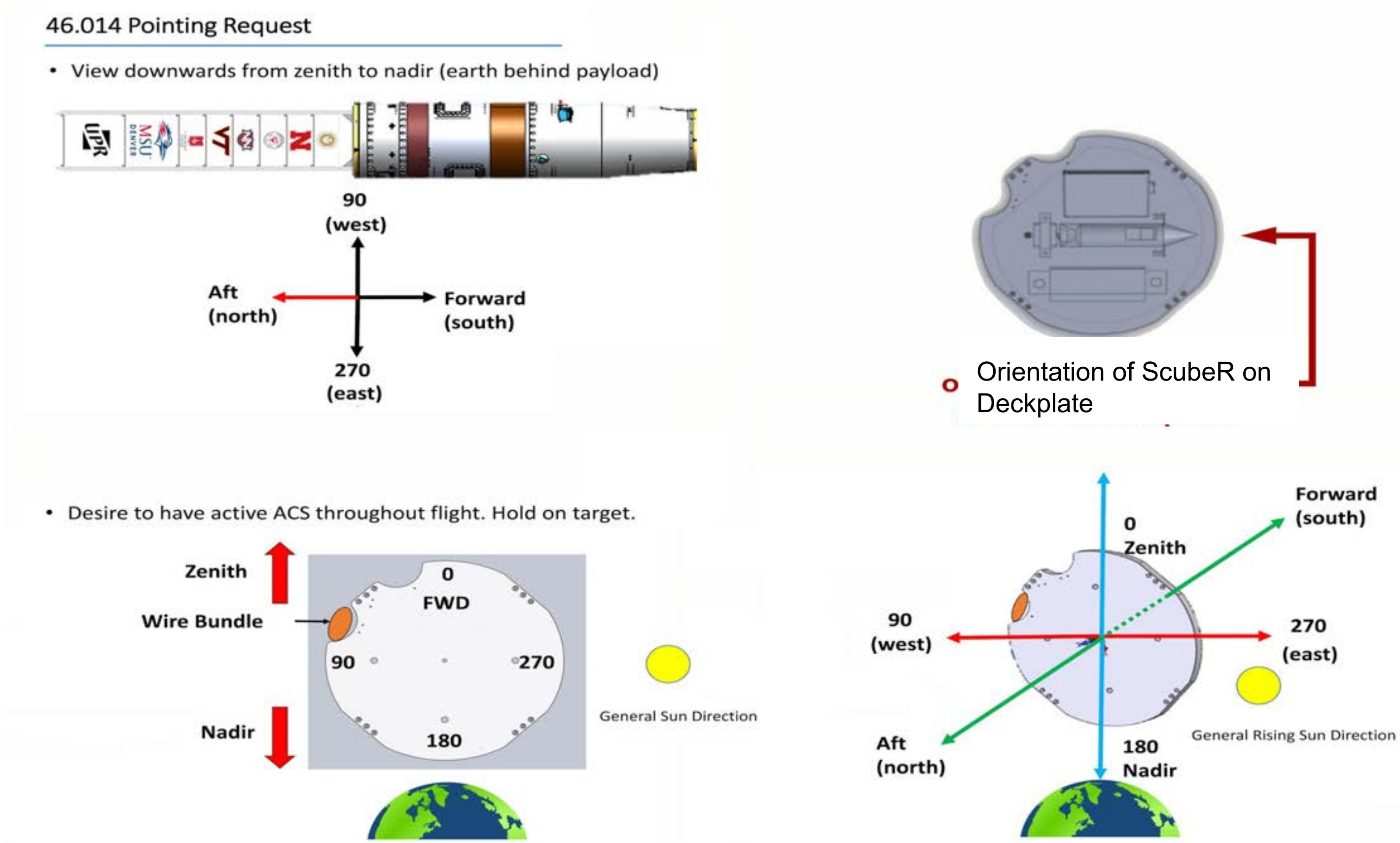
We are not utilizing any hazardous components or substances in either our mechanical or electrical designs.

Notes:

- we are not using a H.V. source
- ScubeR will travel an approximate 10 cm in 11 seconds.
- ScubeR will be deployed at approximately t= +118s and will not be returning to the CarRoLL

System Overview: Special Requests

Our only special request for WFF is to have an orientation of the release of ScubeR in direct sunlight—the preferred direction is along the eastern edge of the horizon.



Jared

Description of Partnerships

Build Teams:

Project Imua Mission 10 currently consists of three student teams from Windward Community College, Honolulu Community College, and Assets High School.

Sponsors:

Hawaii Space Grant Consortium (HSGC) for the funding of Project Imua.

NASA for deck space within their 2-stage suborbital sounding rocket.

3.0 Integrated Subsystem Testing Status

Subsystem Integration Outline

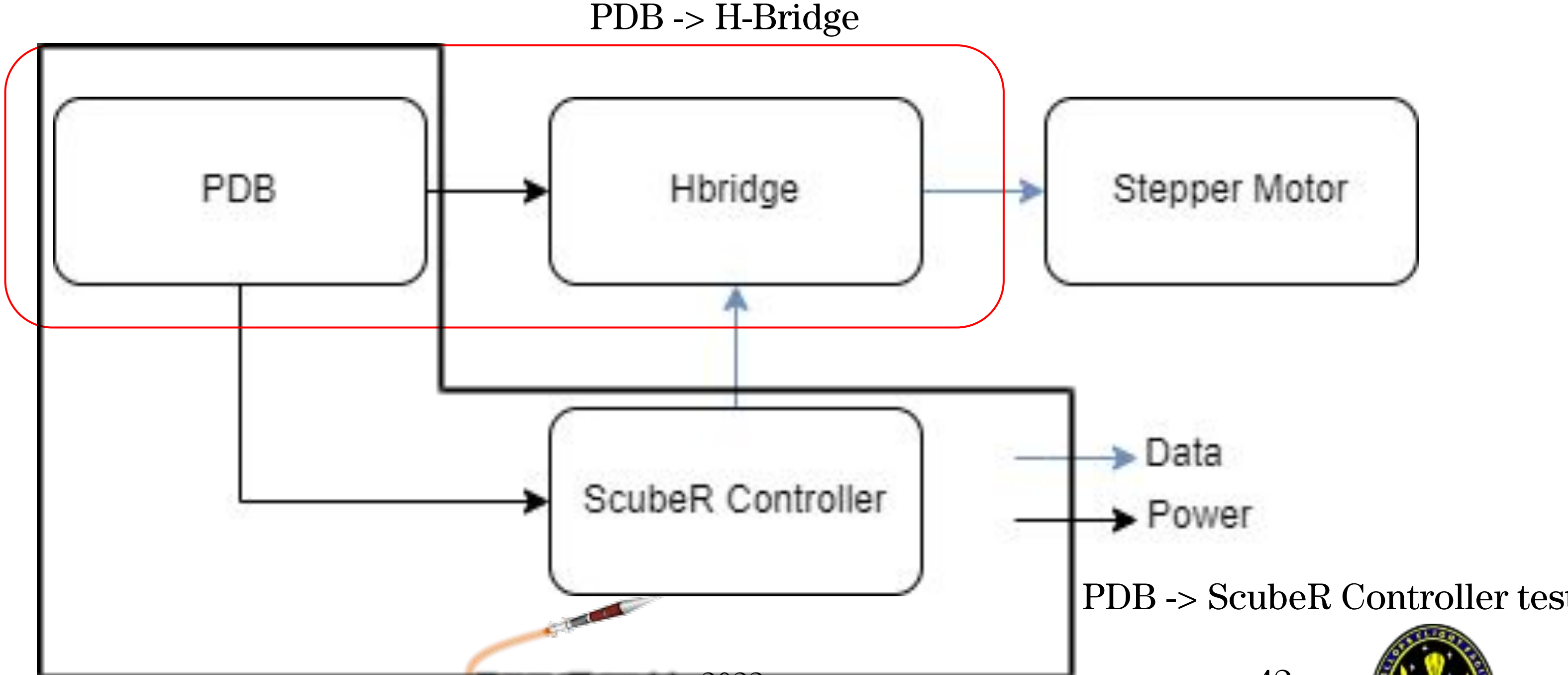
Windward Community College inner-campus integrated tests

1. LM2958 buck converter integrated test for PDB 1/22/22
2. PDB -> H-bridge power 1/29/22
3. PDB -> ScubeR controller power 2/5/22
4. PDB -> ScubeR controller -> H-bridge powered 2/26/22
5. PDB -> ScubeR controller -> H-bridge -> stepper movement 3/5/22
6. PDB -> ScubeR controller -> H-bridge -> stepper programming validation, power and temp test 3/26/22
7. PDB -> ScubeR controller -> H-bridge -> ScubeR physical deployment 4/2/22
8. PDB-> Artemis 4/2/22
9. Power Test: Mobius Cameras, Data Controller -> 4/2/22
10. Integrated Power Test -> 4/9/22
11. Image Capture Test -> 4/9/22
12. Power Test: Artemis -> 4/30/22
13. Integrated Payload has been mounted to the deckplate -> 4/30/22
14. Day in the Life Simulations were performed -> 4/30/22

Integrated Subsystem Testing Status: PDB and H-Bridge

PDB, H-Bridge and ScubeR controller — 100%

1. Tested PDB ability to supply power to H-Bridge and ScubeR controller.
   a. completed on 1/29/22
2. Programming motion test involving ScubeR controller, H-Bridge and stepper motor testing
   a. Validated 3/26/22



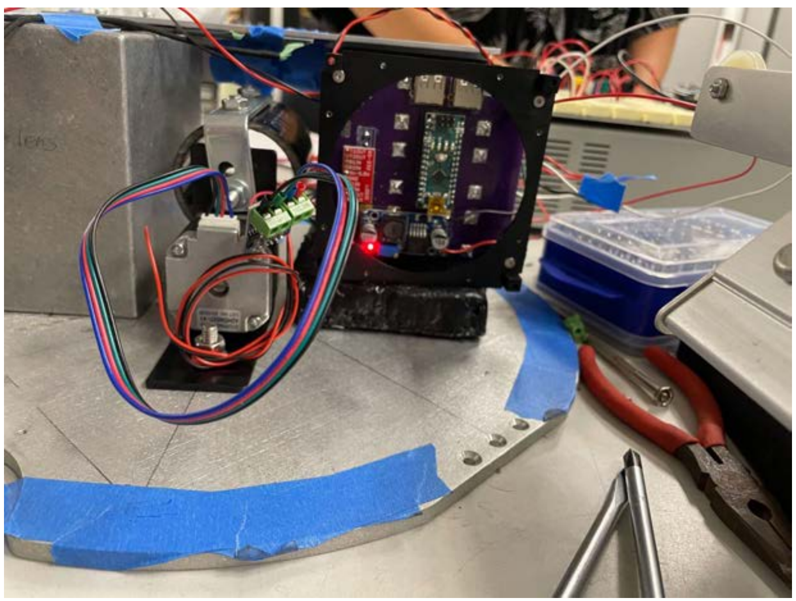
Integrated Subsystem Testing Status: PDB and Artemis

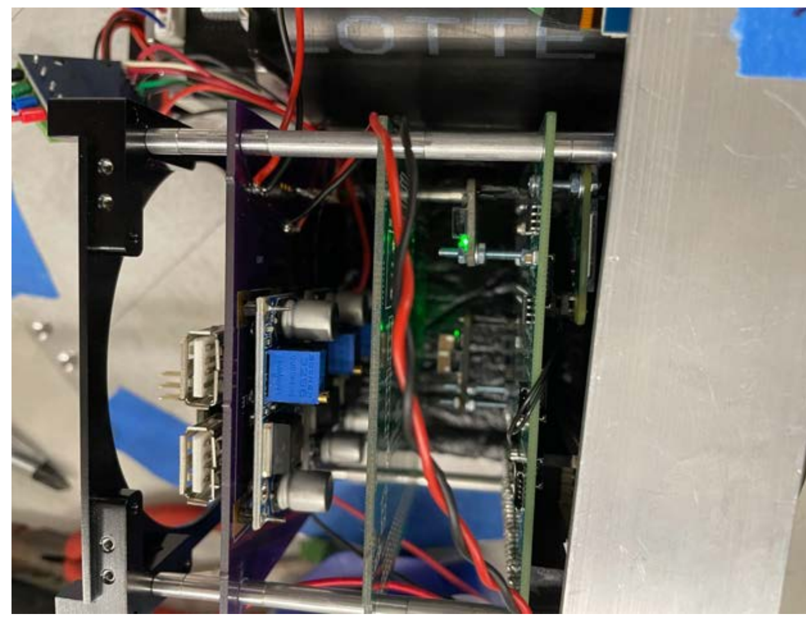
Artemis & PDB

			100%

This test verified the ability for the Power Distribution Board to supply power to Artemis.

Test was completed on 4/29/22





Integrated Subsystem Testing Plan: Image Capture [Mechanical + Software]

Mobius Cameras, ScubeR & ScubeR Controller

100%

Primary Objective(s): Ensure data capture of ScubeR's deployment through pictures and videos collected from the Mobius Cameras.

Secondary Objective(s): To calculate/measure a simulated acceleration and ensure accuracy in data acquisition by comparison to a known theoretical acceleration.

Details:

- Test was completed on April 9, 2022.
- The Mobius Cameras were able to successfully capture multiple videos and photos on ScubeR's simulated deployment.
- Currently, we are still undergoing data analysis to reproduce a calculated acceleration from this experiment which will be compared to a predetermined theoretical value.

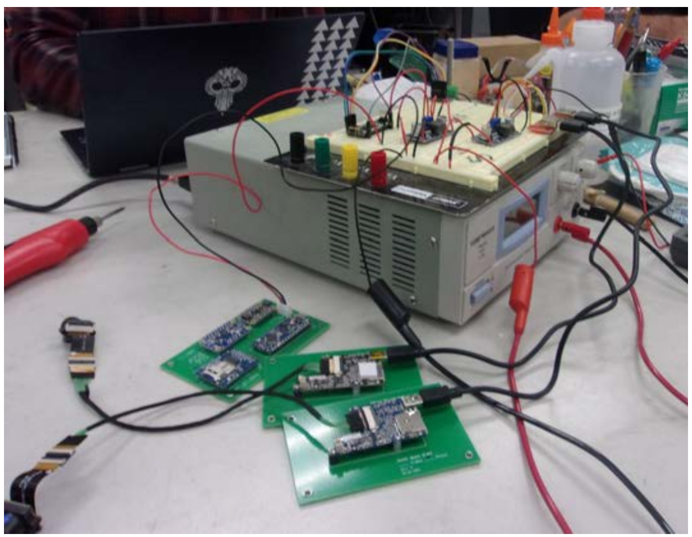
Image Capture Test Pictures

Integrated Subsystem Testing Plan: Power Test for Mobius Cameras [Electrical]

Photo and Video Camera

100%

This test verified that the PDB can supply power to the Mobius Cameras. Video and image capture quality was also deemed to be significant enough for calculations.



Integrated Subsystem Testing Plan: Power Test for Data Controller [Electrical]

D’Elle

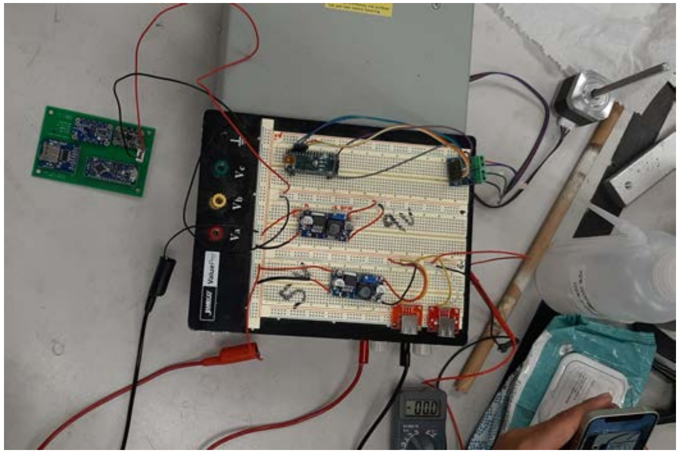
Data Controller

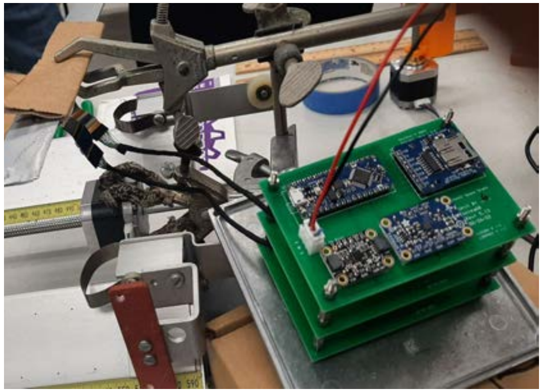
100%

Primary Objective: This will demonstrate the ability for the PDB to turn on the Data Controller and it will also test the Data Controller’s functionality.

Results: This power test was successful.

This test was completed successfully on April 2nd, 2022





Integrated Subsystem Testing Plan: Fully Integrated Power Test [Electrical]

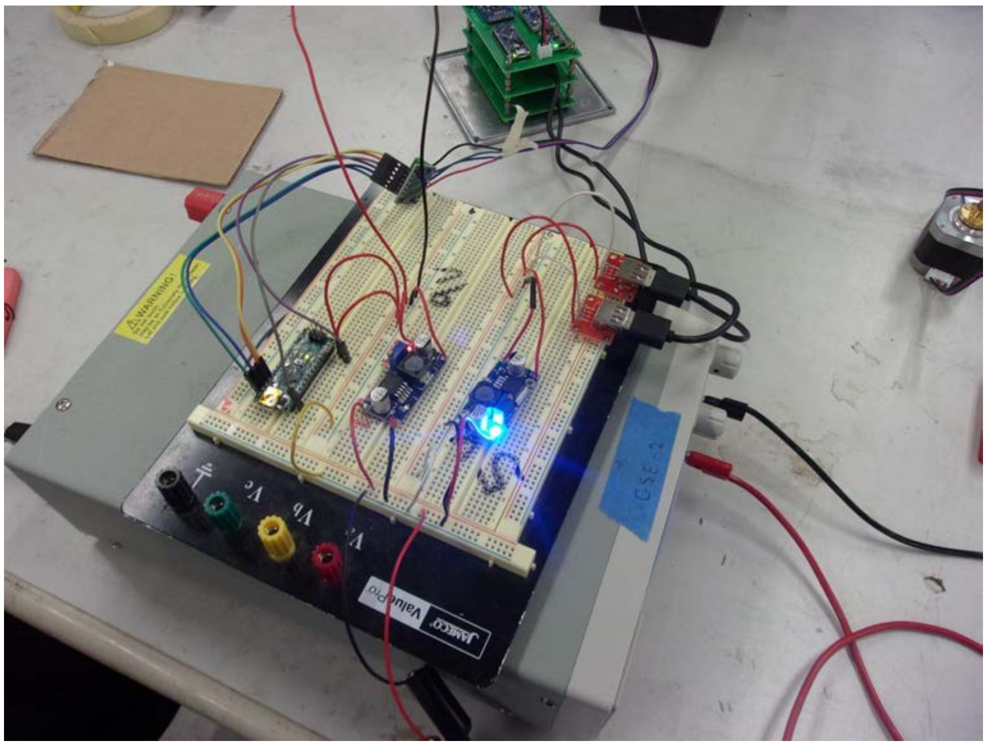
			100%

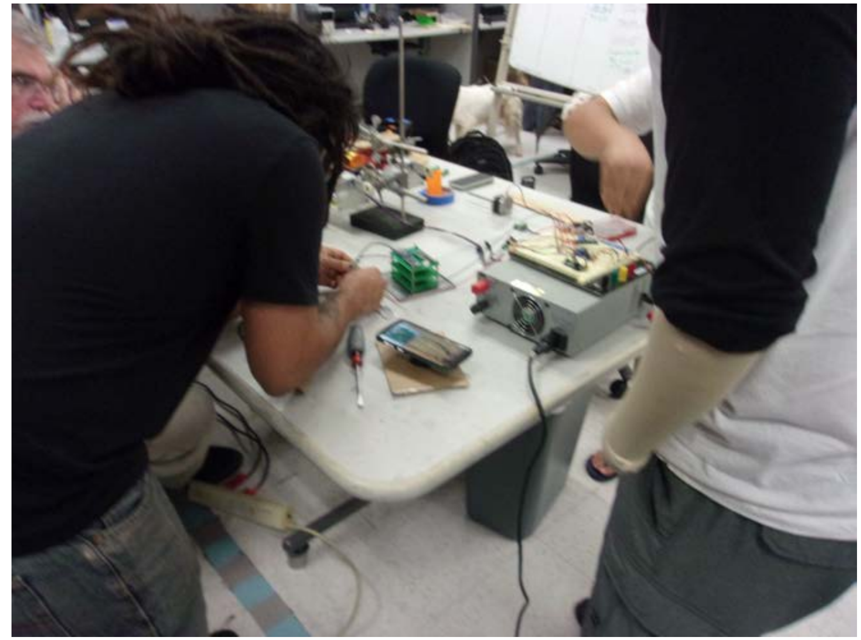
Power Distribution Board

Primary Objective: To ensure that the Power Distribution Board can power on all electrical components of the design payload in addition to testing the functionality of all electrical components.

This test was conducted on 4/9/22 and was a success. However, the Artemis cubesat could not be tested at this time. Since Artemis is not mission critical this test was not repeated by the UHCC team as all critical subsystems were successfully powered on.

Integrated Power Test Pictures





Mechanical Integration

99.9%

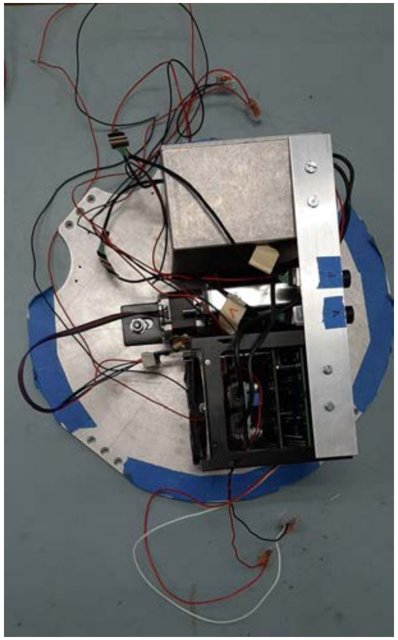
- As of April 25th, 2022 mission critical components have been successfully mounted to the deck-plate.

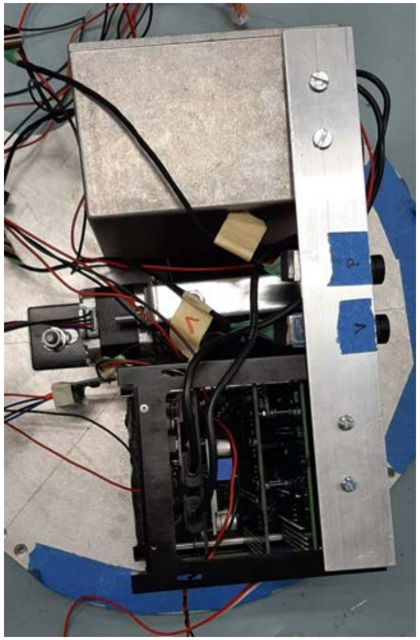
- **<u>Pending Alterations</u>**
- We only need to seal the hammond boxes.
- A puncture pin needs to be prepared to breach a plastic seal over ScubeR’s nozzle.
- The wiring setup will be cleaned up, organized and will include a TE-R interface.
- These remaining steps will be completed by VVC.

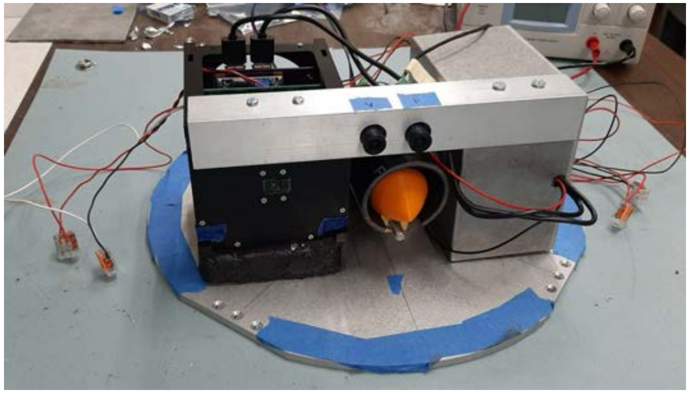
Overall Integration/Testing Status

99%

- Our payload has been fully mounted and integrated, save for the few items mentioned on the previous slide.

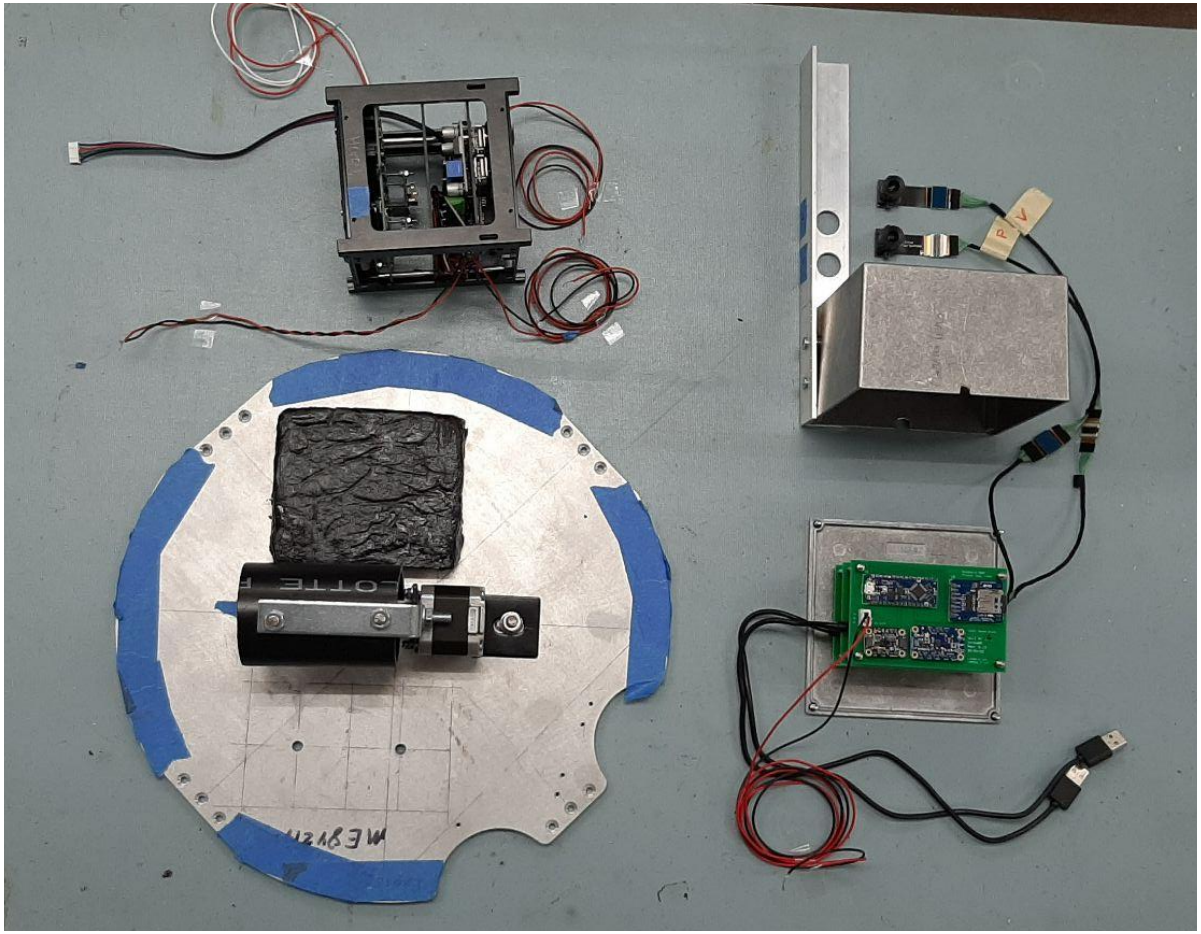




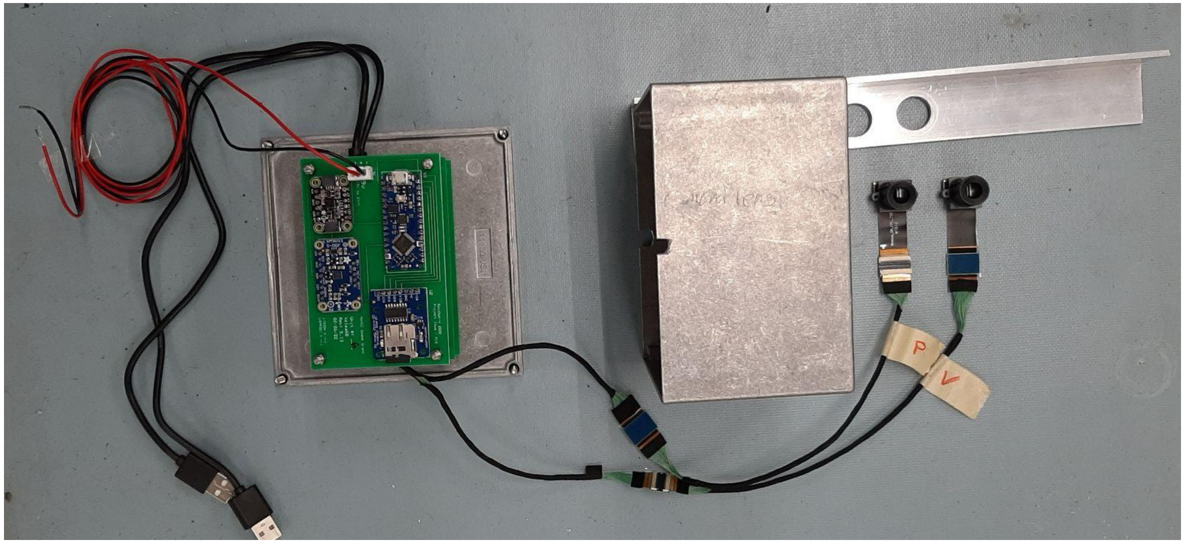


4.0 Full Mission Simulation Results

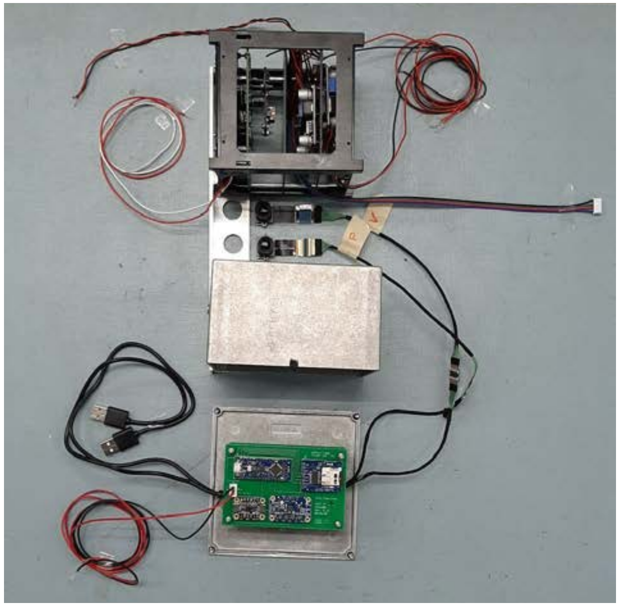
Hardware Pictures

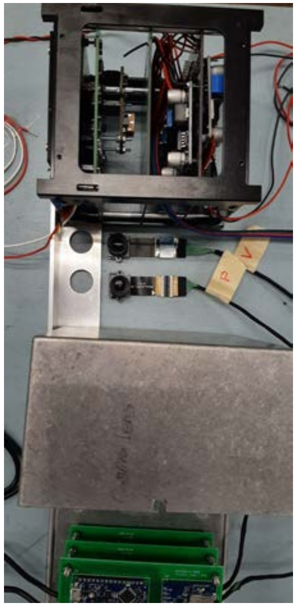


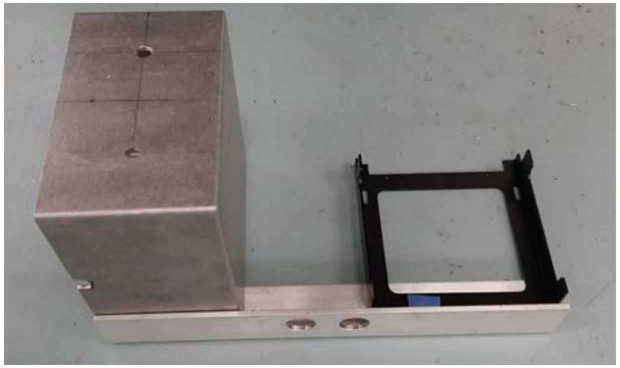
Hardware Pictures



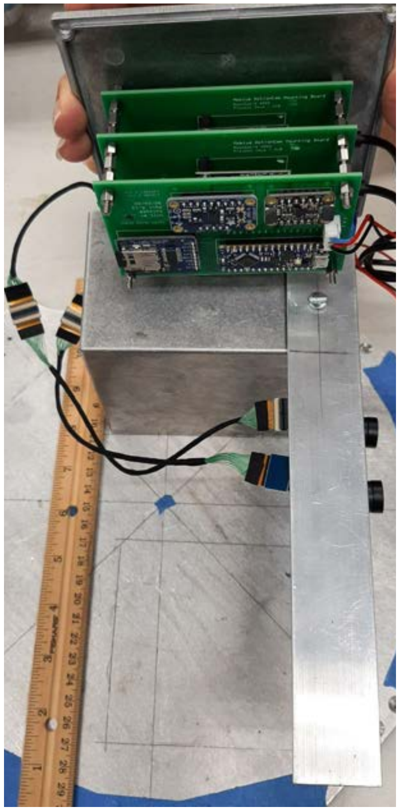
Hardware Pictures

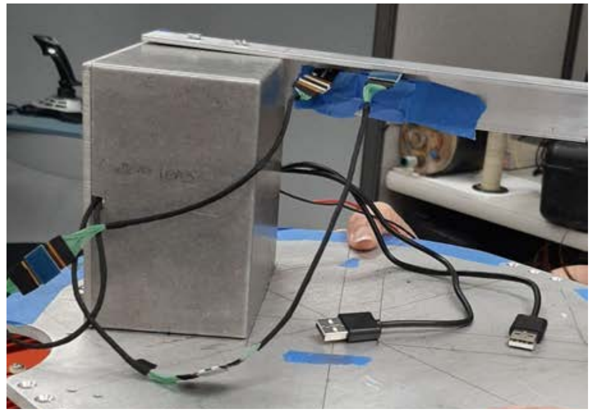


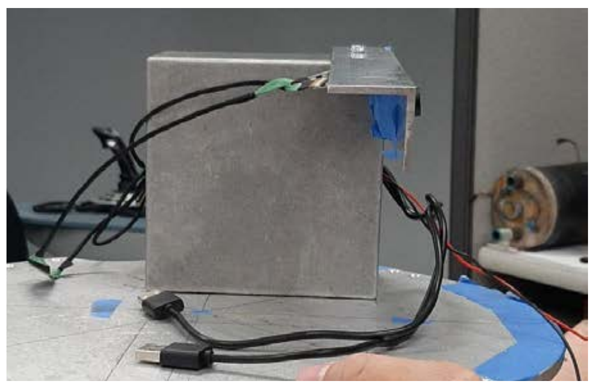


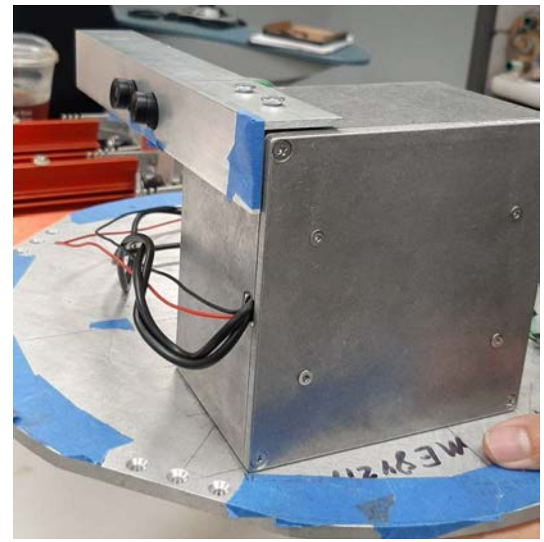


Set Up Pictures









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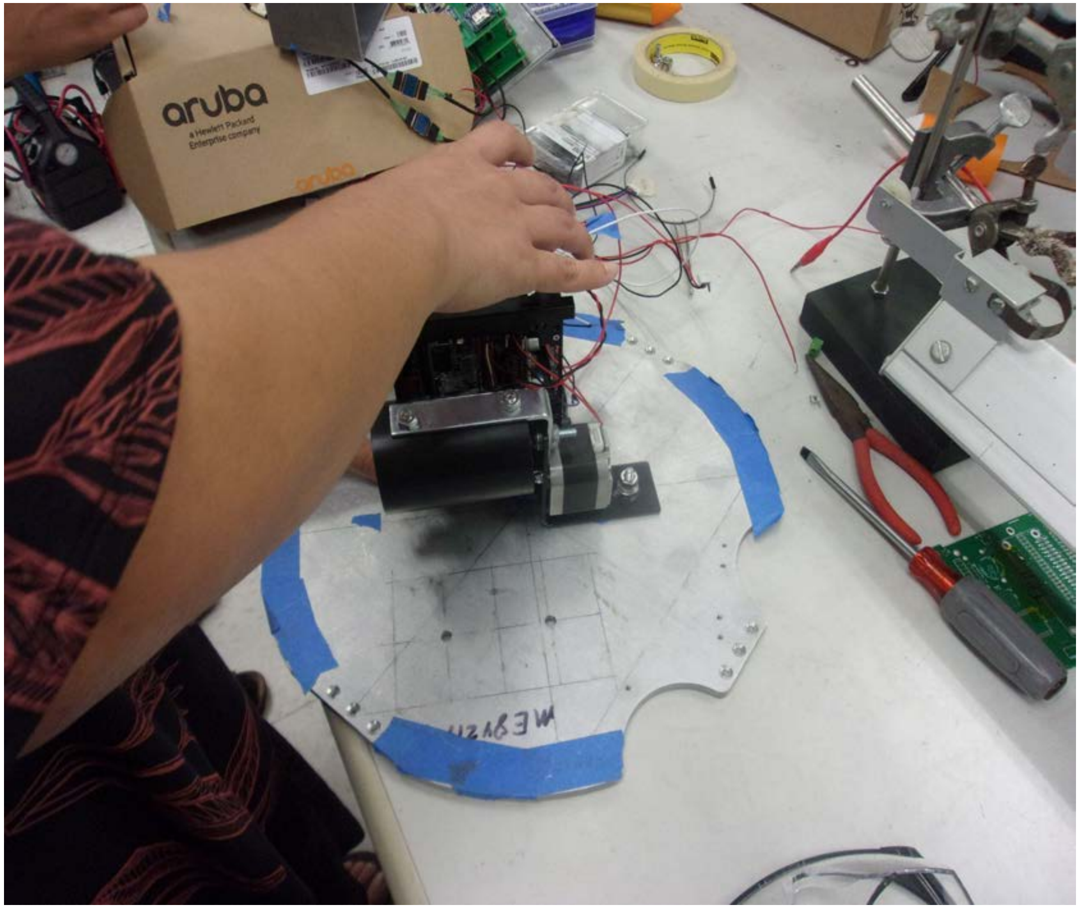

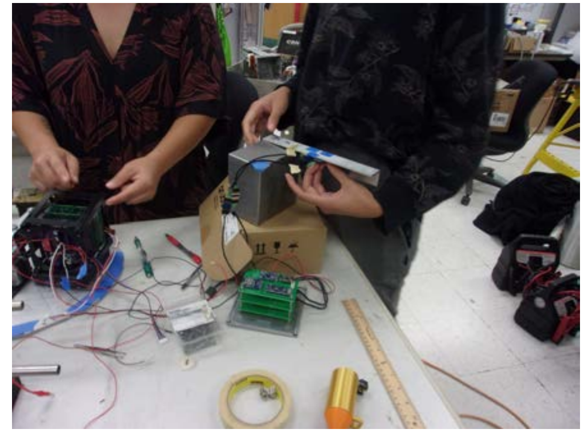

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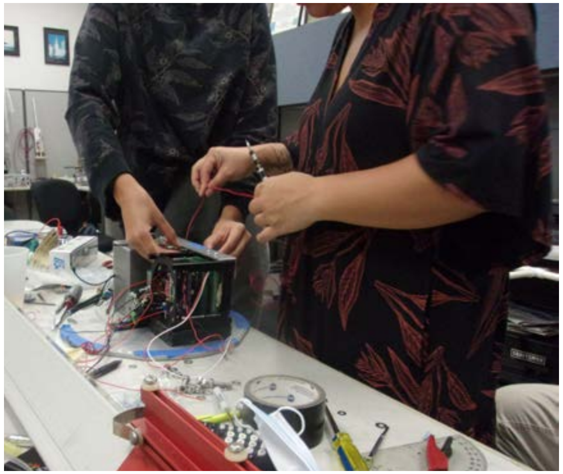
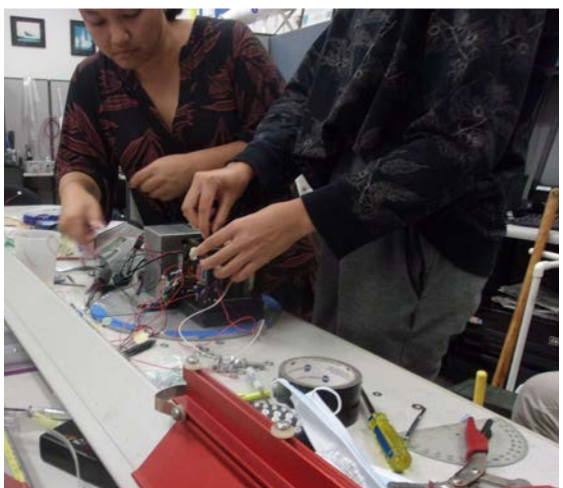
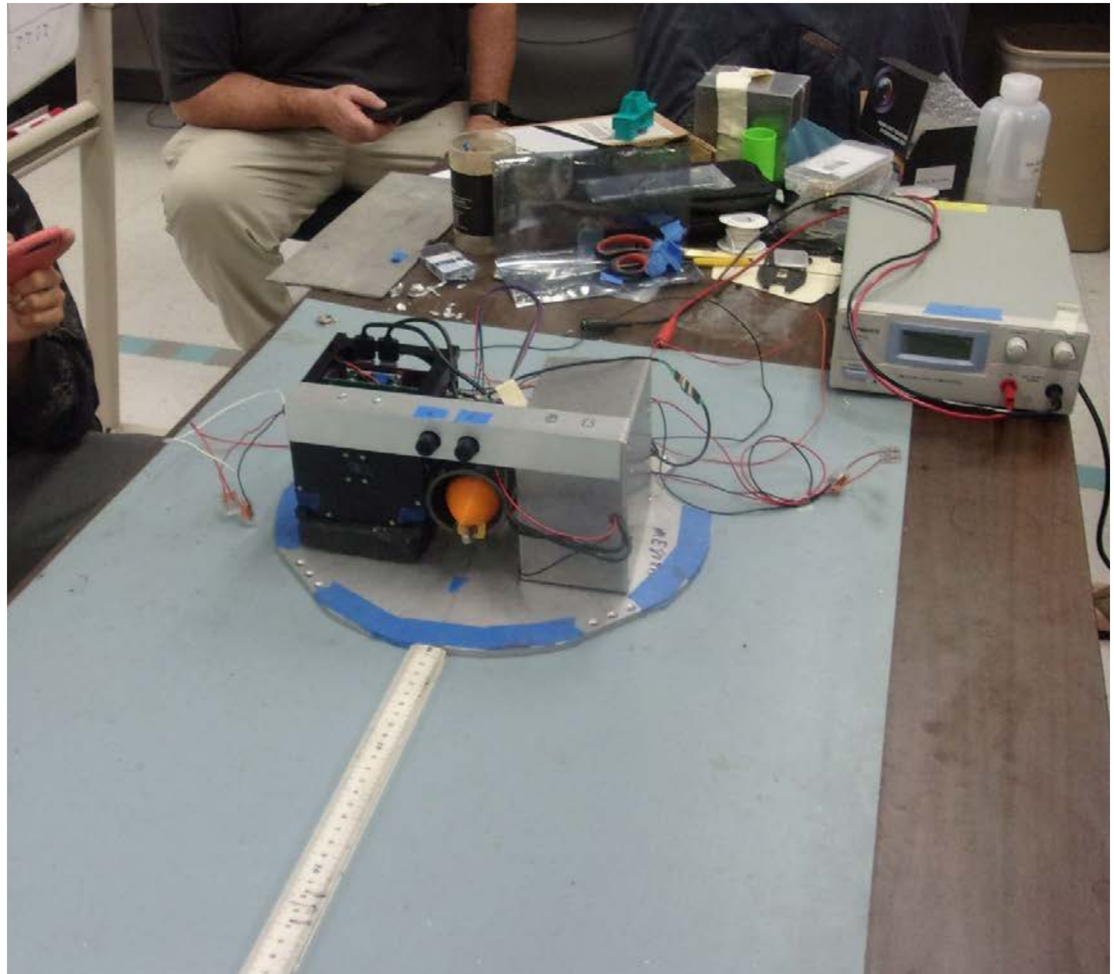
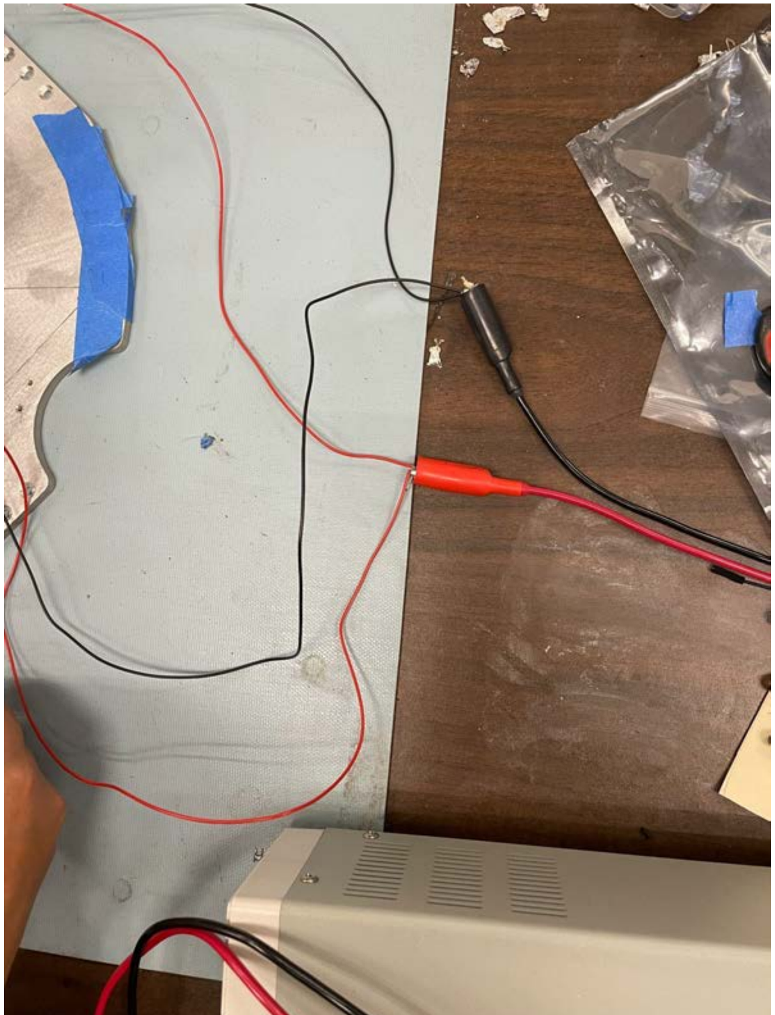
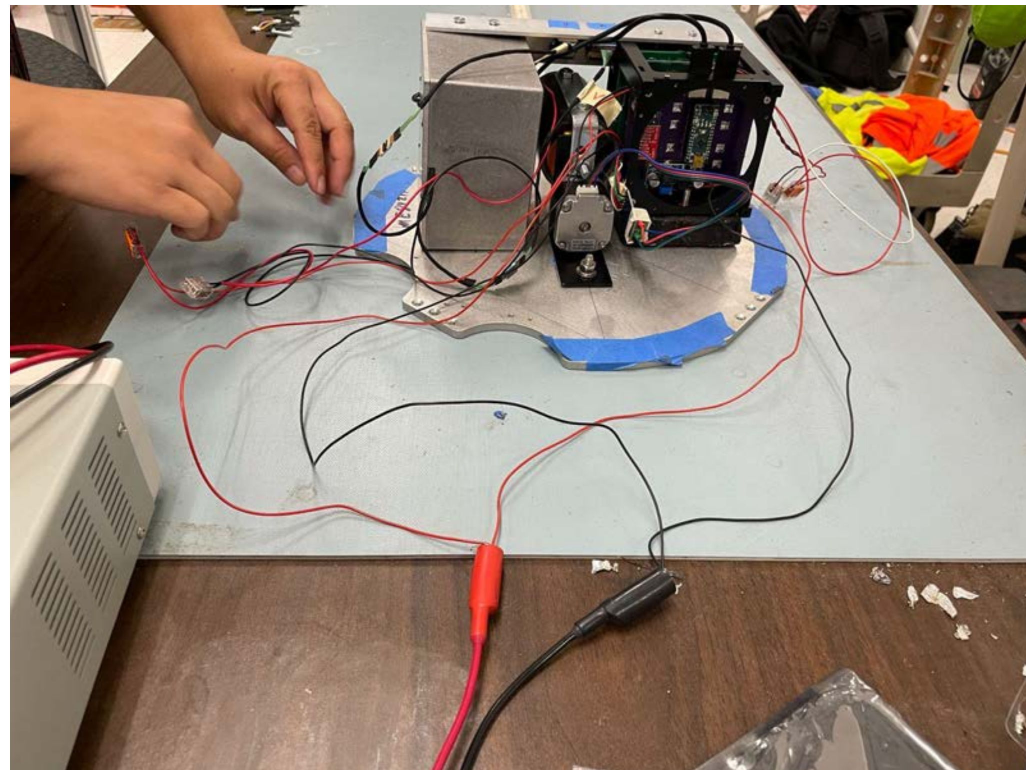






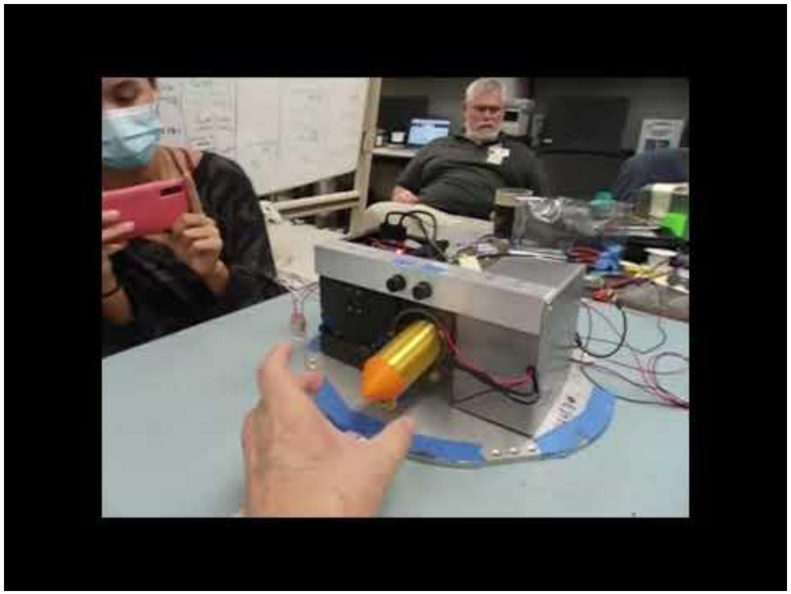
Connection to WFF Power Pictures



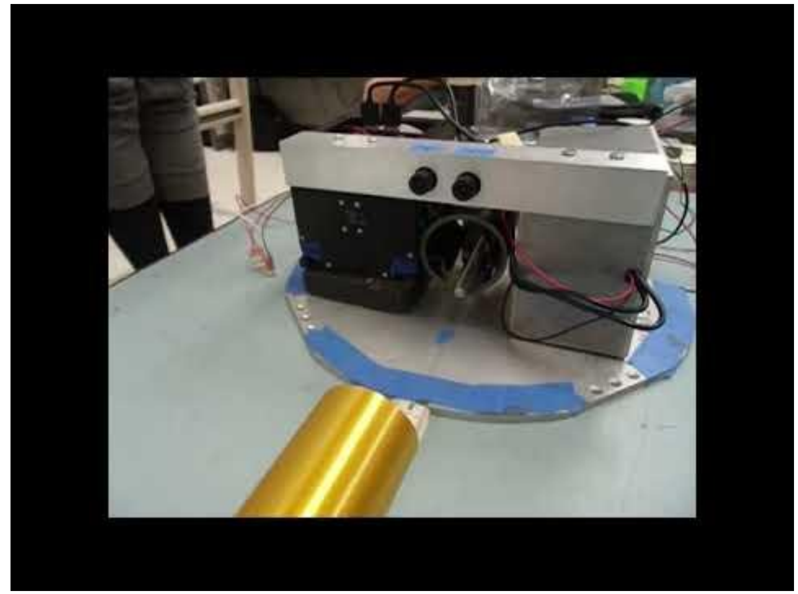


Power Connection

Full Videos of DILS

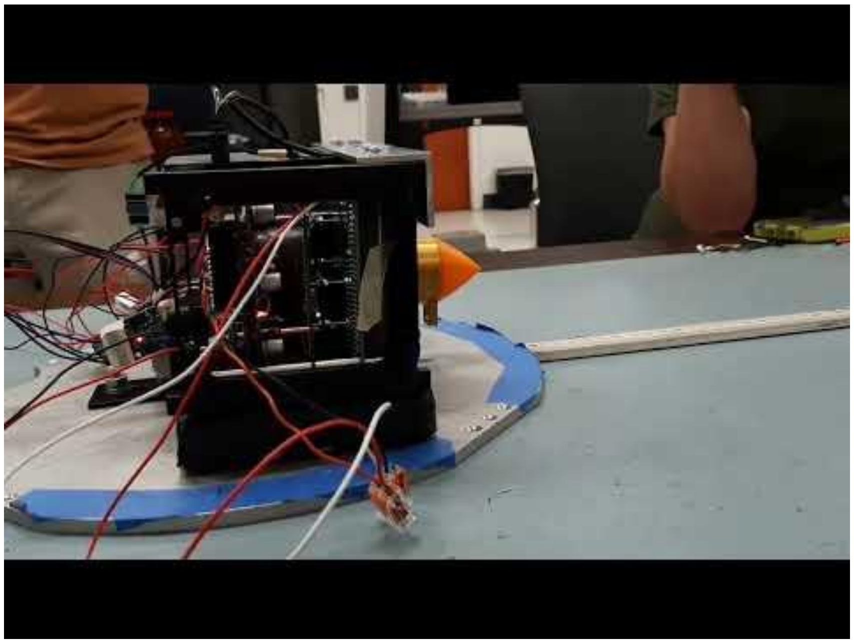


Day in the Life Test 1

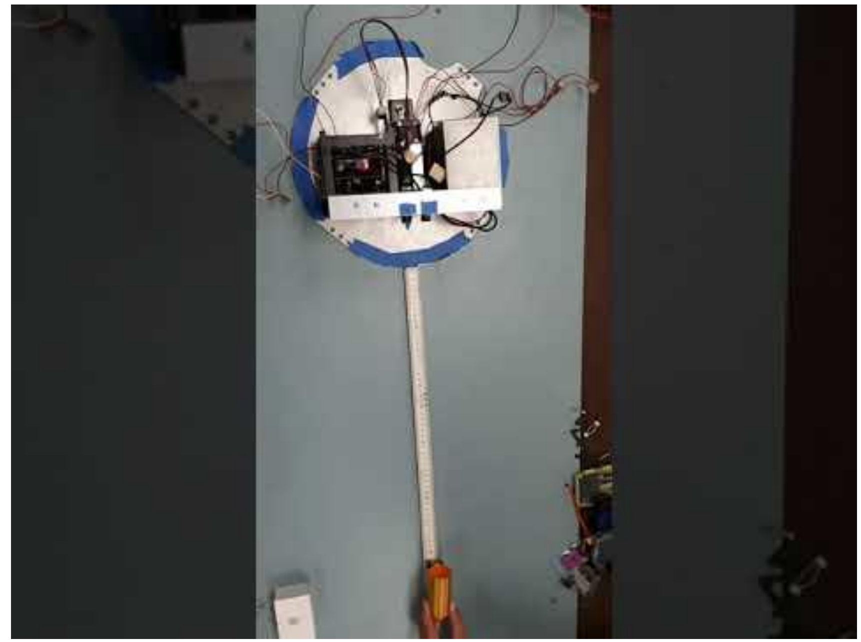


Day in the Life Test 2

Clips of DILS (for presentation)



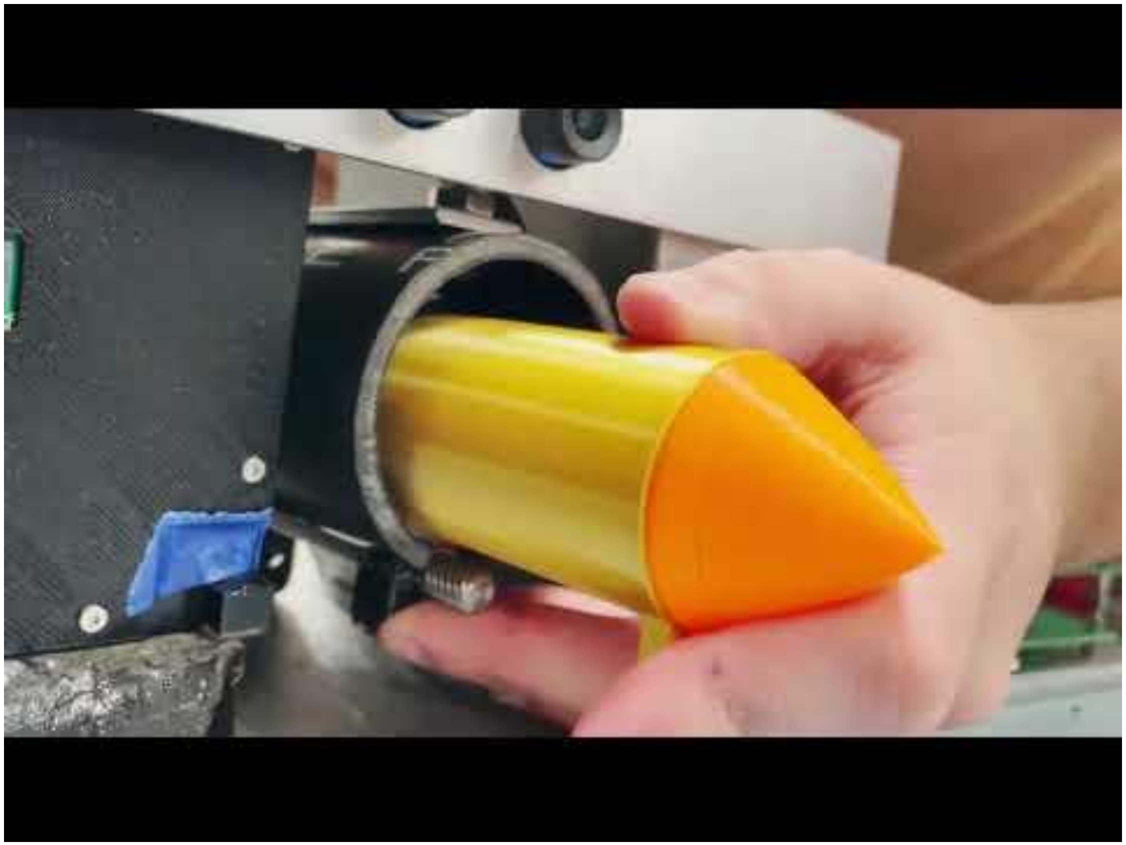
Day in the Life Test 1



Day in the Life Test 2

Video of Inhibit

Video of Setting Up ScubeR



Results and Discoveries

Results:

ScubeR was successfully deployed and the Mobius cameras were fully operational.

All **mission critical objectives** were successfully met during this simulation.

Secondary objectives are currently being analyzed.

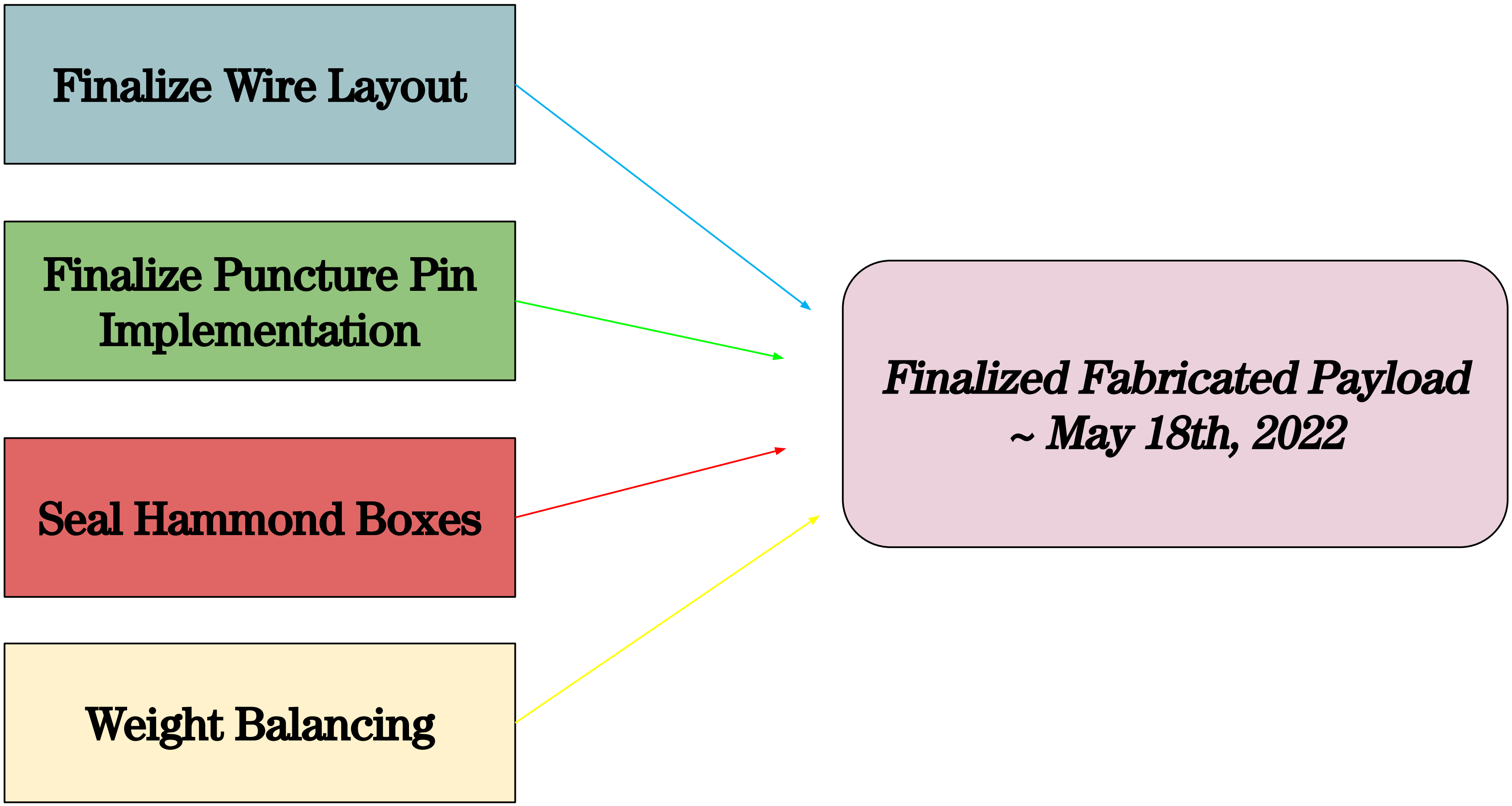
- Team has observed some initial success.

What wasn't tested

- The Puncture Pin for ScubeR
- The TE-R interface

The Items above will be implemented by May 18th, 2022.

Follow-up Plan



5.0 Project Schedule

Schedule: May

May

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4 Deadline: FMSR @ 8:00 am HST	5	6	7
8	9	10	11	12	13	14
15	16	17	18 Materials for VVC Finished Deadline: Balence Deck Plate Deadline: Organize Wires Deadline: Puncture Pin	19 VCC	20 VCC	21 VCC
22 VCC	23 VCC Deadline: Inhibit Procedures Due	24 ~Send Payload to COSGC	25 ~Send Payload to COSGC	26 ~Send Payload to COSGC	27 ~Send Payload to COSGC Deadline: Package & Ship.	28 ~Send Payload to COSGC
29	30	31				

Schedule: June

June

Su	Mo	Tu	We	Th	Fr	Sa
			1 Deadline: Payload to COSGC	2	3	4
5	6	7	8	9	10	11
12	13	14	15 Travel for Seq. Test	16 Travel for Seq. Test GSE Checkout	17 Travel for Seq. Test GSE Checkout	18 Travel for Seq. Test
19 Travel for Seq. Test	20 Travel for Seq. Test	21 Travel for Seq. Test	22 Travel for Seq. Test	23 Travel for Seq. Test	24 Travel for Seq. Test	25 Travel for Seq. Test
26	27	28	29	30		

6.0 June Operations

Required Tools

- Flat-head Screwdriver (¼”)
- Pre-made altered screw which we define as the pin.
  - A matching nut is also required

Inhibition and Reloading of ScubeR

Procedure Summary

- ScubeR is to be removed from the stepper motor to inhibit deployment.
- This process is done by manually removing ScubeR.
  - utilizing a flat-head screwdriver, a screw can be twisted at the back of the stepper motor causing the drive screw to move.
- The same methodology will be used to put ScubeR back onto the drive screw.

Step 1

- Examine the back of the stepper motor, as can be seen in the picture to the right; we <u>define</u> **12-o'clock** to be where the **wire connections** are on the stepper motor **while remaining in this orientation** (a back view).
- Locate the **screw in the back center of the stepper motor**. This screw manually controls the forward and backward motion of the drive screw. For simplicity we will <u>define this screw</u> to be the **control screw**.

Step 2

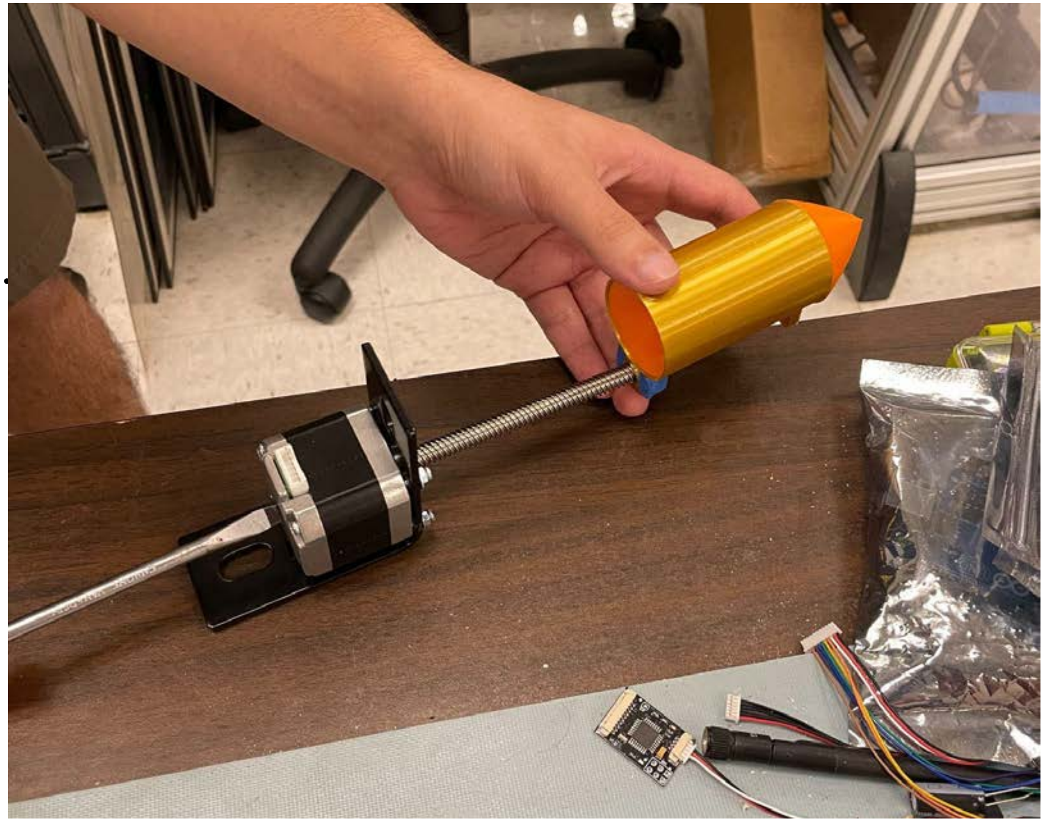
- Utilizing a flathead screwdriver, turn the **control screw** counter-clockwise to cause the drive screw to progress forward which will drive ScubeR forward.

Step 3

- Keep turning the **control screw** counter-clockwise until ScubeR is released from the drive screw.
- Be prepared to catch ScubeR at this time.

Step 4

- To re-habit ScubeR, place the flange nut attached to ScubeR at the end of the drive screw.
- Turn the **control screw** clockwise.
- Do this until ScubeR has caught onto the drive screw.



Step 5

- Using a flathead screwdriver, turn the **control screw** clockwise until ScubeR is approximately 1-inch away from the stepper motor.

ScubeR Puncture Pin

Procedure Summary

- To breach the plastic seal covering ScubeR's nozzle a sharp "pin" will be installed.
- A screw will be modified to have a sharp end.
- Utilizing a mounted cross-bar plate that is level to the nozzle of ScubeR, the altered screw will be placed into a pre-drilled hole while utilizing a nut to fix the screw.

Steps

Step 1

- Place the **pin** into the pre-drilled hole on the cross-bar located on the stepper motor and behind the drive screw.

Step 2

- Utilizing a nut bolt down the pin as tight as possible. This can be done initially by hand and later a flathead screwdriver to tighten further.

7.0 Conclusions

Worries and Concerns

- **Concern 1:** Sublimation Rocket may not clear CarRoLL before re-entry.
  - **Mitigation:** Use of worm gear will guarantee clearing of CarRoLL section.
- **Concern 2:** The Specific Impulse of the sublimation propellant is unknown, resulting in an uncertainty of rocket's maximum reaction mass.
  - **Mitigation:** We had conducted a vacuum pressure test which yield a sublimation rate of 0.7 g/hr. Our expected results assumed a sublimation rate of 1g/hr. Since the thrust is directly proportional to the sublimation rate, the test supports preliminary results and ScubeR will remain under a speed of 1 inch/sec.
- **Concern 3:** Mobius camera data retrieval damage (Still Pictures & Video)
  - **Mitigation:** Hammond box for heat & water proofing.

Conclusion

- Mission deserves to fly because:
  - Provides proof-of-concept and baseline measurements for innovative low-thrust venier rockets.
  - Provides early college students with high-tech NASA-focused design and production experience
  - Proof of Concept Flight for Artemis CubeSat Kit

- **The UHCC team is extremely confident for our payloads success in flight and sequence testing.**

- Next steps towards Sequence Testing
  - Finalizing our RBF procedures
  - Finalize puncture pin and organize wire lay to include Redundant TE
  - Balance weight via screws (countersunk) and washers
  - Loading Camphor into ScubeR (Before VVC)
  - Finalizing VVC
  - Shipping the Payload (To COSGC by June 1st)

Appendix

Acronyms

HonCC – Honolulu Community College

WinCC – Windward Community College

UHCC – University of Hawai‘i Community Colleges

HSGC – Hawai‘i Space Grant Consortium

HSFL – Hawai‘i Space Flight Lab

ScubeR – Super Simple Sublimation Rocket (S^3R)

PDB - Power Distribution Board

Special Names

Mobius ActionCam – On-board cameras

ScubeR Controller - Arduino Nano Every controlling the Stepper Motor

Data Controller - Contains Motion Sensors and Data Storage

Kolea projects - HonCC controller based projects, testing of technology & components, documenting using Google Core Apps