Project Imua Mission 10

Subsystem Test Review

University of Hawai‘i Community Colleges

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February 7, 2021

1.0 Mission Overview

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

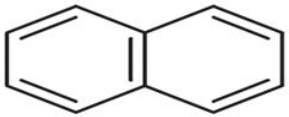
Primary Objectives	Minimum Success Criteria
Engage students in design, fabrication and aerospace engineering.	10 scholarships awarded per semester; 8 students and 3 faculty mentors to attend RockSat-X 2022's test and launch events at WFF with a fully integrated, flight certified payload.
Deploy sublimation 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.

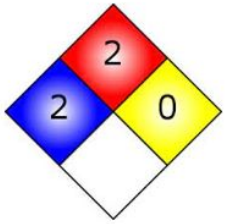
Desirable Success Criteria: Secondary Objectives

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)

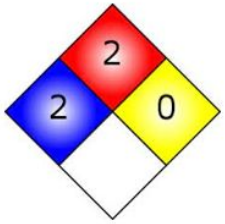
Sublimating Material

- Naphthalene
- Formula: $C_{10}H_8$
- Vapor Pressure: 0.338 Pa
- Molar Mass: 128.1 g/mol
- Density: 1.14 g/cm^3
- Boiling Pt: 218° C
- Melting Pt: 80.3° C





- Camphor
- Formula: $C_{10}H_{16}O$
- Vapor Pressure: 166 Pa
- Molar Mass: 152.2 g/mol
- Density: 0.99 g/cm^3
- Boiling Pt: 209° C
- Melting Pt: 175° C



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, $\dot{R}$.

$$P = \frac{N k_B T_K}{V} = \left(\dot{R} \frac{N_A}{\mathfrak{M}} \Delta t \right) \left(\frac{k_B T_K}{V} \right)$$

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 $\dot{m} = \left(\frac{A_{th}}{A} \right) \dot{R}$.

$$F = \dot{R} A_{th} \left\{ \frac{1}{A} \sqrt{\frac{3 R_u T_K}{\mathfrak{M}}} + \left(\frac{N_A k_B T_k}{\mathfrak{M} V} \right) \Delta t \right\}$$

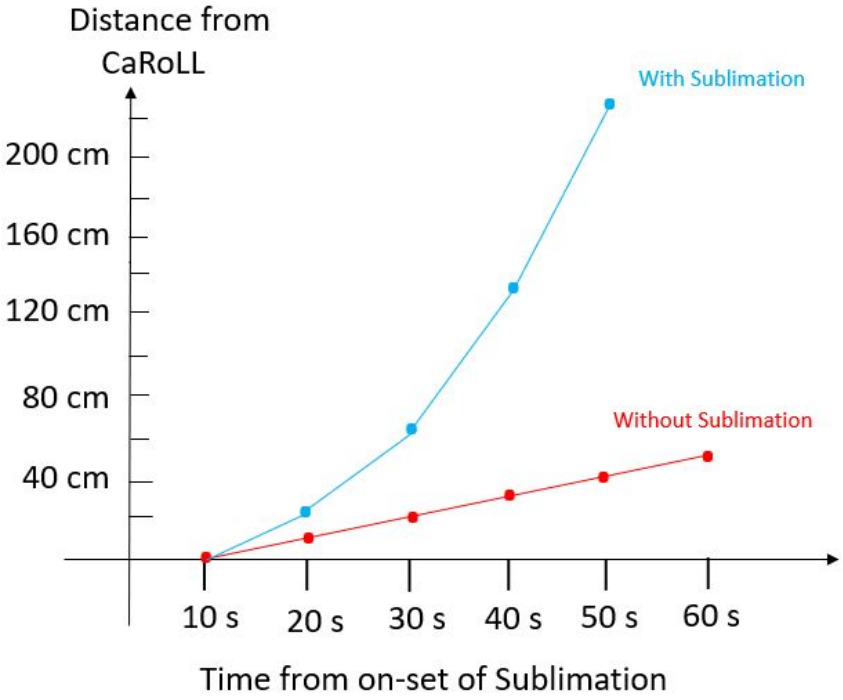
Since not all the volume holding the reaction mass is available for the sublimating material to expand to, we need to include a volume coefficient ϵ indicating the percentage of the volume that is available for the sublimating material to expand into.

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

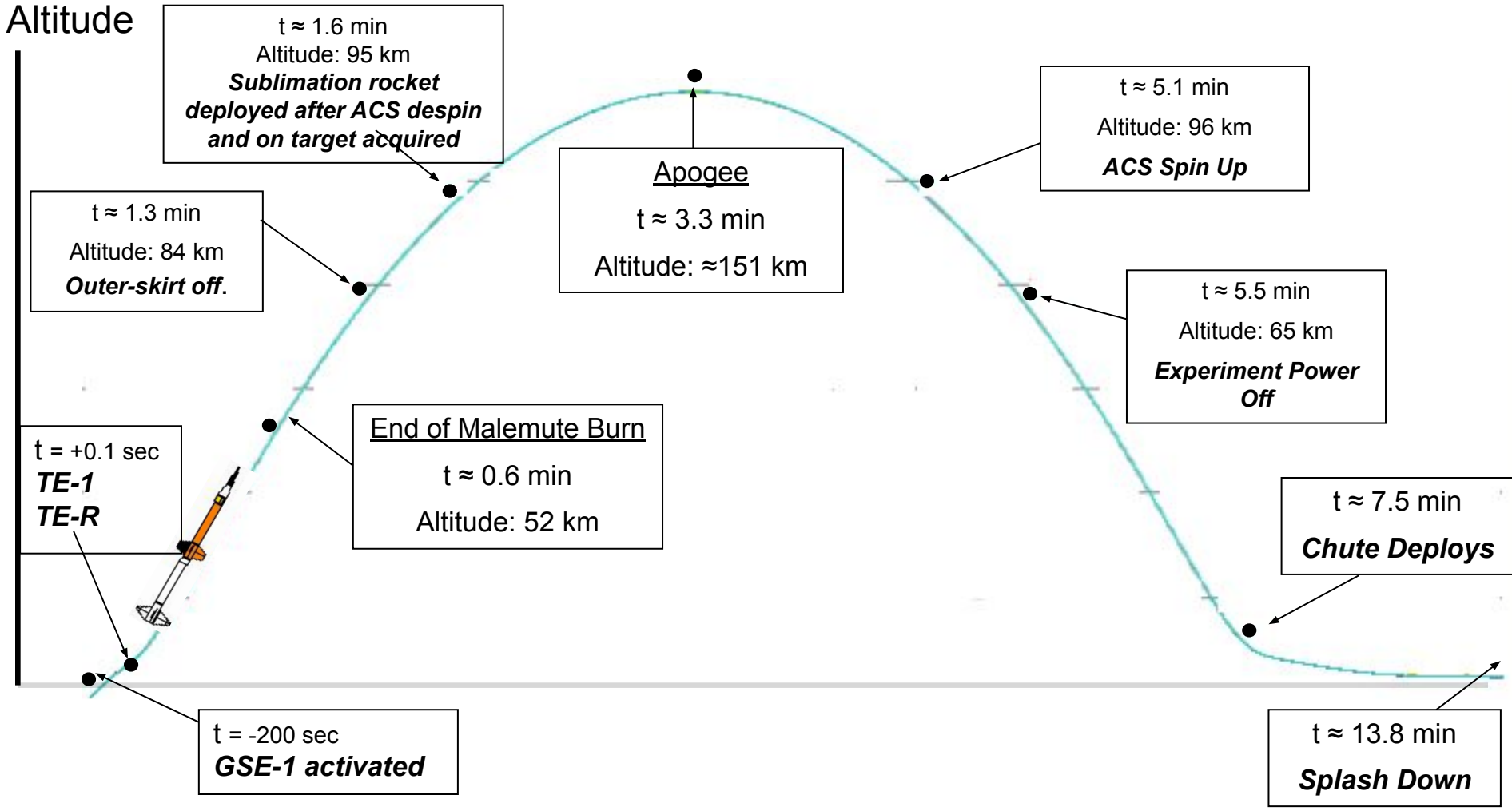
ScubeR Expectations



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

Jared



Concept of Operations [Cont.]

Event	Time On	Dwell	Event Description
GSE 1	T-200 sec	Flight	Powers on Artemis Raspberry Pi.
GSE 2	N/A	N/A	N/A
TE-1	T+0.1 sec	Flight	Supply Power to Power Distribution Board.
TE-2	N/A	N/A	N/A
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.

Timer Event Matrix

Team Name: UHCC
Date: 2/5/22

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

Subsystem Command and Data Handling Mechanical Interface: 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 = +96s	ScubeR Controller to start full backwards turn step command towards puncturing sublimate chamber for experiment start
T = +99s	ScubeR Controller to start full forwards rotation command
T = +110s	ScubeR is released from the shaft
T = +110s	ScubeR Controller to complete command cycle and cease all commands

Subsystem Command and Data Handling Mechanical Interface: 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 Saving Data to MicroSD card
T = +336s	Power off.

Subsystem Design: Command and Data Handling Mechanical Interface (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.

Subsystem Command and Data Handling Mechanical Interface: 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

2.0 Final Design Description

Changes and Action items

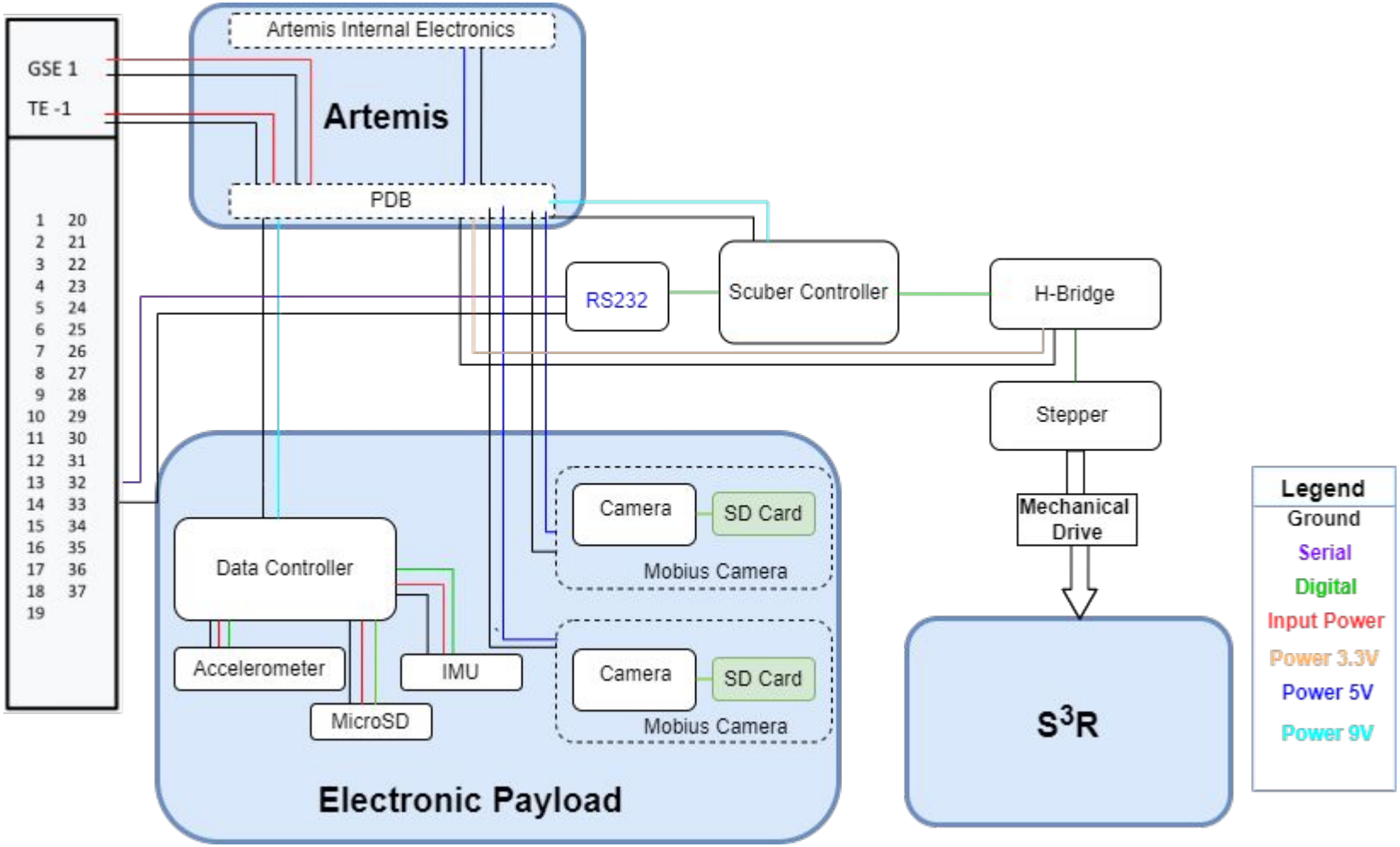
Stepper motor type has been changed
- Proposed motor is no longer available
- Differences in the components below
- Power budget and weight will change
- This will not affect the overall design of the other subsystems
- Electrical design will not change
- Mechanical design layout will not change

Changed component	P/N	Voltage	Amps	Phases	Weight	Dimensions	Screw
Stepper motor Old	42HD0403-11L	1.95V	1.5 per phase	2	90.71g	SQ: 1 5/8", L: 1 3/8"	Diam: 8mm, L: 100mm
Stepper motor New	AW030-100	3.3V	1.5 per phase	2	280g	42 x 42 x 40 mm(L W H)	Diam: 8mm, L: 100mm

Changes and Action items

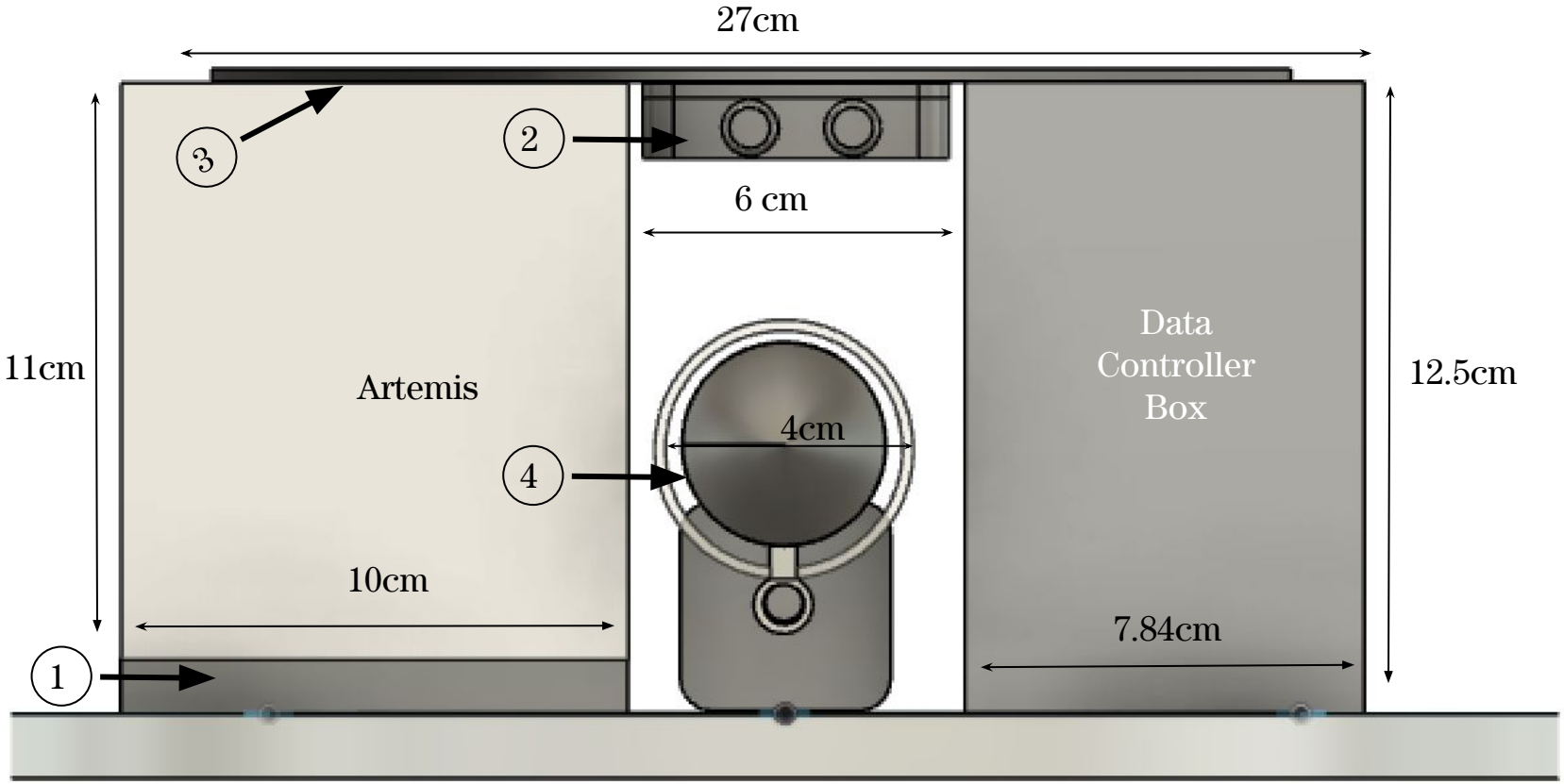
We had no action items, however; we have included some preliminary calculations for ScubeR's performance on which can be seen on slide 15.

System Overview: Functional Block Diagram



System Overview: Mechanical Design

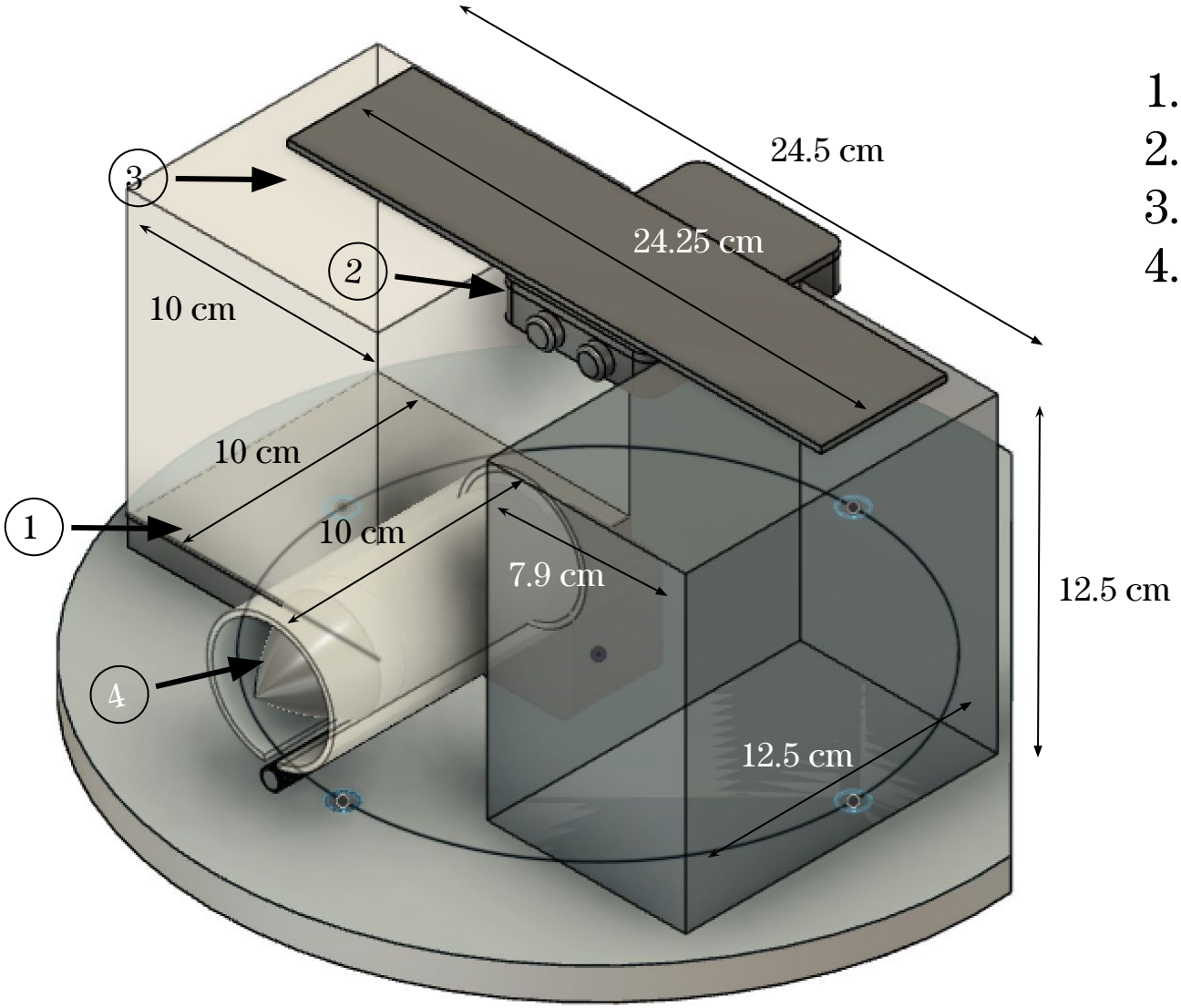
D'Elle



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

System Overview: Mechanical Design

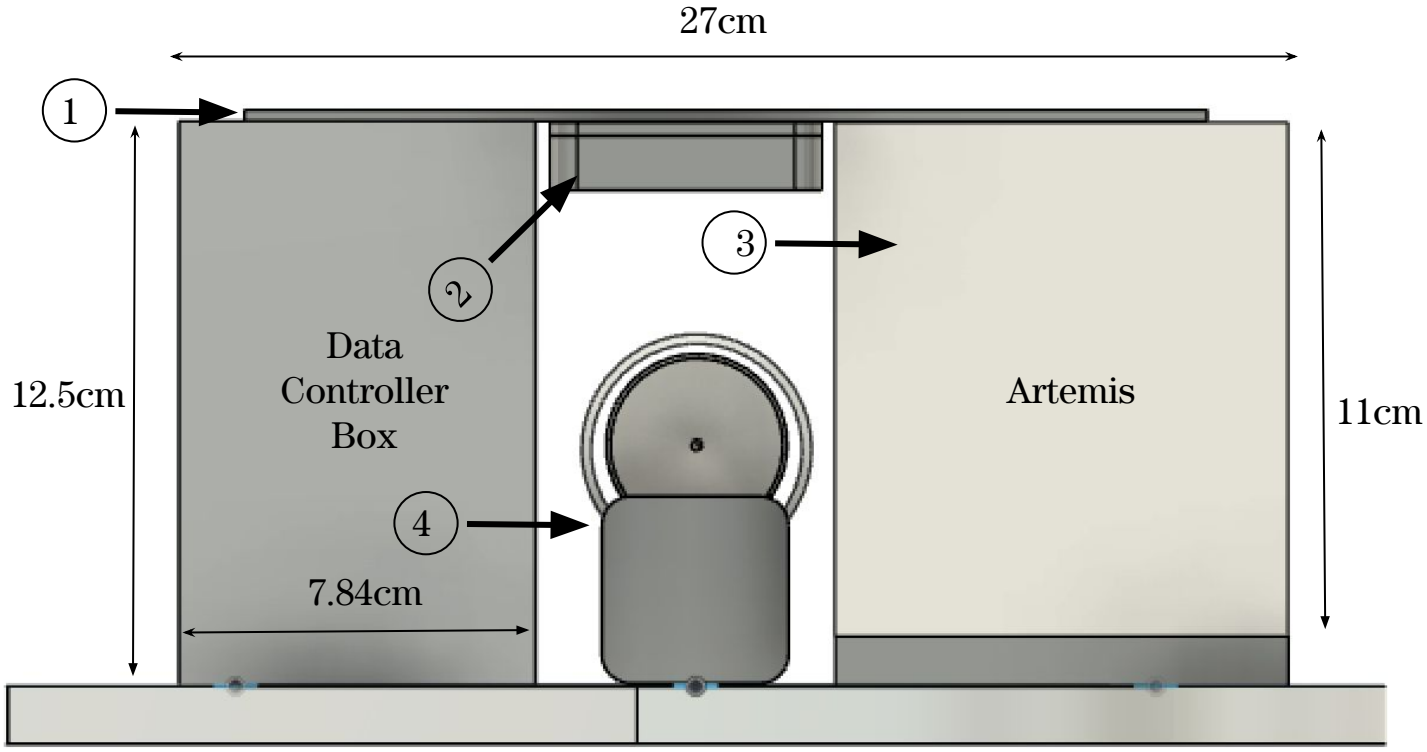
D'Elle



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

System Overview: Mechanical Design

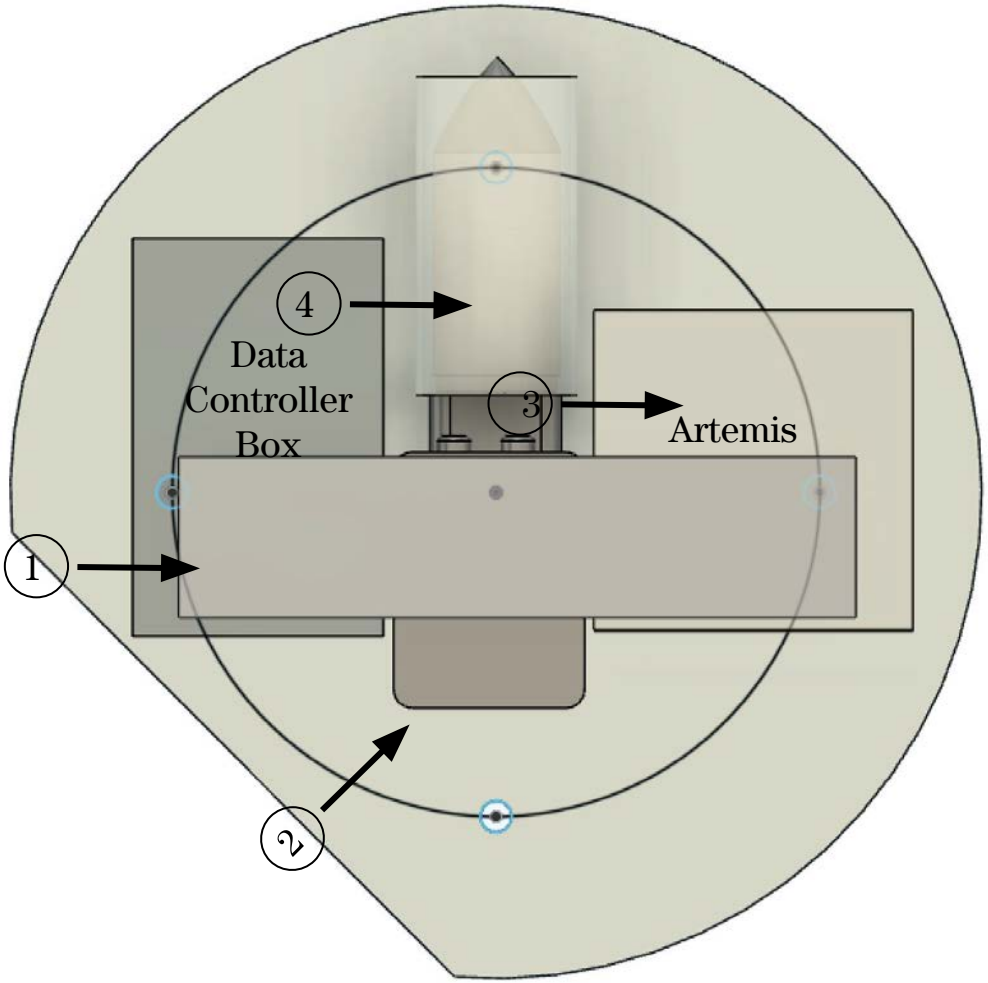
D'Elle



1. Lens Bridge
2. Camera Lense Housing
3. Artemis
4. ScubeR Assembly

System Overview: Mechanical Design

D'Elle



1. Lens Bridge
2. Camera Lense Housing
3. Artemis
4. ScubeR Assembly

Mechanical Design Materials List

D'Elle

ScubeR:

ABS plastic

Camphor

3d printed rail guide

(2) ½" Stainless steel flat head machine screws with (2) hex nut and washer set ups.

Enclosures:

(2) - Aluminum alloy Hammond Boxes (124mm x 124mm x 79mm)

(1) - Aluminum alloy 6063 Hammond Box (60mm x 80mm x 15mm)

(3) - Silicone gaskets

Miscellaneous:

Stainless steel metal bridge (50.8mm x 127mm x 1.6mm) between larger Hammond Boxes.

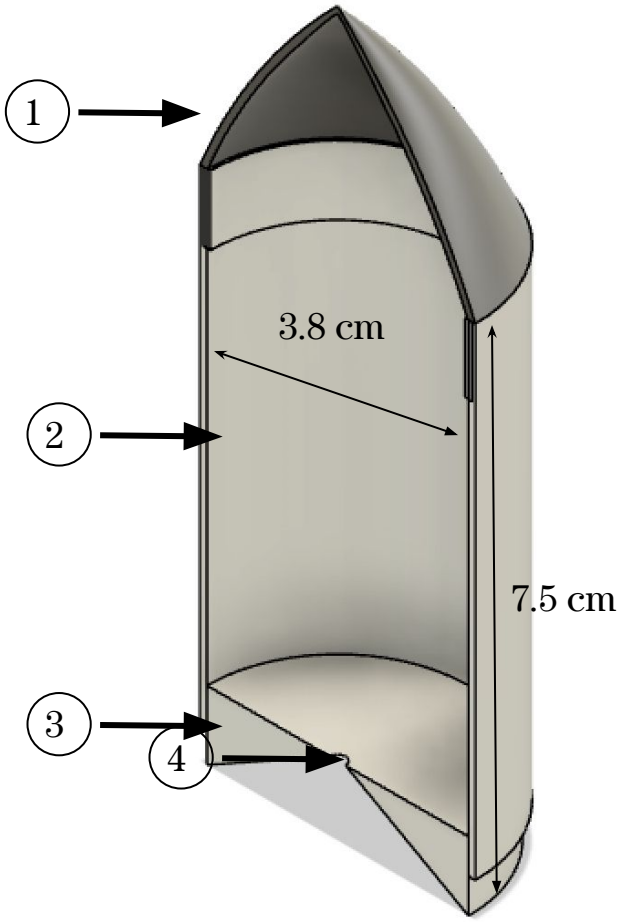
(4) machine bolts with lock nuts and washers to secure bridge.

Deck plate

(4) Allen Wrench head machine bolts with appropriate nuts (4) and washers (4).

System Overview: Mechanical Design

D'Elle

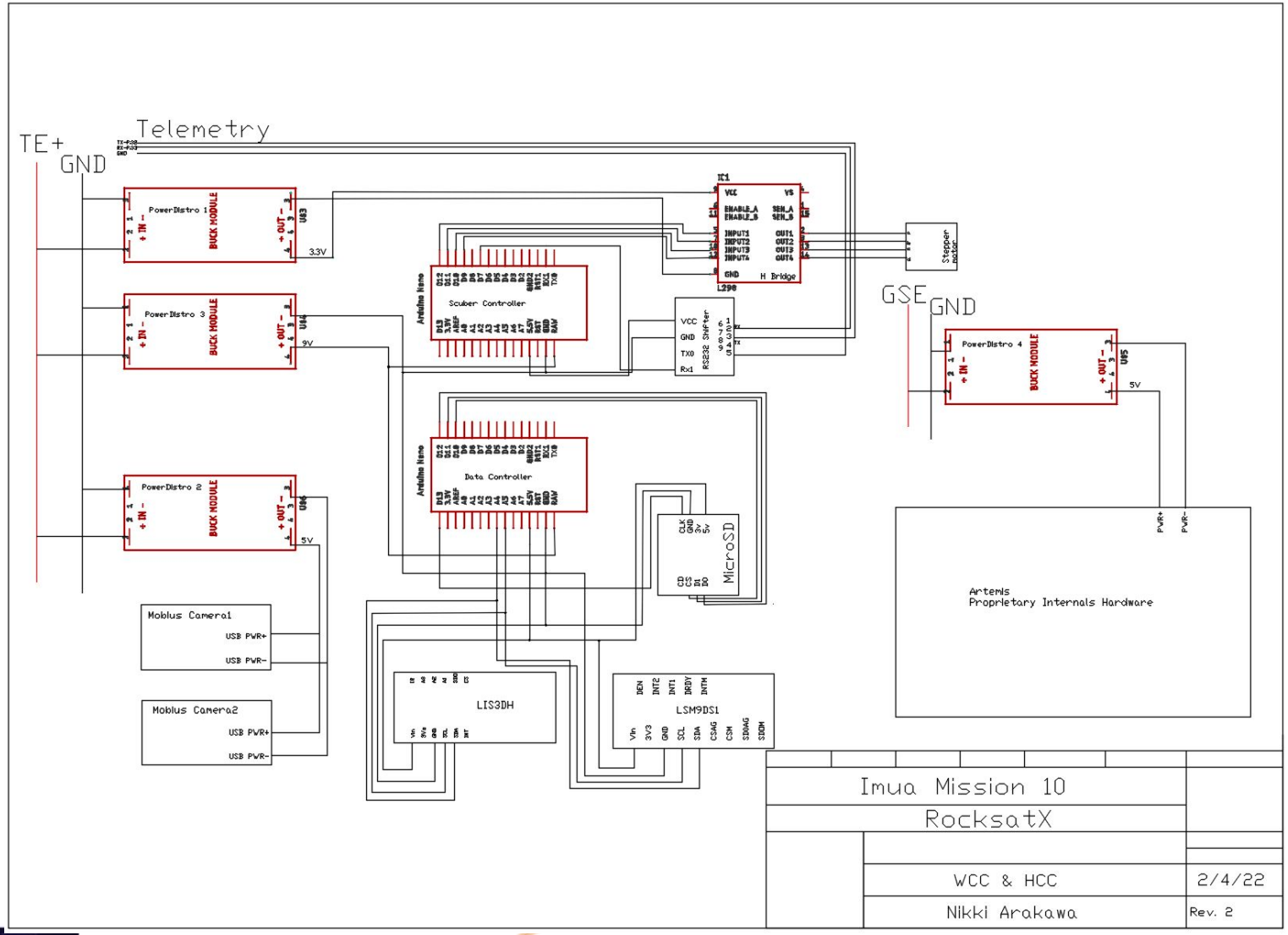


1. Nose Cone
   a. Final design will be solid and closed off from body tube
2. ScubeR body
3. Nozzel
4. 0.23 cm diameter nozzle outlet

Mechanical Design Weight Budget

UHCC - Weight Budget	
Date: 12/2/21	
Subsystem	Total Weight (lbs)
ScubeR	0.768
Artemis	1.31
Data Controller	0.03125
Mobius Cameras (2)	0.13
Hammond Box	0.99
Payload Deck	3.425
Total	6.65425
Over/Under (15 lbs)	Under by ~ 8.35 lbs

System Overview: Electrical Design



Power Budget Deliverable

UHCC - Power Budget							
Date: 12/1/21							
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

Electrical Design Materials List

D'Elle

Power Conditioning Board (PCB):

- Custom printed circuit board which will contain the following items
- L298 DC-DC converters
- Connecting wires

Motor Controller

- Arduino Nano
- Nema 17 Stepper Motor with 100mm Leadscrew
- H-Bridge
- Connection wires

Power Pin Assignment

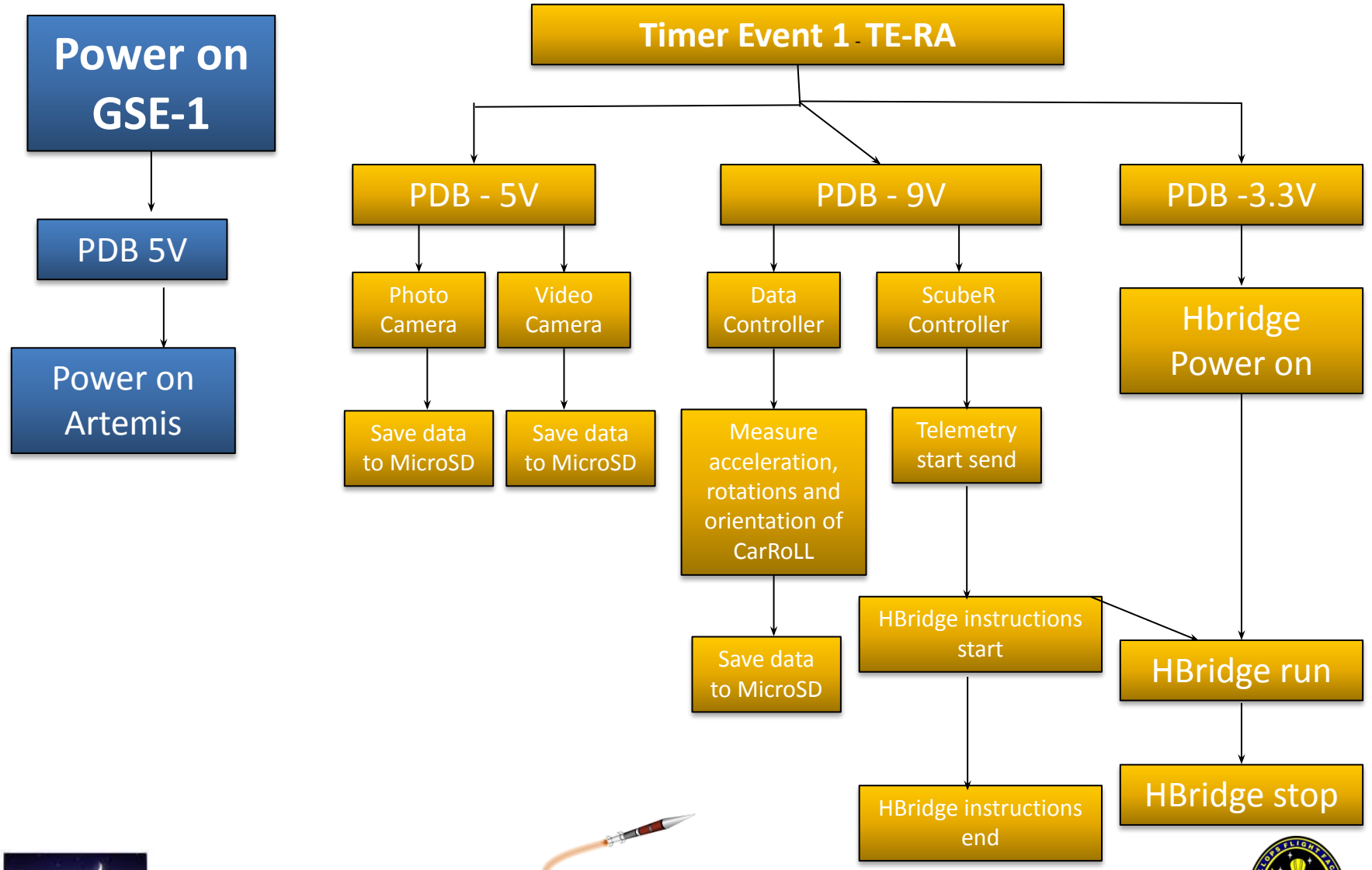
Power Pin	Function	Intended Use
1	GSE 1	Turn on Artemis Raspberry Pi at T = -200 sec
2	Timer Event Redundant (TE-RA)	Failsafe for turning on Power Distribution Board at T = 0.1 sec
3	Timer Event Redundant (TE-RB)	N/C
4	Timer Event 1 (TE-1)	Turn on Power Distribution Board at T = 0.1 sec
5	GND	GSE 1
6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

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

Software Design

Nikki



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.

Hawaii Space Flight Lab (HSFL) for vacuum testing of ScubeR reactant sublimation.

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

De-Scopes and Off-Ramps (Contingency Plans)

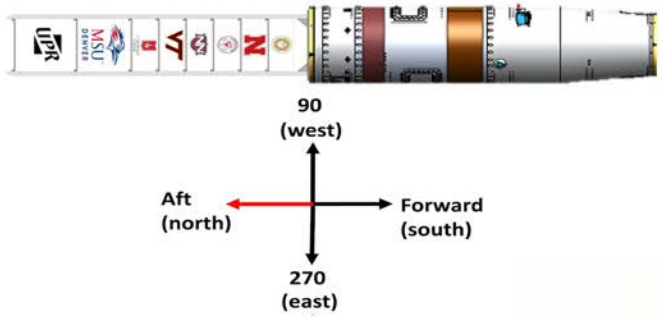
- If fabrication for ScubeR cannot be printed in house by February 12th, it can be printed using a predetermined alternate vendor
- If PCB for PDB cannot be printed, a soldered, wired circuit can be used.

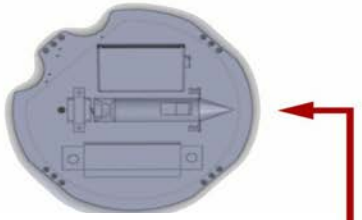
System Overview: Special Requests

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.

46.014 Pointing Request

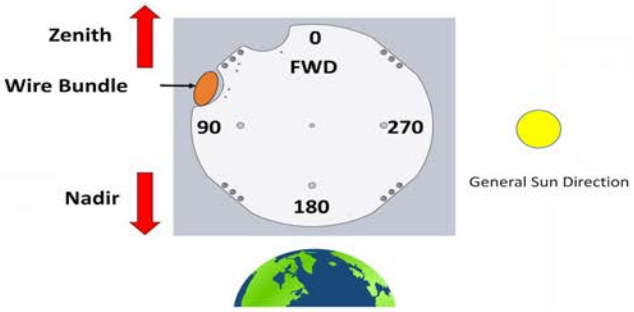
- View downwards from zenith to nadir (earth behind payload)

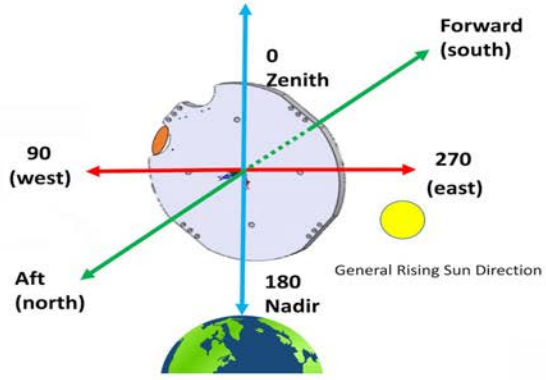




Orientation of ScubeR on Deckplate

- Desire to have active ACS throughout flight. Hold on target.





Hazardous Mechanical and Electrical Materials

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

- Note: we are not using a H.V. source

3.0 Hardware Procurement Status

Mechanical Elements: Components ScubeR

Procured

- ABS plastic
- Stepper Motor
- Hbridge

Manufactured

- None

Yet to Procure

- ScubeR channel guide
- Camphor
- ½" Stainless steel machine screws
- hex nut and washers
- Steel flat bar

Not Manufactured

- ScubeR Rocket
- PCB for PDB
- mass object below Artemis

Mechanical Elements: Components Enclosures and Miscellaneous

Caleb

Procured

- (2) - Aluminum alloy Hammond Boxes (124mm x 124mm x 79mm)
- (1) - Aluminum alloy 6063 Hammond Box (60mm x 80mm x 15mm)
- (3) - Silicone gaskets
- (4) machine bolts with lock nuts and washers to secure bridge.
- 4) Allen Wrench head machine bolts with appropriate nuts (4) and washers (4).

Manufactured

- None

Yet to Procure

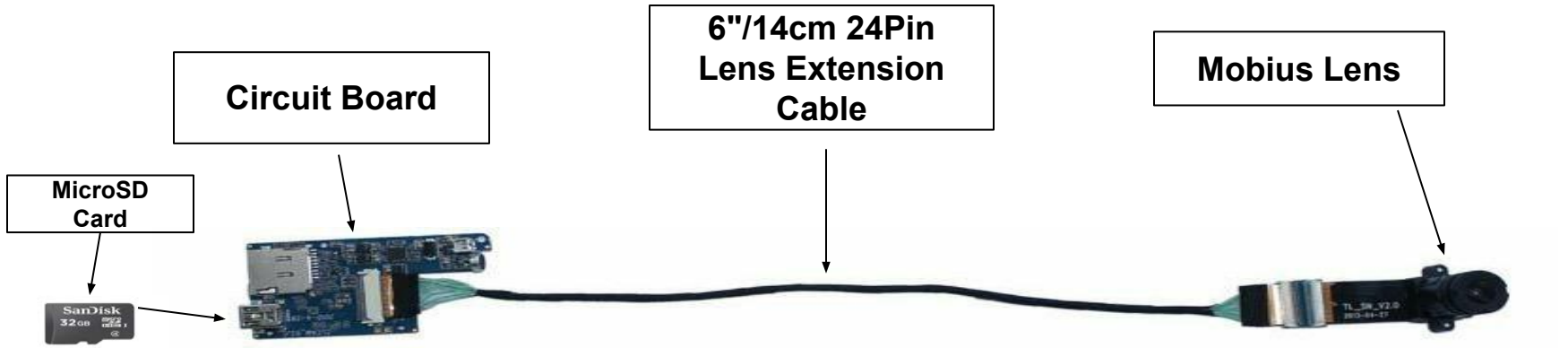
- Stainless steel metal bridge (50.8mm x 127mm x 1.6mm) between larger Hammond Boxes.

Not Manufactured

- none

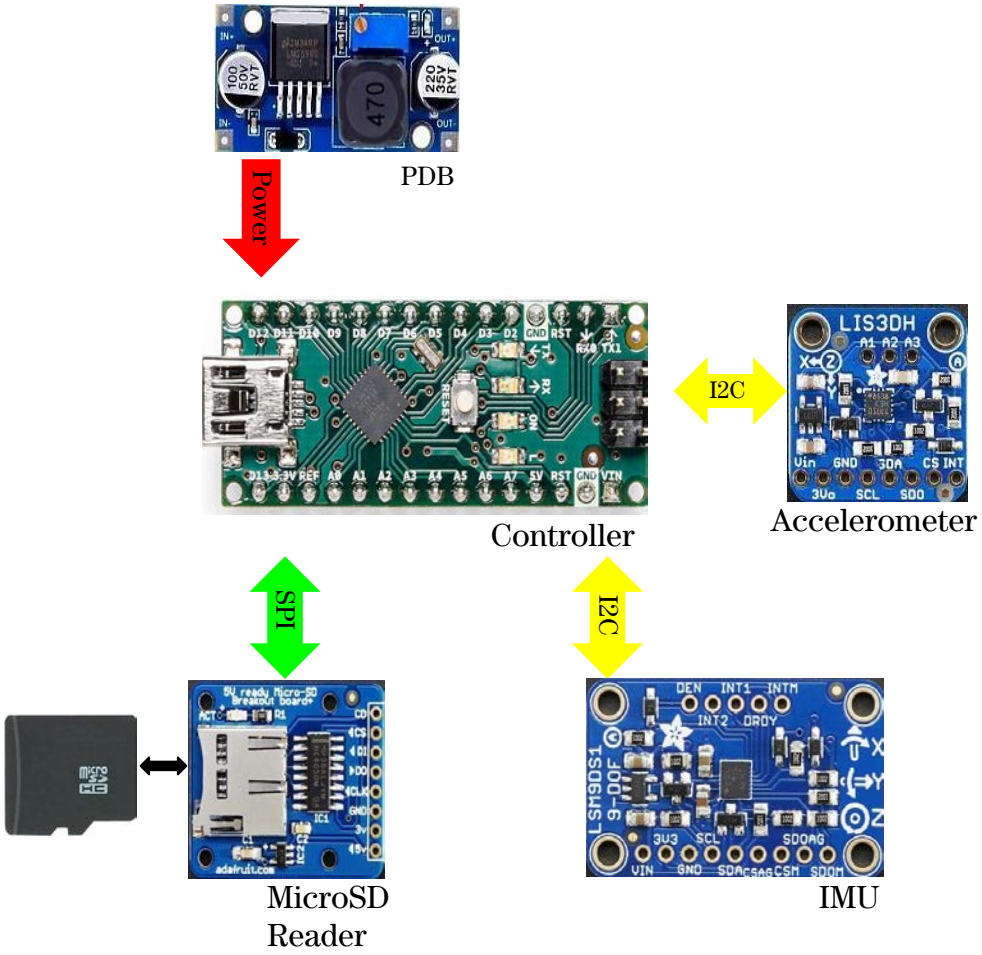
Mechanical Elements - Camera Subsystem

- What has been manufactured/purchased?
  - Mobius ActionCam mini pro
- What has not been manufactured/purchased?
  - Boards to mount camera
  - Power cables for the circuit board to the power cameras



Mechanical Elements - Data Controller

- What has been manufactured/purchased?
  - kolea60 unit 1 and unit 2
  - 1590k Hammond box
- What has not been manufactured/purchased?
  - Printed Circuit board



Electrical Elements: Components

Caleb

ScubeR Controller

Procured
- Arduino nano
- Connecting wires

Manufactured
- None

Yet to Procure
- PCB Breakout

Not Manufactured
- PCB breakout for Arduino nano. Outside manufacturing

Soldered
- none

Not Soldered
- PDB

PCB Revision Status
- Version 1

PDB

Procured
- (4) L298 DC converter
- Connecting wires

Manufactured
- None

Yet to Procure
- PCB breakout

Not Manufactured
- PCB breakout. Outside Manufacturing

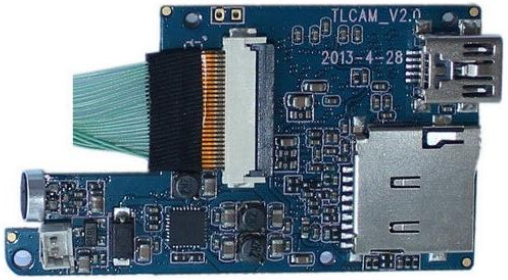
Soldered
- none

Not Soldered
- PDB

PCB Revision Status
- Version 1

Electrical Elements - Camera Subsystem

- The Mobius ActionCam is not applicable to be manufactured /soldering nor PCB revision status.
- The power cables need to be manufactured/soldered and the electrical components still need to be procured.
- Power cable adaptors need to be created for each camera to connect to the 5V dc-dc converter.
- The electrical components of the Mobius ActionCam will be housed in a 1590K Aluminum Hammond Box with microSD cards.

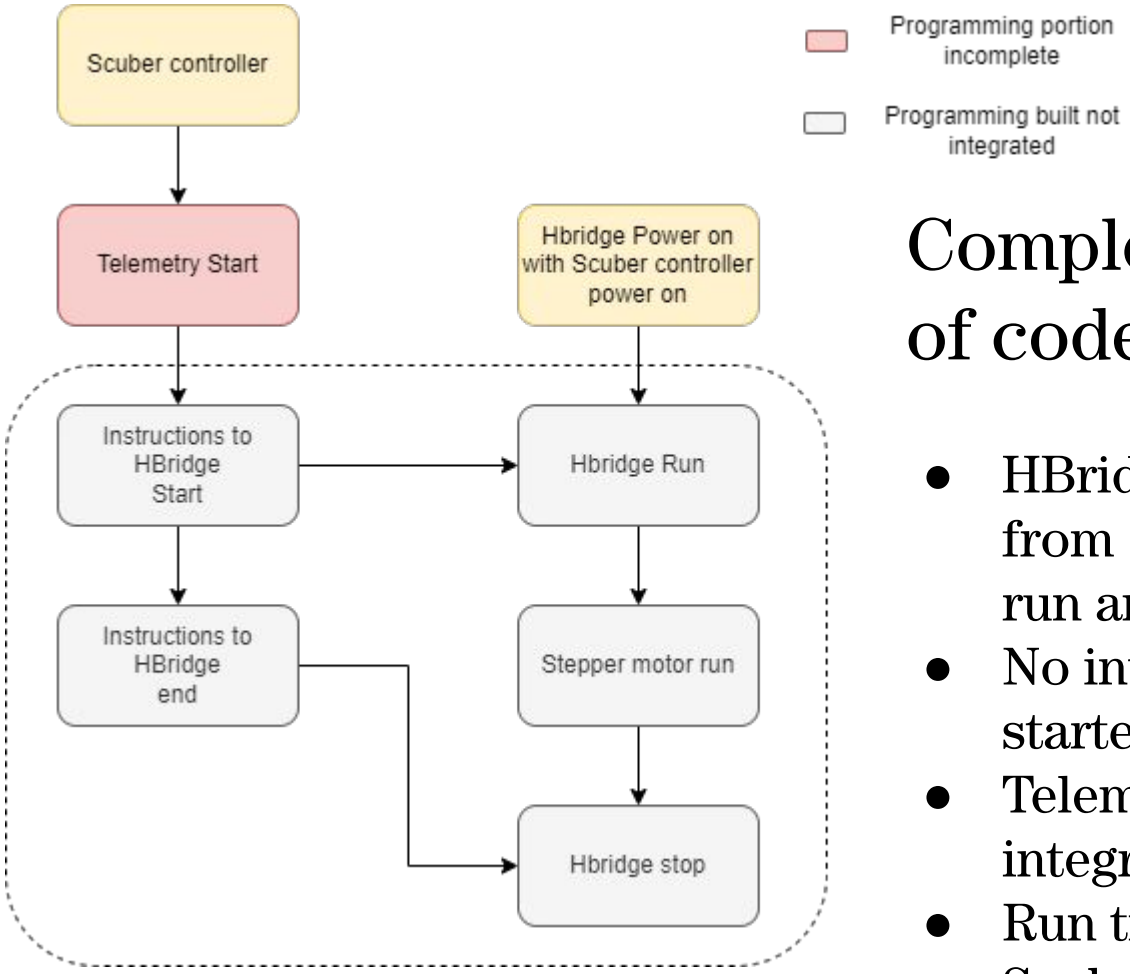


Caleb

Electrical Elements - Data Controller

- The Printed Circuit Board still needs to be manufactured/soldered
- PCB revision status?
  - Schematics done & PCB draft in progress
- What electrical components are in house?
  - LSM9DS1, LIS3DH, MicroSD interface board+, & Arduino Nano Every
- What electrical components still need to be procured?
  - None

Software Elements - ScubeR Controller



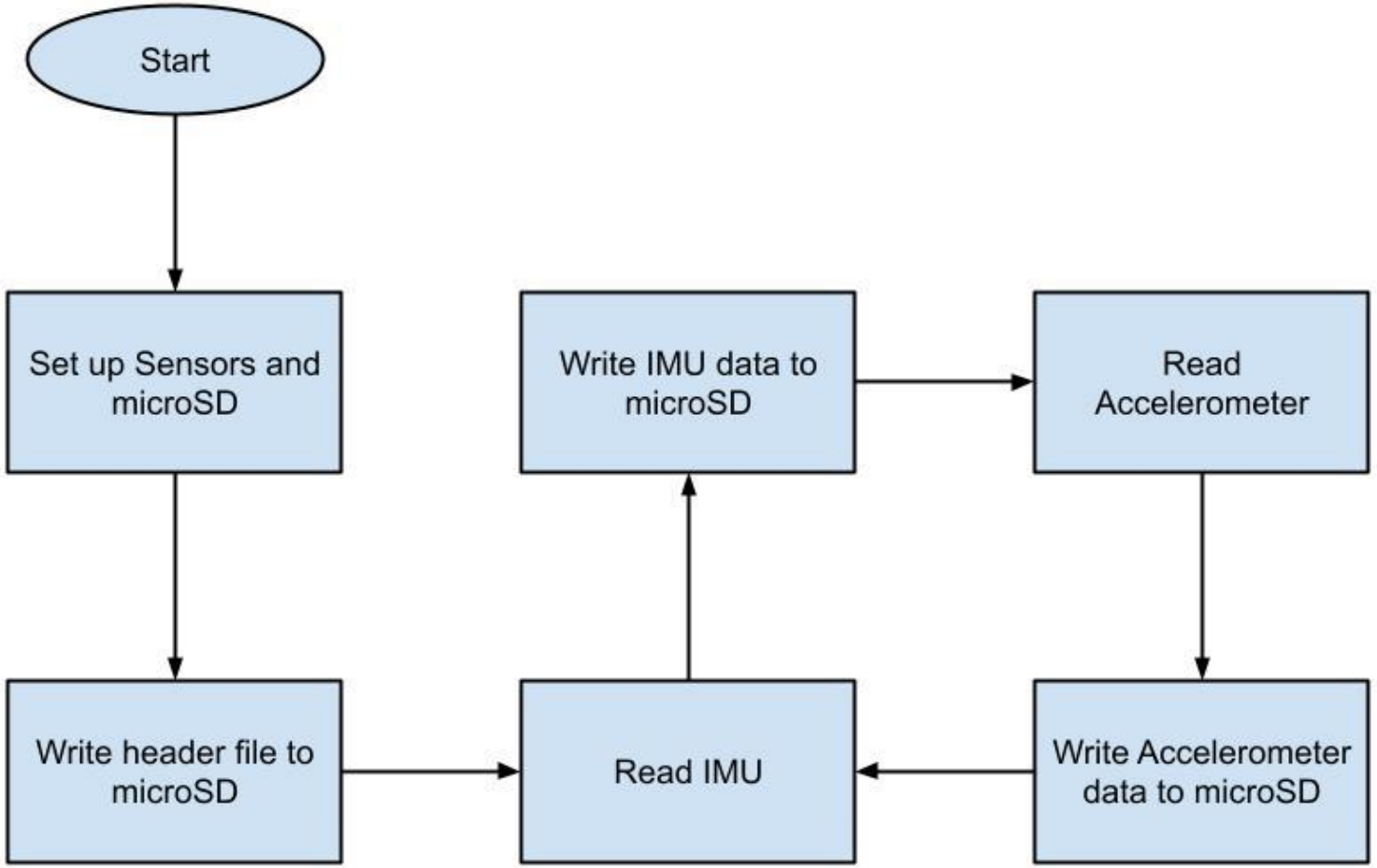
Completed Discrete Blocks of code

- HBridge instruction programming from ScubeR controller able to run and stop motor
- No integration with telemetry started
- Telemetry programming and integration not complete
- Run time for motor to deploy ScubeR not defined as of STR

Software Elements - Data Controller

- What discrete blocks of code are completed?
  - Pre-kolea60-u1 version 1
    - Arduino Nano Every identified kolea60, HonCC, code & sketch version
  - kolea60-u1-sketch nkoleo60-v1.02 version 1.2
    - Data saved to SD card
  - kolea60-u2-sketch nkolea60- v2.00
    - IMU Accelerometer ±2g, Gyroscope ±245 dpi, Magnetometer ±2 gauss.
    - Accelerometer ±16g

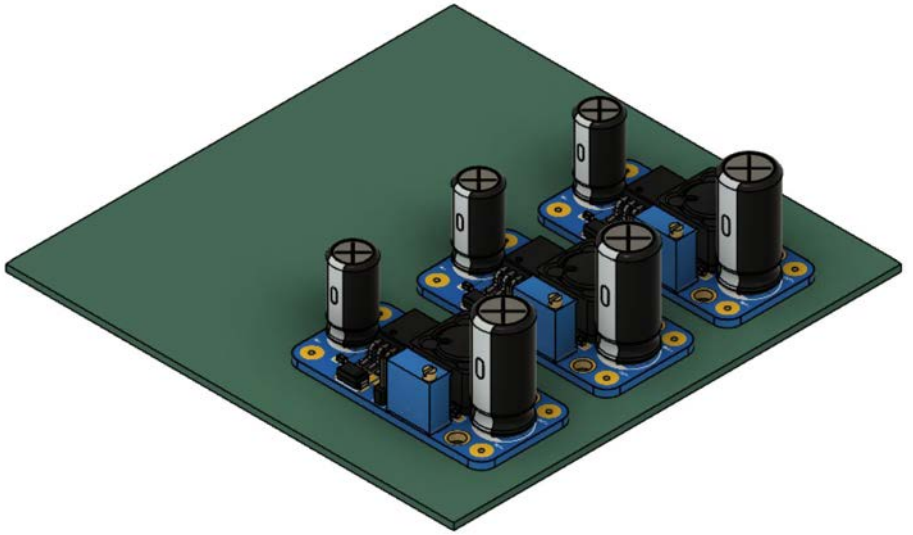
Data Controller Flowchart

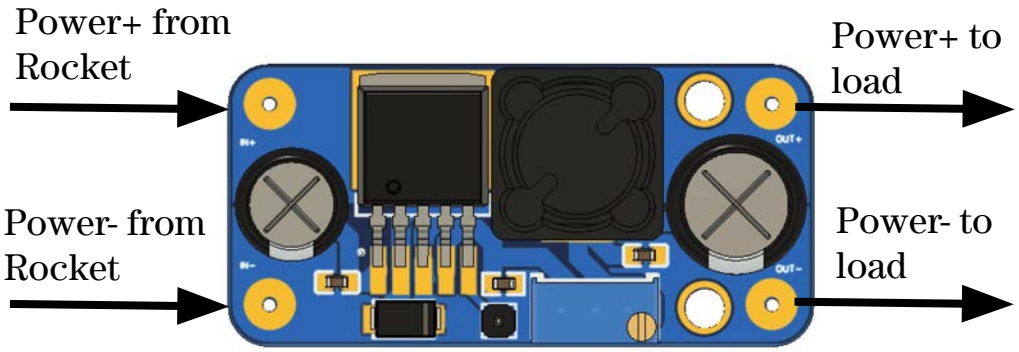


4.0 Subsystem Testing Results

Subsystem Name - PDB

- Power delivery system only
- 3 converters to connect to power on TE
- 1 converter to connect to power on GSE
- L298 connected to printed PCB breakout
- Subsystem weight: 169.79g
- Not Final Design:
  - Physical configuration of L298 on PCB is not final
  - Second PDB with single L298 not final, may include ScubeR controller and Hbridge

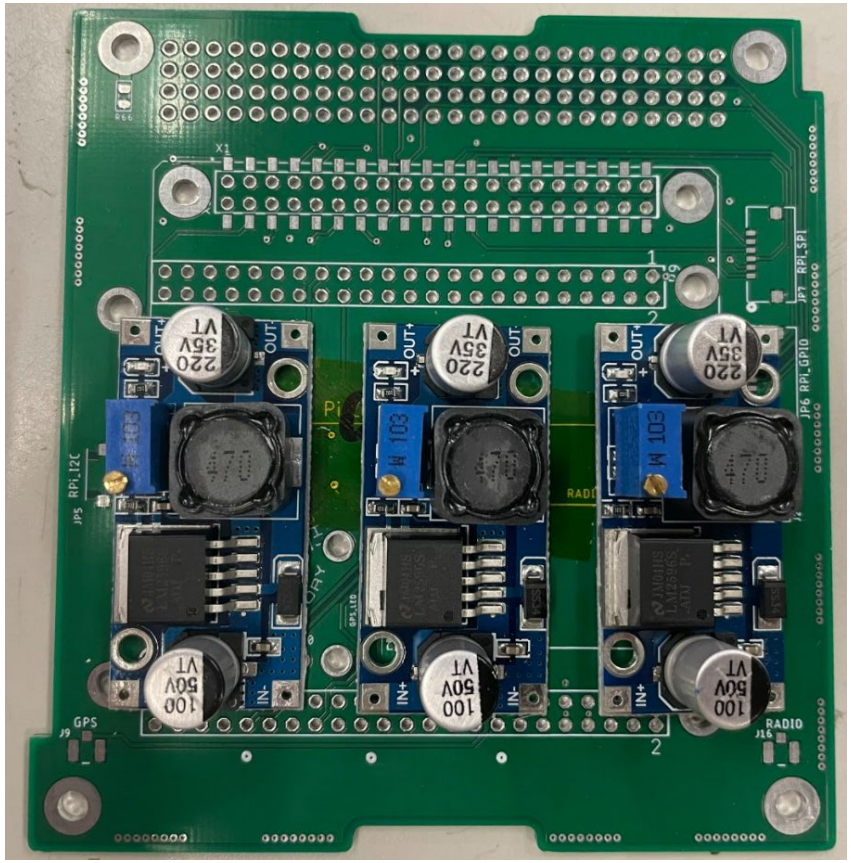




Subsystem Name - PDB

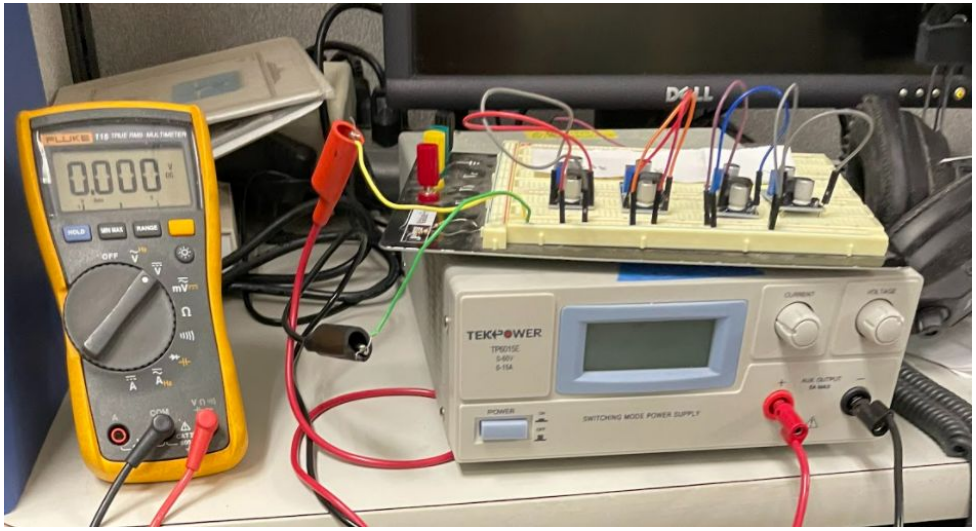
50%

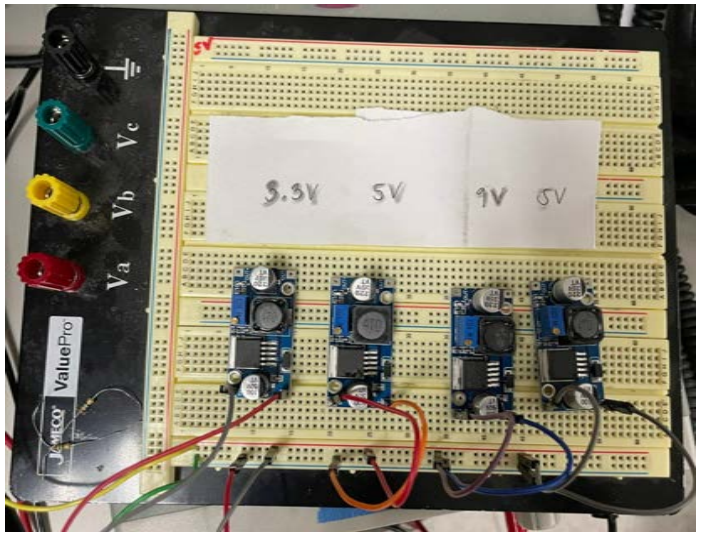
- Quick Status
  - Breadboarded circuit built and tested from 28V to 32V
  - PCB breakout board for PDB not printed or tested
  - Basic footprint of PDB is being determined



Subsystem Name - PDB

- PDB voltage test completed.
  - Dc to Dc converters are able to supply required voltages.





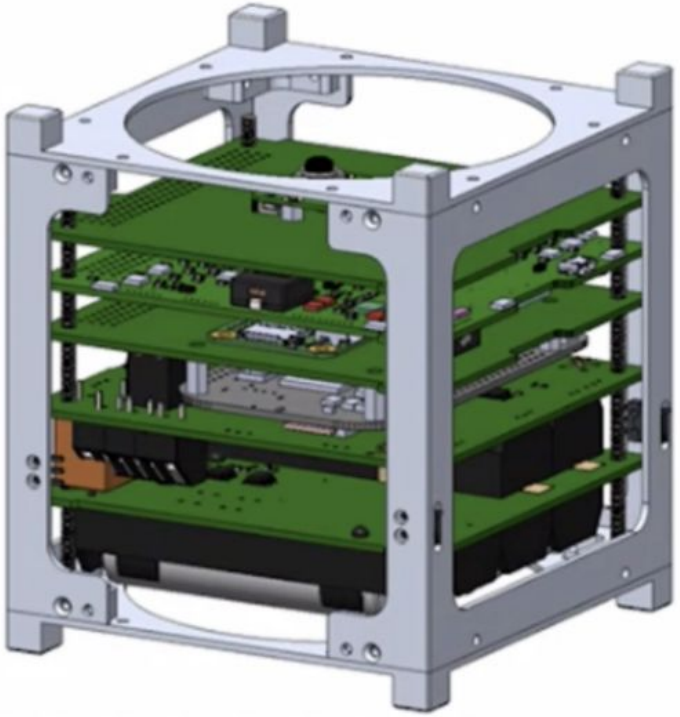
Subsystem Name - PDB

PDB Testing Results

DC Converter	Expected O/P V	O/P V at 32V I/P	O/P V at 28V I/P
L298-1	3.3V	3.3V	3.3V
L298-2	5V	5V	5V
L298-3	9V	9V	9V
L298-4	5V	5V	5V

Subsystem Name - Artemis

- Artemis to receive 5V from the the PDB
- Mechanical and electrical interfaces with other subsystems/Wallops
- Hardware used: 1 Artemis Cubesat Kit
- Subsystem weight: 1.31lbs
- Subsystem Design is Final



Subsystem Name - Artemis

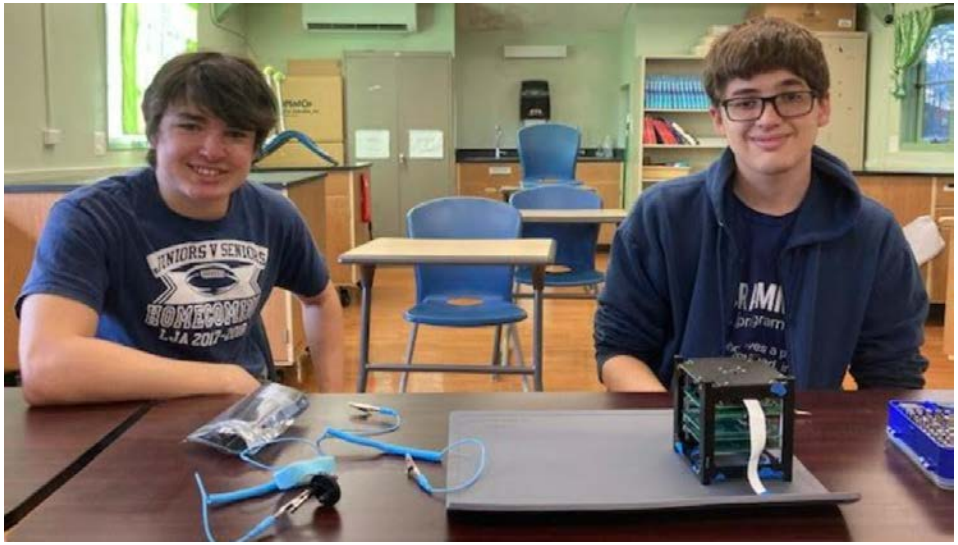
- Quick Status

50%

  - Artemis physical build complete
  - Artemis Electronics have not been powered or tested
  - Artemis completion is based off of completion of PDB.

Subsystem Name - Artemis

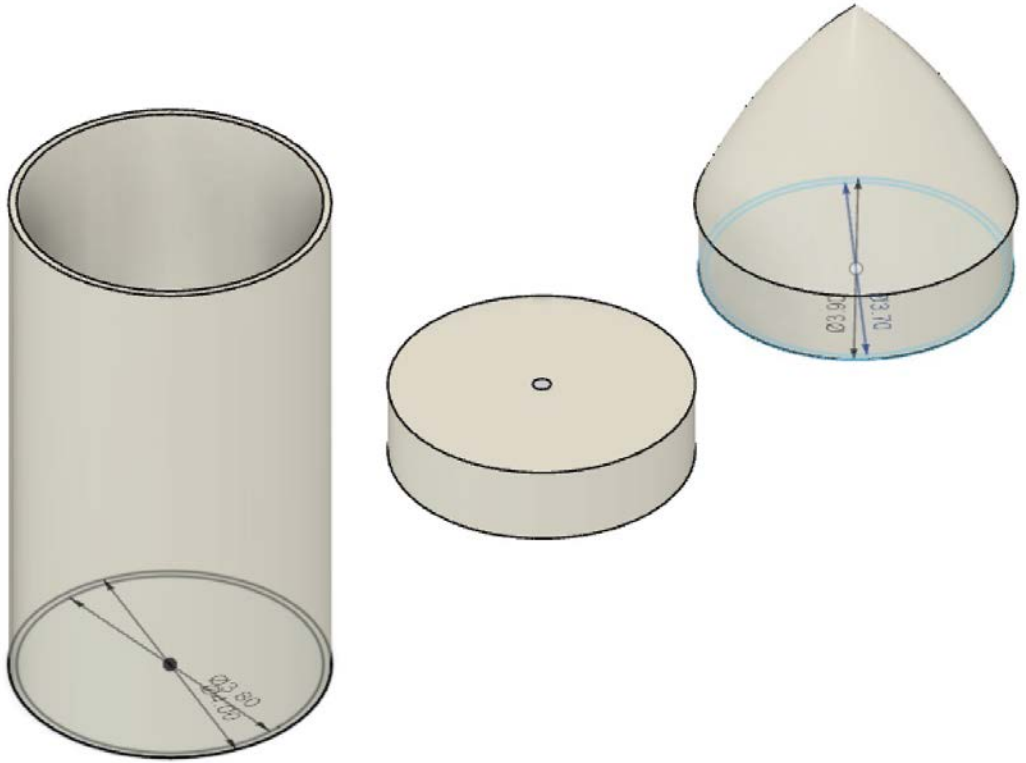
- Testing to be completed by February 26th and results to be obtained by ISTR



Chris Noon on the left Mason Pimentel

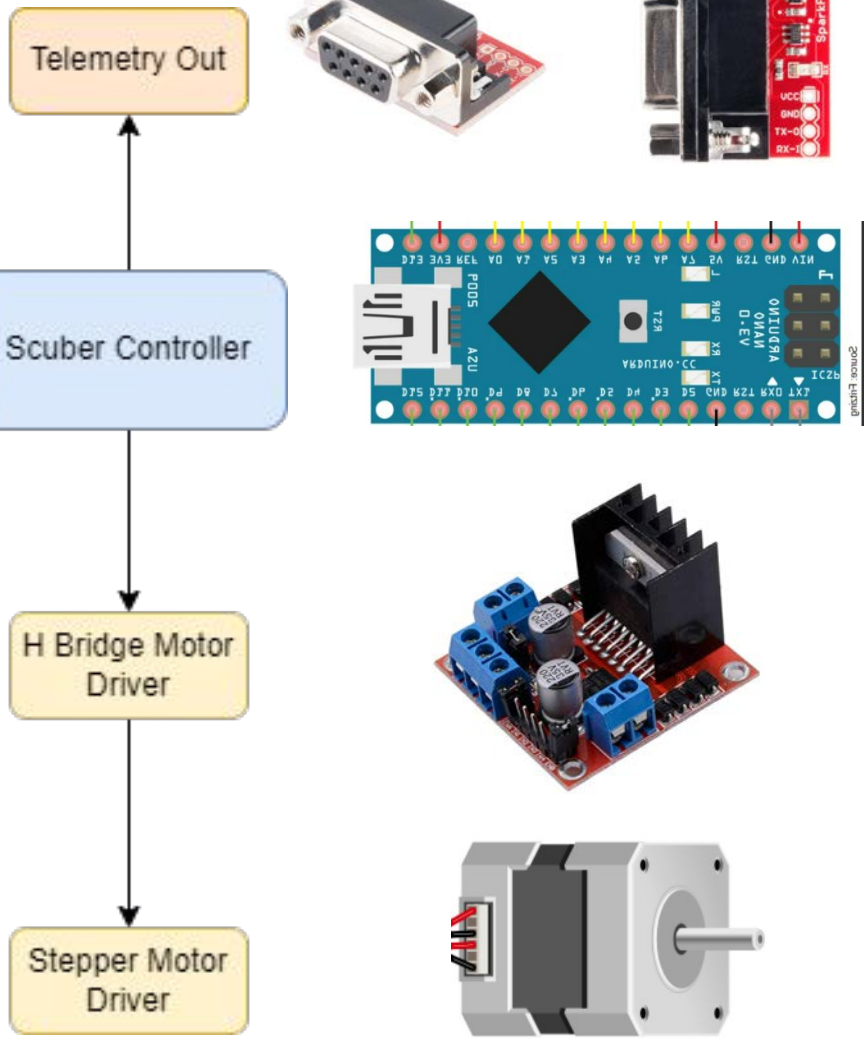
Subsystem Name - ScubeR Sublimation Rocket

- Subsystem weight: 300g
- Final design is dependent on printability of the current design



Subsystem Name - ScubeR Mechanical System

- Expected power draw total: 0.04Ah
- Power delivered from 9V dc converter on PDB
- Data transmission depicted in flow chart (right)
- Parts:
  - RS232 Level Shifter
  - Arduino Nano
  - HBridge
  - Stepper Motor
- Subsystem weight: 348.35g
- Final Design



Subsystem Name - ScubeR Sublimation rocket and mechanical system

Nikki

- Quick Status
  - Complete
    - Parts ordered and received
  - In progress
    - ScubeR sublimation rocket printing
  - Next steps
    - Build circuit and start programming
    - Program testing
    - Motion and Timing test (second week of February)
    - ScubeR Deployment test (third week of February)
    - System testing

Subsystem Name - ScubeR Sublimation rocket and mechanical system

Nikki

- ScubeR test prints starting
  - Fully printed sublimation rocket not complete
  - First print failed due to thin walled design of the sublimation rocket and ABS extruding size
- Testing not started for the ScubeR mechanical system
  - (second and third week of February)
- ScubeR system tests to be completed before ISTR

Subsystem - Onboard Camera

- What is complete/what has been tested?
  - Ability to capture and store imagery to MicroSD card on camera circuit board. (success)
  - Ability to cycle through capture modes (success)
  - Ability to associate time stamps of date w/ imagery files (success)
  - Camera power-up from external power source other than LiPo battery (success)
  - Confirm video data is written to MicroSD card upon power down versus lost due to video data buffering intervals being too long between writes to MicroSD card (success).
- What has not yet been checked out
  - The quality and resolution of imagery sufficient for acceleration calculations.
  - Power test w/ PBD
  - soldering circuit board to breadboard
  - Test fitting camera mount plates in hammond box

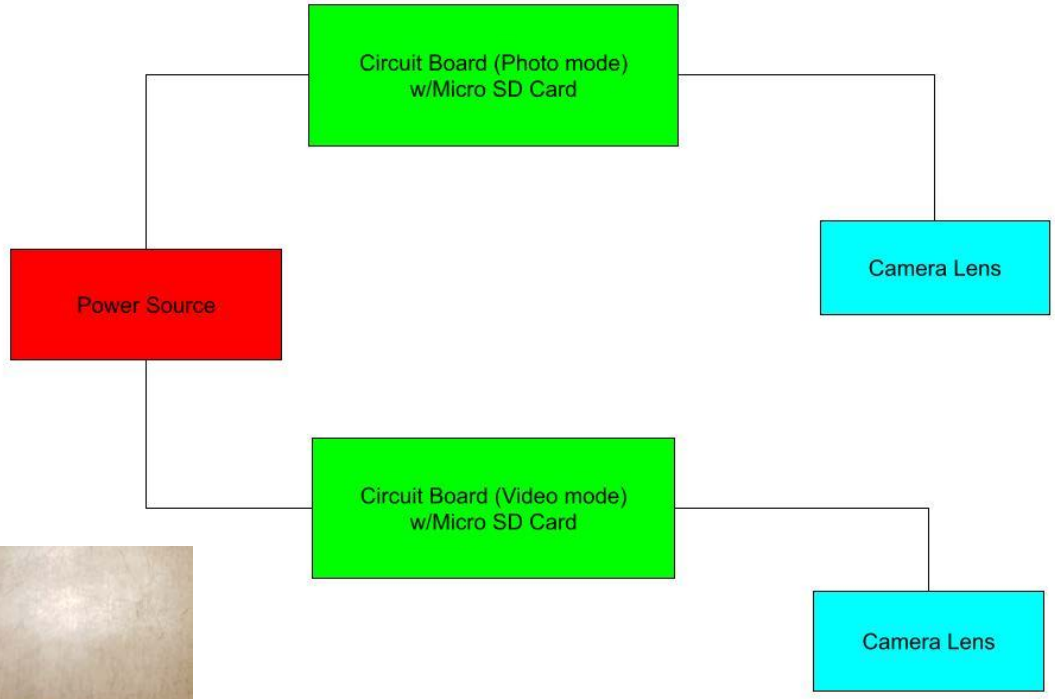
Subsystem - Onboard Camera (not final)

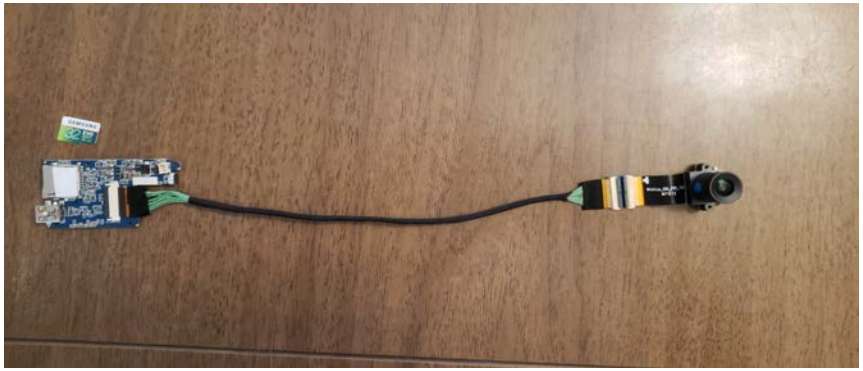
Size: Length = 11 inch

Width = less than 1¼ inch

Weight: 0.067 lbs

Power: 5V for each camera

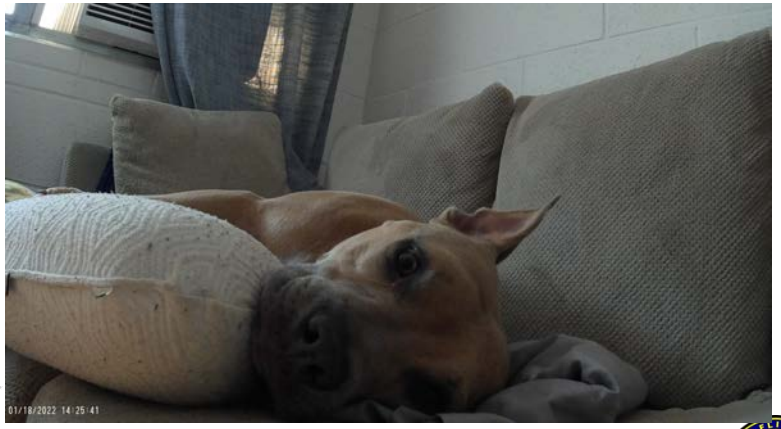




Subsystem - Onboard Camera

Tests with results/ data:

Test 1: Mobius powers up and stores video and photos to Micro SD card(success)



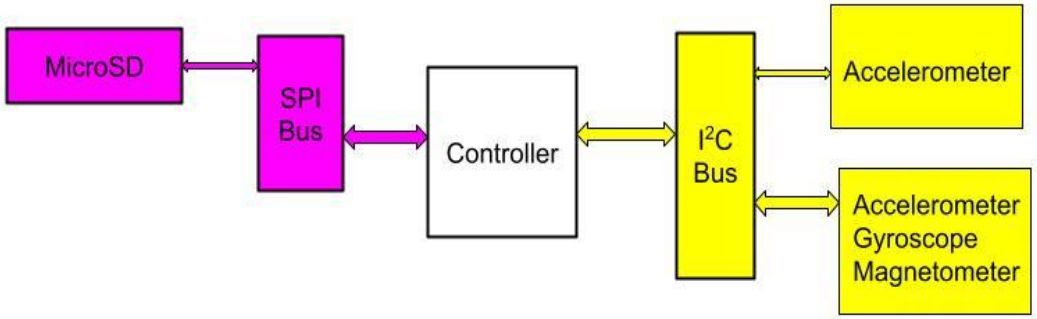
Subsystem - Data Controller

Sizes:

- Arduino Nano Every: 1.77" x 0.7"
- MicroSD Breakout Board+: 1.5" x 1" x 0.15"
- LSM9DS1: 1.3" x 0.8" x 0.1"
- LIS3DH: 3.74" x 2.56" x 0.2"

Weight: 0.03125 lbs

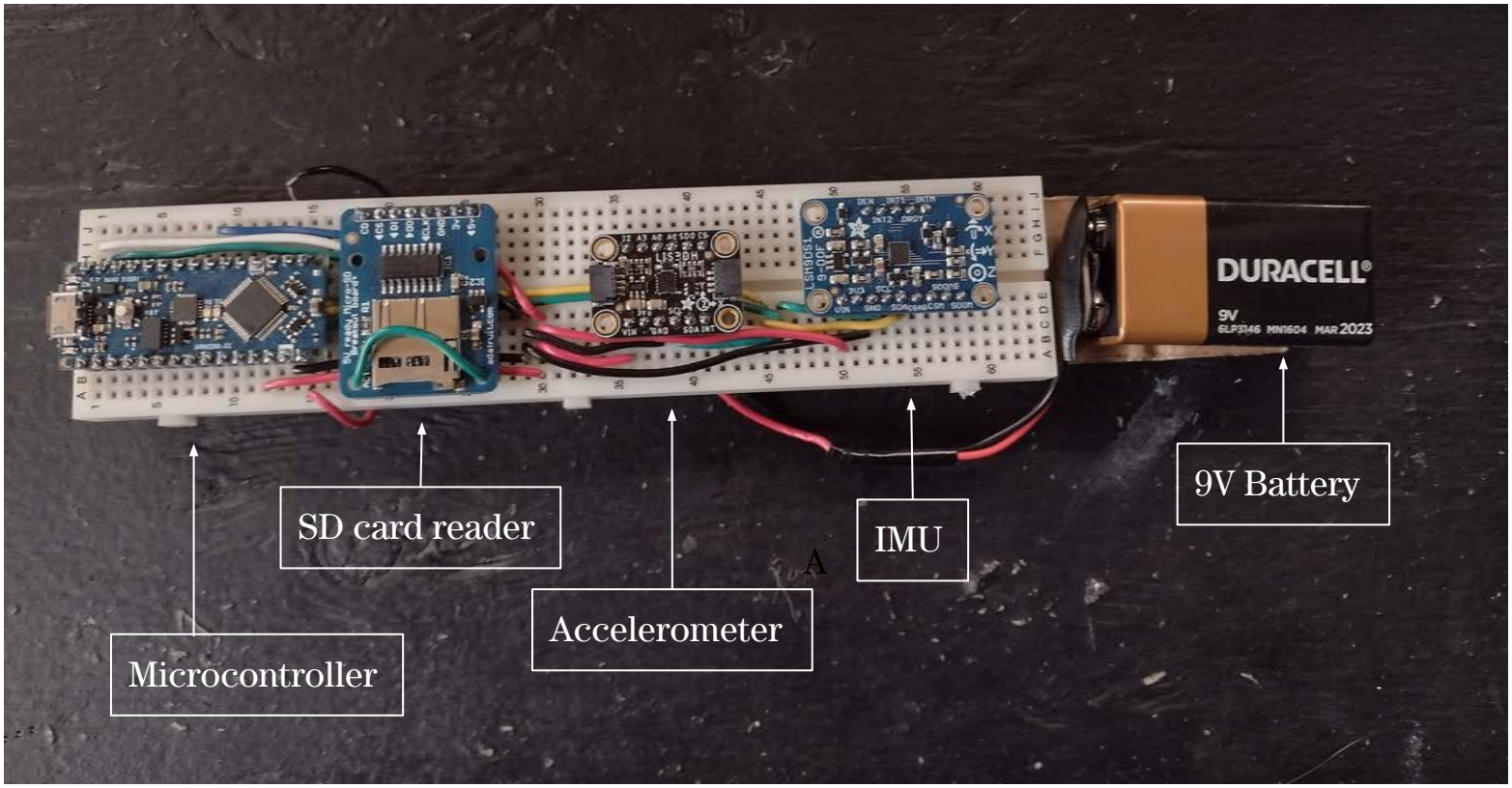
Power: 5V



Subsystem - Data Controller

- What is complete/what has been tested?
  - Lab unit data run
  - Ability to store data to SD card
  - Model rocket flight
    - flight unit kolea60-u2
- What has not yet been checked out
  - Power Test w/ PDB
  - Printed Circuit Board integration
  - Hammond Box integration

Flight unit: kolea60-u2



IMU and Accelerometer Data: nk60-2022-01-22-04

lsm9ds1:accx	accy	accz	magx	magy	magz	gyrox	gyroy	gyroz	li	3dh:accx	accy_1	accz_2	event#	runtime(s)	memoryfree(bytes)	nk60
0.62	-1.31	7.47	-28.33	39.75	-44.34	-0.09	0.02	0.02		0.47	-1.29	10.12	1	0.7	4399	nk60
-0.32	-0.46	11.32	-28.72	40.92	-47	-0.09	0.02	0.02		0.71	-0.71	10.71	2	0.74	4368	nk60
-0.42	-0.26	8.34	-29	43.39	-49.52	-0.1	0.02	0.02		1.06	-2.35	8.71	3	0.77	4368	nk60
-3.05	-0.67	8.73	-31.64	46.74	-49.84	-0.1	0.02	0.02		1.41	-3.18	9.89	4	0.81	4368	nk60
-3.54	1.11	10.87	-35.11	49.58	-50.07	-0.1	0.03	0.02		-0.59	-2.12	10	5	0.85	4368	nk60
-7.64	1.25	12.81	-38.79	49.96	-50.38	-0.1	0.02	0.02		-0.24	-2.35	10.94	6	0.88	4368	nk60
-4.02	-0.77	11.1	-38.92	47.97	-51.24	-0.1	0.02	0.02		1.06	-3.06	11.53	7	0.91	4368	nk60
-1.04	-0.43	6.49	-36.7	48.41	-53.93	-0.1	0.02	0.02		3.06	-0.12	10.59	8	0.95	4368	nk60
-2.06	-0.42	16.9	-38.4	52.06	-52.08	-0.09	0.02	0.02		-1.29	-2.12	12.12	9	0.98	4368	nk60
-3.34	-4.59	9.03	-36.23	55.03	-51.14	-0.1	0.02	0.02		-3.77	-4.71	8.83	10	1.02	4368	nk60
-1.94	-4.06	11.86	-32.56	59.53	-50.45	-0.1	0.02	0.02		-1.77	-1.77	9.77	11	1.05	4368	nk60
-6.35	-2.39	10.6	-31.94	60.65	-46.32	-0.1	0.02	0.02		-0.35	-4.12	8.12	12	1.09	4368	nk60
-2.22	-1.09	9.25	-30.01	59.05	-44.14	-0.1	0.03	0.02		-0.94	-6	8.71	13	1.12	4368	nk60
1.52	-2.93	11.22	-29.58	59.21	-42.41	-0.1	0.02	0.02		-0.94	-4.59	9.3	14	1.16	4368	nk60
-2.61	-0.53	7.9	-31.18	58.13	-36.55	-0.1	0.02	0.02		-1.06	-3.18	7.65	15	1.19	4368	nk60
-3.95	-0.61	7.46	-31.48	58.43	-33.09	-0.1	0.02	0.02		-1.65	-3.3	9.53	16	1.23	4368	nk60
-3.25	-1.25	8.94	-27.61	61.34	-32.59	-0.1	0.02	0.02		-1.29	-2.47	8.94	17	1.27	4368	nk60
-2.83	-0.53	9.1	-25.37	62.41	-32.13	-0.09	0.02	0.02		-1.41	-3.06	8	18	1.3	4368	nk60
-3.87	-1.54	6.32	-24.79	62.74	-30.17	-0.1	0.02	0.02		-1.53	-2.35	6.94	19	1.34	4368	nk60
-2.6	-0.97	7.21	-23.97	63.81	-29.7	-0.1	0.02	0.02		-1.41	-3.06	9.06	20	1.37	4368	nk60
-2.17	-1.46	9.2	-23.52	63.97	-30.24	-0.1	0.02	0.02		-0.59	-1.88	8.94	21	1.4	4368	nk60
-3.17	-1.45	8.73	-22.33	64.13	-30.43	-0.1	0.02	0.02		-0.24	-3.77	8.94	22	1.44	4368	nk60
-3.06	-0.72	9.08	-22.05	64.37	-30.75	-0.1	0.02	0.02		-0.47	-3.41	9.53	23	1.48	4368	nk60
-3.1	-3.68	8.66	-21.65	64.1	-31.23	-0.1	0.02	0.02		-1.41	-3.41	9.06	24	1.51	4368	nk60
-3.43	-2.16	9.51	-20.74	64.41	-30.59	-0.1	0.02	0.02		-1.53	-3.65	9.53	25	1.55	4368	nk60
-3.69	-1.95	9.77	-20.83	63.99	-30.21	-0.09	0.02	0.02		-1.53	-3.53	10.24	26	1.58	4368	nk60
-3.92	-2.58	10.33	-21.16	64.53	-29.39	-0.1	0.02	0.02		-1.65	-3.88	10.94	27	1.61	4368	nk60
-4.47	-1.64	10.63	-22.1	65.93	-27.43	-0.1	0.02	0.02		-0.82	-5.18	10.71	28	1.65	4368	nk60
-4.99	-1.07	10.76	-21.82	67.95	-25.86	-0.09	0.02	0.02		-0.59	-5.41	9.06	29	1.69	4368	nk60
-5.65	-1.45	10.24	-20.93	70.48	-23.82	-0.1	0.02	0.02		-0.59	-4.35	8.83	30	1.72	4368	nk60
-4.35	-1.33	8.21	-18.85	72.17	-22.43	-0.1	0.02	0.02		-0.71	-3.65	7.65	31	1.76	4368	nk60
-3.69	-1.48	7.76	-17.29	72.77	-21.98	-0.1	0.02	0.02		-0.82	-2.59	7.3	32	1.79	4368	nk60

X Y Z

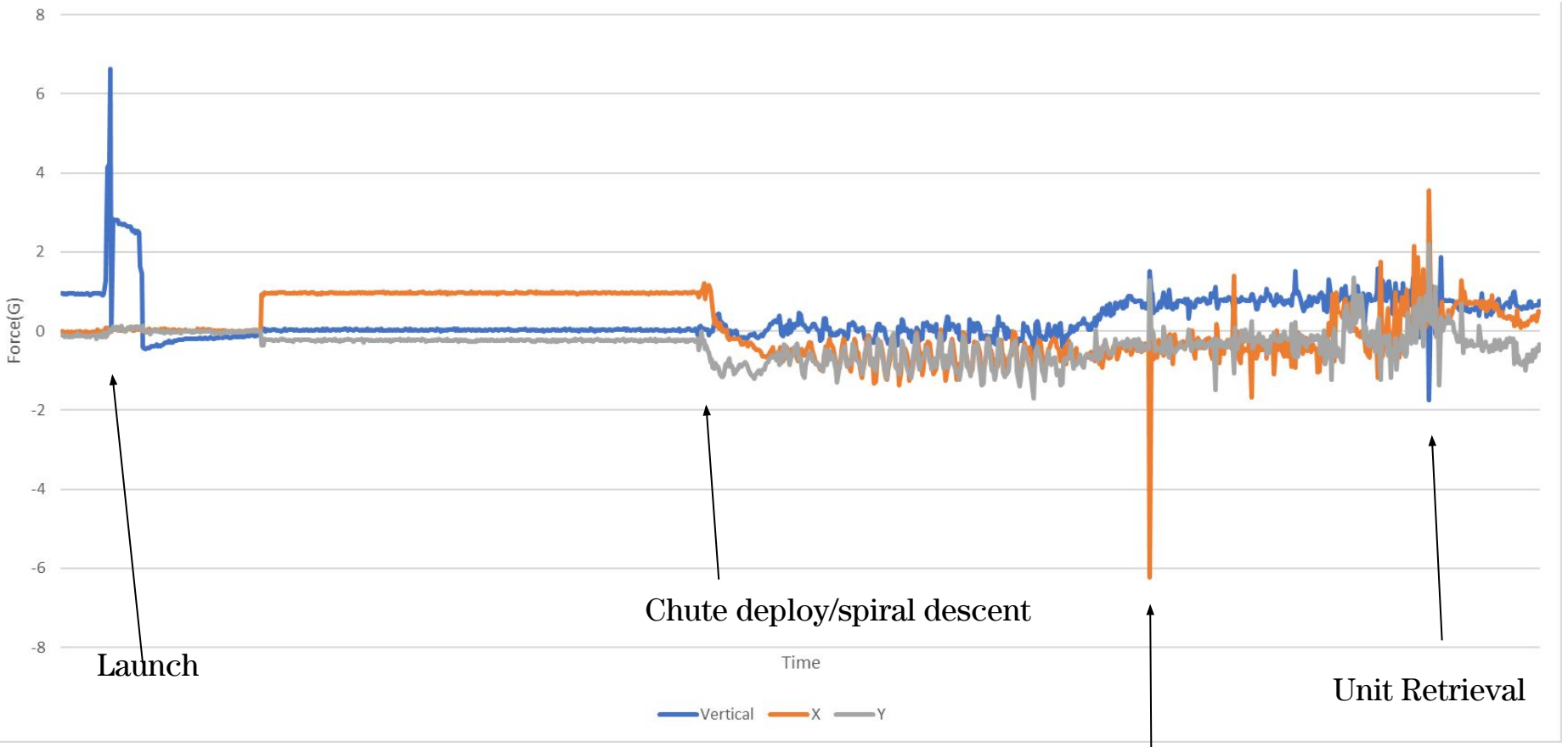
X Y Z

IMU X,Y,Z axis = Accelerometer Y,X,Z axis

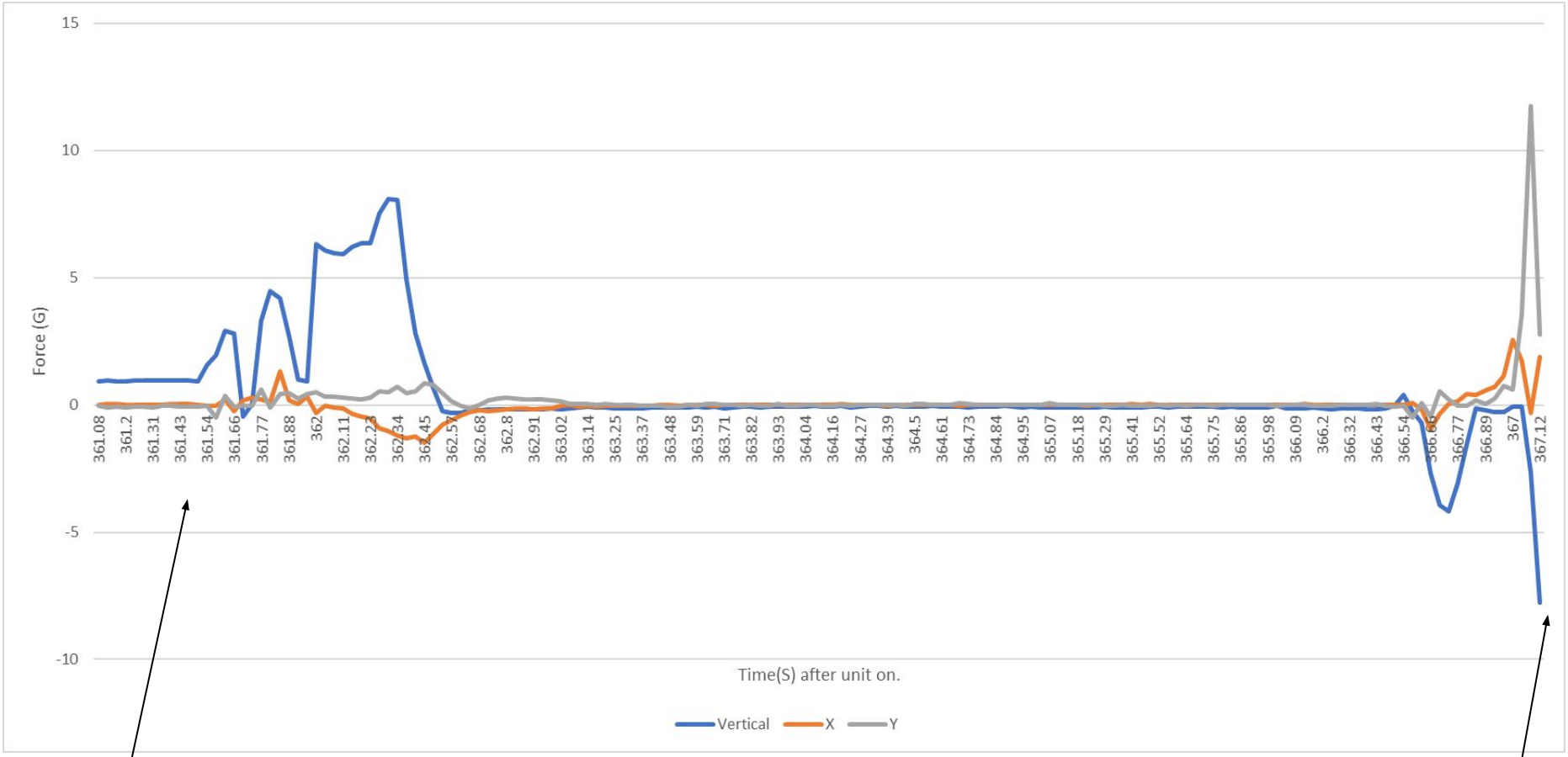
IMU sensitivity set to ±2g to measure small vibrations. Gyroscope set to ±245 dpi. Magnetometer set to ±2 gauss.

Accelerometer sensitivity set to ±16g to measure large forces of rocket propulsion.

Kolea60-u2 LIS3DH Acceleration (02/22/22)



Kolea60-u2 LIS3DH Acceleration (02/22/22)



Launch

Touchdown

~~microSD card ejected upon impact~~

~~on roof due to low altitude chute ejection~~

5.0 Plan for Integrated Subsystem Testing Review (ISTR)

Testing Plan: Mechanical Testing

D'Elle

Mechanical Testing flow:

At present WinCC has prototyped ScubeR and HonCC has prototyped Onboard Camera

2021 Dec => 2022 Feb.

Subsystem Critical Testing:

- Characterize Rocket Thrust in vacuum
- Demonstrate operation of ScubeR Release(photogate+ramp)
- Operation of stepper motor functions
- Perform stress analysis simulation for ScubeR
- Verify Release Velocity of Rocket
- Verify performance of cameras by simulated SubeR deployment via airtrack

Subsystem Testing Review: FEB

Complete fabrication and assembly of ScubeR and Subsystems for ISTR

2022 Feb => 2022 Mar.

Integrated Systems Critical Testing:

- Open bench test
- Verify payload dimensions, weight, and Center of Gravity are within constraints.

Integrated Systems Testing Review: Mar.

2022 Jun <= 2022 Mar.

Make necessary modifications to mechanical layout. Complete payload assembly for testing

2022 Aug <= 2022 Jun.

Contingency for Action Items and potentially fatal failures.

Environmental Testing:

- Closed bench test
- Weight and Balance test
- Shake/spin test
- No mechanical inhibits

Testing Plan: Electrical Testing

D'Elle

Electrical Testing flow:

Boards to be fabricated during winter

2021 Dec => 2022 Feb.

Subsystem Critical Testing:

- Verify the operation of PDB's provides correct voltages
- Verify operation of H-Bridge and Stepper Motor and Artemis
- Verify operation Cameras and Data Controller.

Subsystem Testing Review: FEB

Each subsystem verified and functional for ISTR

2022 Feb => 2022 Mar.

Integrated Systems Critical Testing:

--Open bench testing: Verify the assembly of electrical interfaces

--Collect data from each of sub-systems

--Simulate ScubeR release sequence

Integrated Systems Testing Review: Mar.

2017 Jun <= 2022 Mar.

Closed Bench testing prior to Envr. testing: Electrical testing with full payload assembly

Environmental Testing:

- Verify the integrity of electrical interfaces after each phase of environmental testing
- No electrical inhibits

2022 Aug <= 2022 Jun.

Contingency for Action Items and system failures.

Testing Plan: Software Elements

Software Development flow:

Currently developing software internal to subsystems. Primary focus is on Flight CPU and Data Controller.

2021 Dec => 2022 Feb.

Subsystem Level Development:
- Data Controller
- ScubeR Controller (determines operation of stepper motor)

Subsystem Testing Review: FEB

Subsystem software tested and calibrated prior to ISTR.

2022 Feb => 2022 Mar.

Integrated Systems Development :
- Not Applicable (No data transfer between subsystem)

Integrated Systems Testing Review: Mar.

2022 Jun. <= 2022 Mar.

Testing/Debugging:
- Run Full flight simulations
- Collect and analyze data from simulations to verify integrity of operations.

Integration Readiness Review: Jun.

2022 Aug. <= 2022 Jun.

Contingency for Action Items and potentially fatal failures.

Integrated systems operational for full missions simulation

ISTR Overall Testing Plan/Schedule: February

February						
Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5 Benchmark: PDB Voltage Test V.2.0 Sublimation Test
6	7	8 Deadline: STR	9	10	11	12 H-Bridge Developed Benchmark: Fabricate Prototype of ScubeR
13	14	15	16	17	18	19 Vacuume Test Benchmark: Motion Test Benchmark: Timming Test Lifetime & Temp Test pf PDB
20	21	22 Artimes Developed	23	24	25	26 Benchmark: ScubeR Deployment Test {Int} Power Test: Artimes {Int}
27	28					

ISTR Overall Testing Plan/Schedule: March

March						
Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7 ~ISTR	8	9	10	11	12 Power Test: Mobius Cameras Power Test: Data Controller Power Test: H-Bridge {Int}
13	14	15	16	17	18	19 Benchmark: Integrated Power Test Image Capture Test
20	21	22	23	24	25	26 Deadline: 1st Day in the Life Simulation
27	28 Deadline: 2nd Day in the Life Simulation	29	30	31		

6.0 User Guide Compliance

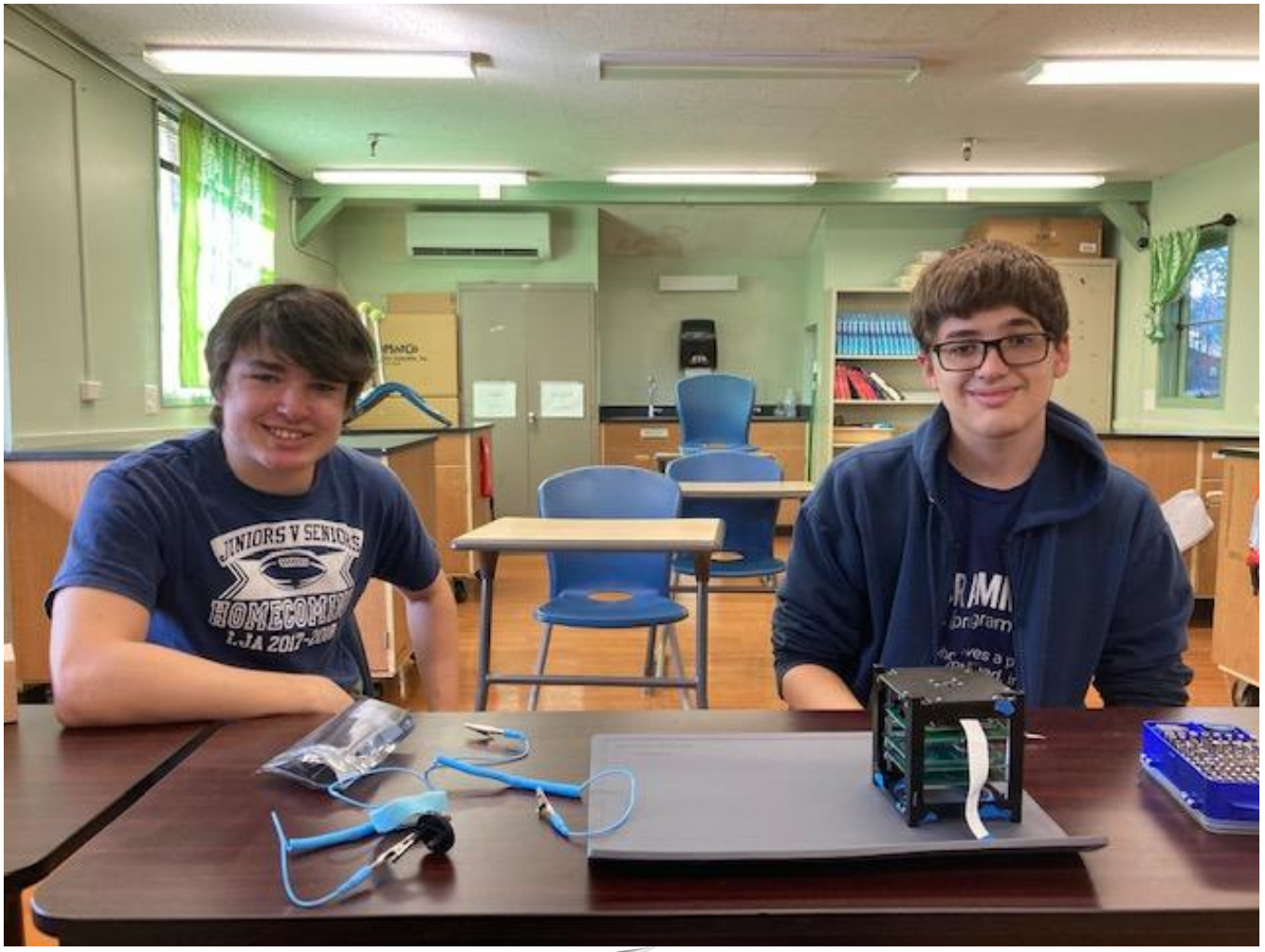
User Guide Compliance: Summary

	Assets	Honolulu	Windward	Total
Weight?	**~1.13 lbs**	~ 1.14 lbs	~ 1.86 lbs.	**~6.52 lbs excluding mounting hardware and including the pyaload 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-1 @ T= -200**	TE-1 @ T= 0.1+	TE-1 @ T= 0.1+ TE-R @ T=0.1 +	**TE-1 @ T= 0.1+ TE-R @ T=0.1+ GSE-1 @ 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**

7.0 Project Management Update

Team Photo [HonCC & WinCC]

Team Photo Cont. [Assets]



Jared

Project Imua Budget: Mission 10

rev 2-5-22

UHCC Project Imua Mission 10: RS-X 2022

Item	Budgeted	Expended/ Encumbered	Balance
Student Fellowships (Fall/Spring/Summer)	37,500	22,500	15,000
Student Summer Travel Stipend	12,330	0	12,330
Mentor Summer Travel	10,357	0	10,357
Supplies	7,000	500	6,500
RockSat-X 2022 launch fee deposit	2,000	2,000	0
RockSat-X 2022 launch fee 1st Install	6,000	6,000	0
RockSat-X 2022 launch fee 2nd Install	6,000	0	6,000
Total	81,187	31,000	50,187

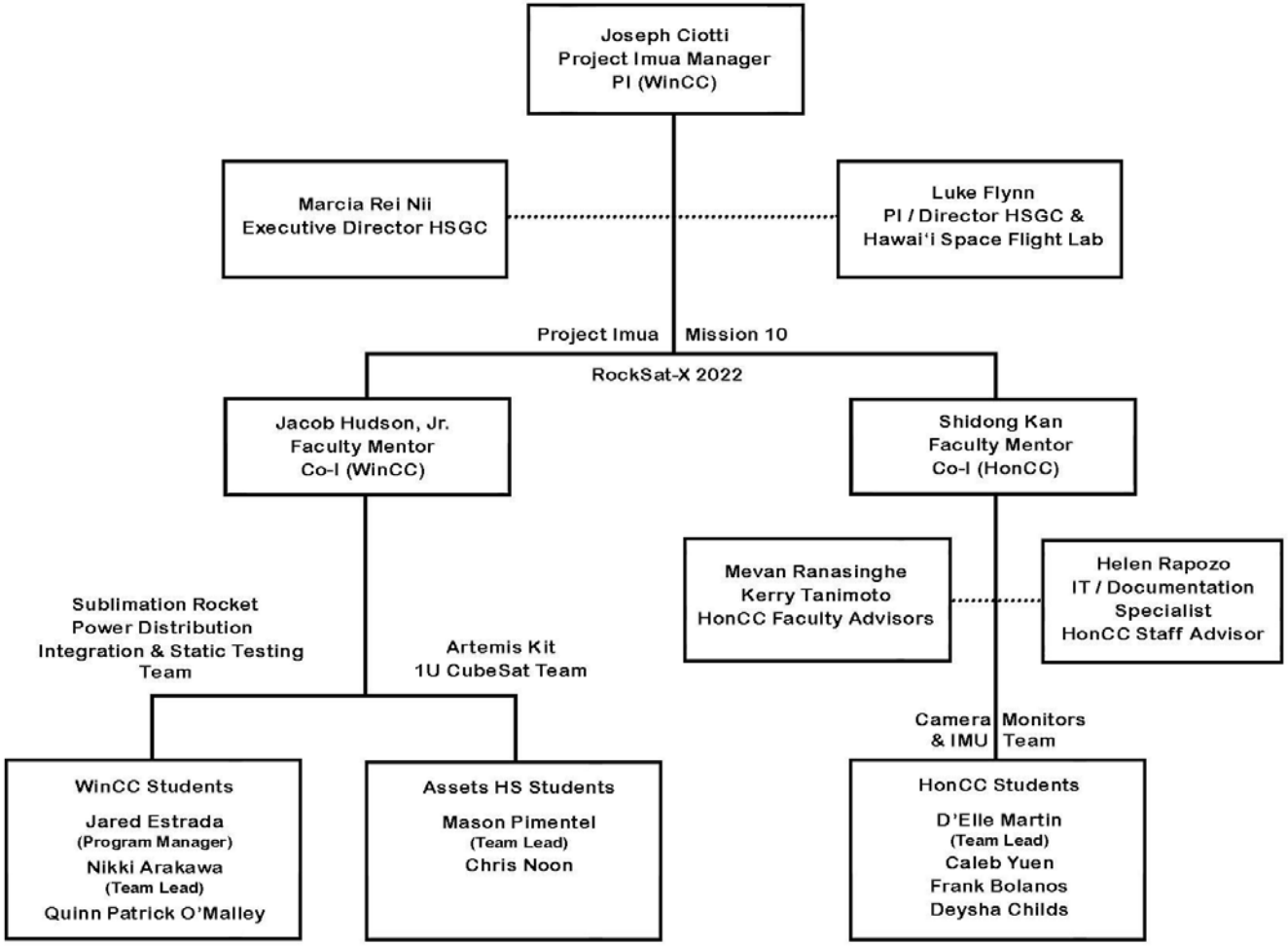
Team Mentors

Jared

revised 10-30-21

University of Hawai'i Community College (UHCC) Project Imua Mission 10		
RS-X 2022 Team Mentors & Advisors		
Institution	**Mentor/Advisor**	**Cell Phone**
Windward CC		
Project Manager (PI)	Joseph Ciotti	808-225-5637
Faculty Mentor (Co-I)	Jacob Hudson	808-347-8246
Honolulu CC		
Faculty Mentor (Co-I)	Shidong Kan	808-724-1533
Faculty Advisor	Mevan Ranasinghe	862-803-0760
Faculty Advisor	Kerry Tanimoto	808-295-3475
Staff Advisor	Helen Rapozo	808-367-3684
Assets High School		
Faculty Mentor	Jacob Hudson	808-347-8246
UH Manoa		
Advisor—HSGC/HSFL Director	Luke Flynn	808-277-7218
Advisor—HSGC/ Program Coordinator/ Executive Director	Marcia Rei Nii	808-384-4684

Team Organization



Schedule

Tasks	October	November	December	January	February	March	April	May	June	July	August
PDB											
ScubeR											
Mobius Camera development											
Mobius Camera fabrication											
Data Controller development											
Data Controller fabrication											
Artemis Cubesat development											
Artimes Cubesat fabrication											
Scuber Controller											
Sub-System test											
Integration											
Full Mission Simulation											
Integration Readiness Review											
Environmental Testing Simulation											
Review/Telecon	CoDR	PDR	CDR	Manifested?	STR	ISTR	FMSR	IRR	ETS	LRR	Launch

Wincc
HonCC
Assets
Everyone

Team Avalibility

	Team Name/School: UHCC Project Imua 10					
	Spring RS-X Team Availability Matrix. STR Week of TBD					
	PLEASE USE MOUNTAIN TIME ZONE TIMES					
HST	MST	Monday	Tuesday	Wednesday	Thursday	Friday
4:00 AM	7:00 AM	4	4	4	4	4
5:00 AM	8:00 AM	4	4	4	4	4
6:00 AM	9:00 AM	3	3	4	3	3
7:00 AM	10:00 AM	4	4	4	4	4
8:00 AM	11:00 AM	4	2	4	4	2
9:00 AM	12:00 PM	4	2	4	4	2
10:00 AM	1:00 PM	4	4	4	4	4
11:00 AM	2:00 PM	4	4	4	4	4
12 noon	3:00 PM	4	4	4	4	4
1:00 PM	4:00 PM	1	4	4	4	4
2:00 PM	5:00 PM	4	4	4	4	4
	Please Place priority levels for times you are availible. This is done by simply typing a 1,2,3, or 4 in each clear box.					
	Example	1	2	3	4	
		Highest Priority			Lowest Priority	

Team Contact Matrix

revised 12/3/21

Team Name/School: UHCC Project Imua Mission 10							
Fall 2021 RS-X Contact Matrix							
Role	**Name**	**Day Phone**	**Cell Phone**	**Receive Texts?**	**Email**	**Citizenship**	**Add to mailing list?**
Project Manager (PI)	Joseph Ciotti	808-236-9111	808-225-5637	yes	ciotti@hawaii.edu	U.S.	yes
Windward CC							
Faculty Mentor (Co-I)	Jacob Hudson	808-347-8246	808-347-8246	yes	jacobh@hawaii.edu	U.S.	yes
Student (Program Manager)	Jared Estrada	719-440-0941	719-440-0941	yes	jestrada7125@gmail.com	U.S.	yes
Student (Team Lead)	Nikki Arakawa	808-450-4294	808-450-4294	yes	nikkia@hawaii.edu	U.S.	yes
Student	Quinn Patrick O'Malley	808-738-2618	808-738-2618	yes	qomalley@hawaii.edu	U.S.	yes
Honolulu CC							
Faculty Mentor (Co-I)	Shidong Kan	808-845-9499	808-724-1533	yes	shidong@hawaii.edu	U.S.	yes
Faculty Advisor	Mevan Ranasinghe	862-803-0760	862-803-0760	yes	mevanr@hawaii.edu	U.S. green card	yes
Faculty Advisor	Kerry Tanimoto	808-845-9154	808-295-3475	yes	kerryt@hawaii.edu	U.S.	yes
Staff Advisor	Helen Rapozo	808-845-9202	808-367-3684	yes	rapozo@hawaii.edu	U.S.	yes
Student (Team Lead)	D'Elle Martin	808-358-5743	808-358-5743	yes	dellej@hawaii.edu	U.S.	yes
Student	Caleb Yuen	808-476-8018	808-476-8018	yes	yuenc734@hawaii.edu	U.S.	yes
Student	Frank Bolanos	808-271-3405	808-271-3405	yes	fbolanos@hawaii.edu	U.S.	yes
Student	Deysha Childs	808-375-3331	808-375-3331	yes	dchilds7@hawaii.edu	U.S.	yes
Assets High School (Mentor: Jacob Hudson)							
Student (Team Lead)	Mason Pimentel	808-726-1616	808-726-1616	no	mason_pimentel@assets-school.org	U.S.	yes
Student	Christopher Noon	808-423-1356		no	christopher_noon@assets-school.org	U.S.	yes

Risks/Concerns

- **Concern 1:** Sublimation Rocket may not clear CarRoLL before re-entry.
  - **Mitigation:** Use of worm gear will guarantee clearing of CarRoLL section.
  - Additional vacuum pressure test planned.
- **Concern 2:** The Specific Impulse of the sublimation propellant is unknown, resulting in an uncertainty of rocket's maximum reaction mass.
  - **Mitigation:** Once a prototype ScubeR is constructed, it will be loaded with varying concentrations of different sublimation propellant and tested inside a vacuum chamber at the Center for Aerospace Education.
- **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

- Next steps for your team to get to ISTR:
  - Begin integrated tests of **ScubeR** prototype.
  - Begin PDB integrated tests.
  - Complete all individual Subsystem tests.
  - **Mobius camera system:** Take apart the cameras, Mount circuit boards in Hammond box, configure settings.
  - Complete arrangement, construction, testing of **Power Distribution Board**.
  - Complete construction and testing of **Artemis CubeSat**.
  - **Flight Board**: integrate driver code and test stepper motor execution.
  - **Data controller:** Build flying units to test on model rockets.

Appendix

Acronyms

Jared

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

Jared

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