Project Imua Mission 10

Conceptual Design Review

University of Hawaii Community Colleges

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Table of Contents

Mission Overview

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Mission Statement (Summary)

1. Project Imua
   a. Collaboration of Honolulu Community College (HonCC) & Windward Community College (WinCC)
   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 Artemas 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 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. Project-based internship in aerospace engineering
2. **Objective 2: Primary Experimental Payload**
   a. Deploy sublimation rocket (**S^{3}R**) 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
   b. Proof of Concept of a 1U Artemis CubeSat

Minimum Success Criteria

Primary Objectives	Minimum Success Criteria
Engage students in design, fabrication and aerospace engineering.	5 students awarded scholarship per semester & 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 cameras.	Record deployment of sublimation rocket with visual cues determining acceleration. Record a minimum of three images at three different times.

Desirable Success Criteria

Secondary Objectives	Desirable Success Criteria
Demonstrate operation of 9-axis motion tracking device.	Save data to SD card on deck plate.
Image capture by Artemis CubeSat Kit.	Save images to memory on deck plate.

Theory & Concepts

Primary Experiments

- Super Simple Sublimation rocket (WinCC)
- On-board, deck-mounted imagery cameras (HonCC)

Secondary Experiment

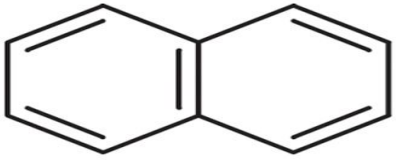
- Multi-axis IMU (HonCC)
- Proof of concept test: Artemis 1U CubeSat (extra camera?)

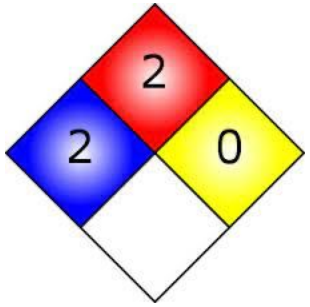
  (Assets School/WinCC/HSFL)

Theory & Concepts: Sublimating Material

Naphthalene

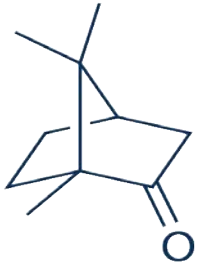
- Formula: $C_{10}H_8$
- Sublimates at: 0.338 Pa
- Molar Mass: 128.1 g/mol
- Density: 1.14 g/cm^3
- Boiling Pt: 218° C
- Melting Pt: 80.3° C

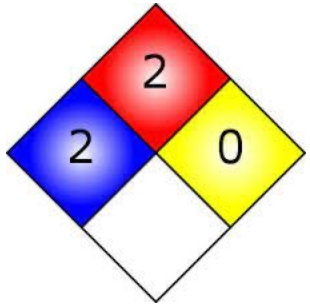




Camphor

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





Theory & Concepts Artemis CubeSat Kit

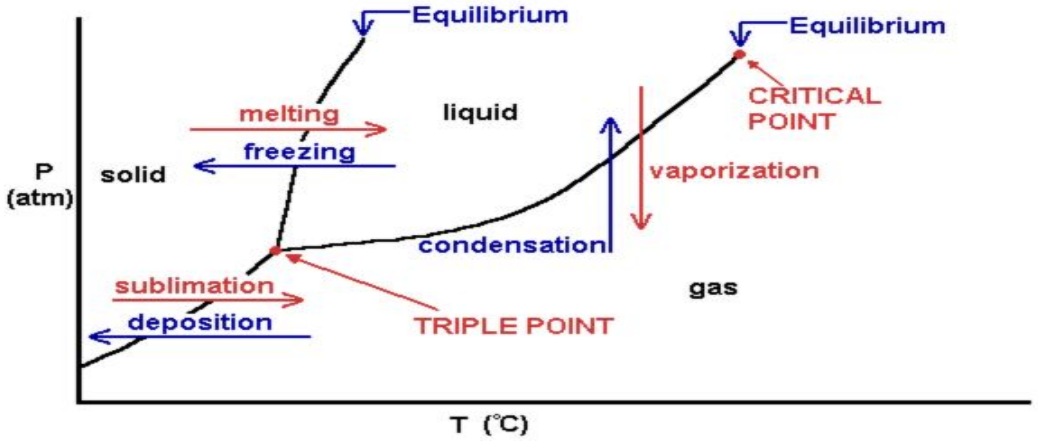
- Part of Hawaii Space Flight Laboratory (HSFL)
- To promote STEM
- The general capabilities of this standard unit satellite (1U) include onboard computing, radio communication, rudimentary dynamic sensors, basic infrared camera, and an electrical power system. The hardware components are designed to be the most basic functionality of a small spacecraft.
- https://www.hsfl.hawaii.edu/artemis-cubesat-kit-2/

Theory & Concepts

Super Simple Sublimation rocket, ScubeR

Sublimation Fueled Rocket:

The sublimation of camphor at low pressure will act as propellant for the rocket, ScubeR. When the camphor vapor is expanding within its container during the sublimation process, the vaporized camphor will act as a reaction mass for ScubeR.



Phase diagram P (atm) vs T (celsius)

Expected Results (Sublimation Rocket)

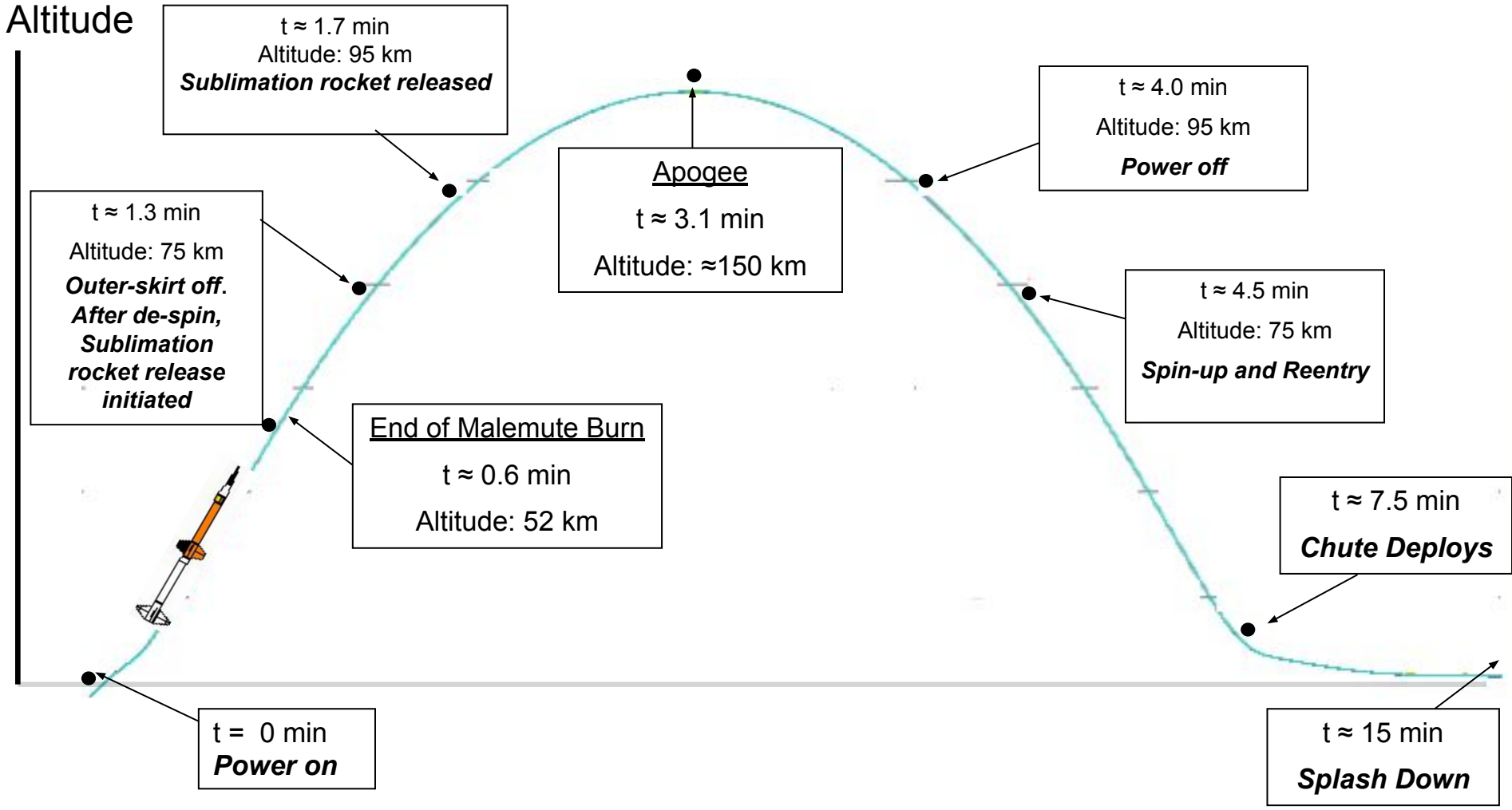
- Possible low temperature means of propulsion
- Maximum depart velocity of 1 inch/sec
- Based on vapor pressure alone; sublimation will increase velocity

Expected Results (On-board Camera Systems)

Capture & Store Imagery of ScubeR Deployment

- Determine ScubeR Distance
- Determine ScubeR Acceleration

Concept of Operations



Design Overview

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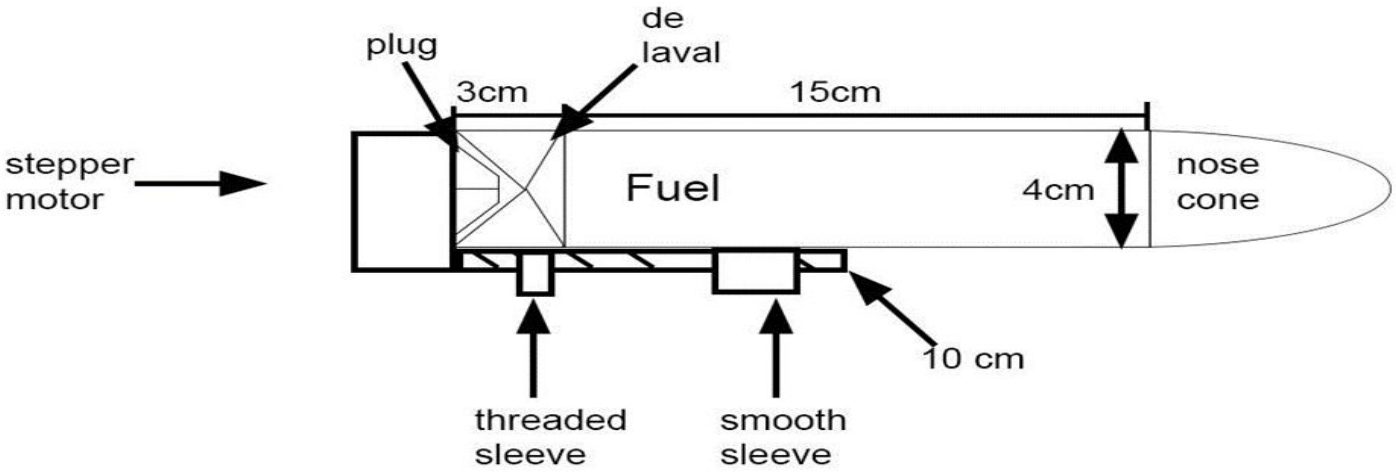
Engineering Design Overview

Subsystems

- **Power Conditioning Board (WinCC)**
  - Step down voltage from 28V to 5V and 3.3V
- **Flight Computer/Data Controller/IMU (All)** - Raspberry Pi 4
  - Process data to fit telemetry protocols
  - Receive data from 9-axis motion detector
- **Super Simple Sublimation Rocket** - ScubeR **(WinCC)**
  - 3D Printed
  - 25cm (estimated)
- **On-board Camera (HonCC)** - Mobius Camera Modules
  - 32GB USB
  - 10cm x 6cm x 1.8cm
- **Heritage Elements**
  - Raspberry Pi
- **Major technology dependencies?**
  - No
- **Artemis CubeSat**
  - Redundant Camera System?

Design Overview cont. (Sublimation Rocket)



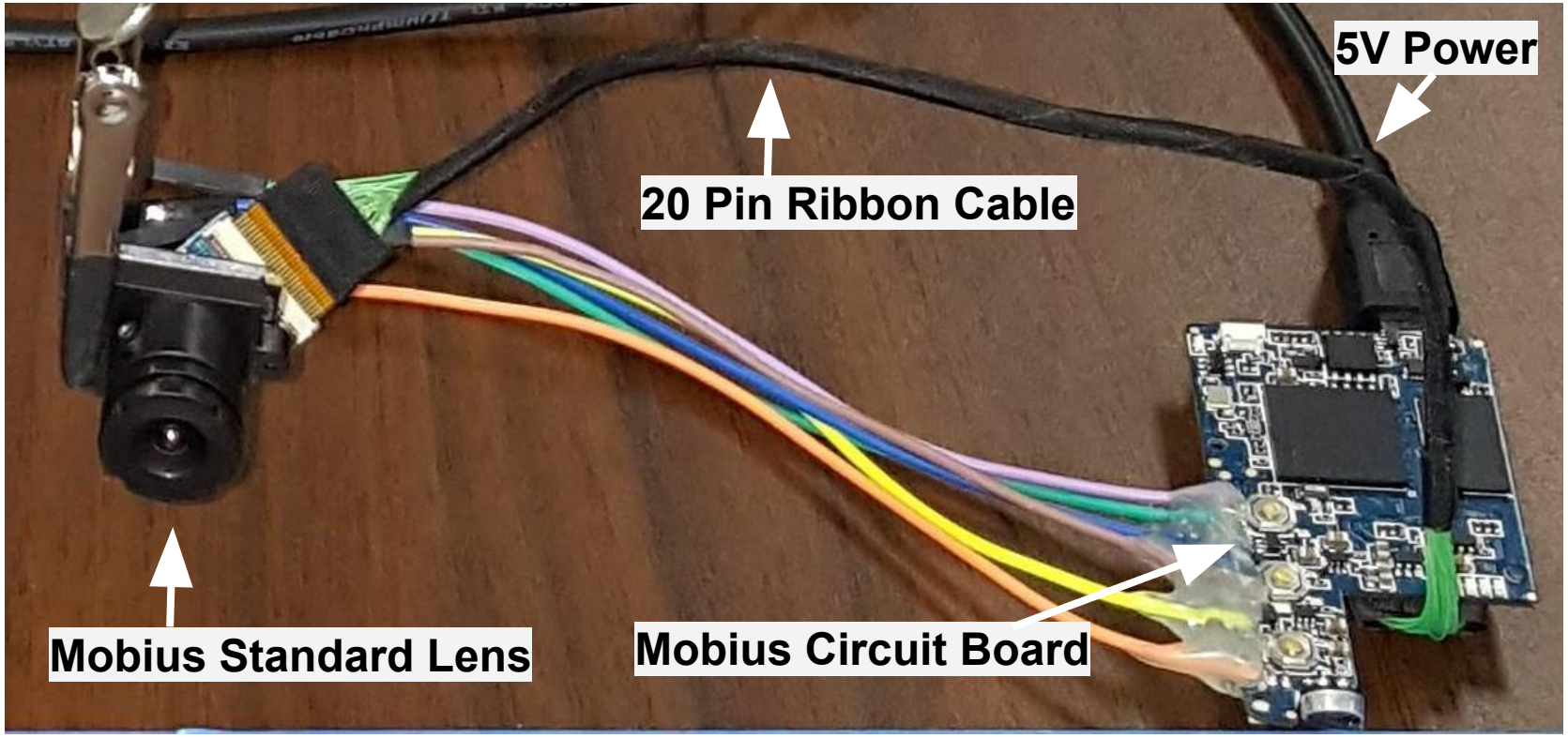
- Lulzbot Taz 5 (3D Printer): Fabrication of rocket (ScubeR)
- NEMA 17 Stepper Motor
- Compressed Solid Camphor

Design Overview: LM2596 DC-DC Adjustable Step Down Voltage Regulator

Nikki

- Input Voltage Range: DC 3 - 40 V
- Output Voltage Range: DC 1.5 - 35 V
- The input must be 1.5 V higher then the output voltage.
- The maximum current recommended is 2 A (as is).
- This can be increased to 3A if an additional heat sink is used.

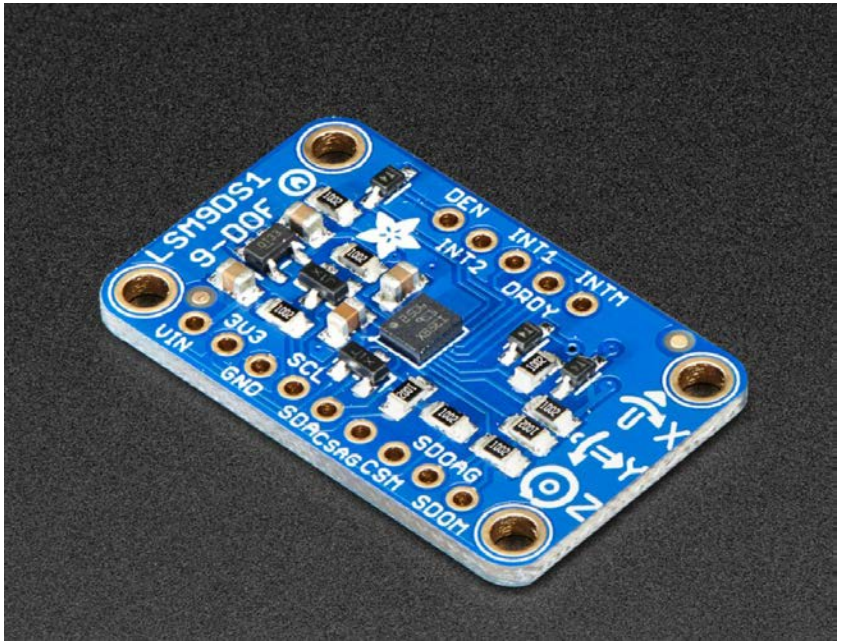
Design Overview: (on-board Camera System)



Design Overview: Artemis CubeSat Kit

- 10 cm x 10 cm X 11 cm (1U)
- Opportunity to test concept
- The Batteries and Transmitter will be removed
- Any data obtained will be stored on-board
- Will house the Power Distribution Board (PDB) for the other experiments

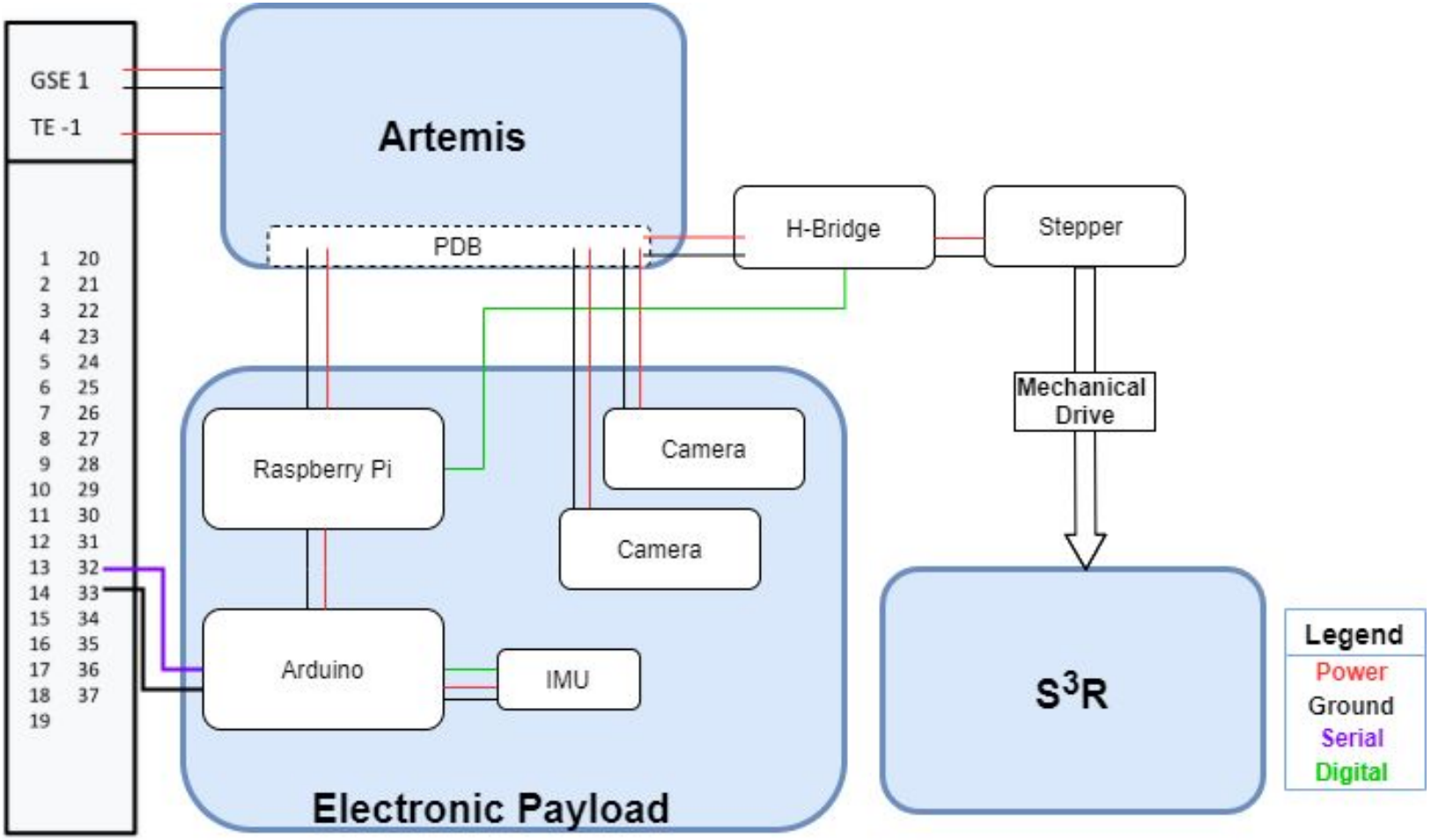
Design Overview (9-Axis Motion Detector)



Adafruit LSM9DS1

- Input : 3-5V DC
- Accelerometer ±2/±4/±8/±16g
- Magnetometer ±4/±8/±12/±16 gauss
- Gyroscope ±245/±500/±2000dps

Functional Block Diagram



Payload Layout

Components:

- Sublimation Rocket: 25 cm x 4 cm x 4 cm
- Raspberry Pi: 8.5 cm x 5.6 cm x 1.7 cm
- Mobius Camera Module: 2.03 cm x 2cm x 0.9 cm
- All components within keep out area

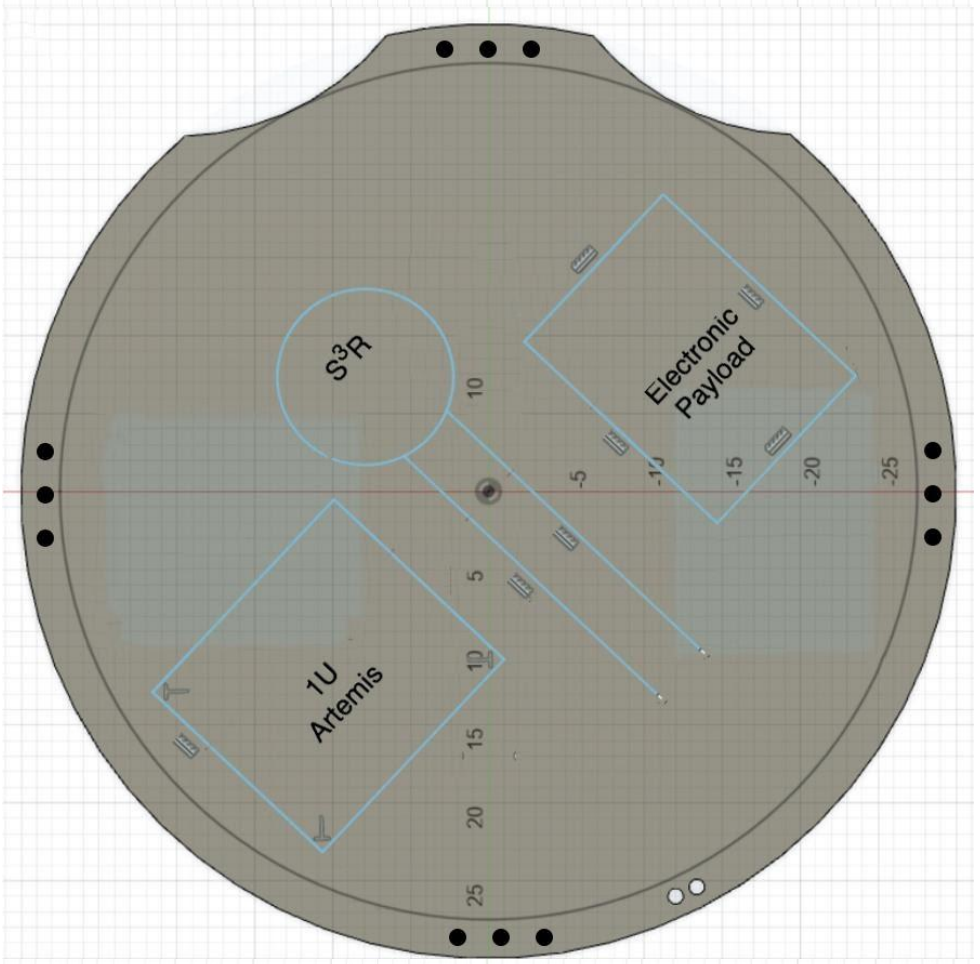


Fig : Top View Payload layout not to scale

Management

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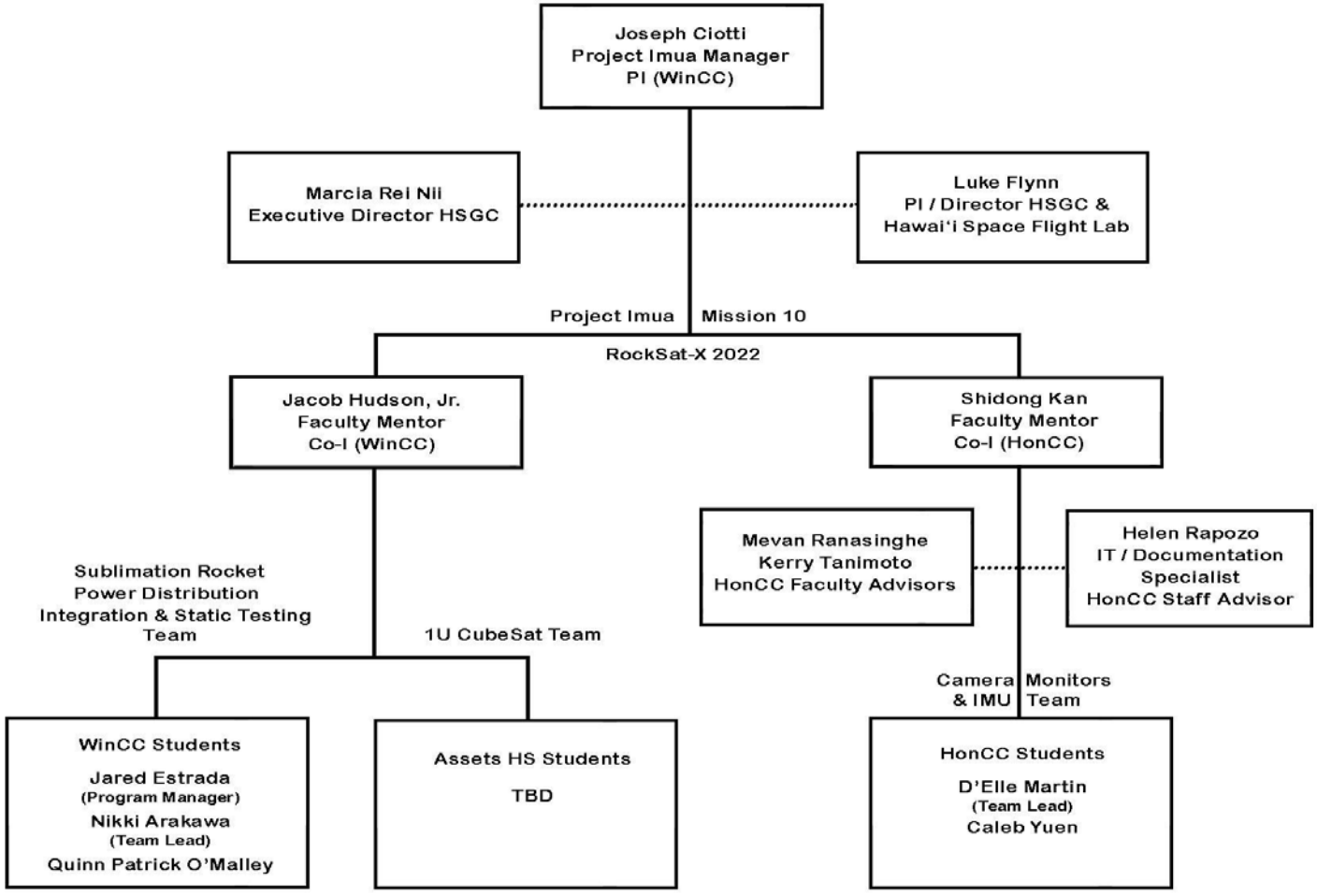
Management: Team Organization



Project Imua: Mission 10 Budget

rev 10-8-21			
UHCC Project Imua Mission 10: RS-X 2022			
Item	**Budgeted**	**Expended/ Encumbered**	**Balance**
Student Fellowships (Fall/Spring)	16,500	7,500	9,000
Student Summer Travel Stipend	12,330	0	12,330
Mentor Summer Travel	10,357	0	10,357
Supplies	7,000	0	7,000
RockSat-X 2022 launch fee deposit[1]	2,000	2,000	0
RockSat-X 2022 launch fee 1st Install	6,000	0	6,000
RockSat-X 2022 launch fee 2nd Install	6,000	0	6,000
Total	60,187	9,500	50,687
[1]PO already processed; check to be sent to COSGC by 10-13-21			

Management: Preliminary Schedule

Gantt Chart UHCC RockSat-X 2022											
Tasks	October	November	December	January	February	March	April	May	June	July	August
PCB											
ScubeR											
Mobius Camera development											
Mobius Camera fabrication											
Data Controller/IMU development											
Data Controller/IMU fabrication											
Flight Computer											
Sub-System test											
Integration											
Full Mission Simulation											
Review/Telecon	CoDR	PDR	CDR	Manifested?	STR	ISTR	FMSR	IRR	ETS	LRR	Launch
WinCC											
HonCC											

Wincc
HonCC
Everyone

Management: Team Contact Matrix

Jared

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

Management: Availability Matrix

	Team Name/School: UHCC Project Imua 1C					
	Fall RS-X Team Availability Matrix. CoDR Week of Oct 11					
	PLEASE USE MOUNTAIN TIME ZONE TIMES					
HST	MDT	Monday	Tuesday	Wednesday	Thursday	Friday
3:00 AM	7:00 AM	4	4	4	4	4
4:00 AM	8:00 AM	3	4	3	4	4
5:00 AM	9:00 AM	2	4	2	1	1
6:00 AM	10:00 AM	1	4	4	4	3
7:00 AM	11:00 AM	2	1	1	4	1
8:00 AM	12:00 PM	2	1	1	4	1
9:00 AM	1:00 PM	4	4	4	4	4
10:00 AM	2:00 PM	4	4	4	4	4
11:00 AM	3:00 PM	4	4	4	4	4
12 noon	4:00 PM	4	4	4	4	4
1:00 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	

NOTE: Mainland ends Daylight Saving Time on **November 7, 2021**. Time listed in the second column is **MDT.** HST is currently 4 hours behind MDT.

RockSat-X User's Guide Compliance

	Honolulu	Windward	Total
Weight?	53.5g-Mobius Cam ~200g-data controller	~ 700 g.	**~3000g excluding mounting hardware**
Dimensions?	H=17mm x 85mm x 56mm Unknown for data controller at this time	Height = 40mm Base = 250 x 40mm	**Within space**
Deployments?	No	Yes	**Yes**
ADC Lines?	No	No	**0**
Async/Parallel?	Yes/No	No/No	**Yes/No**
Power/Timer Events?	TE-1 @ T= 0.1+	TE-1 @ T= 0.1+	**TE-1 @ T= 0.1+**
Understand CG Requirement?	Yes	Yes	**Yes**
High Voltage?	No	No	**No**
Hazardous Procedures?	No	No	**No**
RF?	No	No	**None**
Bottom of Deck Plate Flush?	Yes	Yes	**Yes**
US Persons for whole team?	No	Yes	**No**
ITAR?	Compliant	Compliant	**Compliant**

Risks & Concerns

- **Concern:** Sublimation Rocket may not clear CarRoLL before re-entry
- **Mitigation:** Use of worm gear will guarantee clearing of CarRoLL section
  - ❖ Additional vacuum pressure tests planned

Risks & Concerns (continued)

- **Concern:** 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.

Risks & Concerns (continued)

- **Concern:** Mobius camera data retrieval damage (Still Pictures & Video)
  - **Mitigation:** Hammond box for heat & water proofing.

Conclusions

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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 PDR:
  - Face-to-face meetings of all students to coordinate design efforts
  - Begin requirement flow down process for system and subsystems
  - Determine participation of Assets High School students