HASP Student Payload Application for 2023

Payload Title: FLC Ionizing Radiation vs. Solar Insolation (IRSI) Experiment

Institution: Fort Lewis College

Payload Class (Enter SMALL, or LARGE): SMALL	Submit Date: 1/16/2023

Project Abstract:
The Fort Lewis College HASP team will launch an ionizing radiation measuring experiment ionizing radiation vs. Solar insolation with updated systems from previous HASP and DemoSat balloon flights. The primary experiment uses counter-facing Geiger counters to record ionizing radiation vs. Solar insolation. The system will be controlled by an Arduino Pro Mini with downlink data utilizing the HASP system as well as being backed-up to a micro-SD card. A communication system will be used to downlink the data. A power management system will monitor the power to each system using DC current sensors. A temperature control system will record the temperature of each system and activate heaters, as needed, to help maintain normal functionality. A digital camera system will also be installed on the payload to record the entirety of the flight. The Spacehawk's payload design could potentially prove to be a cost-effective way of accurately measuring ionizing radiation present in the atmosphere depending on the Solar insolation.

Team Name: Spacehawks	Team or Project Website: TBD

	Student Leader Contact Information:	Faculty Advisor Contact Information:
Name:	Sally Thompson (TBD?)	Dr. Charles Hakes
Department:	Department of Physics & Engineering	Department of Physics & Engineering
Mailing Address:		1000 Rim Drive
City, State, Zip code:		Durango, Colorado, 81301
e-mail:		hakes_c@fortlewis.edu
Telephone:		970-247-7242

The signature below indicates that the student lead and faculty advisor have read and understood the HASP CFP and Student Payload Interface manual, commit to providing the required HASP deliverables by the indicated due dates and agree to respond to HASP management inquires in a timely manner.

Commitment Signature:		

Flight Hazard Certification Checklist

NASA has identified several classes of material as hazardous to personnel and/or flight systems. This checklist identifies these documented risks. Applying flight groups are required to acknowledge if the payload will include any of the hazards included on the list below. Simply place an (x) in the appropriate field for each hazard classification. **Note:** Certain classifications are explicitly banned from HASP and the remaining hazards will require additional paperwork and certifications. If you intend to include one of the hazards, you must include detailed documentation in section 3.8 of the application as required by the HASP Call for Payloads.

This certification must be signed by both the team faculty advisor and the student team lead and included in your application immediately following the cover sheet form.

Hazardous Materials List		
Classification	**Included on Payload**	**Not Included on Payload**
RF transmitters	**X**	
High Voltage	**X**	
Lasers (Class 1, 2, and 3R only) Fully Enclosed		**X**
Intentionally Dropped Components		**X**
Liquid Chemicals		**X**
Cryogenic Materials		**X**
Radioactive Material		**X**
Pressure Vessels		**X**
Pyrotechnics		**X**
Magnets less than 1 Gauss*		**X**
UV Light		**X**
Biological Samples		**X**
Non-Rechargeable Batteries	**X**	
Rechargeable Batteries		**X**
High intensity light source		**X**

* Magnets greater than 1 gauss are banned.

Student Team Leader Signature: ____

Faculty Advisor Signature: ____

Table of Contents

Flight Hazard Certification Checklist ii
1. Payload Description 3
1.1 Payload Scientific / Technical Background 3
1.1.1 Mission Statement 3
1.1.2 Mission Background and Justification 4
1.1.3 Mission Objectives 4
1.1.4 Scientific Relevance to the HASP Platform 4
1.2 Payload Systems and Principle of Operation 5
1.3 Major System Components 5
1.4 Mechanical and Structural Design 5
1.5 Electrical Design 13
1.6 Thermal Control Plan 13
2. Team Structure and Management 14
2.1 Team Management 15
2.2 Team Organization and Roles 15
2.3 Timeline and Milestones 15
2.4 Anticipated Participation in Integration and Launch operations 16
3. Payload Interface Specifications 16
3.1 Weight Budget 16
3.2 Power Budget 17
3.3 Downlink Serial Data 17
3.4 Uplink Serial Commanding 17
3.5 Analog Downlink 18
3.6 Discrete Commanding 18
3.7 Payload Location and Orientation Request 18
3.8 Special Requests 18
4. Preliminary Drawings and Diagrams 18
5. References 19
Appendix A 21
Appendix B: NASA Hazard Tables 22
Appendix B.1 Radio Frequency Transmitter Hazard Documentation 22

Appendix B.2 High Voltage Hazard Documentation....................23
Appendix B.3 Laser Hazard Documentation....................24
Appendix B.4 Battery Hazard Documentation....................25

1. Payload Description

The primary goal of this experiment is to measure upper-atmospheric, ionizing radiation vs. Solar insolation (IRSI). Time will be recorded to account for the location of the sun above the horizon. The payload will contain two counter-facing Geiger counters to measure the radiative flux of beta and gamma rays. The Geiger counters will have brass shutters that alternate between open and closed to differentiate between gamma, beta, or other ionizing radiation. This will be done using servos with flaps that alternately cover and uncover the detectors. When covered, gamma rays are the most probable ionizing radiation to be detected. When open, beta radiation can be detected. The payload will also be equipped with a temperature control system (TCS), power management system (PMS), and communication system (COMMS).

A secondary goal is to incorporate a camera system to monitor flight progress. The camera will record the flight from liftoff and will utilize HASP power to operate. The TMS will record the temperatures of distinct parts of the payload to be able to cross reference them with the data from the other systems should any thermal anomalies occur. The TCS will also be able to heat a certain system, if necessary, to keep normal functionality. The COMMS system will back up the data from each system on a micro-SD card and control the downlink and uplink capability. Each separate system will operate using Arduino Pro Minis. The previous versions of the systems mentioned above have been used by past Fort Lewis Collage teams for payload flights on HASP and weather balloon flights as part of the DemoSat Colorado Space Grant balloon launch. This is a repeat flight with improved system designs. The Spacehawks team is comprised entirely of new members, and each system will be redesigned and engineered with resources and experiences from these past projects.

1.1 Payload Scientific / Technical Background

The primary experiment conducted through the payload will be focused on ionizing radiation data collection vs. Solar insolation, in addition to time-of-day data. Counter-facing Geiger counters will measure gamma and beta radiation that interact with the payload during flight. A Geiger counter has a small tube known as a Geiger-Muller tube that allows ionized radiation to pass through it. The tube is filled with a mixture of argon and methane that is easily ionized (~5 eV). The radiation creates an argon ion and an electron which hits the positive electrode and creates a pulse that can then be recorded to an SD card using an Arduino pro mini. The voltage difference between the positive and negative electrodes is typically between 400–900 volts. This makes the Geiger counters high voltage devices, so the entire payload will sit within a Faraday cage. The intended voltage for the Geiger counters is approximately 500 volts. The Geiger counters will face in the opposite direction on two sides of the payload to measure ionizing radiation counts over the payload's journey. The data collected from the Geiger counters will be compared to the payload's altitude to show how much ionizing radiation hits the payload in each direction, depending on altitude and time of day.

1.1.1 Mission Statement

The Spacehawks team will create a small payload at Fort Lewis College that will fly on the HASP platform and be capable of recording and monitoring ionized radiation through on-board data collection and live transmission, which will demonstrate an affordable system that records ionization radiation data that can be used as part of further experiments.

1.1.2 Mission Background and Justification

Many organizations, including the United States Government Department of Energy and Atmospheric Radiation Measurement (ARM) facility, monitor Earth's atmospheric radiation [1]. Using this data is crucial to understand how aerosols, certain gases, and particles affect the amount of ionizing radiation that is currently entering the atmosphere from space. According to an ARM study done by the American Meteorological Society, the data from the observation of atmospheric radiation is used to create "accurate climate and earth system models" [2]. These models are especially relevant in predicting the temperature increase due to climate change and any changes in the protective gas layers of the Earth's atmosphere that filter out ultraviolet radiation [3]. Cosmic radiation affects travelers at higher altitudes, and recording the amount of high energy radiation detected as a function of Solar insolation is crucial in high-altitude aircraft design to protect the passengers [4]. A NASA experiment, like the one we are proposing, is NASA's Radiation Dosimetry Experiment (RaD-X) [4]. This experiment studied high altitude radiation and how to improve "monitoring for aviation" [4]. The Spacehawks are proposing the 2021 payload as a cost-effective alternative for a similar experiment. The Sky Hawks payload proposed could potentially prove be a cost-effective way of accurately measuring high energy radiation present in the atmosphere vs altitude. A group of former Fort Lewis College students with the same mentor participated in a DEMOSAT Colorado Space Grant balloon launch. They launched a similar radiation experiment, but an issue arose mid-flight and only data from half the flight was recoverable.

1.1.3 Mission Objectives

The primary mission objective is to create a payload capable of accurately measuring ionizing radiation present in the atmosphere vs. Solar insolation. The secondary objectives are to create a TMS, PMS, COMMS, and camera system, and power switching system that, as part of the payload, will record data with an Arduino Pro Mini to SD cards and downlink data.

1.1.4 Scientific Relevance to the HASP Platform

The primary goal of this experiment is to measure upper-atmospheric, ionizing radiation vs. Solar insolation (IRSI). The payload will contain two counter-facing Geiger counters to measure the radiative flux of beta and gamma rays. The Geiger tubes are enclosed in a brass box with shutters that can open to detect all types of radiation, and close to prevent non-gamma ionizing radiation from being detected. The goal is to distinguish between radiation associated with the sun and other sources, and between gamma ray ionizing radiation and beta or other types of ionizing radiation that would be blocked by a thin metal plate. The high energy radiation hitting the detectors will be not only from the sun, but from other sources, such as ions trapped in the Earth's magnetic field, or possibly from other galactic sources. Down-facing Geiger counters on previous DemoSat flights have shown that some backscattering exists from atmospheric interactions. Time will be recorded to account for the location of the sun above the horizon. As the sun changes position in the sky, the incident flux on the face of the up-facing Geiger counter should change as the cosine of the incident angle. By recording data throughout the day, while the sun is changing its relative incident angle, this experiment should be able to relate the measured ionizing radiation to the calculated solar insolation.

1.2 Payload Systems and Principle of Operation

There are four main systems in the payload: the TCS, PMS, Comms, and Geiger counter systems. A monitoring camera is also attached to track the flight visually. The Geiger counter system (dual, counter-facing) will be on one side of the payload sled and the other systems will be on the other side as shown below in Figure 1. The payload will be mounted to the small HASP mounting platform in a vertical position, with the threaded rods being bolted to the HASP mounting platform. This orientation will maximize space, allowing all necessary components with a minimal footprint.

1.3 Major System Components

- Counter-facing Geiger Counter System
- Power Management System (PMS)
- Temperature Control System (TCS)
- Communication System (COMMS)
- Camera System

1.4 Mechanical and Structural Design

The payload structural design will use two distinct parts, a sled and an outer case. Both will be composed of G10 fiberglass and secured to the provided mounting plate via two ¼-20 threaded rods. The payload covers an area less that 6x6 inches and is 12 inches tall up to the top of the rods. The sled holds all electrical components perpendicular to the mounting plate, as seen in Figure 1, and consists of two 10x5x1/8-inch-thick fiberglass sheets in which all the components are mounted. The colored boxes below represent the mounted components. The threaded rods pass through two separate aluminum spacers, placed between the sheets of the sled. The sheets are screwed to the spacers and nuts were used at the top and bottom of the threaded rods to secure the sled in place. The outer case also holds the sled vertically as the rods are permitted to protrude from the top.

The outer case is a rectangular case made of a thinner, 1/16-inch fiberglass and is held together with 1-inch L-brackets and bolts. The outer case used the threaded rods from the top of the sled and corner brackets on the bottom of the case to attach to the mounting plate. As the desired scientific goal is to detect Solar radiation, a rectangular hole is made in the top of the outer case and the mounting sled to expose the Geiger counters to direct radiation. Overall, the rectangular design maximizes the payload's usable volume within the confines of the mounting plate dimension as shown in Figure 2 and Figure 3.

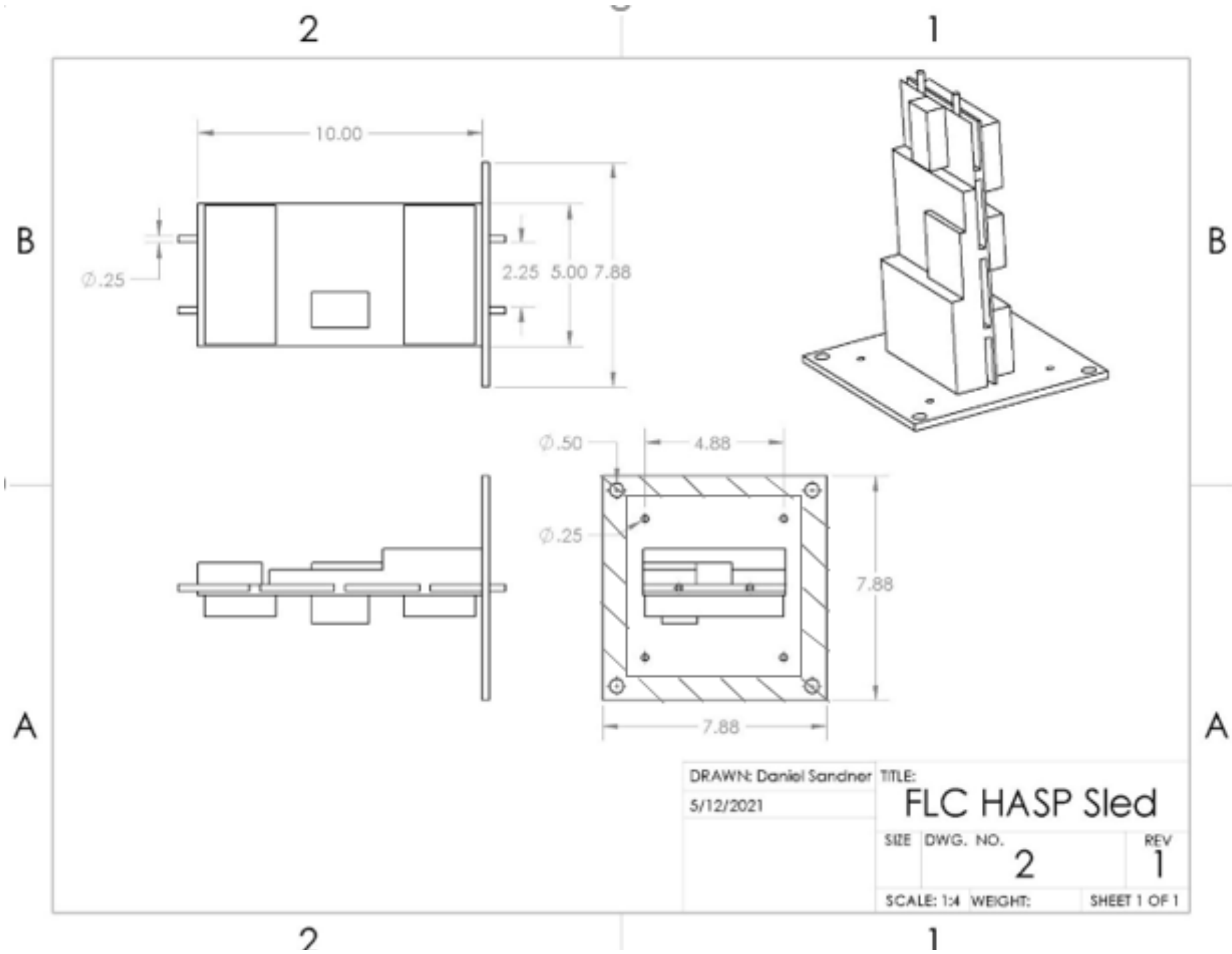


Figure 1: Preliminary CAD design of the HASP sled structure.

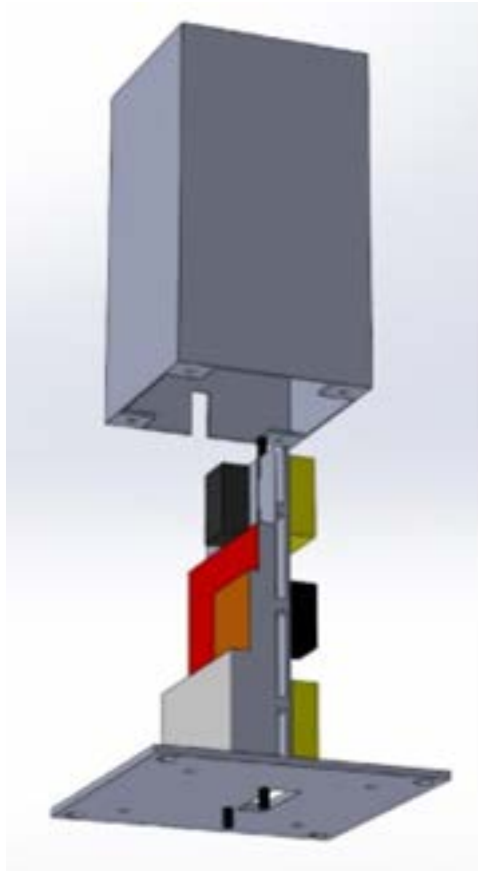


Figure 2: Preliminary CAD design of the HASP sled structure and case.

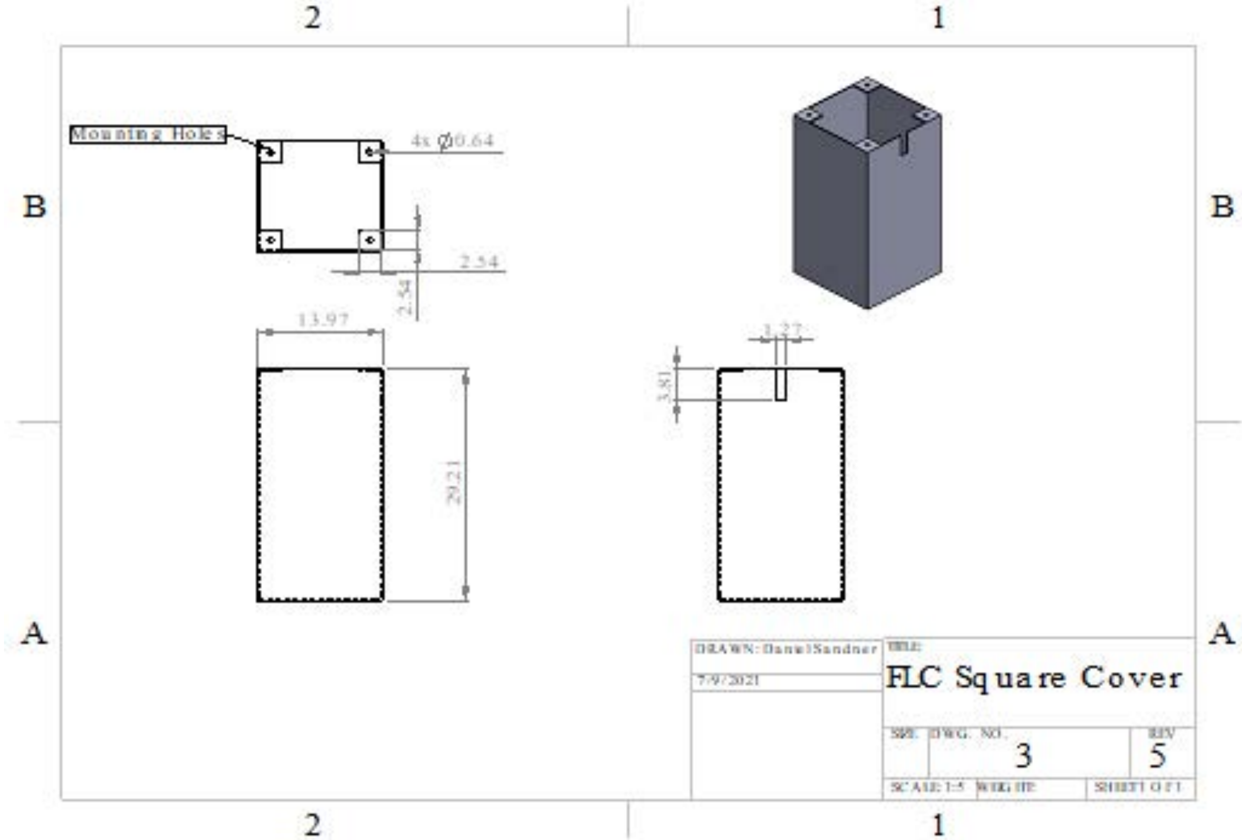


Figure 3: Preliminary CAD design of the HASP casing.

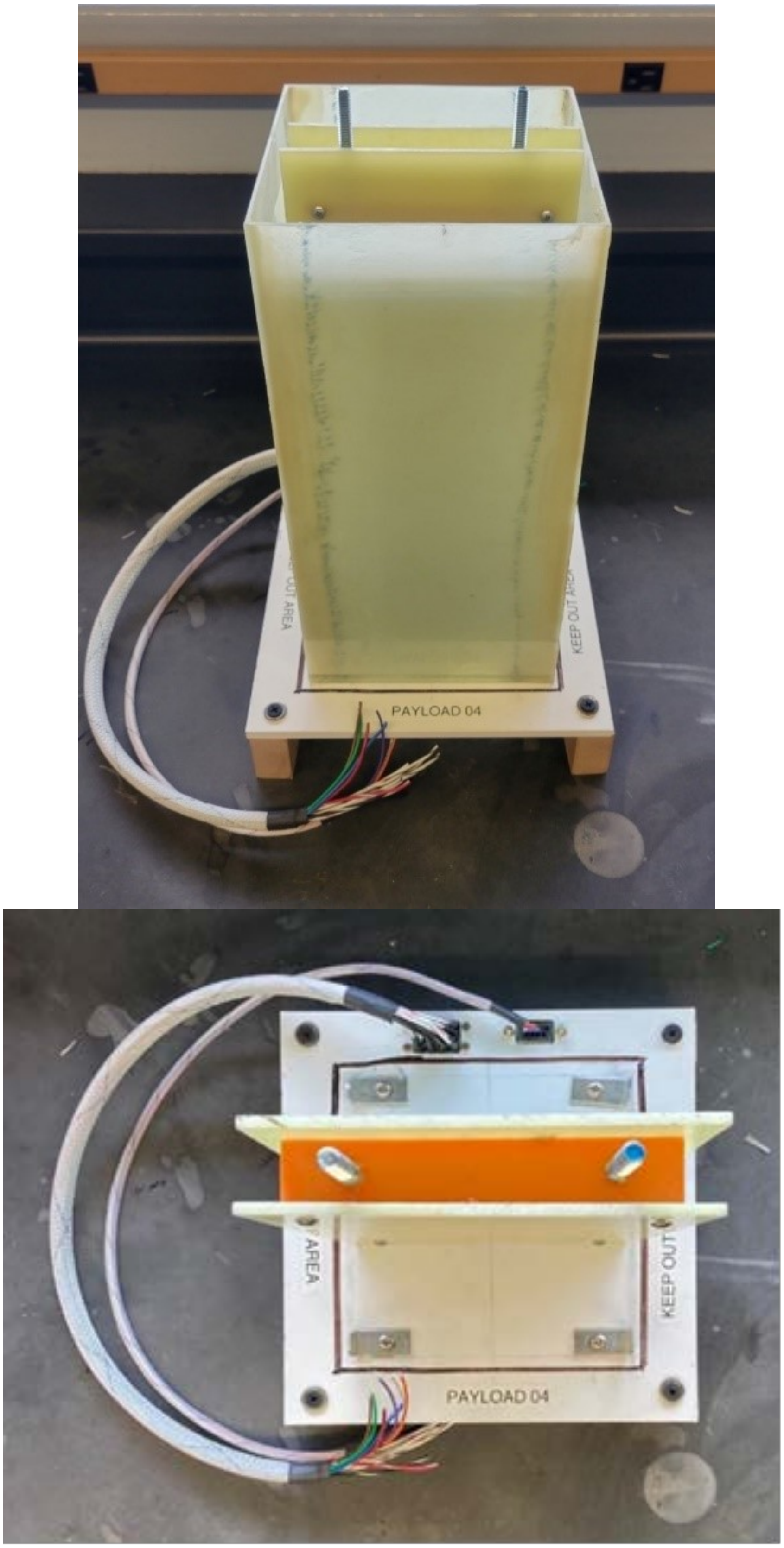
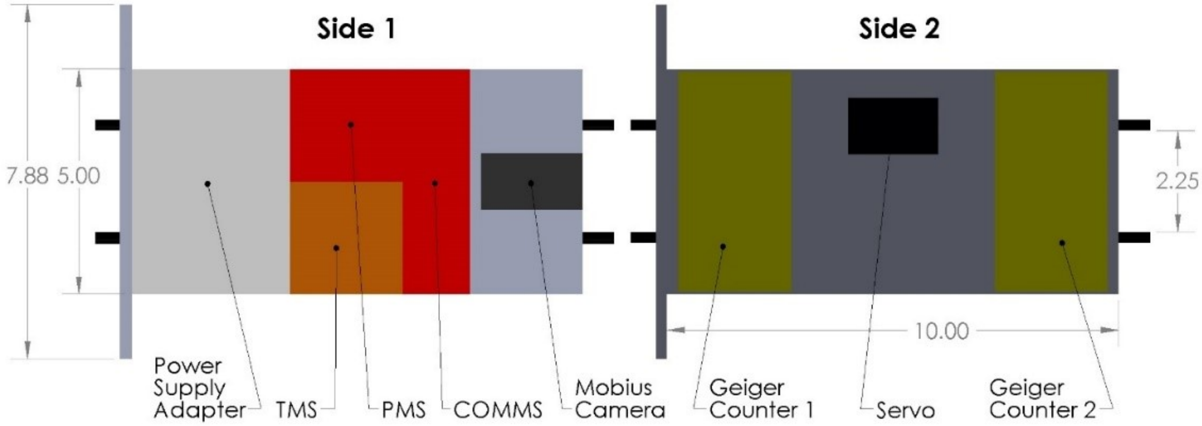


Figure 3: Previous outer case and sled showing spacing.

The electrical components are attached to both sides of the payload sled seen in Figure 3. The sled and case are designed to be slightly smaller than the maximum specified volume of 6x6x12 inches to accommodate any hardware that may protrude from the outer case. The internal layout stayed similar to the initial design. Side 1 of the sled holds the HASP systems while Side 2 holds the Geiger Counter system.

Both finished sides of the final HASP design are shown in Figure 4. The sled is shown to be mounted perpendicularly to the mounting plate with HASP systems on one side and Geiger systems on the other. Due to the square case, space is maximized, allowing for a push-rod door mechanism to open the Geiger counter enclosure. The final design is secure, strong, and easy to open for maintenance. All systems are adequately mounted and protected with this design.


Side 1
Side 2
7.88
5.00
2.25
10.00
Power Supply Adapter
TMS
PMS
COMMS
Mobius Camera
Geiger Counter 1
Servo
Geiger Counter 2

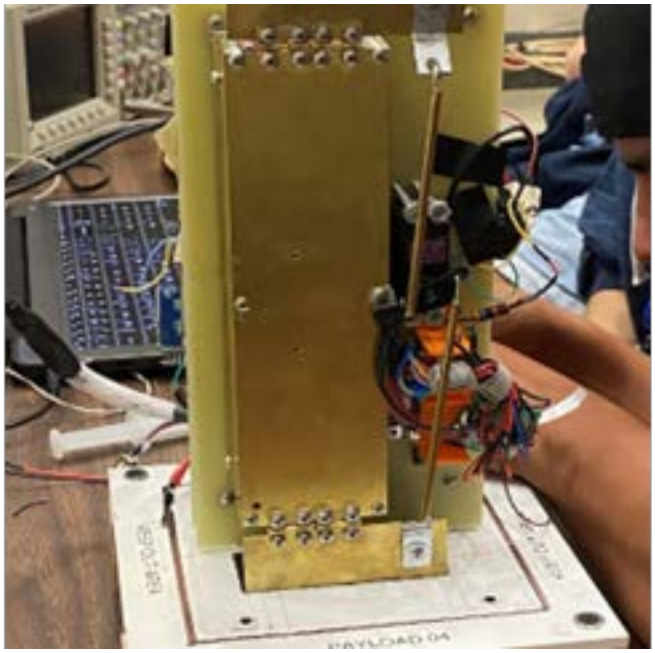


Figure 4: Proposed (above) and final sled designs (below).

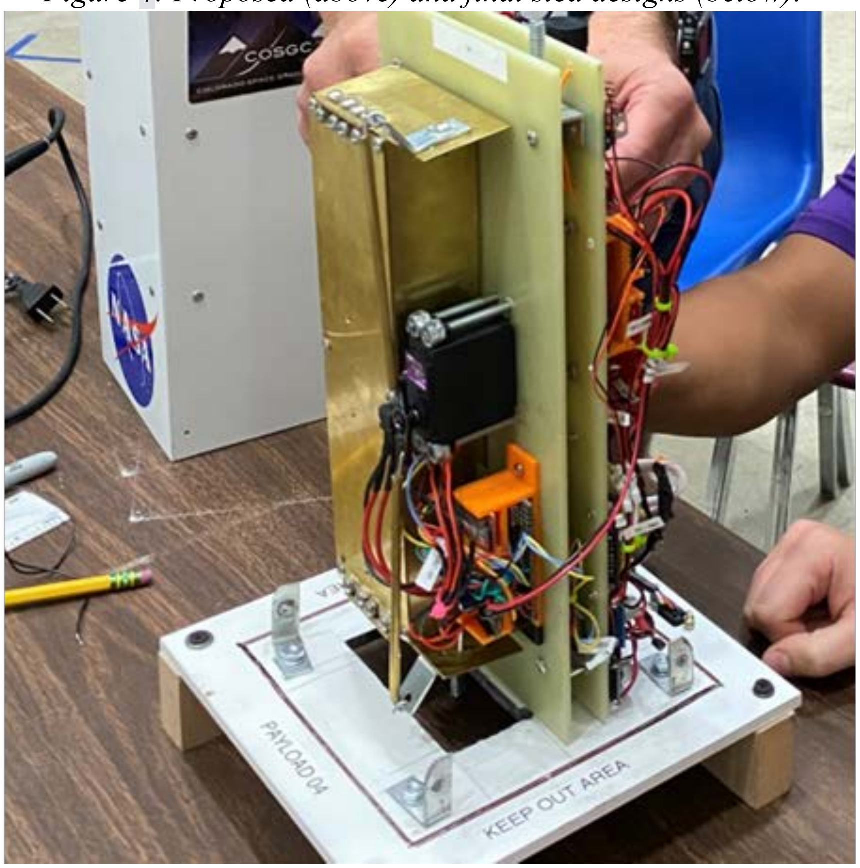


Figure 5: The previous 2021 HASP payload goes through final testing before integration.

The finished payload was painted in white, and some stickers were added to distinguish from other payloads.

1.5 Electrical Design

The HASP supplies a nominal 28 volts to each payload. Internal voltage level converters will provide between 3.7 V and 7.4 V to the various subsystems on the payload.

Power from HASP will go to the PMS system which sends power through LED indicators and then to INA169 DC current sensors for four of the subsystems. The current data from each subsystem is recorded from the Arduino Pro Mini to a micro-SD every second. Each current sensor range was calibrated by adding resistors, so that measurements could be taken in the appropriate current range.

Figure 6 displays the internal block diagram of the PMS. Power provided by HASP connects to an optical relay system. The optical relay system is controlled by an Arduino Pro Mini that allows the PMS to disable payload subsystems. All currents are measured by INA169 current sensors. The fuses are in line with the current sensors to disable the payload if they receive too much current. All data is saved to a microSD card. The system illustrated in Figure 6 is repeated six times for each of the six different current sensors.

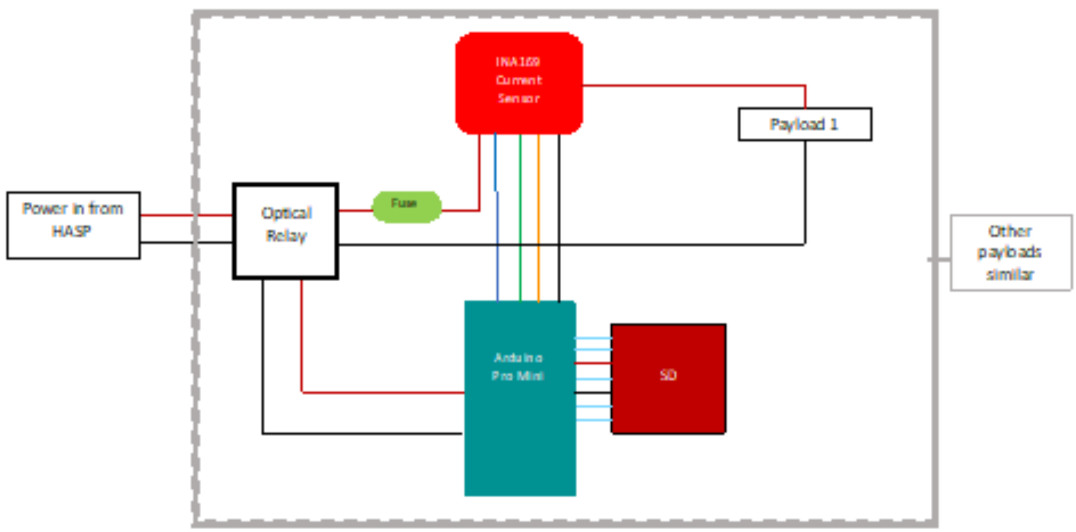


Figure 6: Internal block diagram of the PMS.

1.6 Thermal Control Plan

The temperature control system (TCS) monitors the temperature of each of the subsystems and if necessary will engage to heat those systems. The TCS PCB, Arduino, and SD card reader are all situated in a 3D printed housing where the PCB is on the bottom, while the Arduino and SD reader are on top. The TCS saves all temperature data to the SD card. Figure 7 shows a model of the temperature sensors used in the experiment.

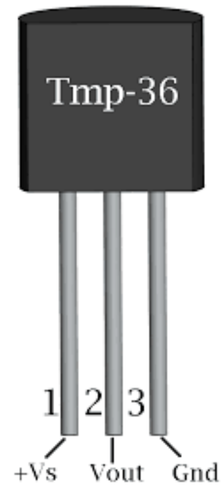


Figure 7: Temperature Sensors pin-out.

There are six temperature sensors placed in essential positions throughout the payload. The six sensor placement locations are as follows: the top and bottom of the payload (outside), the PMS, the COMMS Arduino, the camera's battery, and the servo for the brass doors. Figure 8 shows the TCS design.

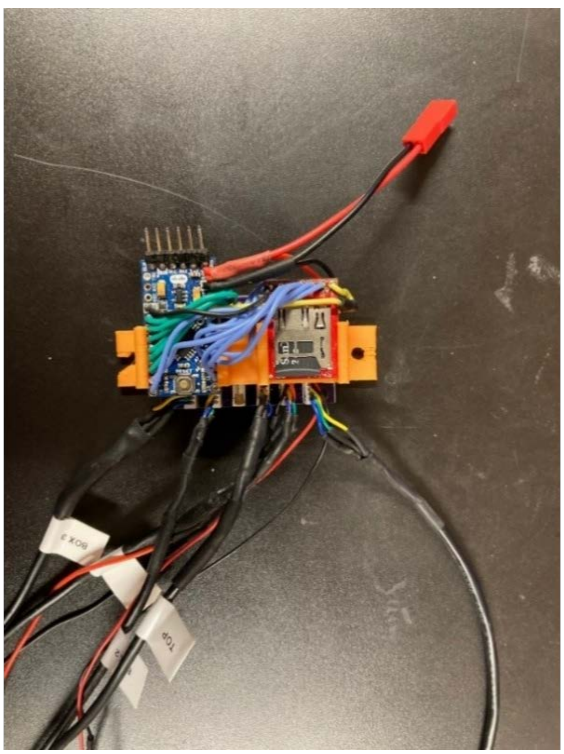


Figure 8: Temperature Control System (TCS) monitors and maintains all subsystem temperatures.

2. Team Structure and Management

2.1 Team Management

The Spacehawks team is comprised of undergraduate students from Fort Lewis College, with external support from previous graduates. All physical work on the payload will be performed by active students at Fort Lewis College. Most of the work will be done during the summer. The whole team will meet at least once per month during the school year, with weekly meetings happening for subsystem teams. Subsystem team leads will coordinate with the faculty supervisor and graduate assistant(s) to determine the progress and future direction of their subsystems. As new team members are recruited, they will be integrated into the teams which best suit them and become familiar with the roles and duties required of them. Flight-team managers will be responsible for communication between subsystem teams and overall system integration and testing. The Skyhawks IRSI team anticipates no more than six undergraduate students to participate in the design and experimental procedures, and depending on actual involvement, subsystem teams will be reorganized to maximize overall project development. Ideally, all members will attend testing at CSBF in Palestine.

The faculty advisor will devote a significant amount of time to assisting and mentoring the Skyhawk team as they develop the payload for the experiment. Depending on the initial progress of the experimental design, adjustments to team orientation will be determined and optimized. Project funding comes from the Colorado Space Grant Consortium and is distributed through NASA.

2.2 Team Organization and Roles

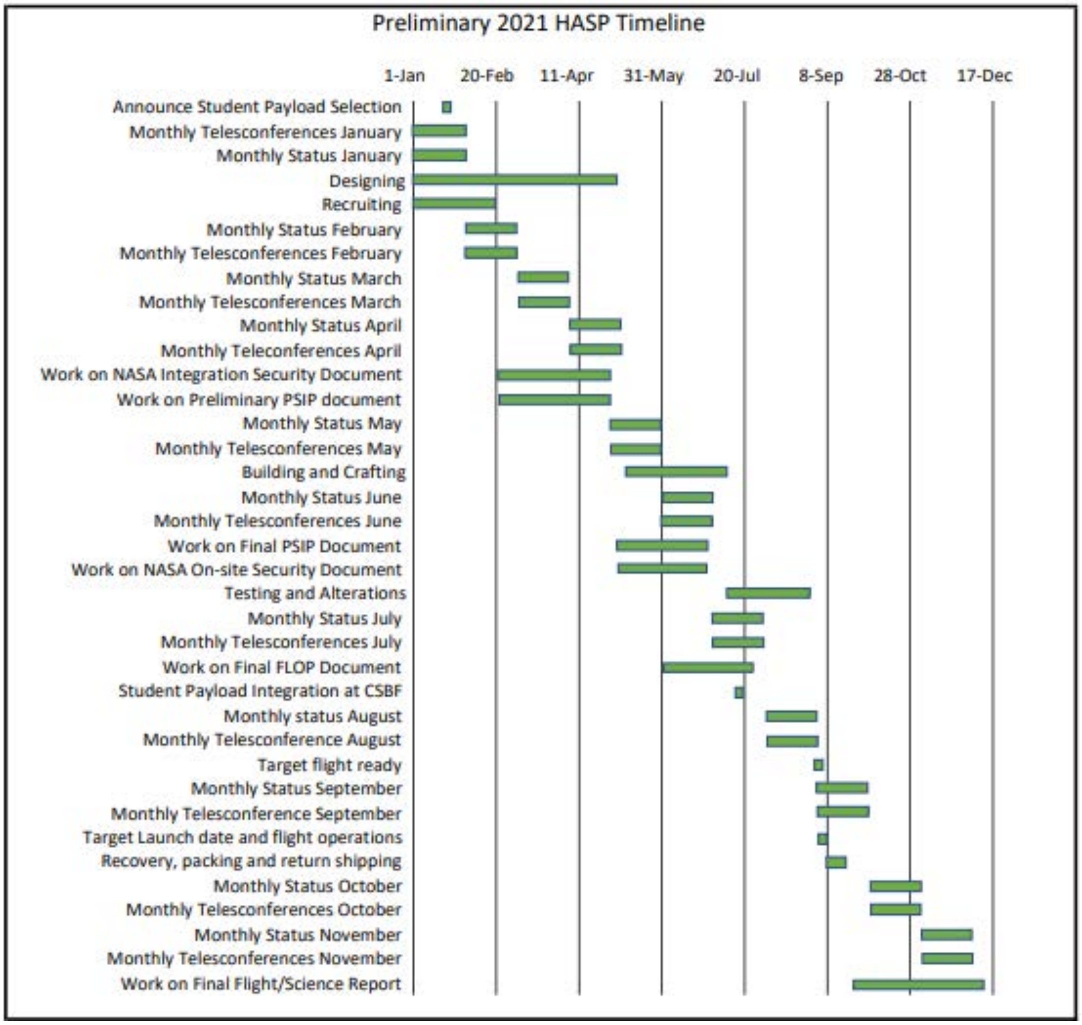
The Spacehawks team are a new group of students with a faculty advisor. The team plans to recruit more members and define roles by the end of February. Most of the work is expected to be done over the summer.

Table 1: Team members' affiliations and contact information.

Team	Roles/Responsibilities	Student Status	Contact Information
Sally Thompson	Team Member	Freshman Undergrad	sethompson@fortlewis.edu
Max Stieglitz	Team Member	Junior Undergrad	mistieglitz@fortlewis.edu
Zach Dunlop	Team Member	Freshman Undergrad	zjdunlop@fortlewis.edu
Brandon Engle	Team Assistant	Recent FLC Graduate	bengle@fortlewis.edu
Charles Hakes	Advisor Space Grant Affiliate	Faculty	hakes_c@fortlewis.edu 970-749-8889

2.3 Timeline and Milestones

The following Gantt Chart from 2021 shows the approximate schedule that can be followed in 2023.



2.4 Anticipated Participation in Integration and Launch operations

The Spacehawks plan to take part in the CSBF integration and the flight operations at Ft. Sumner. The team may be involved remotely if it coincides with the beginning of the fall semester in 2023. Ft. Sumner is only 6.5 hours away from the Spacehawks, so we will be able to join if any last-minute changes happen.

3. Payload Interface Specifications

3.1 Weight Budget

The weight of most of the systems come from the measurements of similar systems that flew on the 2021 HASP launch. The maximum weight for the small payload is 3kg and the size of the payload cannot exceed 15cm in width and 15cm in length.

Item	Mass (g)	Uncertainty (g)	Comments
Camera	65	5	From previous payload

Payload Sled	500	50	From previous payload
Internal Structure Pallet	40	5	From previous payload
Fiberglass Casing	1000	50	From previous payload
Geiger Counters	400	50	From previous payload
TOTAL	2005	160	

3.2 Power Budget

The maximum power supplied from the HASP is 28 volts at 0.5 amps, which equals 14 watts. The payload will use DC to DC converters to reduce the voltage and increase the current. A 0.5-amp fuse will be used to make sure the payload does not exceed the 0.5-amp limit.

Item	Voltage (V)	Current (A)	Power (W)	Comments
PMS, Comms, GPS	3.3	0.45	1.5	From previous payload
TMS	5.0	0.15	0.75	From previous payload
Mobius Camera	5.0	0.5	2.5	From previous payload
Geiger Counters	5.0	0.03	0.15	From previous payload
Total	18.3	1.13	4.9	

3.3 Downlink Serial Data

This year's team plans to expand the Communications system into separate subsystems, in order to make full use of the HASP communications capability. The preliminary plan is to continue using an Arduino microcontroller to coordinate uplink and downlink commanding. The Communications system will receive measured data from all other subsystems and process for downlink, additionally, it will interface with all other enabled subsystems to send uplinked commands. The 1200 baud rate and RS232 logic will remain the interface.

The proposed data interface will begin at the DB9 connector on the HASP platform. The data transmission lines will feed into an RS-232 to TTL converter, which allows an Arduino microprocessor to control the communications. These converted lines will then feed directly into the Arduino, which interfaces with each system in a separate I2C communications process.

All downlink data will be packetized. The maximum downlink rate will be 544 bps. Strings will be no more than 64 bytes in length. They will be transmitted on a two second cycle.

3.4 Uplink Serial Commanding

The team does not plan to uplink any data but will upload serial commands to control subsystems.

3.5 Analog Downlink

There is no analog downlink planned; all communication will be done through a serial connection.

3.6 Discrete Commanding

A command will be sent to the HASP team in hexadecimal format. This command will then be relayed to the payload through HASP. All demands will be communicated to the HASP team in Google Sheets. We will have a set of commands that perform programs such as: power reset, turn our payload off permanently, turn on the experiment, turn on the camera, and open/close shutter. These commands will allow us to command our payload from the ground to perform basic functions.

3.7 Payload Location and Orientation Request

There are no specific requests for location or orientation on the payload for HASP.

3.8 Special Requests

The payload will have high voltage components that will be inside a Faraday cage. A non-rechargeable battery will be used to maintain the correct time stamp on the camera.

4. Preliminary Drawings and Diagrams

The payload structural design will use two distinct parts, a sled, and an outer case. Both will be composed of G10 fiberglass and secured to the provided mounting plate via two ¼-20 threaded rods. The payload covers an area less that 6x6 inches and is 12 inches tall up to the top of the rods. The sled holds all electrical components perpendicular to the mounting plate, as seen in Figure 9, and consisted of two 10x5x1/8-inch-thick fiberglass sheets in which all the components are mounted. The colored boxes in below represent the mounted components. The threaded rods pass through two separate aluminum spacers, placed between the sheets of the sled. The sheets were screwed to the spacers and nuts were used at the top and bottom of the threaded rods to secure the sled in place. The outer case also held the sled vertically as the rods were permitted to protrude from the top.

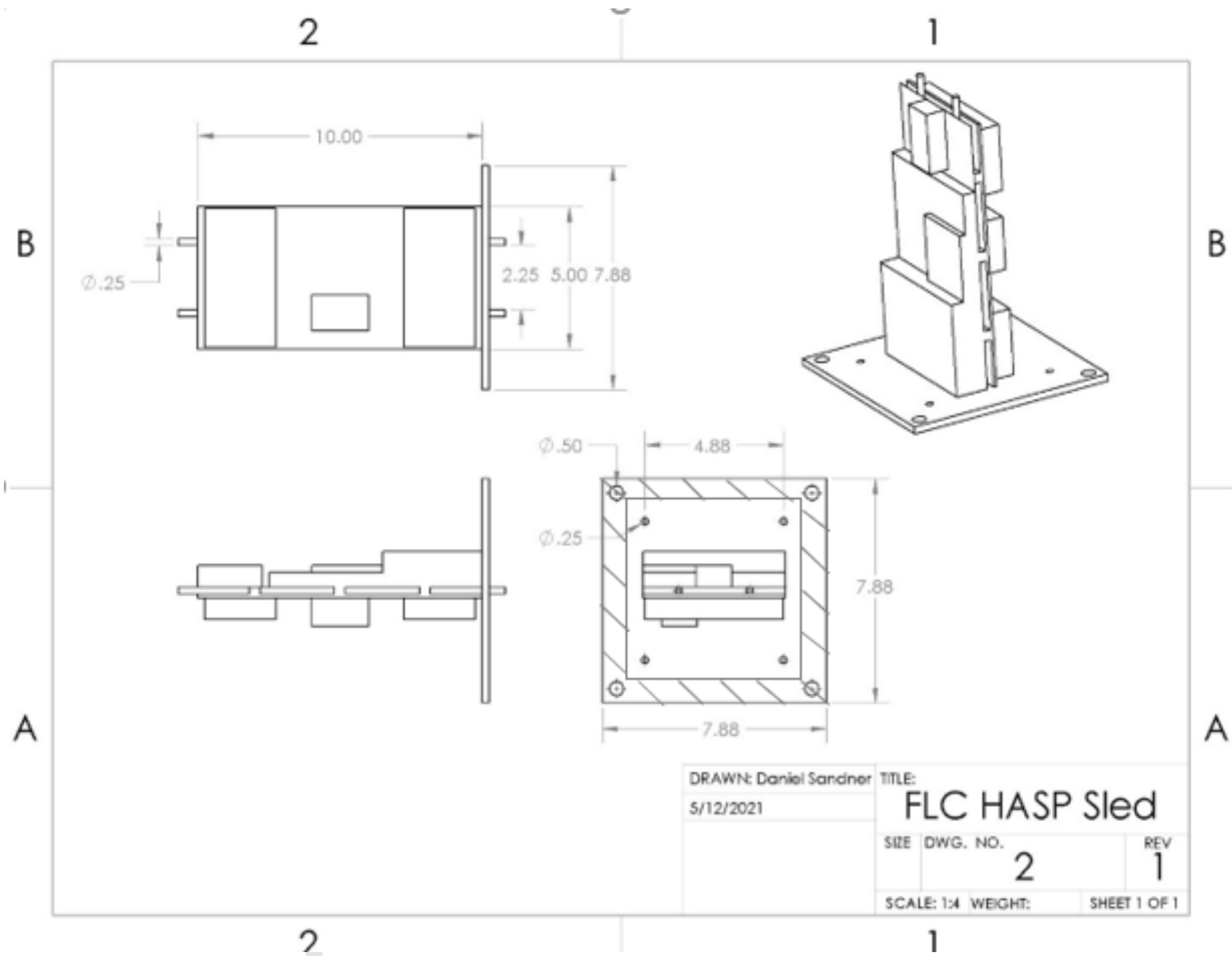


Figure 9: Preliminary CAD design of the HASP sled structure.

5. References

[1] "DOE Explains...Atmospheric Radiation," *Energy.gov*. [Online]. Available: https://www.energy.gov/science/doe-explainsatmospheric-radiation. [Accessed: 08-Jan-2021].

[2] J. Uin, A. C. Aiken, M. K. Dubey, C. Kuang, M. Pekour, C. Salwen, A. J. Sedlacek, G. Senum, S. Smith, J. Wang, T. B. Watson, and S. R. Springston, "Atmospheric Radiation Measurement (ARM) Aerosol Observing Systems (AOS) for Surface-Based In Situ Atmospheric Aerosol and Trace Gas Measurements," *AMETSOC*, 01-Dec-2019. [Online]. Available: https://journals.ametsoc.org/view/journals/atot/36/12/jtech-d-19-0077.1.xml. [Accessed: 08-Jan-2021].

[3] S. Forsythe, K. Leichman, R. Bleicher, J. Lambert, B. Soden, A. Edwards, and A. Henderson, "Energy: The Driver of Climate," *Climate Science Investigations South Florida - Energy: The Driver of Climate*. [Online]. Available: http://www.ces.fau.edu/nasa/module-2/how-greenhouse-effect-works.php. [Accessed: 08-Jan-2021].

[4] M. Johnson-Groh, "NASA Studies Cosmic Radiation to Protect High-Altitude Travelers," *NASA*, 25-Jan-2017. [Online]. Available: https://www.nasa.gov/feature/goddard/2017/nasa-studies-cosmic-radiation-to-protect-high-altitude-travelers. [Accessed: 08-Jan-2021].

Appendix A

Items that must be included in the Appendix section:

- Detailed electrical drawings not required in previous sections
- Detailed mechanical drawings not required in previous sections
- Detailed timeline and milestone WBS document

Items that may be included in the Appendix section:

- Additional images of existing components
- Preliminary PCB layouts

Appendix B: NASA Hazard Tables

Appendix B.1 Radio Frequency Transmitter Hazard Documentation

HASP 2023 RF System Documentation	
Manufacture Model	Altus Metrum
Part Number	TeleMega
Ground or Flight Transmitter	
Type of Emission	
Transmit Frequency (MHz)	433MHz
Receive Frequency (MHz)	N/A
Antenna Type	¼ wave wire
Gain (dBi)	
Peak Radiated Power (Watts)	
Average Radiated Power (Watts)	

Appendix B.2 High Voltage Hazard Documentation

HASP 2023 High Voltage System Documentation	
Manufacture Model	N/A
Part Number	N/A
Location of Voltage Source	On Geiger counter board
Fully Enclosed (Yes/No)	Yes
Is High Voltage source Potted?	No
Output Voltage	~500V
Power (W)	<1mW
Peak Current (A)	<1µA
Run Current (A)	0A

Appendix B.3 Laser Hazard Documentation

HASP 2023 Laser System Documentation (NOT IN USE)			
Manufacture Model			
Part Number			
Serial Number			
GDFC ECN Number			
Laser Medium			
Type of Laser			
Laser Class			
NOHD (Nominal Ocular Hazard Distance)			
Laser Wavelength			
Wave Type		*(Continuous Wave, Single Pulsed, Multiple Pulsed)*	
Interlocks		*(None, Fallible, Fail-Safe)*	
Beam Shape		*(Circular, Elliptical, Rectangular)*	
Beam Diameter (mm)		**Beam Divergence (mrad)**	
Diameter at Waist (mm)		**Aperture to Waist Divergence (cm)**	
Major Axis Dimension (mm)		**Major Divergence (mrad)**	
Minor Axis Dimension (mm)		**Minor Divergence (mrad)**	
Pulse Width (sec)		**PRF (Hz)**	
Energy (Joules)		**Average Power (W)**	
Gaussian Coupled (e-1, e-2)		*(e-1, e-2)*	
Single Mode Fiber Diameter			
Multi-Mode Fiber Numerical Aperture (NA)			
Flight Use or Ground Testing Use?			

Appendix B.4 Battery Hazard Documentation

HASP 2023 Battery Hazard Documentation	
Battery Manufacturer	
Battery Type	
Chemical Makeup	
Battery modifications	*(Must be NO)*
UL Certification for Li-Ion	
SDS from manufacturer	
Product information sheet from manufacturer	