HASP Student Payload Application for 2021

Payload Title: FLC RAT (Radiation vs Altitude and Time) Experiment

Institution: Fort Lewis College

Payload Class (Enter SMALL, or LARGE): SMALL	Submit Date:01/05/2021

Project Abstract: The Fort Lewis College HASP team will launch an ionizing radiation measuring experiment RAT (Radiation vs Altitude and Time) with updated systems from a 2015, 2019, and 2020 balloon flights. The primary experiment uses counter facing Geiger counters to record high intensity radiation vs the altitude, orientation, and time of day. The system will be controlled by an Arduino pro mini and recorded to a micro-SD and downlinked through the HASP system. A power management system PMS will monitor the power to each system using DC current sensors. A temperature management system will record the temperature of the different systems and turn on heaters as needed to remain in normal function. A communication system will be used to downlink the data from each system as well as back up the data to a SD card. A camera system will also be installed on payload to record the entire payload flight. The Spacehawks payload proposed could potentially prove be a cost-effective way of accurately measure high energy radiation present in the atmosphere vs altitude.

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Flight Hazard Certification Checklist

Hazardous Materials List		
Classification	**Included on Payload**	**Not Included on Payload**
RF transmitters	X	
High Voltage	X	
Pyrotechnics		X
Lasers		X
Intentionally Dropped Components		X
Liquid Chemicals		X
Cryogenic Materials		X
Radioactive Material		X
Pressure Vessels		X
Magnets		X
UV Light		X
Biological Samples		X
Li-ion Batteries	X	
High intensity light source		X

Student Team Leader Signature: ______________________________

Faculty Advisor Signature: ______________________________

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1. Payload Description

The primary goal of this experiment is to measure upper atmospheric ionizing Radiation vs. Altitude and Time (RAT). This is to account for the location of the sun above the horizon. This will be done with two counter facing Geiger counter and two solid state radiation detectors. The Geiger counters will have shutters that alternate between open and closed to differentiate between gamma and 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 only ionizing radiation detected. The payload will also be equipped with a camera, temperature management system (TMS), power management system (PMS), and communication system (comms). A secondary goal is to incorporate a GPS system and camera, because of limited response from the manufacturer on the current GPS system, return date and access to NASA GPS. The camera will record the flight from liftoff. A lithium battery was used in a previous HASP flight to keep the camera clock working until the payload received HASP power. The TMS will record the temperatures of distinct parts of the payload to be able to cross reference with the data from the other systems if any anomalies in the data occur. It will also be able to heat a certain system if necessary, to keep normal functionality. The GPS system will track the location of the payload. The comms system will back up the data from each system on a micro-SD card and how downlink and uplink capabilities. Each system will run using Arduino pro mini. The TMS, PMS, and Comms have flown previously on HASP and the Geiger-Muller tube detectors flew on a weather balloon flight as part of the Demosat Colorado Space Grant balloon launch.

1.1 Payload Scientific / Technical Background

The primary experiment on the payload will be high ionized radiation data collection vs altitude, and time of day. The Geiger counters measure high energy Beta and Gamma rays that hit the payload during flight. The Geiger counters will face in the opposite direction on two side of the payload. The data collected from the Geiger counters will be compared to the altitude to show how much high energy radiation hits the payload in each direction depending on altitude. A Geiger counter has a small tube know as a Geiger-Muller tube that allows ionized radiation to pass through it. The tube is filed with a mixture of argon and methane that is easily ionized. 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 considered high voltage therefore both will be inside a faraday cage on the payload. The intended voltage for the Geiger counters is approximately 500 volts.

The solid-state radiation detectors create a detectable signal from elections that are removed semi conductive as partials move through it [5]. Ionizing radiation hits a front electrode and goes through a silicon volume and hits the back electrode [5]. This gives the back electrode a negatively charged and the front electrode (possibly more than one front electrode) positively charged [5]. This is because a p-n junction occurs in the silicon when ionizing radiation passes through [6]. The current created is then amplified and is used to tell how much ionizing radiation is passing through at a sertain instant.

1.1.1 Mission Statement

The Spacehawks team will create a small payload at Fort Lewis College that will fly on the HASP platform. It will be capable of recording and monitoring ionized radiation. It will demonstrate cheap system that the records ionization 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 (DOE) Atmospheric Radiation Measurement (ARM) facility, monitor Earth's atmospheric radiation [1]. Using this data is crucial to understand how aerosols, certain gasses, and particles affect the amount of high energy 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 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. Recording the amount of high energy radiation is detected as a function of altitude is crucial in high altitude aircraft design to protect the passengers [4]. A NASA experiment similar to the one we are proposing is the 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 high energy radiation present in the atmosphere vs altitude and time. The secondary objectives are to create a TMS, PMS, Comms system, and camera system that as part of the payload that will record data with Arduino minis to SD cards. The TMS will record and monitoring the temperature at different parts of the payload and turn on heating elements when necessary. The PMS will monitor the power of each sub-system as compared to time. The secondary goal includes a camera that will record the payload's flight, and the addition of a TeleMega GPS to gather telemetry. The TeleMega GPS flew in the 2019 HASP and 2020 Demosat balloon launch but was unsuccessful with in receiving telemetry.

1.2 Payload Systems and Principle of Operation

There are four main systems in the payload are the TMS, PMS, Comms, and Geiger counter system. The secondary systems are the Camera and GPS system. The Geiger counter system will be on one side if the payload sled and the other system five systems will be on the other side as shown below in Figure 1.

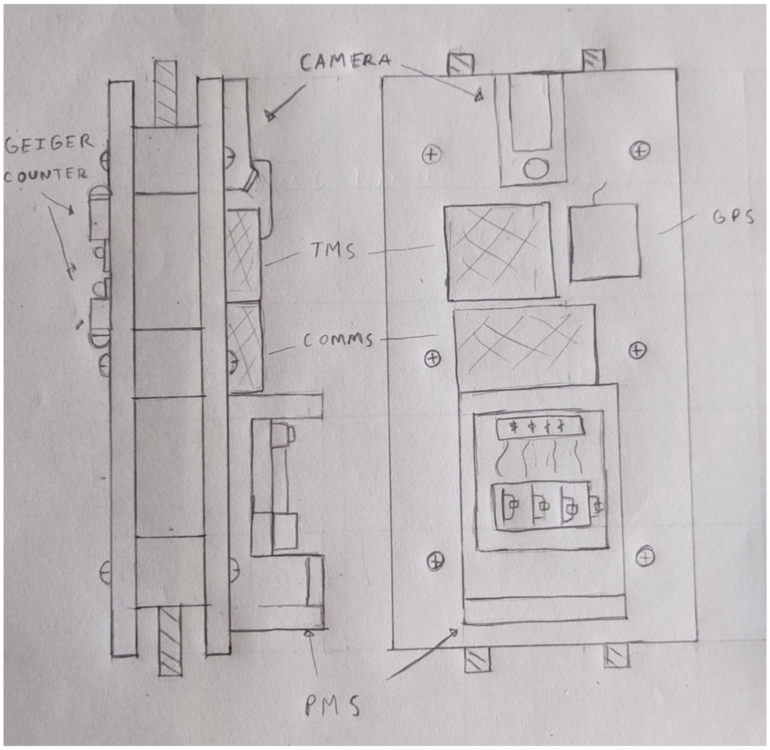

Figure 1: Primary Payload Sled Design

1.3 Major System Components

- Geiger Counter System
- Temperature Management System (TMS)
- Electrical System
    - Power Management System (PMS)
    - COMMS
- Camera System

1.4 Mechanical and Structural Design

The payload will be built on a 36 square inch area. The structural design will be built on 5 by 10-inch back-to-back plates contained inside an outer shell. There will be only one endcap which is similar to the one used in the 2019 Fort Lewis HASP payload , and a lid that will be removed to easily operate on the payload. This design will allow easy access to fix and work on the components without having to take systems apart. One side of the sled will host the Geiger counter while the other side will house the power monitoring, thermo, communications, and the camera.   We are building off the design from last year's team and making certain changes to improve the design.

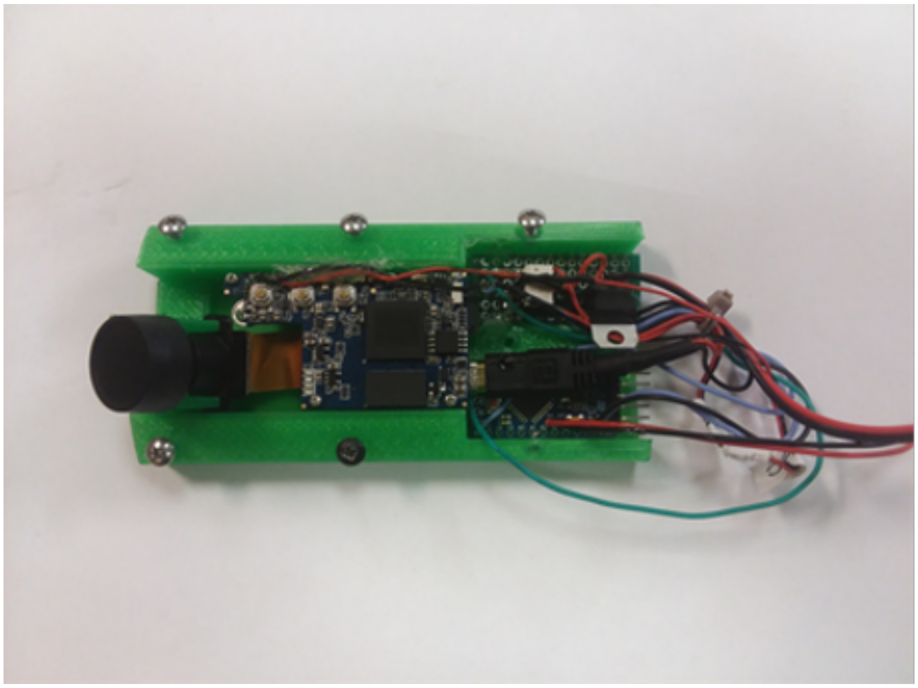

Figure 2: Mobius Camera System

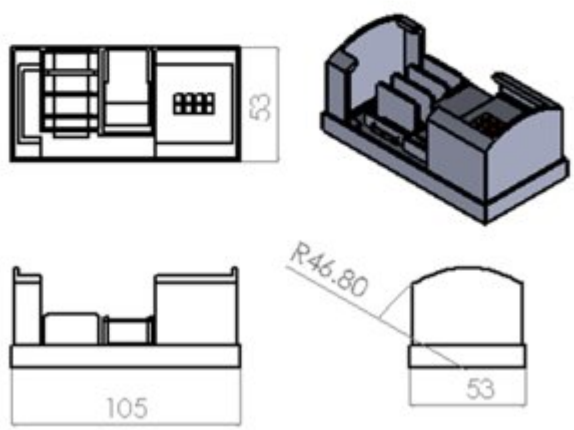

Figure 3: Last Year's PMS Housing Design

To collect radiation data two Geiger counters purchased from SparkFun™, seen in Figure 4, are being used. To detect incoming ionizing radiation the Geiger counters, use Geiger-Mùller tubes. These tubes contain an electrode in the center of the tube surrounded by gas at low pressure, this gas being an inert gas, usually argon or helium. A large electric potential is built up between the case of the counter and the middle electrode, so when an ionizing ray or particle enters the tube a spark happens, which then allows the Geiger counter to register the radiation as a count. In addition, two solid state radiation detectors will be included.

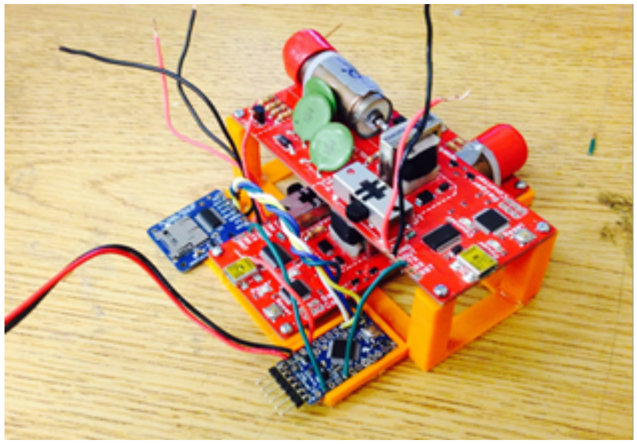

Figure 4: SparkFun Geiger Counters Used in Previous FLC Flights

1.5 Electrical Design

Figure 5 displays last year's design of the PMS housing. The curved surfaces were designed to fit into a specific sized cylinder. This year's team is planning on building the PMS housing on a flat plate which will change the rounded edges to be flat for a more simplified design.

Figure 5: PMS on Payload Sled

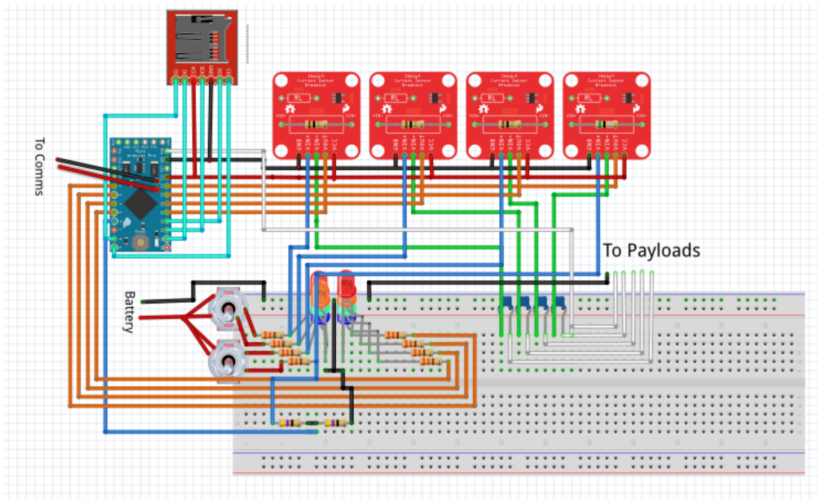

Figure 6: PMS Circuit Diagram

Figure 6 displays the power monitoring system (PMS). Power from HASP will go to the PMS system which sent power through LED indicators and then to INA169 dc current sensors for four of the payloads. The current data from each payload is recorded from the Arduino Pro Mini to a micro-SD every second. Each current sensor range was calibrated by adding resistors. The TMS current sensor, GPS current sensor, Peltier, PMS, and Comms current sensor had 1Ω resistor with a current sense range of 35mA – 350mA. The Mobius Camera had a 0.5Ω resistor to give a current sense range of 175mA - 1.75A.

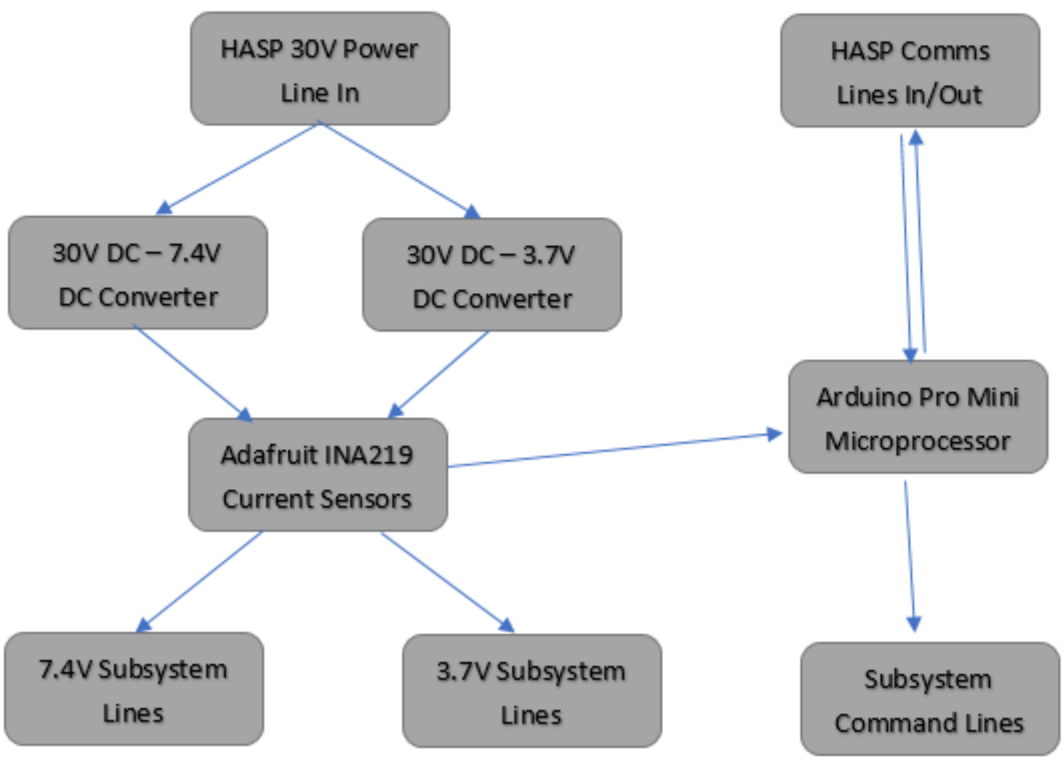

Figure 7: HASP Power Diagram

The HASP supplies a nominal 28 volts to each payload. Internal voltage level converters will provide between 7.4 V and 3.7 V to the various subsystems on the payload. It is expected that some internal batteries will be needed for shutting down running software efficiently and to keep the time stamp running before HASP power in provided. The power lines are then run through current sensors, which monitor the subsystems' power supplies and consumptions. These lines are then connected to optical diodes to control subsystem supplies independently, before finally being routed to their respective subsystems.

1.6 Thermal Control Plan

At high altitudes temperature drops drastically and this can have negative effects on both batteries and payload equipment. To negate these effects the heating system was designed to keep temperatures above -20℃ as well as log data from temperature sensors. Last year's team performed tests during the summer of 2020 which the results can be seen in Figure 8 and Figure 9. Figure 9 displays the temperatures of all the subsystems on the payload during the flight. There were minor glitches in temperature collection at the start of the flight caused by RF interference. RF interference was from the GPS transmitter.

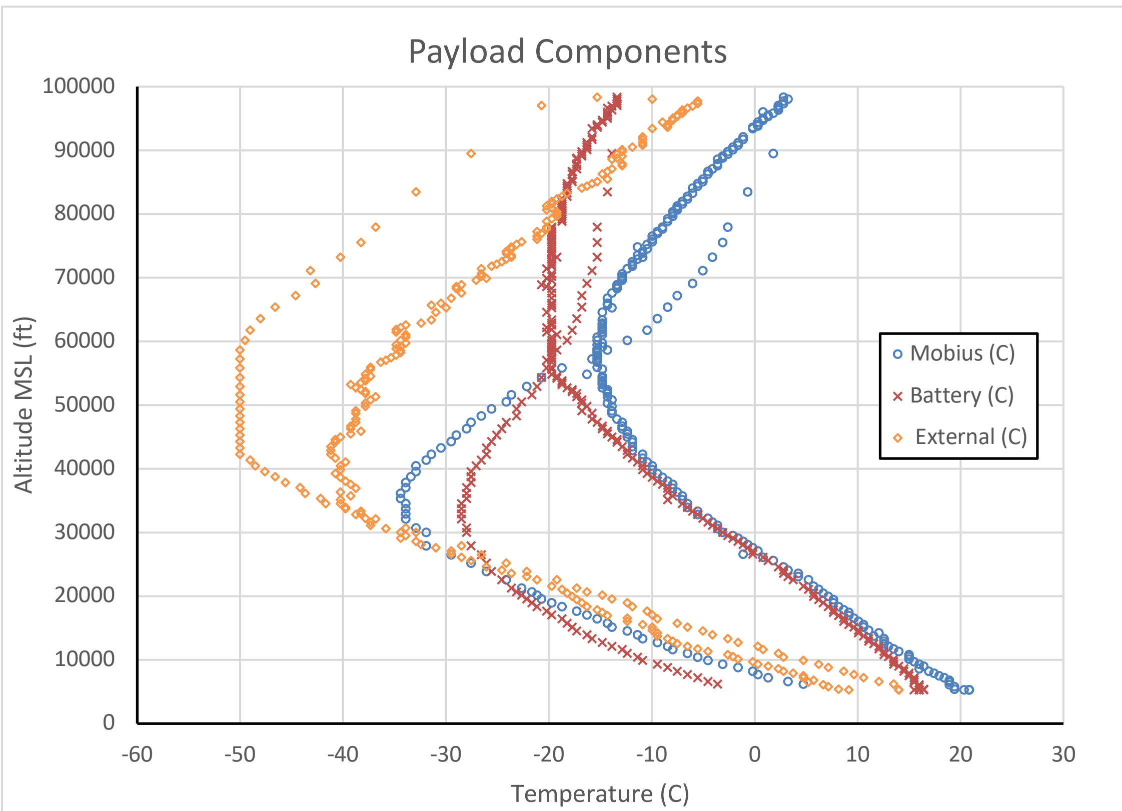

Figure 8: Summer 2020 Temperature Flight Test Results: Altitude vs. Temperature

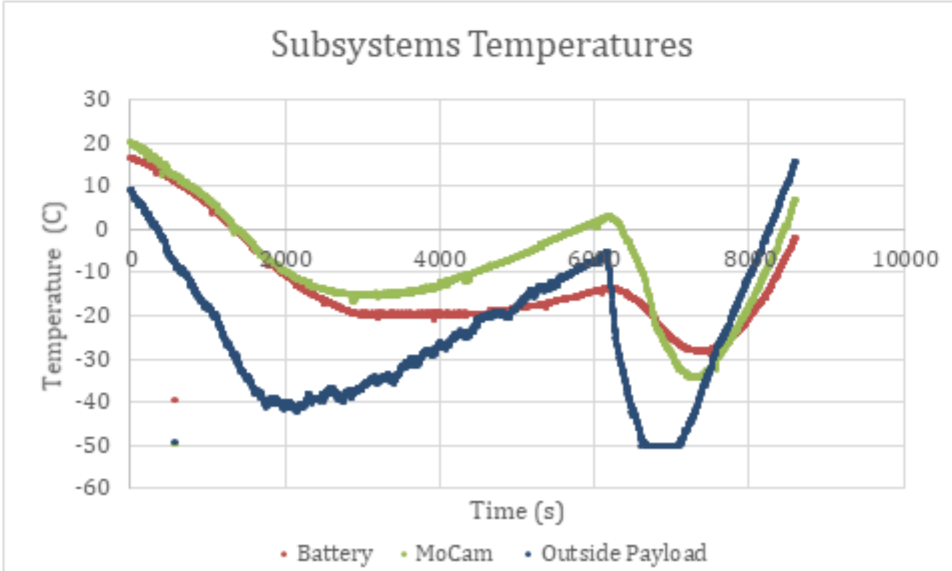

Figure 9: Summer 2020 Temperature Flight Test Results: Temperature vs. Time

We will be altering their design in order to make a more successful payload that can record accurate data with RF interference by altering software.

Figure 7 shows the block diagram for the previous TMS, powered by 7.4-volt batteries. The previous Arduino board, Arduino Pro Mini, read temperature sensors from all components and operated resistor heaters as needed when temperature dropped. The Arduino Pro Mini managed the path of the two voltages, 7.4 volt is the main power and applied to the heaters, 5-volt is applied to the sensors. All temperatures, heater statuses, and times were written to an internal SD card. Figure 10 shows the previous circuit schematic for one resistance heater and sensor. The same system was duplicated to heat as many subsystems as needed based on the platform.

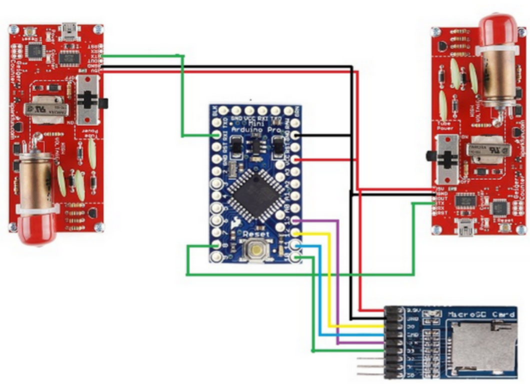

Figure 10: Wiring Diagram for Radiation Experiment

2015’s team performed two cold tests, each lasting an hour long, and found that the resistors drained the battery within 40 minutes. Our team will focus more on the use of too much current which we will control by turning off the heaters.

2. Team Structure and Management

2.1 Team Organization and Roles

The Spacehawks have one member who was involved in Colorado Space Grant Consortium Demosat 2020 balloon launch and two new members. The team plans to recruit more members 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
Nikolas Conmy	Team Leader Comms, Camera, and Geiger	Junior Undergrad	ngconmy@fortlewis.edu 808-856-6646
Jessie Urban	Team Member Power Management Systems and Geiger	Sophomore Undergrad	jpurban@fortlewis.edu 505- 331-3383
Hannah Carlson	Team Member Thermal System and Geiger	Sophomore Undergrad	hgcarlson@fortlewis.edu 719-964-6414
Charles Hakes	Advisor Space Grant Affiliate	Faculty	hakes_c@fortlewis.edu 970-749-8889

2.2 Timeline and Milestones

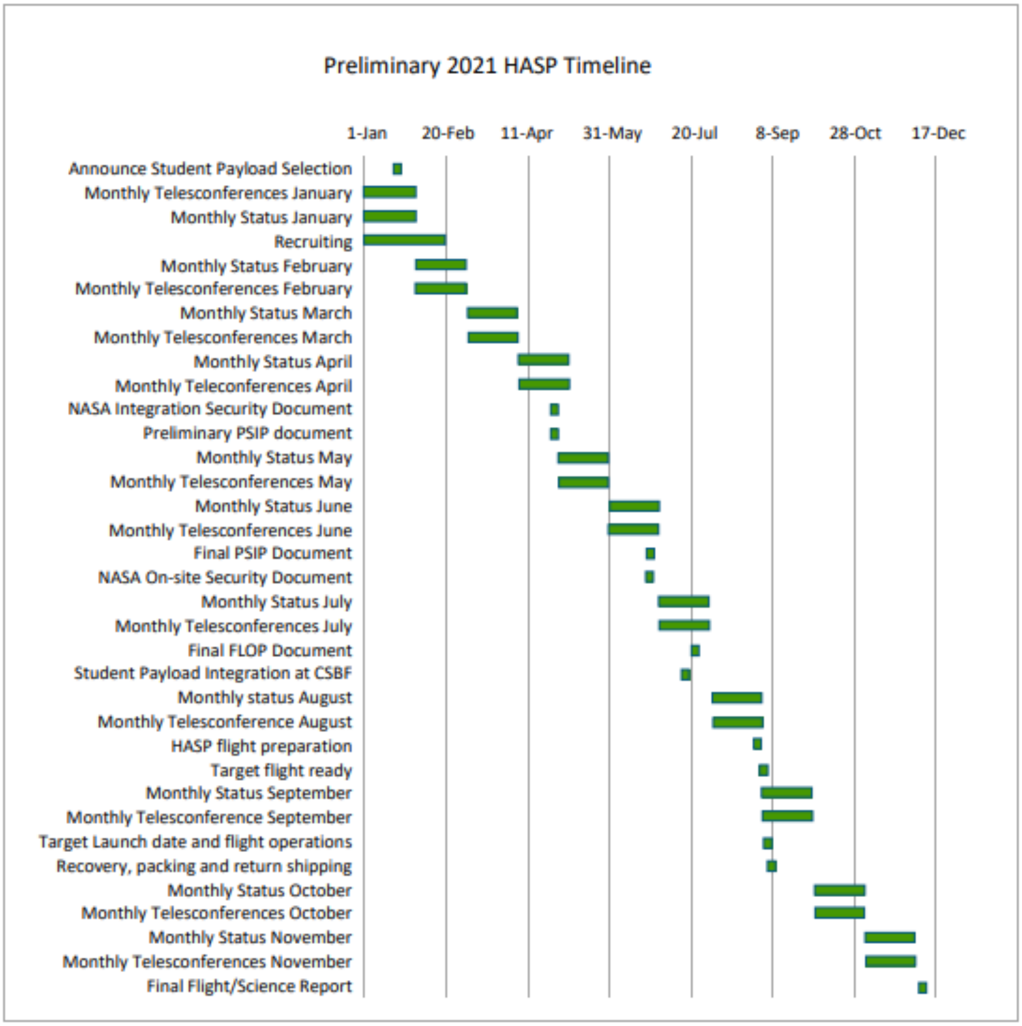

Figure 10: A Gantt chart for the HASP schedule for 2021.

2.3 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 2021. 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

Table 2: Weight of the subsystems

Subsystem	Weight (g)
Mobius Camera	61.7
Payload sled	500
Internal Structure pallet	39.6

GPS*	23.8
Fiberglass case	1000
Geiger counters	200*2
Total	2025

The weight of most of the systems came from the measurements of similar systems that flew on the 2020 Demosat balloon launch. The maximum weight for the small payload is 3kg and the size of the payload cannot exceed 15cm in width and 30cm in length.

3.2 Power Budget

Table 3: Weight of the Power Systems

Component	Power (watt)
PMS, Comms, GPS	1.5
TMS	0.75
Mobius Camera	2.5
Geiger Counters	0.15
total	4.9

The maximum power supplied from the HASP is 28 volts 0.5 amps which equals 14 watts. The payload will use DC to DC converters to reduce the voltage and increase the current. This means that before this system a 0.5-amp fuse will be used to make sure the payload does not exceed the 0.5-amp limit.

3.3 Downlink Serial Data and Uplink Serial Commanding

This year's team plans to expand the Communications system into a separate subsystem, 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. 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.

3.7 Payload Location and Orientation Request

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

3.8 Special Requests

The payload will have high voltage components that will be inside a faraday cage. In Fort Lewis Collage's previous HASP payload, a small lithium battery was used for shutting down software efficiencies and we are looking into possible using one again. If the GPS Fort Lewis college owns returns in time from the manufacturer, it will be an RF transmitter.

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].

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