HASP Student Payload Application for 2021

Payload Title: NOVA		
Institution: College of the Canyons		
Payload Class (Enter SMALL, or LARGE): SMALL		Submit Date: 1/8/2020

Project Abstract:

Utilizing our HASP 2017 mechanical design, The College of the Canyons Aerospace and Sciences Team plans to build a compact scintillator that will detect antimatter collisions in the stratosphere. By detecting gamma ray and neutrino activity, the primary products of antimatter collisions, we expect to estimate the amount of antimatter collisions in the upper stratosphere where HASP will be flying. By collecting data on the frequency of antimatter collisions, we can better estimate the natural occurrence of antimatter particles in the upper stratosphere and in turn increase our understanding of the composition and origin of the universe. By using a plastic scintillator, we can test the effectiveness and longevity of this class of radiation detector during prolonged exposure to UV and cosmic radiation. Additionally, we are building upon our 2017 HASP EPC design to house and protect the plastic scintillator, improving on the structural design and materials used. Using an altimeter, we will expose the BC-412 scintillator to the atmosphere at an altitude of 100,000 feet, using a photomultiplier tube to count scintillations.

Team Name: College of the Canyons Aerospace and Sciences Team		Team or Project Website: https://teresaciardi.wixsite.com/cocast
Student Leader Contact Information:		Faculty Advisor Contact Information:
Name:	Sean Tomer	Teresa Ciardi
Department:	Computer Science	Earth, Space, & Sciences
Mailing Address:	26455 Rockwell Canyon Road	26455 Rockwell Canyon Road
City, State, Zip code:	Santa Clarita, CA 91355	Santa Clarita, CA 91355
e-mail:	smtomer@icloud.com	Teresa.Ciardi@canyons.edu
Telephone:	(661)-600-7204	(661)-313-6015

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 (grey filled items on table below) 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**
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: *Sean Tomer*______________________________

Faculty Advisor Signature: *Teresa Ciardi*____________________________________

HASP 2021: Team NOVA

College of the Canyons Aerospace and Sciences Team

January 2021

Contents

1 Payload Description

1.1 Payload Scientific / Technical Background

1.1.1 Mission Statement

The College of the Canyons Aerospace and Sciences Team plans to build a compact scintillator that will detect antimatter collisions in the stratosphere. By detecting gamma ray and neutrino activity, the primary products of antimatter collisions, we expect to estimate the amount of antimatter collisions in the upper stratosphere where HASP will be flying. By collecting data on the frequency of antimatter collisions, we can better estimate the natural occurrence of antimatter particles in the upper stratosphere and in turn increase our understanding of the composition and origin of the universe.

1.1.2 Mission Background and Justification

Upon the creation of antimatter particles, a particle and its antimatter particle annihilate when they meet, disappearing and their kinetic plus rest-mass energy is converted into other particles (E = mc2). For example, when an electron and a positron annihilate at rest, two gamma rays, each with energy 511 keV, are produced. These gamma rays go off in opposite directions because both energy and momentum must be conserved . [LBL]

Today, antimatter is primarily found in cosmic rays – extraterrestrial high-energy particles that form new particles as they zip into the Earth's atmosphere. Utilizing our spot on NASA HASP, we can use a detector to find those cosmic rays as they enter the stratosphere. [Hig]

In 2011, the European satellite PAMELA—short for Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics— found a self-renewing supply of antiprotons in the Van Allen radiation belt. This belt is actually two donut-shaped rings of charged particles surrounding our planet, with an inner belt nestled under an outer belt. [Tha] Sensors aboard PAMELA found evidence of 28 antiprotons orbiting Earth, our payload looking to confirm those findings.

We intend to use a BC-412 plastic scintillator on our payload. When a BC-412 scintillation crystal is hit with gamma and cosmic rays it scintillates, converting the radiation into visible light. By converting the gamma radiation into visible light, we can now count the number of cosmic rays produced in the upper stratosphere. By counting the number of scintillations, we can count the number of cosmic rays hit

by the detector in our direction, which is proportional to the number of antimatter particles present in that region of the stratosphere. [Sai]

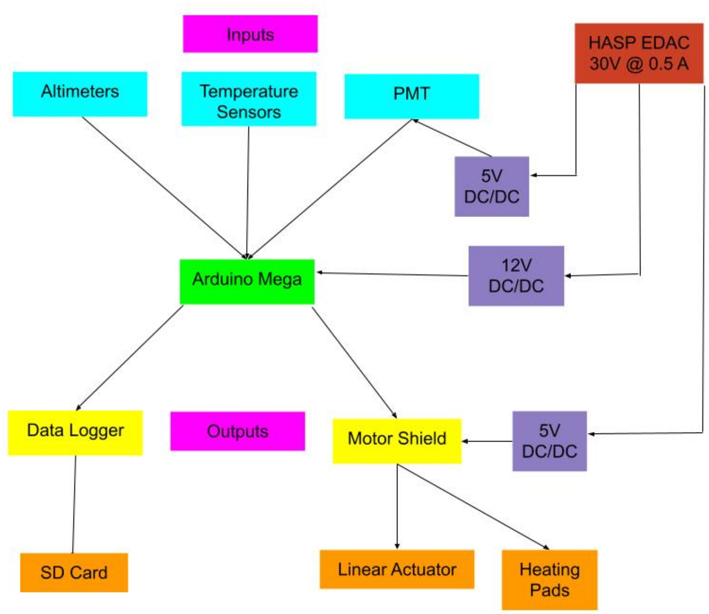
1.1.3 Mission Objectives

Our three mission objectives are to

1. Test the effectiveness of plastic scintillators in the upper stratosphere
2. Improve the design of our 2017 EPC such that we prioritize limiting light input when closed
3. Count the number of antimatter collisons in the upper stratosphere

By using a plastic scintillator, we can test the effectiveness and longevity of this class of radiation detector during prolonged exposure to UV and cosmic radiation. Additionally, we are using our 2017 HASP EPC design to house and protect the plastic scintillator, improving on the structural design and materials used.

1.2 Payload Systems and Principle of Operation



The detector itself has two main components, the PMT and the BC-412 Plastic Scintillator. Using an altimeter, we will exposed the BC-412 scintillator to the atmosphere at an altitude of 100,000 feet, 20,000 feet below the maximum altitude. The crystal will then be exposed for 20 minute increments, scintillating as it is hit with gamma rays coming from anti-matter collisions. The PMT will then count the number of scintillations and send that signal to the Arduino Mega which will log the number of scintillations during that given period.

We plan to take measurements in 20 minute increments to ensure that the BC-412 scintillator does not get damaged by long-term exposure to ultraviolet light. On the top of the clam-shell that will be covering the scintillator will be a fabric microfiber cloth that will take any dust off of the plastic scintillator, ensuring that the scintillator can come in contact with as many gamma-rays as there are present.

A gamma ray interacting with a scintillator produces a pulse of light that is converted to an electric pulse by a PMT. The PMT consists of a photocathode, a focusing electrode, and 10 or more dynodes that multiply the number of electrons striking at each dynode. These electic pulses are then sent to our Arduino Mega and counted as individual anti-matter collisions.

1.3 Major System Components

1.3.1 Radiation Detector

Figure 1: BC-412 Plastic Scintillator

BC-412 Scintillator

Our scintillation of choice is a BC-412 Plastic Scintillation crystal. It has a high luminescence efficiency and level of optical output. It will withstand high ultraviolet radiation and has the longest attenuation length. It is able to absorb 100keV to 5MeV gamma rays as well

as fast neutrons and charged particles. Its durability and option to attach to the PMT will prove to be very efficient.

Unlike other scintillators, BC-412 does not degrade when exposed to long periods of UV radiation, making it a better option than Sodium Iodide and Bismuth Germinate. The PMT that counts these scintillations and sends the signal to the arduino mega is further explained section 1.5.3.

1.3.2 Clam-Shell Enclosure

The plastic scintillator enclosure (PSE) houses the main science instrument of the payload and must be designed to withstand the extreme environmental conditions of launch, flight, and landing. Despite being such an important element, the mechanical design of the enclosure is relatively simple. The criteria for the materials used in the PSE is fairly high: they must be able to withstand a temperature range of -60°C to 70°C without shrinking or warping and be a strong insulator against high voltages. While metals are able to withstand low temperatures like the ones described, they are great conductors for electricity. The PSE will be constructed using the base polycarbonate Serpac RB33 electronics enclosure. The RB33 provides mounting points for the PSE instrument, but still needs to be modified a great deal to serve as the PSE. Holes that are drilled for screws to mount onto the actuator assembly need to include silicone sealing washers so that contaminants do not seep through the threading. The PSE instrument gets mounted into the enclosure with 4 nylon standoffs on the corner of the assembly. Since the entire enclosure is then relatively airtight, a hole on one of the sides is drilled and covered with a 2.5-micron nanofilter to allow air pressure to equalize but stop dust from coming in.

1.3.3 Actuator Assembly

The actuator assembly responsible for the opening and closing of the PSE is arguably the most important mechanical component on this payload. The proper operation of this system determines the success of the mission. The entirety of this assembly will be machined out of aluminum 6061 with dimensional tolerances accounting for the temperatures expected during flight. The system operates by compressing and extending an actuator to pivot a lift-arm mounted to a hinge using a clevis to open and close the PSE. The linear actuator chosen for this task is the lightweight and strong Firgelli L-16 actuator with 12V operating voltage and a 1:210 steel gear ratio able to deliver 15-20 newtons of extension force. The L-16 version used for flight will include a built-in potentiometer for positional feedback and a wide array of functional applications such as stall detection and an adjustable opening angle. For use in the harsh environment expected during flight, the active thermal control system (Section 1.6) will use heaters to keep its operating temperature above -10°C. This system proved effective during the HASP 2017 flight to manage the motor temperature and prevent failure. To ensure proper sealing of the PSE upon closing, there must be a strong force applied evenly across the O-ring that maintains the seal to prevent contamination. A CNC-milled aluminum force-distributer plate is mounted by 4 screws to the PSE to create an even distribution of force on the O-ring when the actuator is extended. To provide extra force needed to ensure a good seal, a spring-mechanism is added to the base of the actuator to provide the additional force.

1.4 Mechanical and Structural Design

A serious consideration for the HASP 2021 payload is the easy accessibility of flight components during fabrication and debugging and the seamless operation of dynamic mechanical systems.

1.4.1 Frame

An aluminum internal frame will be used to support the payload instrumentation. The frame is composed of 4 aluminum struts on 4 corners of the payload that join two aluminum base plates. This allows the plates to be fully supported by the support struts without needing to be held up by the side panels as in the previous design. This will allow free accessibility to the internals of the payload without the constraint of having panels blocking the work space. With this design, electronic wire management and repair can be performed effectively and valuable time can be saved. In addition to the ease of access, the frame provides the rigid strength needed to overcome the +/-5g horizontal shocks in the XY-directions and +/-10g shocks in the Z-direction, as required by HASP payload criteria.

1.4.2 Internal Design Layout

We will incorporate the EPC lift arm system from the previous 2017 HASP payload (Solaris) into our 2021 build. The lift arm mechanism will stay on the opposite side panel of the electronics. The PMT and scintillation crystal will be housed in a larger compartment on the top panel of the payload. The Arduino and Adafruit data logger will be placed in the electronics mounting plate on the side panel. The Arduino accelerometer will be placed on the bottom side of the payload.

1.4.3 Materials

The Mylar sheet, a highly reflective polyester film, will be wrapped along the frame of the payload. It is incredibly durable due to its high tensile strength, chemical stability, and electrical insulation. This material will reflect approx. 92-97 percent of bulbs' light.

1.5 Electrical Design

Our preliminary electrical schematics are shown in section 1.2. The diagram shows each electrical component along with where they draw power from.

1.5.1 Microcontoller

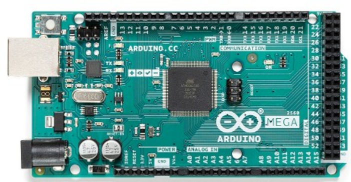


Figure 2: Ardunio Mega

The standard option is an Arduino Mega due to the string of successful flights that have utilized this board. The Flight computer's main task is to provide a primary hub for passive sensor data monitoring, sensor data processing, battery/relay control, logic checks, and controlling/staging various hardware. Additionally, the board provides power and communication to any required shield expansion boards needed for interfacing with sensors and data storage devices.

1.5.2 Data Logger

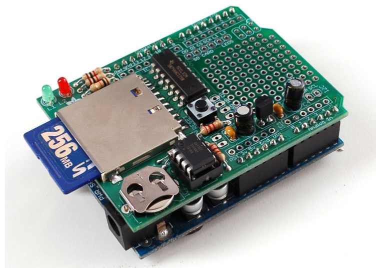


Figure 3: Adafruit Data Logger

The data logging protocol and design for this mission will be aimed towards storing data safely and reliably to preserve a record of every process during the flight. From lessons learned in the previous flight, data loggers can be delicate systems if operated without the use of correct fail-safe circuitry and software. Multiple data logging devices will be used to ensure that vital flight information is not lost if one data logger fails. The same Adafruit data logger used in the previous flight will be used in this flight with the addition of improved software and an SD card capable of protecting data from rapid shutdowns.

The Samsung PRO series 16GB SD card provides excellent protection from data corruption caused by rapid power shutdowns. Smarter programming for the shield will allow the serial data downlink to send down status reports on how much data has been logged to the SD card.

1.5.3 Photomultiplier Tube

Figure 4: Hamamatsu H10722-01

We plan on using the Hamamatsu H10722-01 photosensor module, which contains a metal package PMT, a low-power consumption high-voltage power supply circuit, and a low-noise amplifier. The amplifier converts the PMT current output to a voltage output so that the signal can be easily processed. Also, the amplifier is connected close to the PMT anode output pin in order to make the signal less affected by external noise.

By using this photosensor, we cut the need for an external amplifier that would convert the output from amperage to voltage, meaning we can directly connect the PMT to the arduino. Additionally, this PMT can be run using a simple 5V power supply, eliminating the need for a high voltage power converter.

1.5.4 Sensors

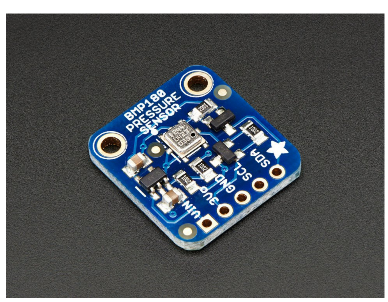


Figure 5: Altimeter

Altimeter

A set of digital altimeters (barometers/pressure sensors) will measure the altitude throughout the flight to determine the opening and closing of the scintillator enclosure. Two BMP180 barometric pressure/temperature sensors will be connected to the flight computer in order to give accurate altitude readings. The reason for using two sensors is to avoid discrepancy by taking both measurements and creating an average altitude for improved accuracy and additional backup in case on sensor fails.

However, since the pressure sensing range of the sensor is 50,110 kPa (up to 10 Km in altitude), a timing based system would have to take over based on the ascent rate of the balloon. the timer will begin when the altimeter senses a significant drop in air pressure (launch), to countdown to opening the scintillator enclosure at 100,000 ft. Once the pressure sensor detects a significant rise in air pressure (descent), the scintillator enclosure will immediately close.This simple system has worked in the past to successful results and total auto.

Figure 6: Thermistor

Thermal Sensors

We are using thermistors because they have the advantage over conventional analog and digital temperature sensors due to their simplicity and robustness over a wide range of temperatures. To handle noise from other payloads, HASP systems, and internal power converters, the analog signals will be transmitted through an unshielded twisted pair cable along designated harness paths that are routed around elements that emit EMI noise. We plan on having 10 total thermistors, 2 next to the PMT, 2 next to the linear actuator, 2 next to the arduino (part of the active thermal control system in section 1.6), 2 in the internal payload and 2 in the PSE to track the temperature of the atmosphere as we count scintillations. Similar to our

reasoning for using 2 altimeters, we are going to average the readings from each thermistor to get the most accurate reading per section.

1.5.5 Motor Controller

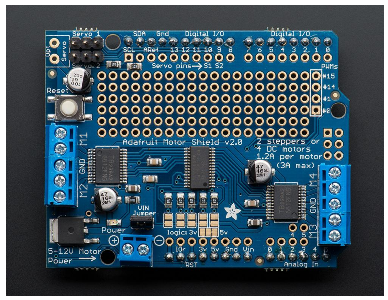


Figure 7: Adafruit Motor Shield V2

Control of all motor activity will be done through a motor control shield connected to the arduino flight computer. The chosen motor shield is the Adafruit motor shield V2, capable of controlling 2 Servo motors, 4 bi directional DC motors, and 2 stepper motors. The board features a fully dedicated PWM driver chip onboard with the ability to reliably control multiple motors at a time using only SDL and SCL serial pins.

Only one bi directional DC motor (linear actuator) will be used for scintillator enclosure closing and opening. The board will have a polarity protected 2 pin terminal block and jumper to connect external power, for separate logic/motor supplies. Therefore, 2 separate voltage supplies will be used one 12V for controlling the arduino flight controller, and one 5V for powering the motor connected to the motor shield. The motor shield will also power 2 electric heating pads from its DC motor terminal block connections.

1.5.6 Power Management

Figure 8: Recom Power Converter

The supplied 30V @0.5A will be internally converted into multiple different voltages by way of the power control PCB. The board will convert the given voltage into one 12V output and two 5V outputs through the use of 3 simple DC-DC converters. The 12V converter will be used for powering the flight controller, and the 5V converter will be used to power the motor shield, electric heaters, and PMT. The 5V converter to be used is the Recom Power R-78C5.0-1.0. This converter takes an input voltage of +8-42VDC and converts it to +5VDC at 93 percent efficiency. It outputs a maximum current of 1A and a maximum power output of 5W. The converter is temperature rated between -40°C and 85°C.The 12V converter to be used is the Recom Power R-78C12-1.0 . This converter takes an input voltage of +15-42DC and converts it to +12VDC at 96 percent efficiency. It outputs a maximum current of 1A and a maximum power output of 12W. The converter is temperature rated between -40°C and 85°C.

1.6 Thermal Control Plan

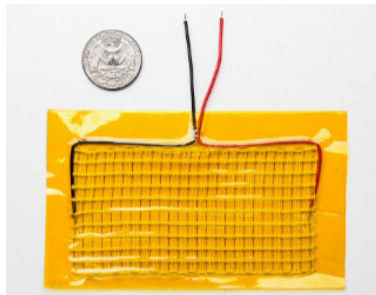


Figure 9: Heating Pad

We will use two means of thermal control, both active and passive, to assure it properly regulates its internal temperature through all stages of the flight. Multi-layer mylar will be used as a passive means to insulate the payload's interior walls. These sheets are comprised of 26 mylar layers sealed by reflective kapton tape. We have achieved nominal results with this particular composition and will be applied to the internal walls of the payload's side panels as well as the valve chamber of the intake manifold where temperature sensitive electronics are located.

In the active thermal control system, flexible heaters are used as a means to further regulate and control temperature around more sensitive components. The heaters can be modified to fit any configuration and fully envelope the exterior of the component, directing heat evenly over the entire surface. The electric heating pads contain a metal polymer fiber composite conductive yarn integrated into a fabric. This material is contained within a flexible Kapton (polyimide film) sheath to control even heat distribution and avoid direct contact to sensitive surfaces . The heating pad takes an input voltage and current of 5V @ 0.74A to attain a peak temperature of 40 degrees celsius across the entire surface area.

The heating pads will be connected in series and powered through the motor shield's DC motor terminal block connection (Section 2.3.3). This configuration will draw a maximum of 1.85 watts from the motor shield at a lower current of 0.37A to attain the same peak temperature of 40°C.Since the motor shield is able to handle 1.2A per channel and a 3A peak current, the 2 heating pads will be able to operate (even at maximum power consumption) without harming any of the electronics.

These heating pads will be placed in three strategic regions in the payload: around the motor within the motor housing, around the PMT, and around the insulated voltage converter enclosure. Two standard low power DS18B20 digital temperature sensors will be used to monitor the temperature inside the motor housing insulation and outside the high voltage enclosure . The sensors have a $\pm$0.5°C accuracy from -10°C to +85°C and a range of operation from -55 to 125°C. They will give live feedback directly to the main flight computer, which will in turn command the motor shield to activate or deactivate the heaters to keep the operating temperature at a minimum of 10°C. All temperature data logged throughout the entirety of the flight will be saved to data logging shield SD memory card (Section 1.3.2).

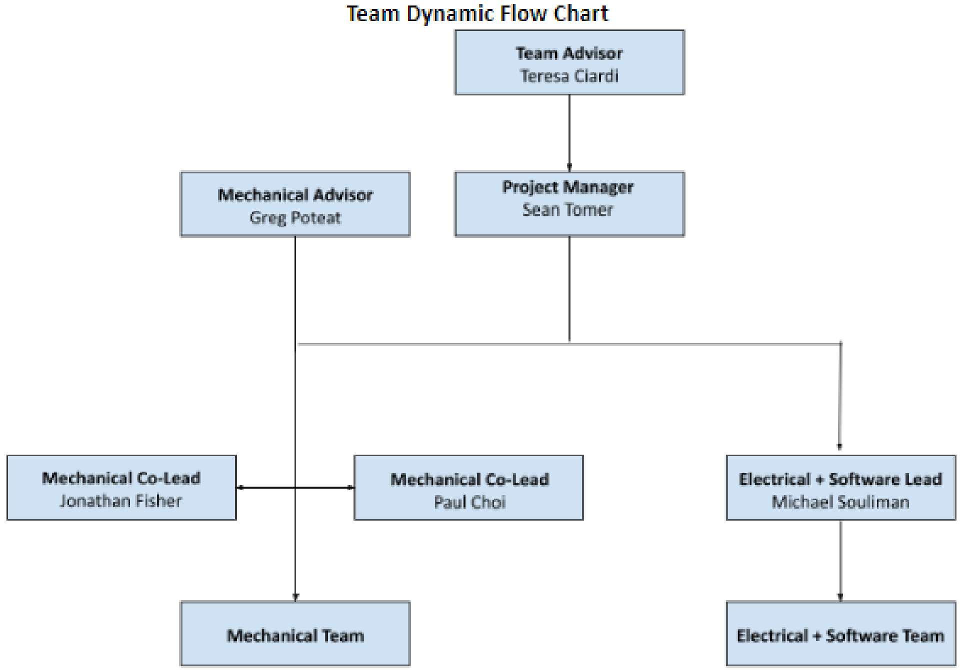
2 Team Structure and Management

2.1 Team Organization and Roles

A strong team dynamic completed with passionate and devoted student makes up Team NOVA, some returning veterans of the project guide a new cohort of students into what it takes to conceptualize, design, fabricate, test, and integrate a payload capable of withstanding the harsh stratospheric conditions. Sean Tomer is the project manager for the first time and Teresa Ciardi returns as the Logistics Adviser and Financial Consultant and will be helping to support the team as they progress through various stages of the payload's development. Greg Poteat is also returning as the Manufacturing Advisor and will oversee the machine shop where students will work on the mechanical components of the payload.

Due to having fewer members the electrical and software teams were combined with its leader being Michael Souliman. This team will be responsible for producing electrical systems and relaying power to all components and for writing the code that controls the operation of various components of the payload. The Mechanical Team is responsible for the design, integration, manufacturing, and testing of all mechanical and structural systems with co-leaders being Jonathan Fisher and Paul Choi.

Team Dynamic Flow Chart



Name	Role	Email	Phone
Sean Tomer	Project Manager	smtomer@icloud.com	(661)-600-7204
Teresa Ciardi	Team Advisor	Teresa.Ciardi@canyons.edu	(661)-313-6015
Greg Poteat	Mechanical Advisor	gregory.poteat@canyons.edu	(661)-670-9108
Electrical + Software Team			
Michael Souliman	Team Lead	mssouliman1@my.canyons.edu	(818)-480-0728
Thomas Kellog	Member	thomaskelloggtik@gmail.com	
Shaun Ford	Member	shaun.t.ford@gmail.com	
Ganiru Ekwekwuo	Member	ganiruekwekwuo@outlook.com	
Ilker Loza	Member	loza.ilker@gmail.com	
Mechanical Team			
Jonathan Fisher	Team Lead	jrfish032004@gmail.com	(661)-481-4983
Paul Choi	Team Lead	pjchoi3524@gmail.com	(818)-860-9181
Hector Torres	Member	hector.torres.427@my.csun.edu	
Dean Sanchez	Member	dfsanchez@my.canyons.edu	
Brandon Canedo	Member	brandon.canedo.760@my.csun.edu	
Marilyn Johnson	Member	marilyncjohnson02@gmail.com	

2.2 Timeline and Milestones

Month 2020	**Objectives**
November	• Consolidate 2021's mission objectives and select the platform for the new experiment. • Begin work for the 2021 proposal • Begin design phase and define principle of operation.
December	• Develop a preliminary budget plan to get fabrication started.
Month 2021	**Objectives**
January	• Finish and revise 2021 proposal.
February	• Await flight status from HASP, if selected begin proposal revisions as requested. • First parts ordered, begin manufacturing of testing rig and components
March	• Start fabrication of payload and continue testing payload structure. • Begin work on electrical and computer systems
April	• Preliminary thermal-vacuum testing on select components
30th	**Preliminary PSIP deadline**
May	• Finish payload construction and electrical systems
June	• Integrate both mechanical and electrical systems and begin preliminary tests of complete system
25th	**Final PSIP deadline**
25th	**NASA Flight On-Site Security Document due**
July	• Final assembly and testing of payload ready payload for integration
23rd	**Final FLOP deadline**
26-30	**Integration at CSBF**
August	• Prepare team leads for Texas trip and establish a plan to make integration as seamless as possible
September	• Follow through with HASP officials to confirm payload arrival at Ft. Sumner
TBD	**Launch, monitor and operate payload systems for entire flight**

7-11	**Payload returned, begin preliminary extrapolation of results, start writing science report**
October	• Continue working on science report
November	• Rough draft of report enters peer review
December 10th	**Submit science report and repeat process**

2.3 Anticipated Participation in Integration and Launch operations

For our Preliminary Integration Plan, the team will plan to ship a fully assembled and tested payload to CSBF prior to traveling there for integration. In previous years the team discovered the difficulties of arriving and assembling, testing and modifying a full payload and with this year's plan we hope to improve on our efficiency and make the best use of our time during integration. Anything required for the payload to operate successfully will be done no less than two weeks in advance prior to integration to allow time for payload to reach Texas. Upon arriving at the balloon facility we will run preliminary tests to ensure all systems that were reported working with our last series of tests are still operational and ready for integration. These values will be confirmed in the basic power tests run by HASP officials. If non-nominal values are returned the team will assess the problem and spend the first day working on an appropriate solution until the payload's systems meet expected values.

In the event of an emergency, we will bring some spare equipment to make any repairs or modifications to the payload as the integration process determines any weak points that might compromise our mission. With no need to assemble our payload the team will focus on collaborating with other teams and HASP personnel to optimize performance and streamlining operation procedures to increase the chances of a successful mission. This will be an ongoing cycle until TV testing begins. During the TV test the team will again check for expected results and make sure all systems are capable of handling the environment; testing back on campus should have set the standards for expected results and if everything is functioning correctly the results should be comparable to one another. Should NOVA not pass the TV test for whatever reason the remainder of the day will be dedicated to preparing the payload for another test the following day. This process may be repeated until the last day which will either clear or ground the payload for final flight.

The preliminary plan for the flight operations is, on the morning of launch no less than two members from the team will be awake and present at the site. As the day progresses this team of two or more will rotate in shifts around the clock to assure the payload is monitored throughout the flight. One individual will respond to prompts on the HASP integration spreadsheet while the other logs any relevant data for redundancy. Should there be a problem in a specific area team leads will be consulted as needed to suggest solutions and oversee their execution. The general timeline is as follows:

- Pre-Flight:
  - Once power is turned on, team members will observe any data coming in and check for nominal outputs.
- During Flight (First Stage):
  - Team members will continue to track valves through ascent.
- During Flight (Second Stage):
  - At float altitude team members will begin collection of stratospheric atmosphere and allow air into collection chambers for approximately 2 minutes. The valve will then be given the command to close and the samples will be given time to become saturated with the solution. Misting will occur in short bursts every half hour through a specified command. In the event of malfunction or emergency the chambers can be evacuated at any time through a preprogrammed function. When readings start to occur on the spectrometers they will be plotted to charts by those tracking the data at this time and preliminary hypotheses can be conducted. Once the sample is saturated the valve will open and the fan will turn on once again to repeat the cycle.
- During Flight (Third Stage):
  - During descent the valve will remain closed to preserve the integrity of the samples and remain closed until power down.
- Post Flight (Fourth Stage):
  - Team members will reach out to HASP personnel and ask if the valve remained closed to confirm a safe landing. The team will anticipate the return of the payload to campus and conduct post-flight analysis on the payload and possible samples.

3 Payload Interface Specifications

3.1 Weight Budget

System	Mass (g)	Deviation (g)
Frame	300	20
EPC Assembly	350	10
Actuator Assembly	500	20
Adafruit Motor Shield	20	3
Arduino Mega	40	5
Adafruit Data Logging	22	3
DS18B20 Wire Digital Temperature Sensor IC	9	1
Hamamatsu PMT	90	5
BC-412 Plastic Scintillator	120	10
Thermal Protection	100	20
Total	1551	97

Figure 10: Weight Budget

Total mass of the payload will be well under 3kg, weighing in at about 1.6 kg. This number is an overestimate that has been derived from careful examination of solidworks mass analysis figures and mass measurements of the few components already purchased. 1.6 kilograms includes the weight of all electronic components, insulation, wiring, machine screws, nuts, washers, and of course the entire payload assembly as rendered in CAD.

3.2 Power Budget

System	Input Voltage (V)	Power (W)	Current(A)
Linear Actuator	5	3.15	0.45
Arduino Mega	12	0	0.01
Motor Shield	5	6	1.2
Altimeters	0	0.2	0.04
Thermistor	0	0.2	0.04
Photomultplier Tube	5	0.31	0.062
Heatings Pads	0	1.85	0.37
Totals	27	11.71	2.172

Figure 11: Power Budget

Power consumption based on preliminary calculations will not exceed 15 Watts (30Vdc @ 0.5A)on input. Included is a table showing the power consumption of each electrical instrument onboard the payload.

3.3 Downlink Serial Data/Uplink Serial Commanding

Due to the passive nature of the scientific instrument to be flown, uplink and downlink data will not be needed at this present time. The flight computer will perform in total autonomy once power is turned on for the payload before launch. As stated in section 1.3.4, the software will be based on 1-2 digital altimeters to determine the proper opening and closing time for the scintillation enclosure. The flight computer will also actively regulate internal temperatures, log all data listed in section 1.3.2, and control the motor from altimeter readings. The EDAC connector will be only used for power and the DB9 will not need to be used at all at this present time.

3.4 Analog Downlink

The payload does not intend to utilize the analog downlink capabilities provided via the EDAC cable on HASP.

3.5 Discrete Commanding

The payload does not request the ability to utilize the extra discrete commanding (not power on/power off discrete) capabilities provided

by HASP. Because we are using our own altimeter to determine when we need to use the linear actuator and expose the scintillator.

3.6 Payload Location and Orientation Request

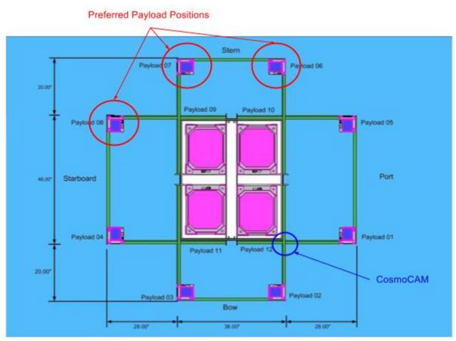


Figure 12: Preferred Location

A top priority for the payload location is to have it in the field of view of the CosmoCAM during flight. A visual confirmation of the scintillator enclosure opening and closing will be the best possible validation of experiment success and actuator mechanism functionality in the flight environment. Providing the CosmoCAM did not change from its 2017 orientation, Payload numbers 8, 7, and 6 located at the starboard and stern of the platform would be ideal locations in the field of view of CosmoCAM. For payload orientation, it is preferred that the payload is rotated so that the status and power LEDs are visible by the CosmoCAM. This orientation also provides the best viewing angle to watch the scintillator enclosure opening and closing.

4 Preliminary Drawings and Diagrams

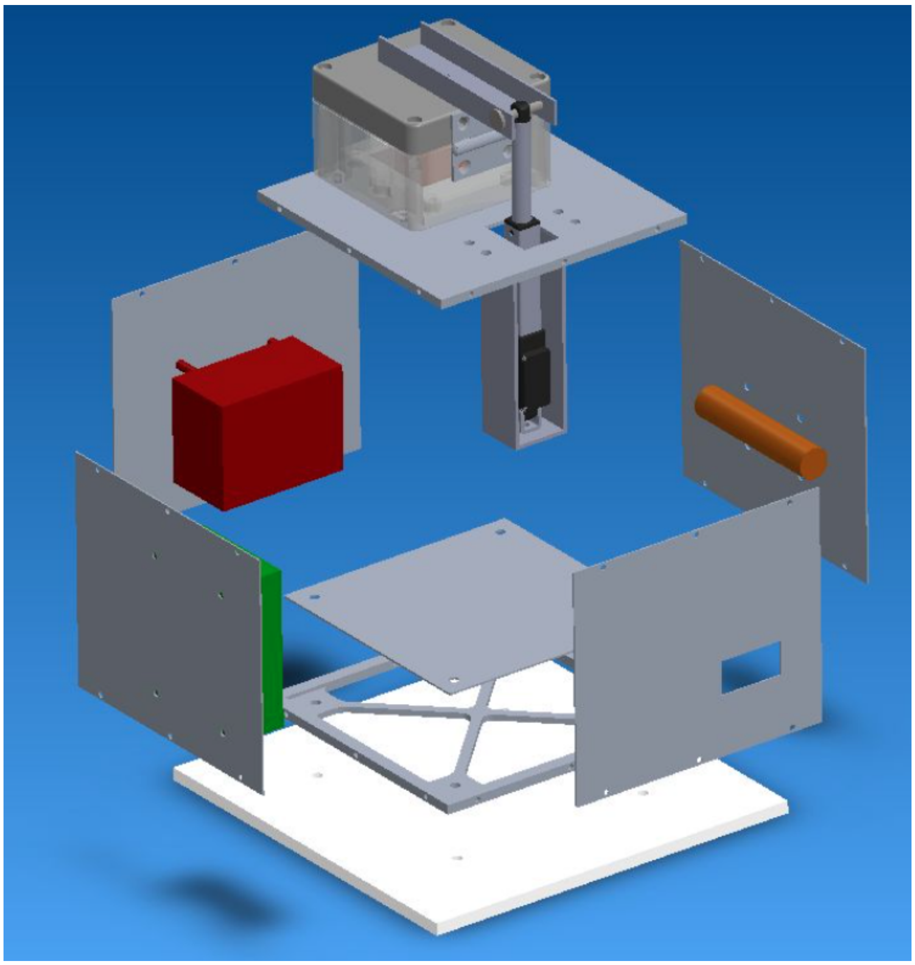


Figure 13: Expanded View

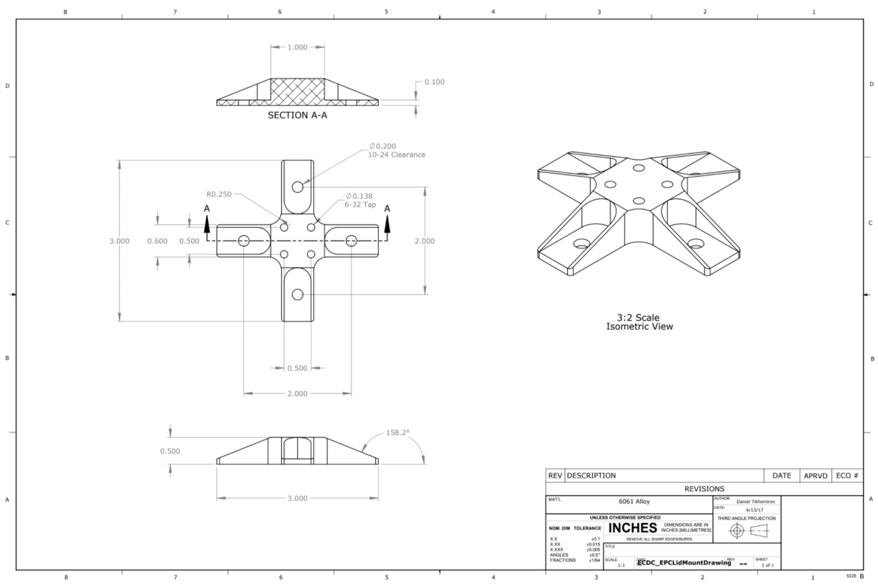


Figure 14: PSE Lid Mount

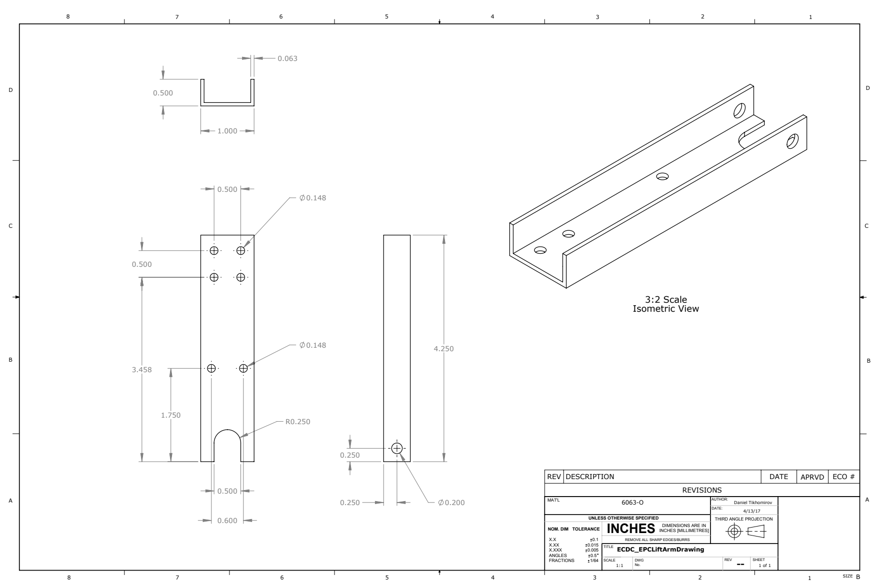


Figure 15: Lift Arm

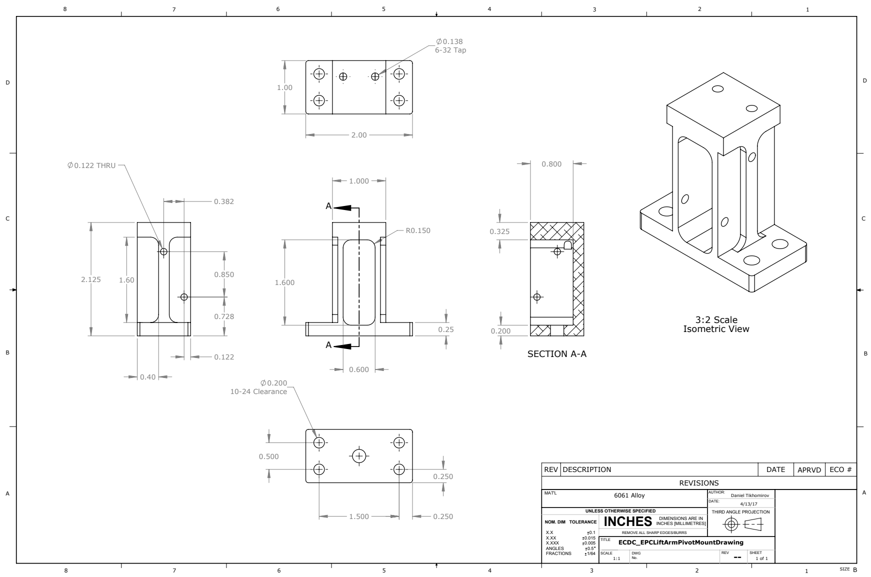


Figure 16: Lift Arm Pivot

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