HASP Student Payload Application for 2018

Payload Title: Stratospheric On-board Laminar-flow Acidic Reduction Inspection System (SOLARIS)

Institution: College of the Canyons

Payload Class (Enter SMALL, or LARGE): SMALL	Submit Date: 12/15/2017

Project Abstract: Increased human activity after the industrial revolution has begun to alter the natural balance of our environment. Pollutants from transportation, manufacturing, and decomposition have been infiltrating the atmosphere with a haze of acids that find their way into the stratosphere. It is here that the gaseous acids react with sunlight and a redox reaction occurs that breaks down ozone. Over time this has created a thinner ozone layer and the products of these reactions remain in the atmosphere, creating a barrier from which less and less heat can escape. New insights into geo-engineering are discovering what intervention, if any, can be performed to help reduce these pollutants in the stratosphere. Pulling inspiration from SCoPEx - an experiment from Harvard set to launch in 2020 - SOLARIS aims to explore alternate delivery systems and testing platforms that use common substances as a base to neutralize the harmful acid products. The team's objective is to contribute to ongoing research in this emerging field by actively experimenting in stratospheric conditions in ways never before tested. The NASA HASP 2018 program will provide an opportunity to test a developing hypothesis while collecting valuable data that will aid in a better understanding of the stratosphere environment, the processes that contribute to the destruction of ozone, and perhaps a viable solution into mitigating the effects of climate change.

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Table of Acronyms

HASP	High Altitude Student Platform
LSU	Louisiana State University
NASA	National Aeronautics and Space Agency
PPB	Parts Per Billion
IDP	Interplanetary Dust Particle
TV	Thermal Vacuum
PSIP	Payload Specification and Integration Plan
FLOP	Flight Operations Plan
ATC	Active Thermal Control
PATC	Passive Thermal Control
UV	Ultra Violet
IR	Infrared

1– Introduction

1.1 – Mission Proposal

Climate change research and prevention, specifically the relation it may have towards rising temperatures on Earth, is one of the biggest emerging scientific fields in the new millennia. While many theories and practical uses of carbon offsets have already been introduced, Geo Engineering and the implications it could have on the planet are gaining momentum and beginning to be recognized for its potential to mitigate the impact human activity has had on our environment. This is where the **S**tratospheric **O**n-board **L**aminar flow **A**cidic **R**eduction **I**nspection **S**ystem or SOLARIS comes in. College of the Canyons' SOLARIS project aims to study and actively experiment with a process to neutralize harmful acids in the Earth's stratosphere using calcium based solutions. This project represents pioneering advances in geo-engineering related experimentation geared towards learning about various methods of easing the effects of climate change, and testing the efficacy of these theoretical models.

1.2 – Scientific Objectives

The SOLARIS project consists of 3 interdependent scientific objectives:

1. Validate the collection of stratospheric atmosphere using our payload collection system
2. Measurement of acid concentrations present in untreated stratospheric atmosphere using payload sensors
3. Measurement of acid concentrations present in stratospheric atmosphere treated with a basic solution

For the mission to succeed, all three of the scientific objectives must present conclusive evidence that shows the efficacy of this type of delivery and treatment system. Collection of the atmosphere into the collection system (Objective 1) is crucial, in order to perform the isolated experiments (Objectives 2 and 3), and for accurate analysis of objectives 2 and 3. If successful, future research may allow for the distribution of solutions on a larger scale outside of containment. Mission success will be defined as a drop in overall pH levels after treatment is applied to the stratospheric atmosphere, in comparison to the untreated control chamber of stratospheric atmosphere.

1.3 - Chemistry and Agents

With SOLARIS' primary objective in mind, the team aims to deliver a payload that can challenge contributors to climate change by neutralizing acids that break down our ozone layer. The use of base substances, like calcium carbonate and sodium bicarbonate, can reduce the buildup of acids such as hydrochloric and sulfuric acid. These chemical substances are not hazardous or toxic and are a naturally occurring byproduct of limestone production. Inspiration for the project began with the team's discovery of a Harvard based solar geo-engineering project. SCoPEx is an ongoing development planned for a 2020 launch that will use calcite aerosols to reflect UV radiation and attempt to neutralize acids on a large-scale; such experiments are the first of their kind and SOLARIS will be a test of concept related to the SCoPEx project. We are proposing a related experiment with similar substances but using different delivery methods to assess the validity of this system and contribute to ongoing research in a field that until recently was considered impractical. SOLARIS may bring the scientific community one step closer to optimally removing acids in the stratospheric layer.

An enclosure will be constructed with two distinct experiment chambers along-side sensors and components that will measure air qualities such as pressure, temperature, and acidity. At float altitude a valve will open allowing air to enter, and when each chamber is closed, the captured air in one chamber will be exposed to a solution containing a base substance of calcium carbonate. The sensory data should then show the ability of the basic solution to neutralize harmful acids.

In order to determine the optimum solution concentration, the team will test acid/base reactions with calcium carbonate solutions. Specifically, the mission targets the reactions with Hydrochloric, Sulfuric, and Nitric acids

Calcium carbonate + hydrochloric acid produce carbon dioxide gas + water + dissolved calcium.

$CaCO_3 + 2HCl \rightarrow CO_2 + H_20 + Ca^+ + 2Cl^-$

Calcium carbonate + sulfuric acid produce calcium sulfate + carbon dioxide gas + water

$CaCO_3 + 2H_2SO_4 \rightarrow Ca(SO_4)_2 + CO_2 + H_2O$

Calcium carbonate + Nitric Acid produce calcium nitrate + carbon dioxide + water

$CaCO_3(s) + 2HNO_3(g) \rightarrow Ca(NO_3)_2(s) + CO_2(g) + H_2O(g)$

The carbon dioxide from these reactions takes a gaseous form while allowing these acids to be converted into calcium sulfate, calcium nitrate, chlorine, and water. Just about any acid can produce these results, but dilute hydrochloric acid or vinegar are the two recommended acids for testing the effectiveness of calcium carbonate solutions. The result of these reactions will be the neutralization of acids present in the stratospheric layer of our atmosphere with the byproducts produced being more benign substances.

As atmospheric pressure lowers the boiling points of liquids and the temperatures of the flight promote subzero temperatures, the solution agent used will be a 50/25/25 mix. 50% of the solution will contain a mixture comprised of filtered water taken from a 100 mL tank with 35.9 grams NaCl (salt) dissolved into it. This ensures a maximum soluble mixture of around 39.5% salt to water percentage. Salt water has a higher boiling point than regular untreated water and resists freezing more efficiently. 25% of the solution will be propylene glycol concentrate, which is often used as an anti-freeze agent. Propylene glycol is classified as nontoxic to humans as well as being relatively stable at a range of temperatures which will assist in keeping the solution stable. Lastly, 25% of the solution will contain calcium carbonate concentrate to act as a neutralizing agent for acidic particles in air samples.

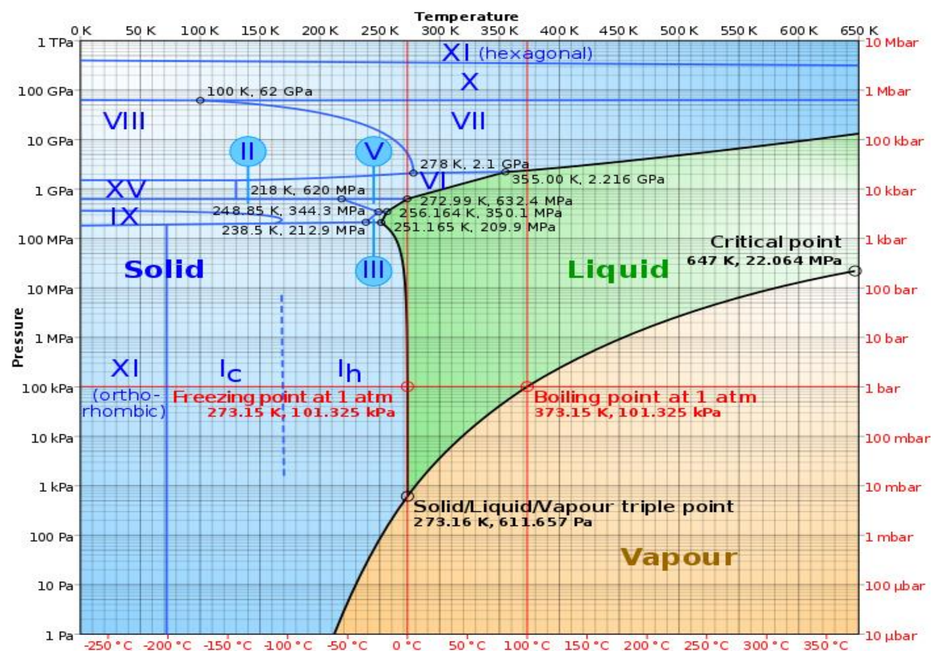


Table 1.3A – Phase diagram of the various states of water at various pressures and temperatures

1.4 – Project Timeline

Month 2018	Objectives
January	Complete any requested revisions of proposal and continue building team structures
February	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 in College of the Canyons vacuum chamber
25th	**Preliminary PSIP deadline**
May	Finish payload construction and electrical systems
June	Integrate both mechanical and electrical systems and begin preliminary tests of complete system
27th	**Final PSIP deadline**
July	Final assembly and testing of payload ready payload for integration
31st	**Final FLOP deadline**
August	Prepare team leads for Texas trip and establish a plan to make integration as seamless as possible
4th-8th	**Integration at CSBF**
September	Follow through with HASP officials to confirm payload arrival at Ft. Sumner
TBD	**Launch**, monitor and operate payload systems for entire flight
October	Payload returned, begin preliminary extrapolation of results, start writing science report
November	Rough draft of report enters peer review
December	Submit science report and repeat process

1.5 – Recovery and Analysis

Experimentation will be performed in flight with data analyzed in real time. Recovery of the payload will require little effort other than disconnecting umbilical feeds and removing it from the balloon gondola. Post flight analysis will be performed under clean room conditions, with analysis of the physical filters installed to confirm electronic sensor results. Data will be downloaded from data loggers and sensor computers for in depth analysis, and the opportunity for further extrapolation may present itself through physical samples.

2 – Payload

2.1 – Principle of Operation

Collection of stratospheric atmosphere is performed by a laminar flow intake installed to the top of the payload. The intake funnels this air into the two isolated experiment chambers, where measurement of pH levels is performed using the onboard sensors. One chamber is then exposed to the neutralizing agent via a misting delivery system and filtration device, which allows the fine particulates to mix and bind with acids present. Chamber one will be exposed to a calcium carbonate derived solution, while chamber two will remain untreated and serve as a control for baseline comparisons. Each chamber will be analyzed with onboard sensors to determine if a drop in pH has occurred in the neutralization chamber when compared to the control. Measurements may be obtained in PPB but is not required for the experiment to be deemed a success.

2.2 – Mechanical Systems

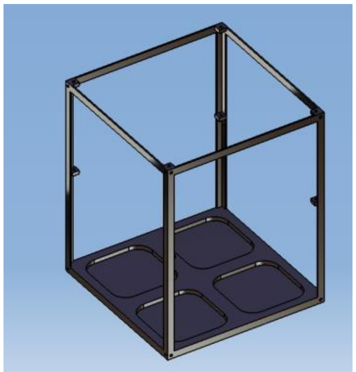
2.2.1 – Mass Budget

Component	Quantity	Mass (Kg)	Deviation +/- .01 Kg
Aluminum Frame	1	0.275	0.285
Polycarbonate Chamber	1	0.39	0.40
Nylon Intake	1	0.408	0.418
Aluminum Side Panels	4	0.098	0.108
Flight Computer	1	0.002	0.012

Mounting Plate			
Nylon Power Box	1	0.129	0.139
½" Valve	1	0.39	0.40
Electric Fan	1	0.005	0.015
Spectrometer	2	0.120	0.130
Cuvette Holder	1	0.540	0.550
Cuvette	1	0.001	0.011
Pump	1	0.100	0.110
Micro tubing Mister	1	0.025	0.035
Solution	N/A	0.015	0.025
Solution Chamber	1	0.003	0.013
Voltage Regulators	4	0.005	0.015
Sensors	12	0.012	0.022
Arduino Mega	1	0.037	0.047
Arduino Sensor Shield	1	0.020	0.030
Arduino SD Card Shield	1	0.020	0.030
Wiring	N/A	0.100	0.110
Insulation	N/A	0.010	0.020
Heating Pads	10	0.050	0.060
Total Mass		**2.76**	**2.99**

2.2.2 – Frame

A frame both isolate and control the conditions ~~in~~ to which the experiment chamber is exposed. It's primary purpose is to protect the sensitive processes within the chambers and provide an expanded space for flight hard ware. The frame will also serve as a mounting point to the HASP gondola and will be constructed from lightweight aluminum 2024 which has been a favorite



material for College of the Canyons for its ease of machining, strength, weight, and previous successes. We have familiarity with the stress/strain and thermal capabilities of the aluminum 2024 from previous HASP missions and know it will provide the necessary support to endure the 10g vertical and 5g horizontal forces while protecting encased components.

Fig 2.2.2A – Aluminum Frame model

2.2.3 – Intake Assembly

The intake assembly consists of a 3D printed snorkel that channels air in through the top and through a one-way electric valve. When opened, the valve allows air to flow into two separate channels which delivers the air samples to their respective enclosures. The snorkel will serve as a mounting point for both the valve and a fan, and will be printed in two pieces to allow the larger valve to be placed beneath the smaller opening for the fan housing. The material of choice for the snorkel is nylon; a strong, flexible non-conductive plastic which will smoothly transition any particulates into each chamber and also withstand the harsh outside environment during flight. The snorkel will remain exposed to the outside conditions, and we expect the snorkel to successfully deliver atmospheric particulates based on the performance of our NASA HASP 2017 snorkel design. Thus, we anticipate success with this method for SOLARIS.

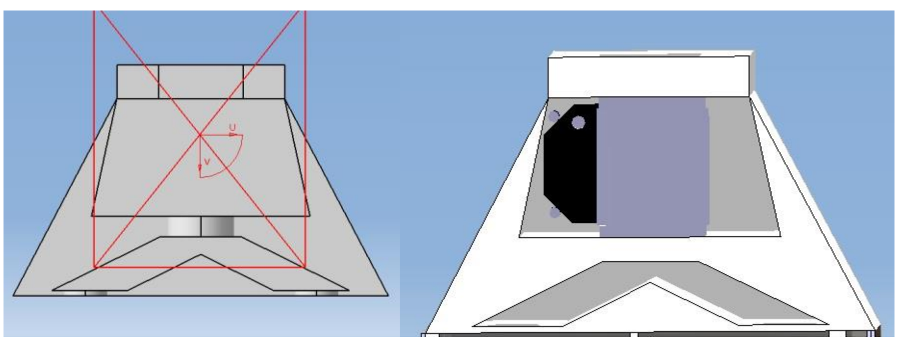


Fig 2.2.3A – Intake Snorkel Diagrams

2.2.4 – Experiment Chambers

The experiment chambers are the heart of the project as they will serve as a clean, isolated environment to provide the opportunity for the greatest accuracy and least risk for contamination.

The chamber is composed of 5 polycarbonate chambers each measuring .220” thick. A single smaller polycarbonate plate measuring .110” thick will serve as the division wall between the two chambers. In efforts to keep each chamber as much of a controlled environment as possible, each joint will be held together with a thin rubber gasket covered with an acrylic resin. Our discoveries in HASP 2016 included the realization that acrylic resin bonds with polycarbonate; this will help make sure the box is sealed on all sides except for the top entrance which will keep the enclosure from acting as a pressure vessel. In addition, a small hole will be drilled into each side of the sample chamber and covered with extremely fine filter paper; in the event of over pressurization, the small opening will act as an escape route for the excess pressure without compromising the results of the experiment. This principle works similarly to an aircraft window. 3D printed slots will be glued to two interior walls for the filter to rest in and the spectrometers and any other sensory equipment will slot into precisely cut holes to prevent the likeliness of sample contamination.

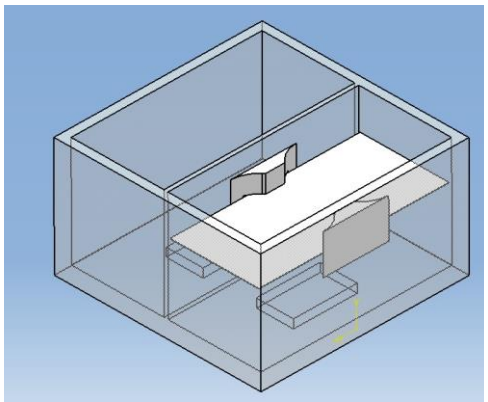


Fig 2.2.4A – Experiment Chamber Models

2.2.5 - Electric Valve

The purpose of implementing a valve into the payloads design was to ensure as much of a quality control environment as possible. The valve can be remotely opened or closed and sits inside the intake snorkel; in order for atmosphere to reach the sample chambers it will first need to pass through this valve. This will limit the amount of atmosphere allowed into each chamber during testing while also preventing any of the neutralizing agent from getting out. It is a contained and isolated system which will make controlling and monitoring the experiment environment easier. In the event that the sample chambers need to be evacuated for any reason the valve may remain open and with the fan working in reverse atmosphere may be removed from the chambers and a new baseline can be established before resuming the experiment. The valve can operate in temperatures from -15~50 Celsius, insulation and heaters will be used to stabilize interior chamber conditions to assure the valve is always operational.

Fig 2.2.5A – Electric Valve

2.2.7 – Stress/Strain Analysis

As previously stated the SOLARIS team is returning to tried and tested materials for their successful runs through previous hasp years. With this year's experiment we will be using less aluminum however and focusing more on thermoplastics for their lightweight and strength characteristics. Polycarbonate and nylon components require significant thermal activity to deform and nylon has a high tolerance to compression and shear forces. The aluminum frame is to provide an exoskeleton for the more sensitive components while still remaining lightweight. It will serve as a buffer from the outside conditions which at -60 Celsius would make the polycarbonate sample chamber quite brittle. The team looked for materials that were readily accessible, easy to work with, and could handle a large variety of temperatures since it is thermal activity which will pose the most risk to any components relevant to the experiment.

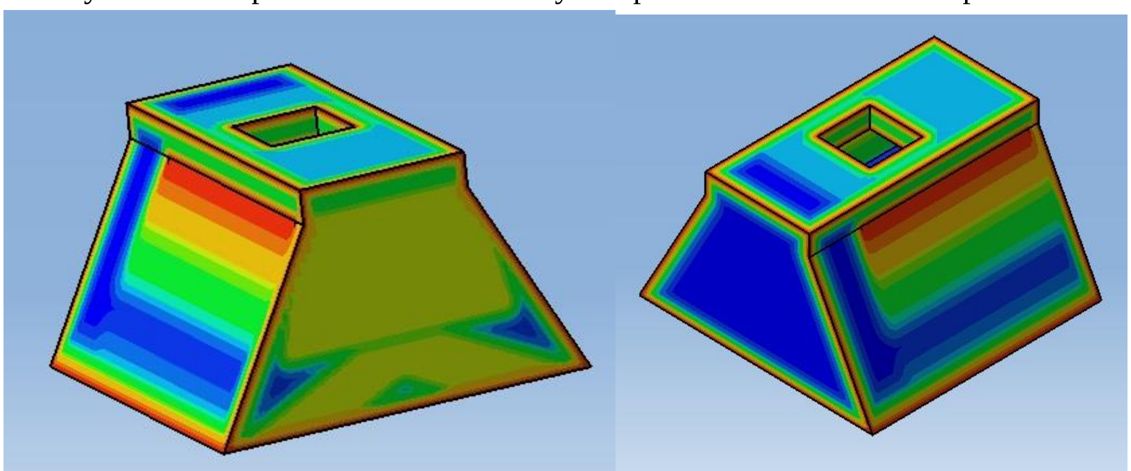


Figure 2.2.7 - Wall thickness Analysis on nylon intake

2.3 – Electrical & Power Management Systems

2.3.1 – Power Budgets

Operational with Intake system – Spectrometers powered off

Component or System	Input Voltage	Specified Current	Quantity Multiplier	Watts	Current (min)	Current (max)
Intake Fan	12	0.08	1	0.96	0.032	0.035555556
Intake Valve	12	0.11	1	1.32	0.044	0.048888889
Arduino Flight Computer	12	0.25	1	3	0.1	0.111111111
Thermistors	5	0.003	10	0.15	0.005	0.005555556
Humidity Sensor	5	0.5	1	2.5	0.083333333	0.092592593
Pressure sensor	2.5	0.032	2	0.16	0.005333333	0.005925926
Current Sensor	5	0.5	1	2.5	0.083333333	0.092592593
Light Sensor	5	0.005	1	0.025	0.000833333	0.000925926
Gyroscope and Altimeter	2.5	0.01	1	0.025	0.000833333	0.000925926
RS Data Logger	5	0.065	1	0.325	0.010833333	0.012037037
Heating Pads	5	0.025	10	1.25	0.041666667	0.046296296
TOTALS				12.215	0.407166667	0.452407407

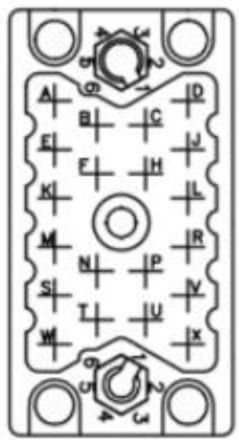
Operational with Spectrometry performed – Intake assembly powered off

Component or System	Input Voltage	Specified Current	Quantity Multiplier	Watts	Current (min)	Current (max)
Spectrometer	5	0.15	1	0.75	0.025	0.027777778
Light Source	3.5	0.57143	1	2.000005	0.066666833	0.074074259
Arduino Flight Computer	12	0.25	1	3	0.1	0.111111111
Thermistors	5	0.003	10	0.15	0.005	0.005555556
Humidity Sensor	5	0.5	1	2.5	0.083333333	0.092592593
Pressure sensor	2.5	0.032	2	0.16	0.005333333	0.005925926
Current Sensor	5	0.5	1	2.5	0.083333333	0.092592593
Light Sensor	5	0.005	1	0.025	0.000833333	0.000925926
Gyroscope and Altimeter	2.5	0.01	1	0.025	0.000833333	0.000925926
RS Data Logger	5	0.065	1	0.325	0.010833333	0.012037037
Heating Pads	5	0.025	10	1.25	0.041666667	0.046296296
TOTALS				12.685005	0.4228335	0.469815

2.3.2 – Power Delivery and Assembly

Stage 1 - Supply Power

Power to the payload is supplied via the HASP EDAC 516 on pins A, B, C, D and grounded through pins W, T ,U, and X (Fig. 2.3.2A) The HASP power supply provides a DC power supply in the range of 29-33 Volts, while current is capped at a maximum draw of .5 Amps.



Pin Layout of EDAC 516-020

Function	EDAC Pins	Wire Color
+30 VDC	A,B,C,D	White with red stripe
Power Ground	W,T,U,X	White with black stripe

Fig. 2.3.2A - EDAC Receptacle

The payload is designed with an input of a maximum of 48 Volts and .45 Amps and is channeled through a custom nylon power box (Fig 2.3.2B / Fig 2.3.2F). Fuses, regulators, and power supply cables are mounted into this box, ensuring that components are held in place and to prevent short circuit conditions.

Fig 2.3.2B - Nylon Power Box

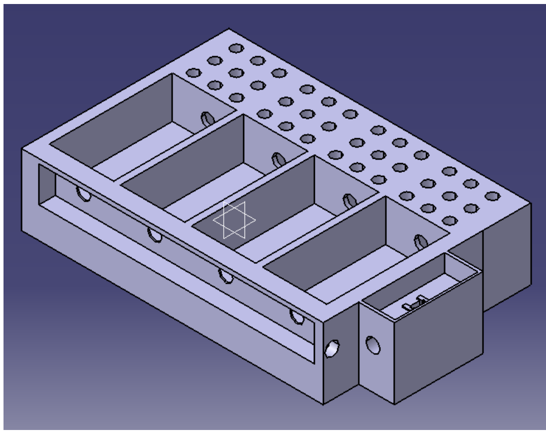
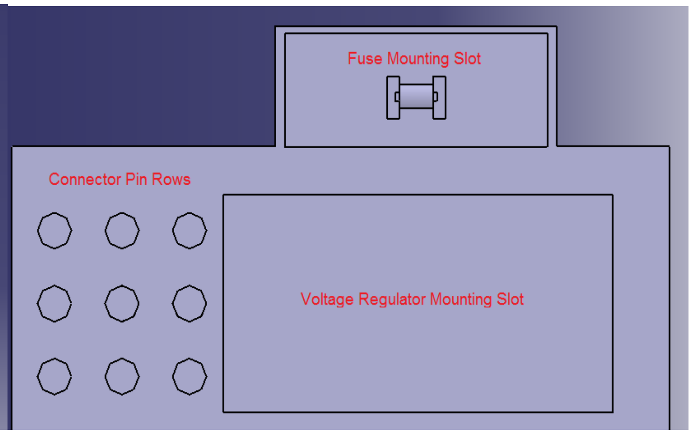


Fig 2.3.2F - Power Box Detail



Stage 2 - Overcurrent Protection

Power from the main input line is first channeled through a master PTC fuse (resettable Polyswitch) (Fig 2.3.2C**)**. The PTC requires a holding current of .16A and has a maximum trip current of .45A, while voltage is capped to a maximum of 48. The benefit of using a PTC is to both protect the HASP power supply as well as the payload from any over current situation, as well as allowing the payload to recover and reset to continue in such an event.

Fig 2.3.2C - PTC

Stage 3 - Power Regulation and Feeds

Next, power from the main line is sampled through both a current sensor in the form of an isolated breakout board, (Fig 2.3.2D) and a voltage sensor based upon a voltage divider model (Fig 2.3.2E). Both of these are connected directly to the Arduino Sensor Shield for real time monitoring by the flight computer and to allow the team to respond to various power system needs.

Fig 2.3.2D

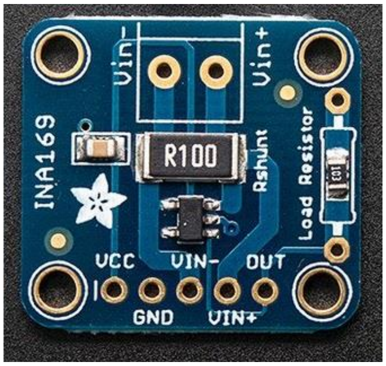


Fig 2.3.2D – Current Sensor

Fig 2.3.2E

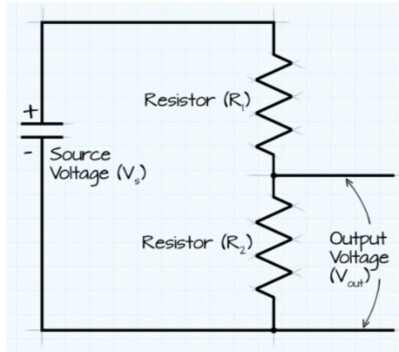


Fig 2.3.2E – Voltage Sensor

After passing through the current and voltage sensors, main line power is split into four separate feeds that are connected into the payload's four variable linear regulators. Each regulator is rated for a maximum of 40V input, while the output is variable and fed into isolated connector pins mounted into the power box's inert casing (Fig 2.3.2F). Table 2.3.2H outlines the planned output for each regulator row and the available connections.

Fig 2.3.2F - Connector Pin Slots On Power Box Casing (Left)

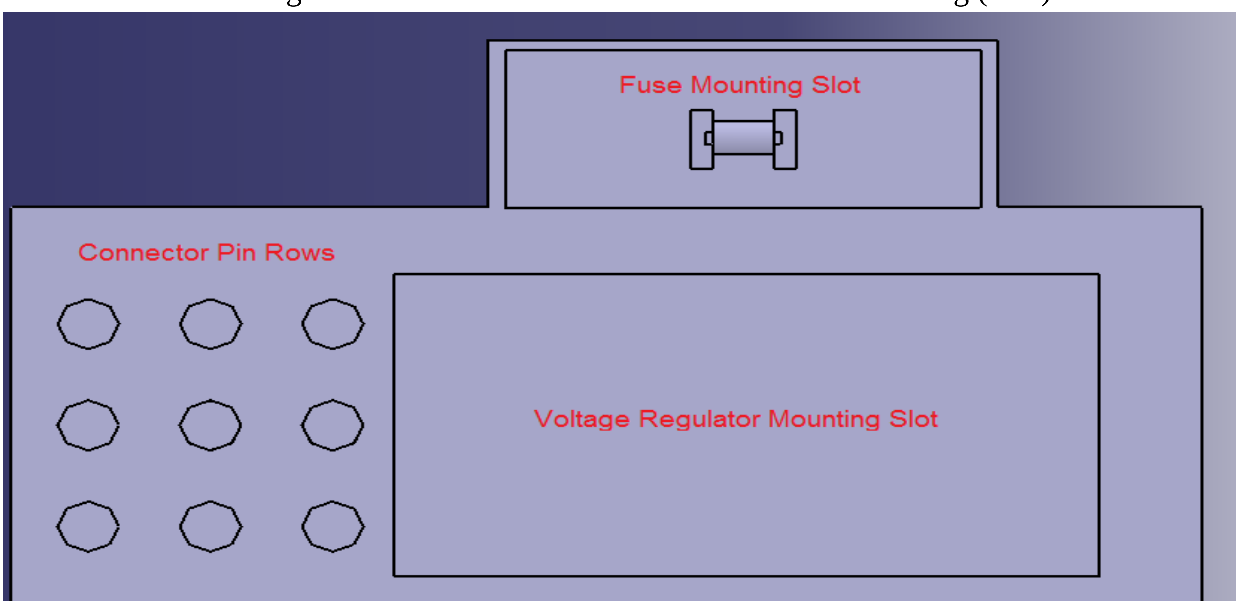


Table 2.3.2H

Regulator Row Number	Regulator Input Voltage	Regulator Output Voltage (planned)	Amount of Connector pins
1	40 volts max	12 volts	9
2	40 volts max	5.5 volts	9
3	40 volts max	3.3 volts	9
4	40 volts max	2.5 volts	9

Several heavy power draw systems are planned to run on isolated power lines fed into the connector pins in the regulator rows, while others will draw power directly from the flight computer or a connected shield. Table 2.3.2I outlines and classifies the payload's systems and components into these isolated or integrated categories.

Table 2.3.2I

Isolated (Connected directly to connector pin)	Integrated (Supplied by Computer or Shield)
Intake fan	Current and Voltage sensors
Intake valve	Temperature sensors
Solution pump	Humidity sensors
Spectrometer light source	Light sensors
Spectrometers	Accelerometers, Gyroscope, and Altimeter
Arduino Mega Flight Computer and Shields	
Thermistor heating systems	

2.4 – Computer and Flight systems

2.4.1 - Flight Computer

The payload flight computer chosen for HASP 2018 is the Arduino Mega due to the "open source" resources available, the availability of pre manufactured expansions, and the processing capability of the board. The Flight computer's main task is to provide a primary hub for serial/analog communication, payload command functions, passive sensor data monitoring, and interfacing with onboard scientific equipment. Additionally, the board provides power and communication to the various shield expansion boards needed for interfacing with sensors and data storage devices. The board also features steady power draw between .05-.06A during all processing applications.

Fig 2.4.1A – Arduino Mega

2.4.2 – Data Logging

Due to the limited amount of scientific data able to be interpreted through the serial downlink, data logging will be of critical importance for analysis once the payload is returned. An Arduino data logging shield attached directly to the Arduino mega will provide a hub for data logging through use of an integrated SD card slot. Unlike the serial data downlink which is limited in scope and detail, raw spectrometer data will be written directly onto the card to be downloaded and analyzed in depth before being processed through the Arduino Mega and translated into the unique serial code being used for real time analysis. Additionally, passive sensor data, serial command processes, and confirmations will be written onto the card to allow for review of the flight timeline. All data will be time stamped for accurate data analysis. The card used will be a SanDisk Extreme Pro SDSDXP-512G-A46, normally reserved for 4k Ultra HD cameras and will provide enough data storage for flight needs.

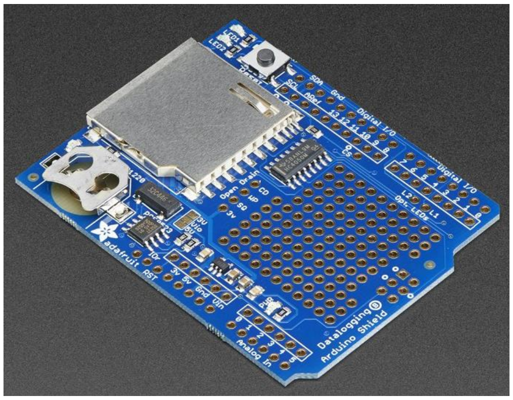


Fig 2.4.2A – Arduino Data Logging Shield

Fig 2.4.2B RS232 In-line data logger

Additionally, an RS232 in-line data logger will record all incoming and outgoing data from the serial downlink and uplinks. The device features a 4g flash memory which will record from both the TX and RX data streams. Upon retrieval, this data can be downloaded for analysis and verification of SD card data.

2.5 – Sensor Systems

2.5.1– Sensor Controller

Sensor power and control for the payload is provided by an integrated Arduino sensor shield in tangent with instruction code from the Arduino Mega. The sensor shield stacks directly on top of the Arduino mega and acts as a power hub by providing dedicated pins for all sensor systems except the payload's spectrography equipment. The Arduino Mega processes and engages with the payload's sensor systems to provide real time monitoring during critical flight areas.

Fig 2.5.1A – Arduino Sensor Shield

2.5.2 – Humidity Sensor

A single humidity sensor will be installed in the lower cavity of the payload, which contains all flight and power systems. It's primary purpose is for monitoring and feedback purposes. Should humidity rise above a predetermined cautionary percentage, the Arduino Mega will respond appropriately by shutting down all non-critical systems to prevent damage and entering a standby mode. Should humidity rise to a predetermined unacceptable level, the Arduino Mega will respond by shutting down all payload systems and components to render the current draw nil. This is to prevent short circuit events and to protect the payload and HASP gondola from electrical or physical damage.

Fig 2.5.2A – Humidity Sensor

2.5.3 – Pressure Sensors

Two barometric pressure sensors will be installed into the experiment chambers for monitoring internal chamber pressure. The experiment chambers should not action as any sort of pressure vessel in planned operation, with air able to freely mix and escape through the intake as necessary. The pressure sensors monitor the experiment chambers to allow the Arduino Mega to shut down intake systems should a predetermined unacceptable pressure event unlikely occur. Although the payload is equipped with an emergency pressure vent, the goal is to prevent resorting to its use by actively monitoring the situation, thus ensuring the safety of the payload and the HASP gondola from physical damage.

Fig 2.5.3A – Pressure sensor

2.5.4 – Voltage and Current Sensors

Voltage and current sensors are detailed in section 2.3.2 – Power Delivery and Assembly under Stage 3 - Power Regulation and Feeds

2.5.5 – Temperature Sensors

Temperature will be monitored through the use of NTC 3k thermistors mounted onto mission critical components such as the flight computer, intake systems, and the solution delivery assembly. Thermistors are advantageous over analog or digital temperature sensors due to the robust and simple nature of the devices, as well as being able to detect a wide range of temperatures.

2.5.6 - Gyroscope, Altimeter, and Accelerometer

A single integrated breakout board will be used to provide basic information on altitude, orientation, and forces encountered for the duration of the flight. Orientation and g force calculation are part of extraneous data which can be used after recovery to track the progression of the payload's flight. Although HASP does monitor altitude of the balloon, secondary input from this altimeter will allow the team a degree of freedom towards base station monitoring and actions regarding moving or altering experiment timelines. Preferably, the payload will be able to perform a float altitude test followed by variable tests at different altitudes along descent (provided it is before the payload is required to be powered down per HASP regulations). At minimum, the payload intake could use altitude information to allow sampling of air to observe target molecules at various altitudes on ascent by opening the intake valve.

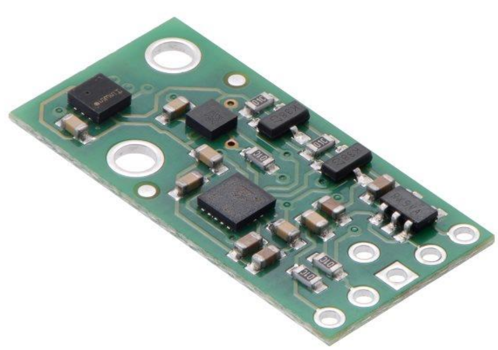


Fig 2.5.6A – Gyroscope, Altimeter, and accelerometer

2.5.7 - Light Sensor

A single breakout board light sensor module embedded with a photo resistor circuit will be mounted at a central point underneath the experiment chambers for external verification of the light source during spectrograph sampling stages. This sensor will also allow post recovery flight progression data.

Fig – 2.5.7A Light Sensor

2.5.8 – Spectrometers

Absorbance spectroscopy is a technique for measuring the interaction of light with matter. The Ocean Optics software, STS series VIS spectrometer, CUV-UV-10 cuvette holder, and the Evocis light source are some of the components that will enable our spectroscopy and are the forerunning equipment of our experiment. The light source will improve the quality of the information gathered from the samples by directing light to the regions where the sample is absorbed the most. The CUV holder will also have a cuvette cover that can be placed over the measured sample to prevent external light from saturating the system. The CUV will be aligned with the optical fibers to intercept the light coming from the source; this is how the absorbance occurs. The spectrometer will measure the amount of light (number of photons) at specific wavelengths and be plugged into the onboard computer system. The Ocean Optics software will display a spectrum of light that the spectrometer measures in absorbance. Once the transmission of a sample is measured it can be converted into other values such as percentages. The absorbance will be measured through a spectrum of wavelengths from 350nm UV to 800nm IR.

Fig 2.5.8A – Spectrometer and light source

2.6 - Delivery System
2.6.1 – Filter

Housed within the agent's sample chamber is a filter that will serve to be the main source of solution exposure for the experiment. The filter will be a simple fine mesh cotton screen that will be cut to the exact interior dimensions of the sample chamber. It will be held in place by two slotted prongs glued on opposite sides of the enclosure. Our calcium carbonate solution will be allowed to soak into the filter, thus absorbing the micro particulates. Atmosphere taken in at float will inevitable have to pass through this filter, thus exposing any acids contained within the sample to the neutralizing agent in the filter, theoretically removing some of the acids in the process.

2.6.2 – Agent Delivery Assembly

To deliver the solution agent used to neutralize acidic quantities in the air samples taken, a simple pump and mister solution will be utilized. The solution is stored in a small container located inside a nylon printed leak proof box to segregate the solution from any possible interaction with electrical or computer hardware and components. The pump selected for payload purposes will also be contained in this unit, directly connected to the solution container on one end and a small mister at the other installed in the experiment chamber. Control of this system will be accomplished with a power connection fed directly into the payload's power box connector, with an interruption of a solid state relay connected to the arduino sensor shield acting as a toggle. Activation will only be provided by a serial uplink command. Once the command is received, the Arduino mega will engage the delivery assembly for a maximum of 1 second before automatically disengaging the system. This is to prevent the need for a deactivation command from the ground team that could otherwise be delayed or fail to be received, ensuring that the assembly will remain undamaged and not pose a risk to payload or electrical system safety.

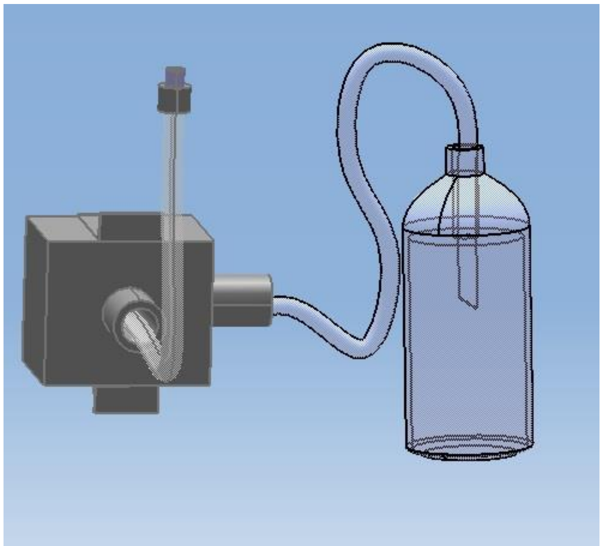


Fig 2.6.1A – Filter Assembly

2.7 - Thermal Management System

2.7.1 - Passive Thermal Control

Multi-layer Mylar insulation and flexible headers will provide all of the thermal protection on the payload. A 16-26 layered Mylar sheet will be used to mask the internal wall of the payloads side panels and the interior chamber of the intake snorkel where temperature sensitive electronics are located. Flexible heaters will be used as a means to further regulate and control temperature around more sensitive components. They can be modified to fit any configuration and fully envelope the exterior of the component, directing heat evenly over the entire surface. These systems have tested well under the conditions supplied by HASP through integration and under normal flight conditions; however the team will do extensive thermal testing before integration to assure all systems continue to function through a range of conditions as a result of the thermal system working properly.

2.7.2 - Active Thermal Control

To assist with providing critical components and areas of the payload thermal protection against the harsh low temperatures of the Stratosphere, a network of flexible resistive-fiber 6.8 ohm heating pads capable of providing 1.6 watts of heat from 3.3V. Power is supplied directly to these pads from a feed to the power box connector pins, interrupted by way of integrated solid state relays. The relays are controlled by a feed from the Arduino Mega, using data from the payload's network of thermistors to automatically engage or disengage based on predetermined temperature levels calibrated specific to each area they are applied.
Additionally, a small network of openly suspended resistors mounted internally near the critical components of the payload will be controlled by the same thermistor data received by the Arduino Mega and relays to help keep ambient power and computer compartment temperatures at a manageable level. A key benefit of placing critical systems deep inside the payload allows for a significant amount of shielding against the elements and harsh temperatures.

2.7.3 - Solution Thermal Control

A critical part of the experiments performed and viable testing of our theory relies on the use of a liquid calcium carbonate solution. As outlined in section 1.3, the solution is a mix of salt water, propylene glycol, and calcium carbonate. This mixture was chosen specifically to assist in lowering the freezing temperature. Additionally, a dedicated thermistor, heating pad, and insulation system attached to the entire delivery assembly will attempt to counteract the act of the solution freezing.

As a final safety precaution, the delivery assembly will be waterproofed by first segregating the system through the use of a 3d printed nylon barrier box, as well as wrapping the components in industrial waterproof plastic shrink wrap.

2.8 – Testing, Risk Assessment, & Fail Safe/Protection Systems

2.8.1 – Testing

Testing begins with 3D printing prototypes to reduce cost and increase the ease of the manufacturing process. The snorkel will be the first thing printed in PLA or ABS just to assure the interior dimensioning of the chamber is adequate to hold all bolt-on components. Any necessary modifications can be done via the modeling software and printed again until achieved results are observed. All potential flight hardware will be tested under a spectrum of thermal conditions using ovens and dry ice to simulate hot and cold conditions respectively. College of the Canyons possesses a small vacuum chamber which will be used to test the workings of the payload at altitude. Any component that fails to meet the minimum expectations for each test will be redesigned and or replaced with and equal or better replacement. Testing will be ongoing and imperative to the success of the payload and the experiment.

2.8.2 – Risk Assessment

The primary risk of our experiment regards the failure of the spectrometers to produce adequate data. Although we expect the spectrometers to offer a broad enough ranges in which to conduct our experiment only through extensive simulated testing will we determine the efficacy of this particular method to collect all necessary data. Because of this, we have devised a cou0ple of contingency plans:

1. Use gas sniffer sensors in place of spectrometers to detect the presence and concentration of stratospheric pH levels. The gas sniffers are much smaller and focus more on the detection of singular substances such as HCL or NO2. They provide digital feedback in which data can be logged to the flight computer which can then be extrapolated and compared to a set control to see if the experiment was successful. The only reason this method isn't the principle of operation is because our team wanted the potential for more versatility in the type of data we could collect over a much larger spectrum. It is however an option in case testing proves the spectrometers to be inadequate for the objectives at hand.

2. The second option revolves around using a suite of smaller on board sensors connected directly to the Arduino flight computer which will log various atmospheric values that aren't

concerned with pH concentration. The payload's onboard filter and solution will take care of the experiment and scientific data will be collected for extrapolation once the payload is received after flight. A physical sample will be produced and after clean room extraction can be sent to localized universities or institutions to run post-flight analysis on. The collected data will be used to produce a picture of the flight's environment and allow hypotheses to be developed in conjunction with any data collected from the investigation of the physical sample.

The team has provided as much research and insight into the spectrometer as possible and deem it to meet the criteria for successful execution of our needs. However these contingency plans stand by on the occasion that our system needs to undergo any modifications regarding the failure of principle operations.

2.8.3 – Fail safes & alarms

In order to protect the payload, systems, and the HASP gondola, several warning and maximum tolerance routines based from passive sensor data will allow the Flight computer and the team to respond to situations that are deemed outside of operational limit. The Flight computer itself will be slaved to these routines so that in the unlikely event humidity, current, or temperature limits are exceeded, it will be able to respond either through a complete shutdown of all payload systems. Additionally, data on sensors that are in the warning or over limit modes will be reflected in the serial downlink information in binary code for the team to view in real time. A reset command will be available through the HASP uplink to continue with the flight should review determine the event was a false alarm or non-consequential event.

Physical protection of the payload is provided in several ways, as detailed through the use of a PTC (Section 2.3.2), Experiment and Solution chamber emergency pressure vents (Sections 2.2.4 and 2.8.4) , protecting the payload against moisture (section 2.7.3), and shielding electronics (Section 2.8.5)

2.8.4 - Solution Pressure Management and Protection

To protect the solution and payload against the pressure changes accounted for in flight, several solutions were implemented. As outlined in section 1.3, the solution mixture contains 50% saline water, 25% propylene glycol, and 25% calcium carbonate. This subsequently helps to protect the solution from increased boiling or freezing rates and allowing it to remain liquid in the confines of the container and delivery assembly. Pressurizing the solution container was deemed by the team as unacceptable per HASP guidelines.

Extensive testing will be implemented with College of the Canyon's pressure chamber to observe the effects of the proposed solution at the various pressures that will be encountered during flight. Current measurements show that at a state pressure of 1 millibar (the minimum amount of pressure expected to be encountered on the flight), pure water boils at a temperature of -28.797°C. The temperature extreme of the flight is expected to range from an average -51°C at Tropopause to a maximum of approximately -15°C at the top of the stratosphere. As experiments will take place at the float altitude of the balloon and inside of the isolated experiment chamber, by keeping the temperature of the solution between 1 and 10°C through the use of the payloads active and passive temperature controls and solution mixture, it is believed the solution can remain stable and protected from atmospheric pressure.

If the solution ultimately cannot be controlled in such environments and stability cannot be determined, the system can easily be removed and a backup plan to using solely a pre coated filter to deliver a calcium carbonate solution can be implemented.

2.8.5 - Shielding and Electrical Protection

Shielding of critical sensors such as the payload thermistors will be accomplished through the use of either nonflammable electromagnetic field shielding paint such as Air Pure (Zero VOC) RF Shielding Paint or application of copper mesh walls around the devices requiring protection. To prevent electricity from jumping across the payload, heat shrink tubing or polyolefin wrap to insulate devices from one another and provide significant shielding and electrical protection properties.

Fig 2.8.5A – Shielding paint

3 - HASP Interface & Integration

3.1– Serial Data Downlink

Data downlink will be performed with the RS232 by using 2 separate data packet protocols to reduce overall Bytes due to the lack of need for scientific data versus crucial flight and systems monitoring data.

Packet 1 consists of various flight and systems monitoring data such as temperature, humidity, altitude, current, voltage, and status information. Packet 1 will be controlled autonomously by the Arduino Mega which will initiate transmission of the data at a rate of once per minute. The total amount of bytes for Packet 1 is 63 which when calculated with HASP documentation stating a max Bps of 1 Byte/8.3ms (Offset to 9ms to account for latency) results in packet transmission total time of ~.567 seconds.

Packet 2 consists purely of Spectrometer data results in the 350-800 nanometer wavelength range. Packet 2 will only be transmitted upon a serial uplink command of several predetermined commands, whereupon the Arduino Mega will halt any transmission of Packet 1 for the duration of transmission of Packet 2 before reverting back to normal operating transmission. The Arduino Mega will interpret the data results of the Spectrometers in flight before converting it into a bit string corresponding to every tenth of a nanometer wavelength encountered, along with removal of the hundredth value (Ex: 35, 36, 37, etc). Additionally, to prevent the need for extraneous dataset transmission such as percentages, levels, and values, the commands given to the Arduino will be processed with predetermined analysis limits of these datasets to allow the team a range of measurements without the need to receive them at ground. An example would be the command S3, where only overall wavelength values exceeding 50% will be translated into a wavelength value other than 00. Table 3.2A lists the available commands to the team. This is purely to reduce the amount of data in packet 2 being sent and for real time analysis attempts. The payload's onboard data logger will store much more complicated data for later ground analysis and will provide a better resolution. The team will be able to interpret this data packet from a base station table which should allow for air sample measurement in real time. Recording will be done manually based upon measurements from the automated data packets to eliminate the need for timestamps and other data, reducing the overall bit size even further. The total amount of bytes for Packet 2 is 92 which when calculated with HASP documentation stating a max Bps of ~1 Byte/8.3ms (Offset to 9ms to account for latency) results in packet transmission total time of ~.828 seconds

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PACKET 1

Byte no.	No. of Bytes	No. of Bits	Title	Description ***Note - In Examples, parenthesis are provided for clarification purposes only. Data packet omits special characters such as hyphens, commas, and decimals to reduce total bits/bytes**
1	1	8	Header_1	1-byte header indicating the start of a data packet. Character used is <
2-9	8	64	Counter	States the number of packets sent since program start / Ex: 00000001
10-15	6	48	Timestamp	Hour, minute, and second / Ex:12(hr)30(min)00(sec)
16-18	3	24	Current_Draw	System current draw in mA / Ex:250
19-22	4	32	Ambient_Pressure	Absolute pressure in mmHg (Torr) / Ex: 750(.)0
21-25	3	24	Ambient_Humidity	Relative Humidity in RH% / Ex: 10(.)5
26-28	3	24	Light_Sensor	Ambient light levels of experiment chamber in % / Ex: 70(.)5
29-31	3	24	Exp_Temp	Experiment Chamber ambient temperature in C / Ex: 20(.)5
32-34	3	24	Internal_Temp	Internal Computer/Power bay ambient Temperature in C / Ex: 30(.)5
35-37	3	24	Intakefan_Temp	Intake fan Temperature in C / Ex: 10(.)5
38-40	3	24	Delivery_Temp	Solution Delivery assembly average Temperature in C / Ex: 40(.)5
41-45	5	40	Alt_data	Altitude measurement in meters / EX: 12345
46	1	8	RHAlarm_Trig	Binary indicator of the humidity alarm trigger
47	1	8	CurrentAlarm_Trig	Binary indicator of the current alarm trigger
48	1	8	Intake_on	Binary indicator of the intake fan and valve
49	1	8	Mister_on	Binary indicator of solution pump
50	1	8	Intake_on	Binary indicator of intake fan and valve

51-58	8	64	Data_Logged	Records no. of packets logged by data logger / ex 0000001
59-60	2	16	Last_Command	last serial uplink command received 00 = none Ex: IO (Intake on)
61	1	8	Command_Status	Binary commanded process status 0=idle/finished ,1 in progress
62	1	8	Last_Discrete	last discrete command received 0 = none Ex: F
63	1	8	Footer_1	1-byte Indicating the end of a data packet Character used is >
	63	504	TOTALS	

PACKET 2

Byte no.	No. of Bytes	No. of Bits	Title	Description *Note - In Examples, parenthesis are provided for clarification purposes only. Data packet omits special characters such as hyphens, commas, and decimals to reduce total bits/bytes
1	1	8	Header_2	1-byte header indicating the start of a data packet. Character used is <
2-90	90	720	Spec_wave	Wavelength spectrometer data in 10's, minus hundredth value. of nanometers (350-800 range) / Ex: 3500360037etc Note: To save data, only one spectrometer will be run at a time.
1	1	8	Footer_2	1-byte Indicating the end of a data packet Character used is >
	92	736	TOTALS	

-Packet Examples-

Packet 1

<0000001123000750010520530510540512345000000000010000>

(Interpretation: Packet start, 1 packet sent, time is 12:30 (24hr format), current, pressure, humidity, light, experiment chamber temp, Computer/Power bay temp, Intake fan temp, Assembly temp, Altitude measurement, binary humidity, current, intake, pump, no of packets logged, last uplink command received, command status, discrete command received, end packet)

Packet 2
<35360038394000004344450000000050510053540056570000000000636465666000000071000074750077000080>
(Interpretation: Packet start, wavelengths displayed in range of specified analysis as corresponding number and 00 as absent, end packet)

3.2– Serial Data Uplink

Primary control of the payload for troubleshooting, initiating scientific experiments, and general operation of certain systems will be provided through the serial data uplink. By allowing the ground team to retain control of certain operations and processes of the payload, the risk of an automated error during key areas of the flight will be negated, while also giving the team a way to flexibly respond to continuously changing flight conditions. The primary commands of the uplink will mainly be used to activate or deactivate the controlling solid state relays for various mechanical systems, overriding perceived false sensor warnings or auto shutdowns, and performing spectography experiments.

Table 3.2A – Uplink Commands

2-Byte Command	Name	Function
RS	Reset	Payload Flight computer reset
IO	Intake_On	Communicates with the flight computer to power the intake system
IC	Intake_Off	Communicates with the flight computer to shut down the intake system
RF	Fan_reverse	Reverses spin of intake fan to vent or cycle chamber air
VO	Valve_open	Opens intake separate from the IO command for venting or cycle purposes
VC	Valve_close	Closes intake separate from the IO command for venting or cycle purposes
PO	Start_pump	Communicates with the flight computer to activate the pump system and begin a mister routine (Routine auto terminates pump after 1 second)
OH	Humidity_Overide	Overrides the humidity sensor warning system shutdown
OC	Current_Overide	Overrides the current sensor warning system shutdown

SD	Shutdown_all	Power down *all* systems, places flight computer on standby
S1	Spec_1	Communicates with flight computer to begin then transmit spectrograph data routine 1: Analysis of all wavelengths *present*
S2	Spec_2	Communicates with flight computer to begin then transmit spectrograph data routine 2: Analysis of all wavelengths *absent*
S3	Spec_3	Communicates with flight computer to begin then transmit spectrograph data routine 3: Analysis of wavelengths *above* 50%
S4	Spec_4	Communicates with flight computer to begin then transmit spectrograph data routine 4: Analysis of wavelengths *below* 50%
S5	Spec_5	Communicates with flight computer to begin then transmit spectrograph data routine 5: Analysis of wavelengths *above* 25%
S6	Spec_6	Communicates with flight computer to begin then transmit spectrograph data routine 6: Analysis of wavelengths *below* 25%
S7	Spec_7	Communicates with flight computer to begin then transmit spectrograph data routine 7: Analysis of wavelengths *above* 75%
S8	Spec_8	Communicates with flight computer to begin then transmit spectrograph data routine 8: Analysis of wavelengths *below* 75%
S9	Spec_9	Communicates with flight computer to begin then transmit spectrograph data routine 9: Analysis of wavelengths *above* 1PPm
S10	Spec_10	Communicates with flight computer to begin then transmit spectrograph data routine 10: Analysis of wavelengths *below* 1PPm
S11	Spec_11	Communicates with flight computer to begin then transmit spectrograph data routine 11: Analysis of wavelengths *above* .5Ppm
S12	Spec_12	Communicates with flight computer to begin then transmit spectrograph data routine 12: Analysis of wavelengths *below*.5PPm
S13	Spec_13	Communicates with flight computer to begin then transmit spectrograph data routine 13: Analysis of wavelengths *above* 1PPb
S114	Spec_14	Communicates with flight computer to begin then transmit spectrograph data routine 14: Analysis of wavelengths *below* 1PPb
S15	Spec_15	Communicates with flight computer to begin then transmit spectrograph data routine 15: Analysis of wavelengths *above* .5Ppb
S16	Spec_16	Communicates with flight computer to begin then transmit spectrograph data routine 16: Analysis of wavelengths *below* .5PPb

3.3 Analog Data Downlink

The analog data downlink available on the HASP Gondola will be used as confirmation for temperature data on the flight computer as well as confirmation that the delivery assembly pump is in the off position after completing the routine. This is monitored to prevent damage to both systems and the payload.

Analog Pin	Reading Type	Voltage	Purpose
(#1) K	Thermistor Temperature	0-5VDC	Temperature of the flight computer
(#2) M	Solid State Relay status	0-5VDC	Status of delivery assembly pump

3.4 Discrete Signals

In the event of loss of serial data communication, discrete signals will be used as a fail-safe system to deactivate or reactivate the payload. This discrete signal can be sent by HASP personnel by way of a 10k pull-up resistor attached to the flight computer, which receives this command to perform the same routine used with the uplink command SD for deactivation or RS to reactivate the payload.

Discrete Pin	Function
(#1) F	Shut all systems down, flight computer enters standby
(#2) N	Reset the flight computer and enter ready mode

4 - Personnel

4.1 - Team Structure

A strong team dynamic completed with passionate and devoted student makes up Team SOLARIS, 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. Patrick Gagnon is the project manager, returning for his third year participating in the HASP program. He was the mechanical lead for College of the Canyons in 2016 and chief engineer in 2017 for a payload whose primary objective was to collect IDPs from the stratosphere. Hunter Napier will be serving as chief engineer and has extensive background knowledge in electrical systems. He works closely with the project manager to oversee the development and operations of the payload.

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. The Systems Team is responsible for the seamless integration of many of the payload's components and ensures they all work in conjunction with one another. Members must be willing to be familiar with all areas and developments of the project and keep track of the payload through its development. The Chemical Team is responsible for providing research towards the reactions of the acid particulates with the solution and the analysis of the results.

The Chief Engineer will work closely with SOLARIS' electrical team which is responsible for producing electrical systems and relaying power to all components. It will typically include soldering, crimping, a working knowledge of circuitry and the ability to problem solve with power related issues. Our Software Team is responsible for writing the code that controls the operation of various components of the payload. Members should be familiar with certain languages and know how to write basic programs. The team lead will become familiar with HASP's interface and operations to assure the success of the team's payload. Finally, the Mechanical Team is responsible for the design, integration, manufacturing, and testing of all mechanical and structural systems. Experience will be introduced through the Mechanical Advisor who the team will work with daily. No team leadership positions have been filled yet though the potential will increase as the team grows through the next wave of recruiting which is slated to begin in February of 2018.

Team Dynamic Flow Chart

Name	Role	Email	Phone
Patrick Gagnon	**Project Manager**	**pwgagnon@my.canyons.edu**	**(661) 666-0278**
Hunter Napier	**Chief Engineer**	**hunternapier@gmail.com**	**(661) 706-2859**
Teresa Ciardi	**Logistics Adviser**	teresa.cirdi@canyons.edu	(661)-313-6015
Greg Poteat	**Mechanical Adviser**	**gregory.poteat@canyons.edu**	**(661) 670-9108**
Systems Team			
Phillip Bonnell	**Member**		
Minerva Cardoza	**Member**		
Daniel Tikhomirov	**Consultant**		
Kyle Strickland	**Member**		
Chemical Team			
Phillip Bonnell	**Member**		
Arthur Berberyan	**Member**		
Electrical Team			
Daniel Tikhomirov	**Consultant**		
Raul Venegas	**Member**		
Richard Lopez	**Member**		
Software Team			

Hunter Napier	**Consultant**		
Raul Venegas	**Member**		
Brandon Gelfand	**Consultant**		
Mechanical Team			
Patrick Gagnon	**Consultant**		
Hunter Napier	**Member**		
Raul Venegas	**Consultant**		
Daniel Tikhomirov	**Consultant**		

SOLARIS Team Dynamics. Table will be updated as roles solidify and team leads named.

5. - Preliminary Integration and Flight Operation

5.1 Preliminary Integration

The team will plan to ship a fully assembled and tested payload to CSBF prior to traveling there for integration in August. 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 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 SOLARIS 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 Friday which will either clear or ground the payload for final flight.

5.2 – Preliminary Flight Operations Plan

The morning of launch no less than two members from Team SOLARIS will be awake and cooperating with HASP personnel. 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 approximate 24 hour 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 hypothesis 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 remained 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.

6 – Miscellaneous Documentation

6.1 – HASP Required Documentation

Section left open for Documentation as required

6.2 – Emergency Contact Information

Patrick Gagnon	**661-666-0278**
Hunter Napier	**661-706-2859**
Teresa Ciardi	**661-313-6015**

6.3 – Form Copies

Section left open for Documentation as required

7 - Diagrams

***All dimensions in centimeters unless otherwise specified**

7.1.1 - Payload Isometric View

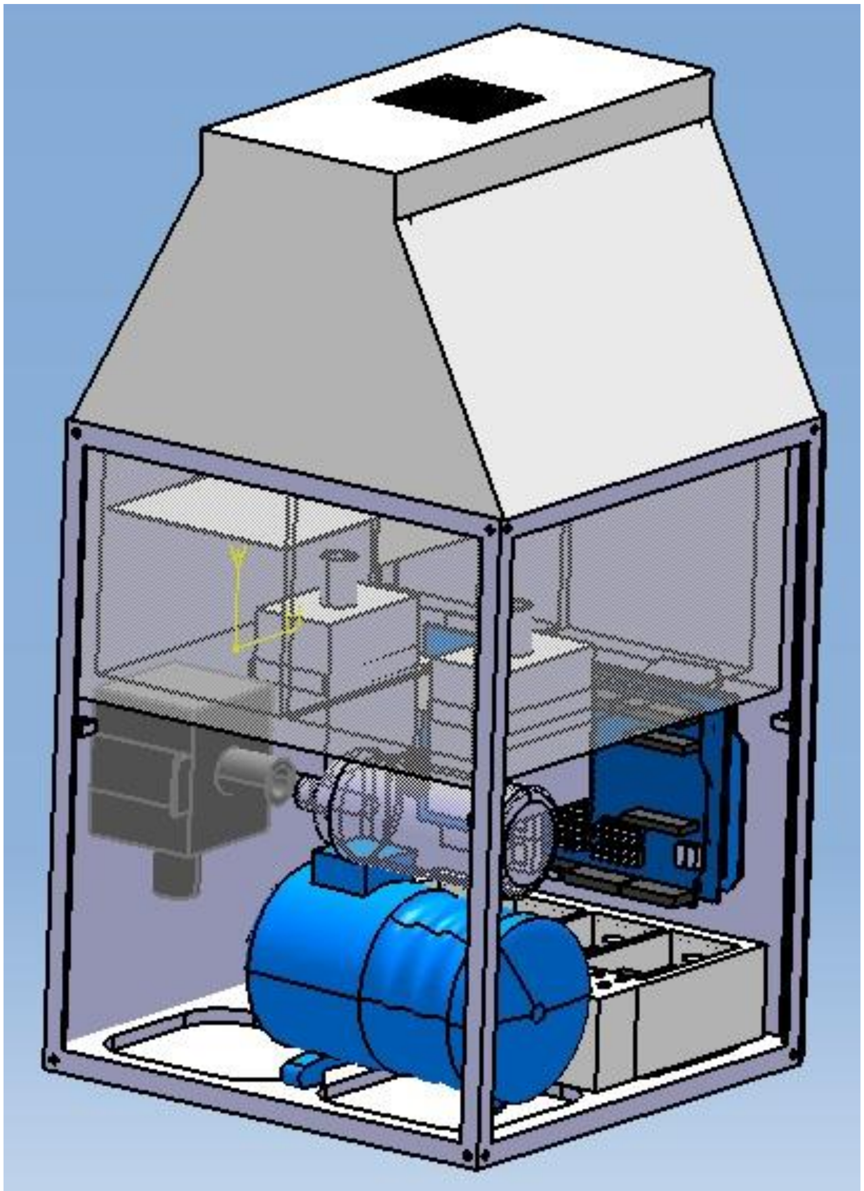
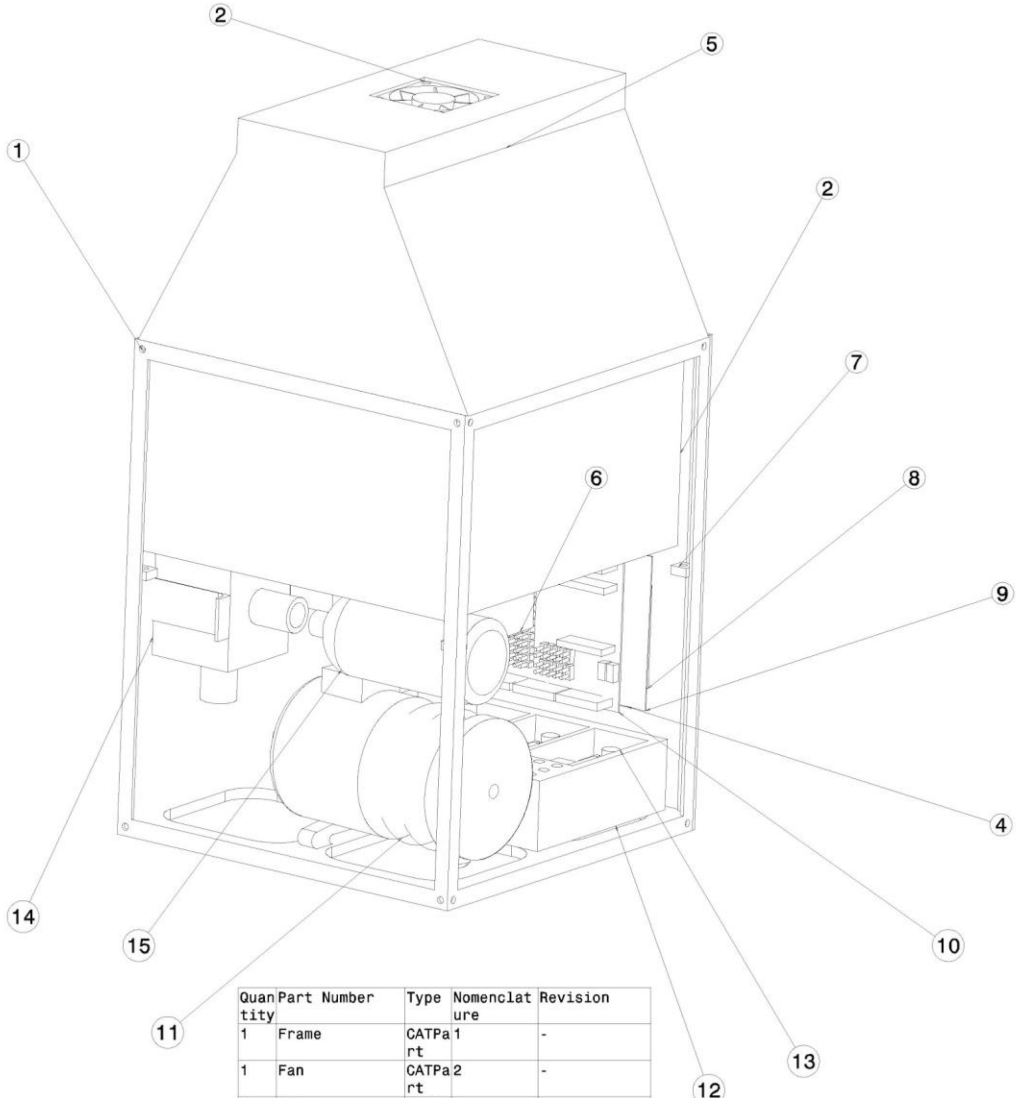


Figure7.1.1A - Isometric View - Internals exposed

7.1.2 - Bill of Materials Drawing



Quantity	Part Number	Type	Nomenclature	Revision
1	Frame	CATPart	1	-
1	Fan	CATPart	2	-
1	Valve	CATPart	3	-
1	Flight Computer Mount	CATPart	4	-
1	Intake	CATPart	5	-
2	Spectrometers	CATPart	6	-
4	Side Panels	CATPart	7	-
1	Arduino mega	CATPart	8	-
1	SD card shield	CATPart	9	-
1	Sensor shield	CATPart	10	-
1	Light Source	CATPart	11	-
1	Power box	CATPart	12	-
4	Regulators	CATPart	13	-
1	Pump	CATPart	14	-
1	Solution Container	CATPart	15	-

Isometric view
Scale: 2:1

Figure7.1.2A - Isometric drawing and bill of materials

7.1.3 - Fully Enclosed and Exploded Views

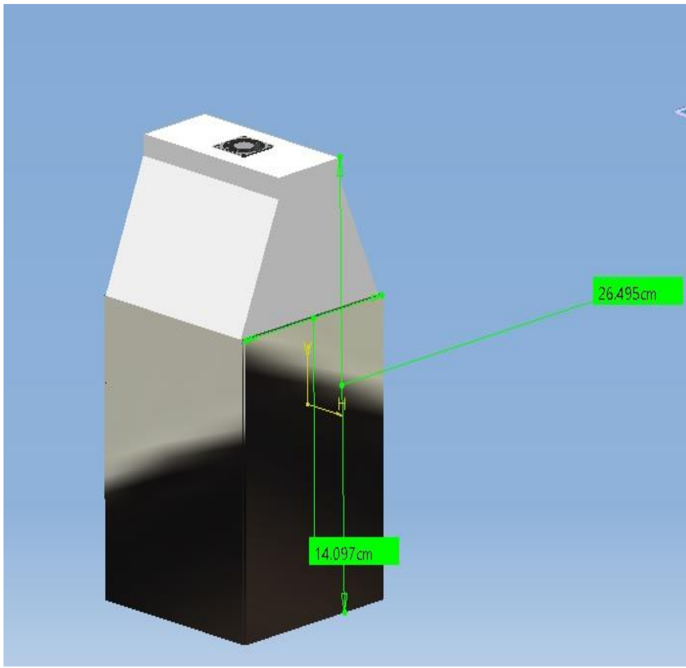


Figure 7.1.3A - Enclosed Isometric view

Figure 7.1.3B - Exploded Isometric View

7.1.4 - Full Payload Dimensional Drawing

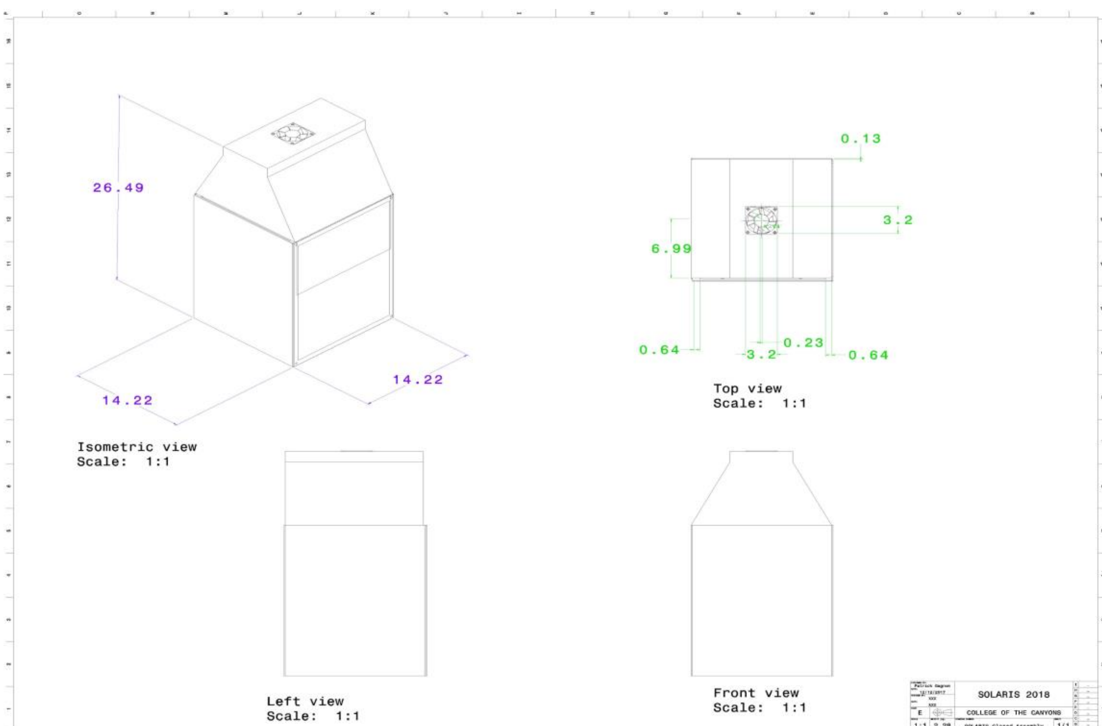


Figure 7.1.4A - SOLARIS Assembly Drawing

7.1.5 Payload Overlay with HASP Integration Plate

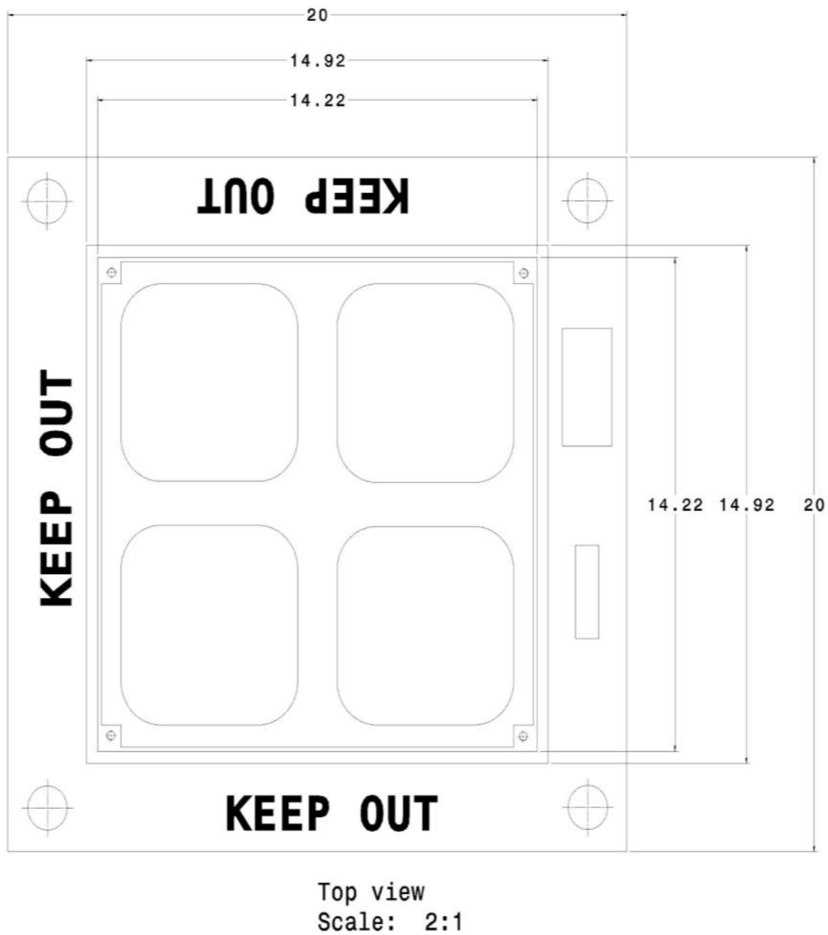


Figure 7.1.5A **-** This diagram shows the maximum footprint of the payload and where it fits in reference to the HASP integration plate.

7.2 - Mechanical Systems

7.2.1 Frame

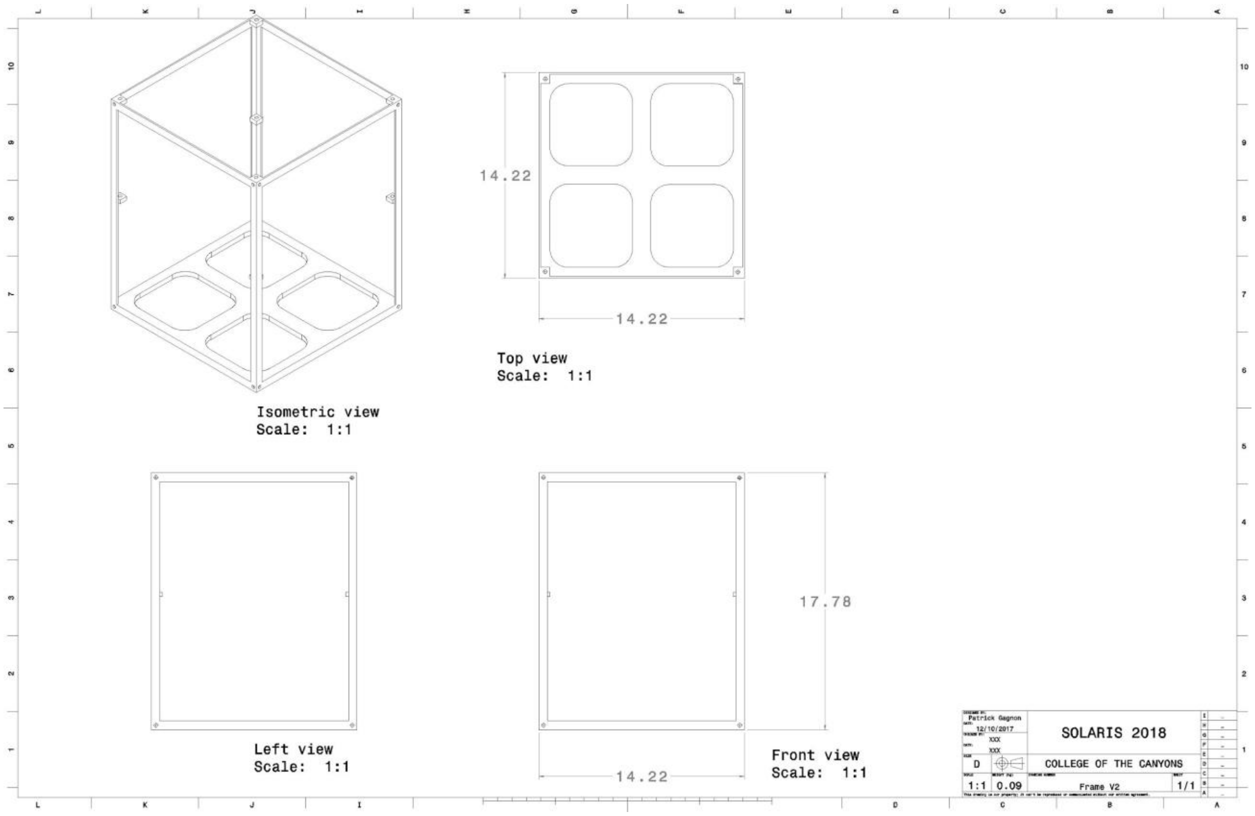


Figure 7.2.1A - Frame Drawing

7.2.2 Intake Assembly

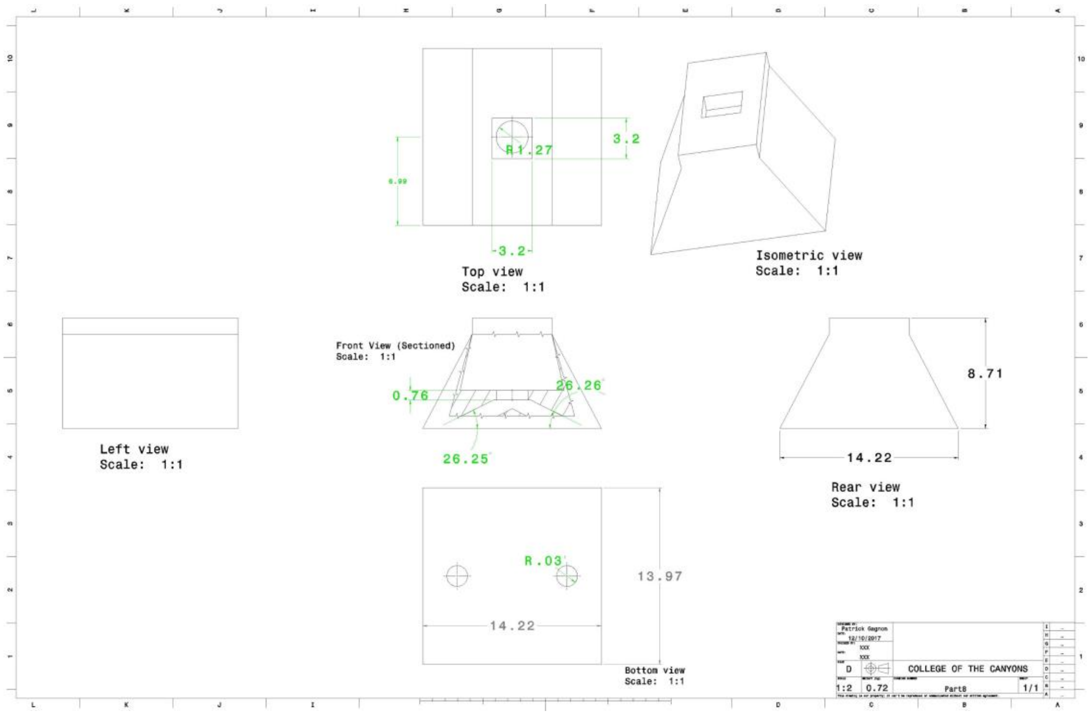
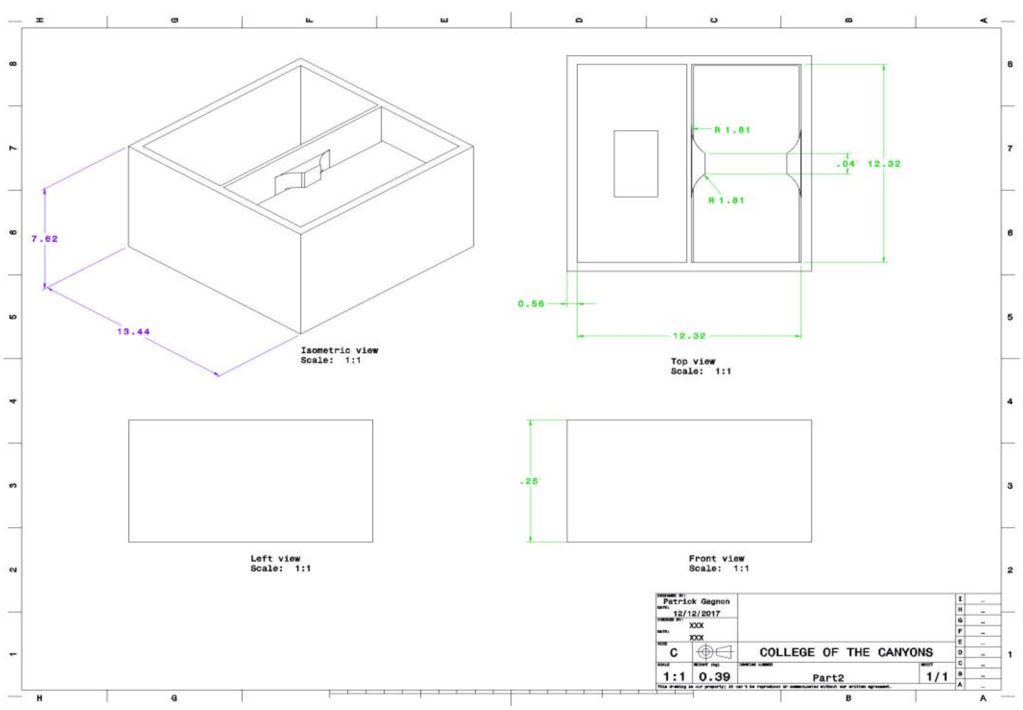


Figure 7.2.2A - Intake Drawing

7.2.3 Experiment Chambers



7.2.4 - Agent Delivery Assembly

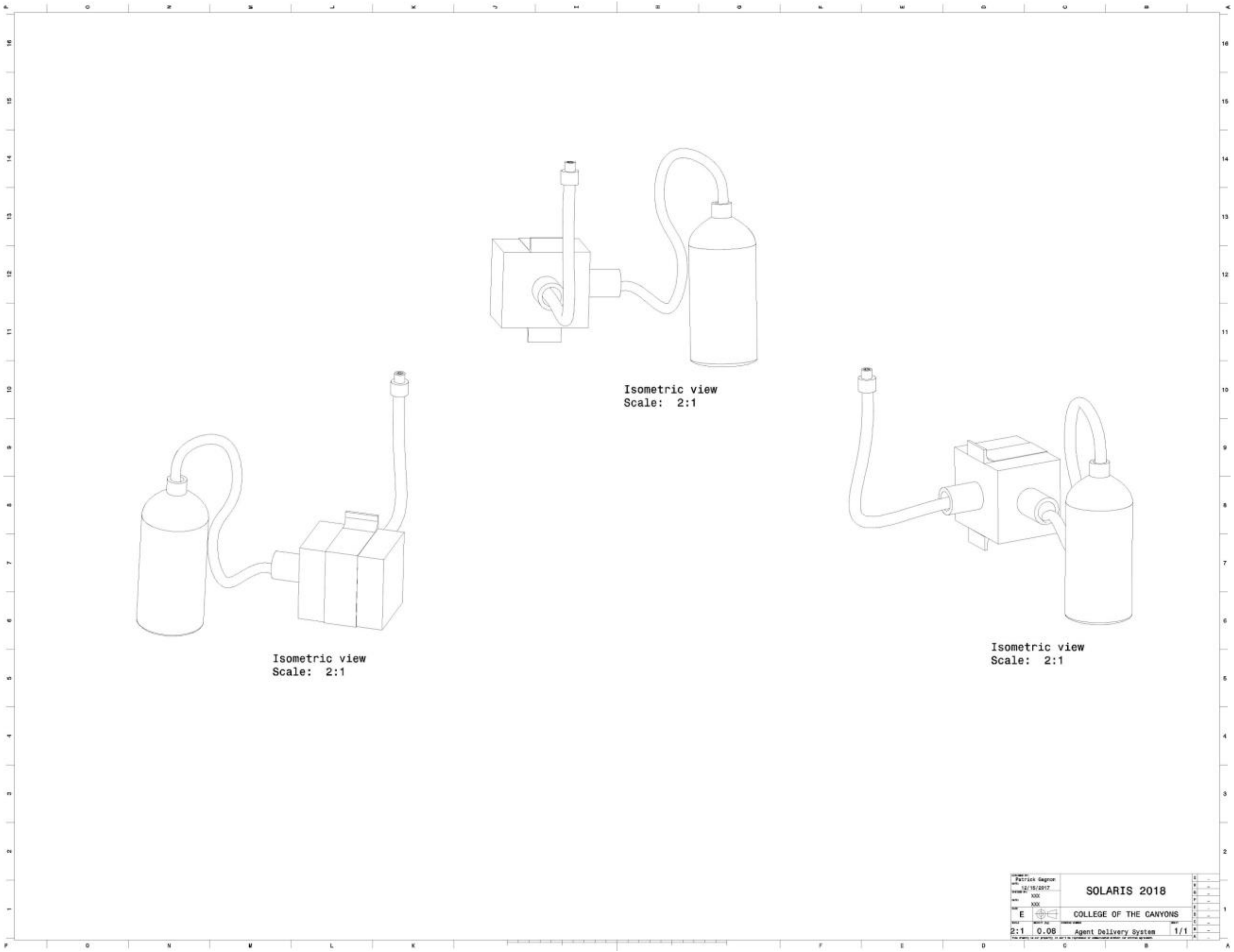
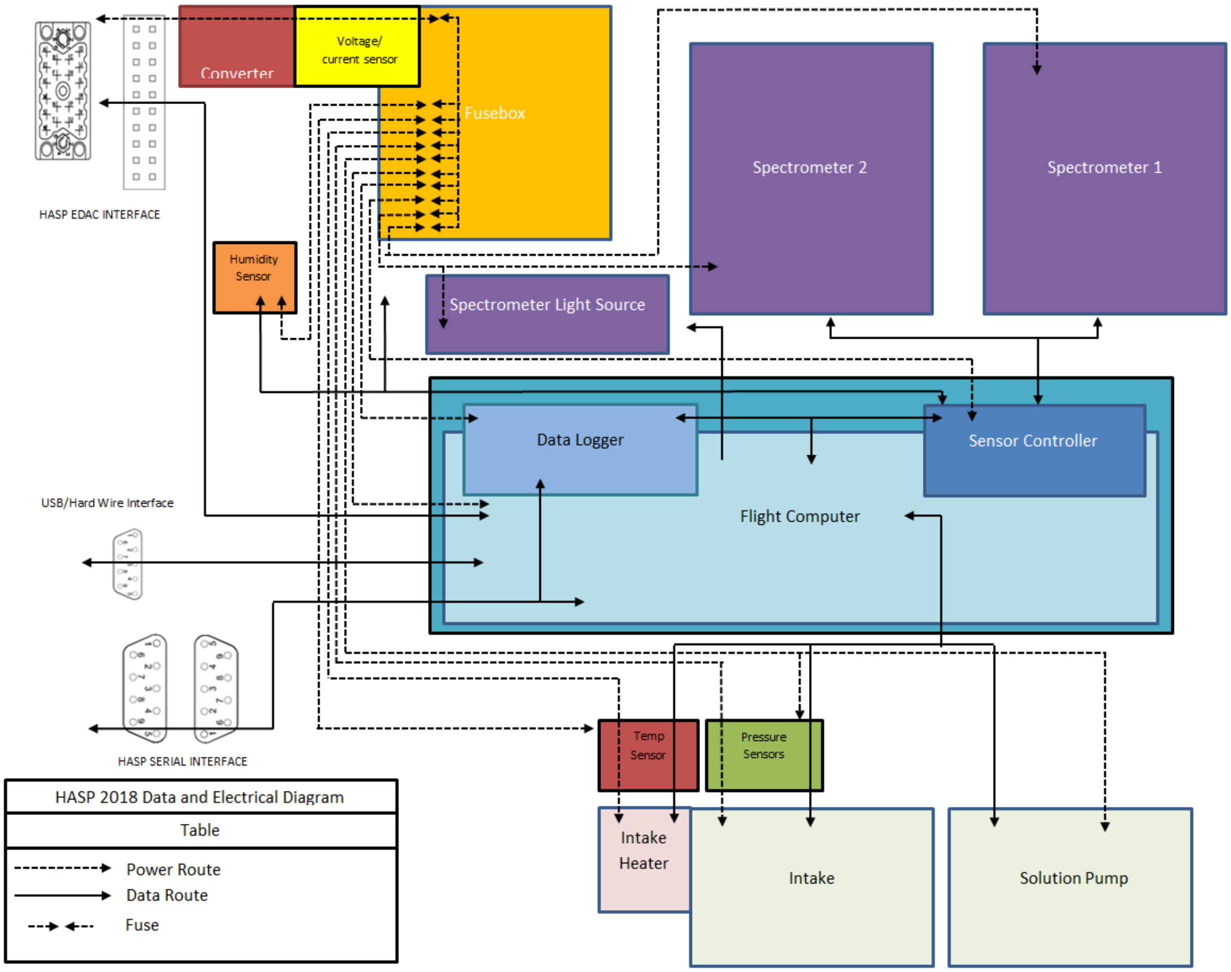


Figure 7.2.4A - Agent Delivery System Drawing

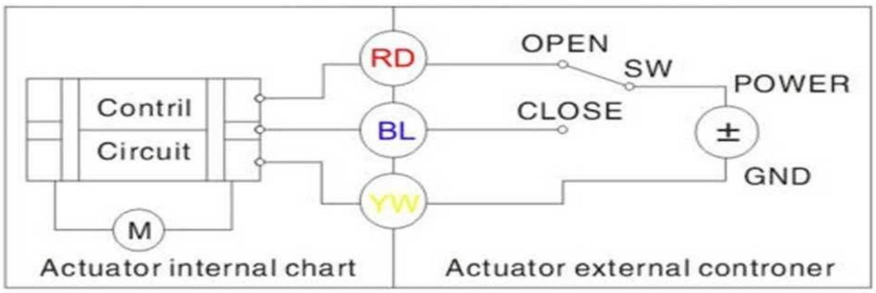
7.3 - Electrical and Power management systems

7.3.1 - Power Assembly



7.3.2 - Valve Electric Schematic

CR-02.



When RD & SW connected,the valve open,the actuator automatically power off after in place , valve remains fully open position

When BL & SW connected,the valve closed,the actuator automatically power off after in place, valve remains fully closed position.