HASP Student Payload Application for 2015

Payload Title: Solar Ultraviolet Radiation Measurement Apparatus (SURMA)		
Payload Class: (check one) ☐Small ☒Large	Institution: Louisiana State University	Submit Date: December 19, 2014

Project Abstract

The goal of the Solar Ultraviolet Radiation Measurement Apparatus payload is to measure UVA, UVB, and UVC irradiance as a function of altitude, with emphasis on the transmission of UV radiation above the stratosphere. Previous Louisiana State University UV measurement payloads featured fixed pointing angles. However, due to rotation of the HASP gondola, the sensors observed solar UV flux at non-optimum angles. This payload will include UVA, UVB, UVC, and broadband UV measurement photodiodes, data acquisition systems, and a solar tracking system. The solar tracking system will maximize the collected UV radiation by ensuring that the sensors remain directed at the sun for the duration of the flight.

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Solar Ultraviolet Radiation Measurement Apparatus

(SURMA)

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December 19, 2014

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1.0 Payload Goals and Objectives

1.1 Background

Ultraviolet radiation is light with a wavelength from 100 to 400 nm. It lies between the visible light spectrum and X-Rays. Its spectrum is broken down into several ‘bands’: The UVA band ranges from 400-320 nm, the UVB band ranges from 320-280 nm, and the UVC band ranges from 280-100 nm. As shown below, each band is transmitted differently through the atmosphere.

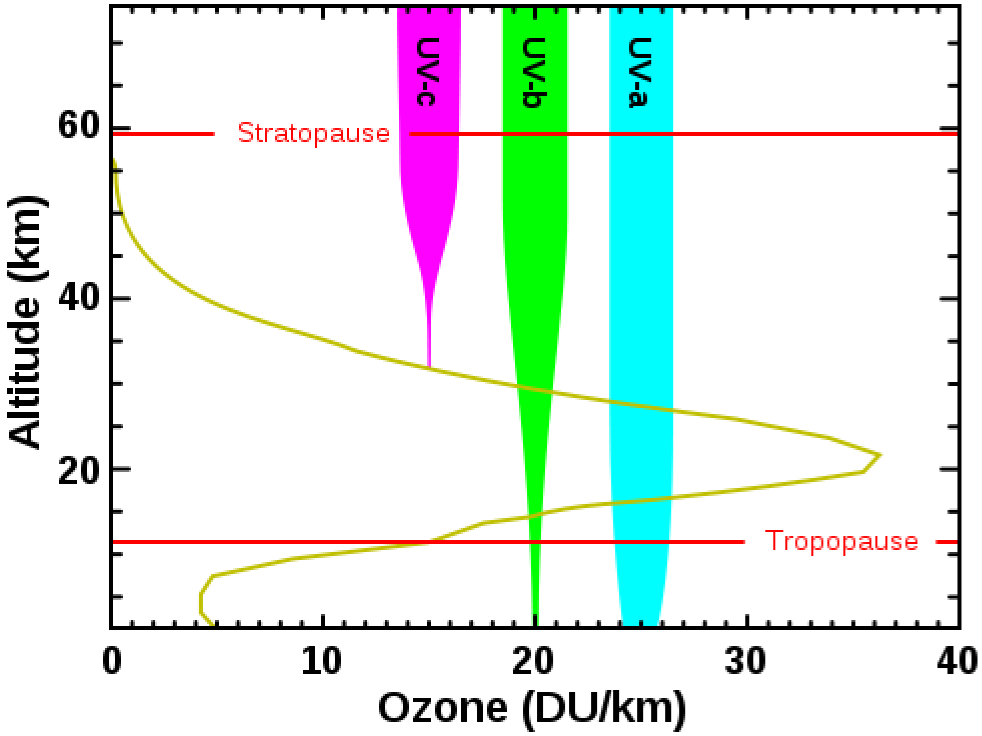

Figure 1: Depiction of UV transmission through the atmosphere [1]

UVA is the lowest energy band, and almost completely passes through the atmosphere. It has negligible effects on organic material. UVB has a higher energy than UVA, but experiences significant attenuation as it passes through the ozone layer. Extended exposure to UVB causes sunburns and some genetic damage. UVC is the highest energy UV band, and is completely absorbed by the ozone layer. Almost no UVC is present below ~30 km altitude. Exposure to UVC rapidly burns the skin and causes significant genetic damage. [2][3]

In 2011, LSU tried to measure UV irradiance in the atmosphere on HASP using a fixed-angle measurement platform. The fixed-angle approach made it difficult to obtain accurate readings from the UV measurement photodiodes because photodiodes exhibit a characteristic response curve based on the angle of incidence of incoming light. As the HASP gondola rotated, the Sun was driven in and out of the peak response area of the photodiodes. This project seeks to create a more accurate model of UV transmission in the atmosphere by using a two-axis solar tracking system to keep the UV sensors pointed at the Sun at all times.

Expected Results

The team was unable to find published, directly measured UV irradiance values in the atmosphere. In order to determine expected results, the team will draw on two credible UV measurement and simulation platforms:

> **SMARTS [4]:** Developed by the National Renewable Energy Laboratory, this program simulates the transmission of UV radiation through the atmosphere. It is capable of calculating expected direct-incidence irradiance values for the UVA + UVB bands on a wide range of atmospheric conditions (i.e. pressure, humidity) at almost given altitude.
>
> **Ultraviolet Radiation in the Upper Atmosphere (URUA) [5]:** This 2011 HASP payload was developed in conjunction with SMITH (payload no. 11). The payload measured UVA, UVB, UVC, and broadband UV irradiance through the entire HASP flight profile. However, the results are sub-optimal. The payload sensors were mounted at a fixed angle, thus were subject to the rotational motion of the HASP gondola and the Sun's movement across the sky.

The measurements from URUA were cross-correlated with the simulated values from SMARTS. The two data sources matched fairly well in terms of magnitude of direct-incidence UV irradiance for the UVA and UVB bands. SMARTS is unable to simulate the UVC band. Despite the motion of URUA, it observed UVC irradiance above 30 km altitude. Taking into account off-nominal sensor angles, URUA provides us with a reasonable expected irradiance curve for the UVC band.

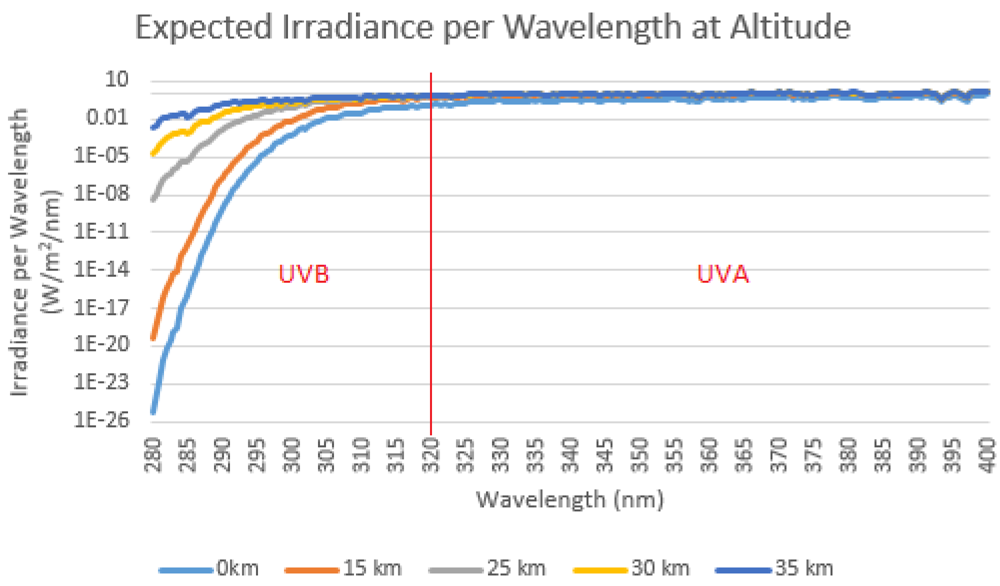

Figure 2: Expected irradiance per wavelength. Irradiance results calculated for 0, 15, 25, 30, and 35 km. Note that the magnitude of UVB is dramatically affected by the atmosphere at different altitudes. The magnitude of UVA remains fairly constant through the flight profile. Data computed using SMARTS.

Using this data, the team was able to calculate the expected irradiance per UV band by integrating the individual curves across each UV band. Computing these integrals yields the following values:

Band	0 km	15 km	25 km	30 km	35 km
UVB	0.046	0.236	0.548	0.807	1.123
UVA	3.361	7.521	8.251	8.407	8.488

Table 1: Computed per-band irradiance (W/m^2) at specified altitudes.

Per-band irradiance values are important because UV photodiodes are sensitive to wide ranges of input wavelengths, so these values represent actual expected sensor outputs at each altitude. Taking the difference between each consecutive altitude measurement and dividing it by two yields the minimum required UV sensor accuracies for each band and altitude.

Expected UVC band irradiance values are obtained from the URUA payload, shown below.

Band	0 km	15 km	25 km	30 km	35 km
UVC	-	-	-	0.001	0.005

Table 2: Measured UVC irradiance (W/m^2) at specified altitudes.

UVC is completely absorbed by the ozone layer. URUA was only able to detect UVC above 30 km. The team expects to see similar UVC readings on this payload.

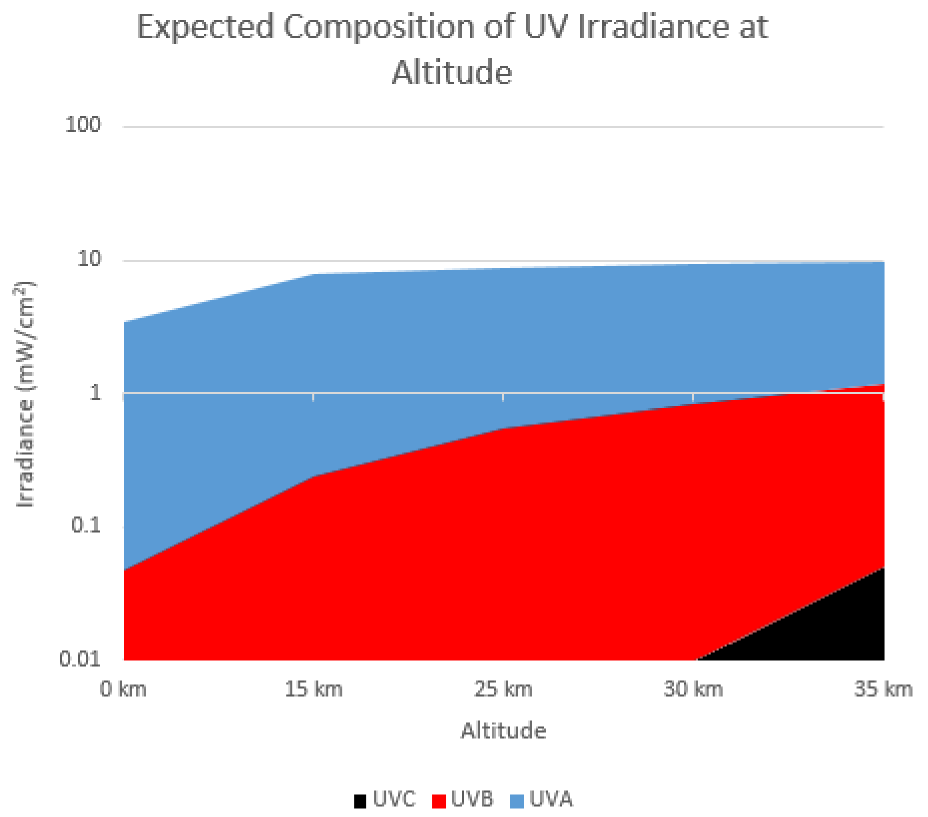

Figure 3: Expected irradiance per UV band. Note the emergence of UVC (black) at 30 km altitude. UVA (blue) and UVB (red) are present through the entire flight profile, although UVA has significantly higher flux in the same measurement area. (Source data from SMARTS simulations and URUA payload measurements.)

1.2 Payload Goals and Requirements

Zeroth Level Requirements

Level	Requirement	Derived
0	The goal of the Solar Ultraviolet Radiation Measurement Apparatus (SURMA) payload is to model the absorption of UV radiation by the atmosphere for the duration of the 2015 HASP flight profile.	Mission Goal

First Level Requirements

Level	Requirement	Derived
0.1	Observe the UV spectrum through the duration of the 2015 HASP flight profile.	Objective
0.2	Model the absorption of UV radiation by the atmosphere.	Objective

Second Level Requirements

Level	Requirement	Derived
0.1.1	Utilize a positioning and orientation device to locate the Sun and point SURMA in the direction of the Sun.	0.1
0.1.2	Meet all payload standards set by HASP management.	0.1
0.1.3	SURMA shall measure and record UVA, UVB, UVC, and broadband UV with respect to HASP vehicle position.	0.1
0.1.4	SURMA components shall operate throughout the flight profile.	0.1

Level	Requirement	Derived
0.2.1	Data shall be recorded for post flight analysis.	0.2
0.2.2	Plot UV irradiance (W/m^2) values as a function of altitude.	0.2
0.2.3	Compute the composition of broadband UV irradiance as a function of the individual bands (UVA/UVB/UVC) at different altitudes.	0.2
0.2.4	Compare results to those of SMARTS / URUA models to verify the recorded payload data.	0.2

Third Level Requirements

Level	Requirement	Derived
0.1.1.1	SURMA shall monitor the Sun's azimuthal orientation with respect to the payload.	0.1.1
0.1.1.2	SURMA shall be capable of keeping the Sun within the peak response region (>90% irradiance detection) of the UV sensors	0.1.1
0.1.1.3	SURMA shall be able to change its elevation angle through the HASP telemetry system.	0.1.1
0.1.1.4	SURMA shall have a method to enable manual override of its azimuthal rotation system.	0.1.1

Level	Requirement	Derived
0.1.2.1	SURMA shall weigh less than 20 kg.	0.1.2
0.1.2.2	SURMA shall be less than 30 cm tall.	0.1.2
0.1.2.3	SURMA shall fit within a 38 cm x 30 cm footprint.	0.1.2
0.1.2.4	SURMA shall accept an input voltage of 29-33 VDC.	0.1.2
0.1.2.5	SURMA shall draw less than 2.5 amps at all times.	0.1.2
0.1.2.6	SURMA shall not interfere with other payloads.	0.1.2
0.1.2.7	SURMA shall be capable of resisting the effects of 10G vertical force and 5G horizontal force.	0.1.2
0.1.2.8	SURMA shall not exceed a serial downlink speed of 4800 bps.	0.1.2
0.1.2.9	For serial communications, the payload shall communicate using the RS232 protocol over a DB9 connector.	0.1.2
0.1.2.10	The payload shall use an EDAC 516 interface with HASP for power transmission.	0.1.2

Level	Requirement	Derived
0.1.3.1	The payload shall have sensors to measure UVA (320 nm-400 nm), UVB (280 nm-320 nm), UVC (100 nm-280 nm), and broadband UV (100 nm-400 nm).	0.1.3
0.1.3.2	The payload shall have a method of determining its altitude.	0.1.3
0.1.3.3	The payload shall have a method of determining its latitude and longitude.	0.1.3

Level	Requirement	Derived
0.1.4.1	SURMA shall maintain a proper operational environment.	0.1.4
0.1.4.2	SURMA shall provide voltage regulation to generate the required component input voltages.	0.1.4

Level	Requirement	Derived
0.2.1.1	SURMA shall interface with HASP to transmit sensor values via its wireless telemetry systems to the HASP ground station for recording and post-flight analysis.	0.2.1
0.2.1.2	SURMA shall save sensor values into an onboard memory unit as a backup for post-flight analysis.	0.2.1

Level	Requirement	Derived
0.2.2.1	UV sensors shall be properly calibrated (i.e. have a method to convert raw values into irradiance).	0.2.2
0.2.2.2	The payload shall have a method to determine the altitude of each data point for post-flight analysis.	0.2.2

Level	Requirement	Derived
0.2.4.1	UV sensors shall be properly calibrated (i.e. have a method to convert raw value into irradiance).	0.2.4
0.2.4.2	The payload shall have a method to determine the GPS location of each data point for post-flight analysis.	0.2.4
0.2.4.3	Record a data point at 0 km, 15 km, 25 km, 30 km, and 35 km altitude to compare with SMARTS predicted UVA and UVB models.	0.2.4
0.2.4.4	Record a data point at 30 km, 31 km, 32 km, 33 km, and 34 km altitude to compare with URUA measured UVC data.	0.2.4
0.2.4.5	The UV Sensors shall have a high enough accuracy to be able to distinguish the data points at the required altitudes.	0.2.4

Fourth Level Requirements

Level	Requirement	Derived
0.1.1.2.1	The UV Sensors shall have a peak response region of at least +/- 15° off-nominal incidence.	0.1.1.2
0.1.1.2.2	SURMA shall be able to counteract at least 20° of HASP gondola azimuthal rotation per minute	0.1.1.2

Level	Requirement	Derived
0.1.1.3.1	SURMA shall have a system that monitors the HASP serial connection for commands	0.1.1.3 0.1.1.4
0.1.1.3.2	SURMA shall have a system that executes valid commands.	0.1.1.3 0.1.1.4

Level	Requirement	Derived
0.1.4.1.1	All components shall remain within operational temperature ranges for the duration of the flight.	0.1.4.1
0.1.4.1.2	The payload shall resist the effects of condensation during ascent.	0.1.4.1

Level	Requirement	Derived
0.2.4.3.1	The UVA+B sensors shall measure irradiance to an accuracy of +/- 20.8 W/m^2 at 0 km altitude.	0.2.4.3 0.2.4.5
0.2.4.3.2	The UVA+B sensors shall measure irradiance to an accuracy of -20.8 to +3.65 W/m^2 at 15 km altitude.	0.2.4.3 0.2.4.5
0.2.4.3.3	The UVA+B sensors shall measure irradiance to an accuracy of -3.65 to +0.78 W/m^2 at 25 km altitude.	0.2.4.3 0.2.4.5
0.2.4.3.4	The UVA+B sensors shall measure irradiance to an accuracy of -0.78 to +0.41 W/m^2 at 30 km altitude.	0.2.4.3 0.2.4.5
0.2.4.3.5	The UVA+B sensors shall measure irradiance to an accuracy of +/- 0.41 W/m^2 at 35 km altitude.	0.2.4.3 0.2.4.5

Level	Requirement	Derived
0.2.4.4.1	The UVC sensor shall measure irradiance to an accuracy of +/- .001 W/m^2 during the 30-35 km altitude regime.	0.2.4.4 0.2.4.5

2.0 Payload Systems

2.1 High Level Design

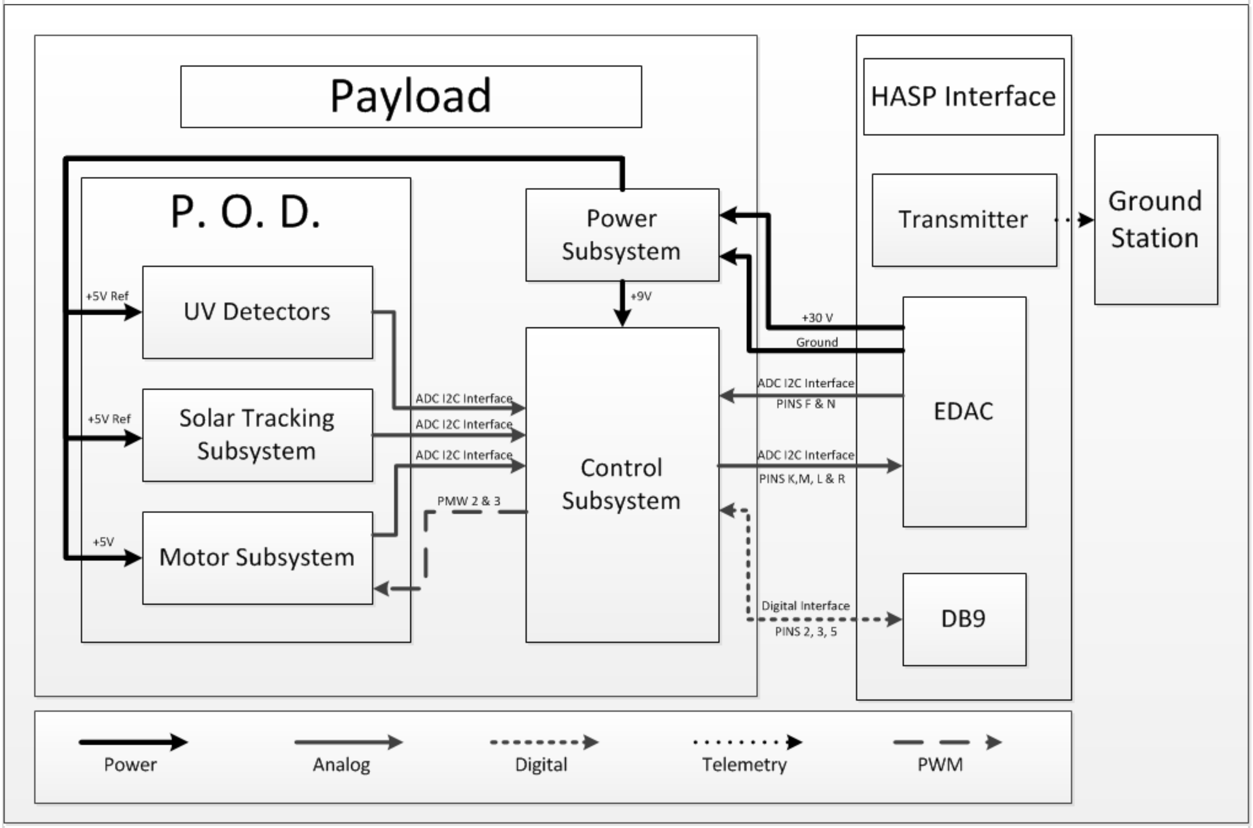

Figure 4: SURMA High Level System Design

In order to achieve its goals and objectives, SURMA will ensure that its UV detectors remain pointed at the Sun for the duration of the flight. The control subsystem will monitor the position of the Sun via solar tracking photodiodes mounted on the exterior of the payload structure, and will command an azimuthal control motor to make corrective turns toward the sun. Payload inclination angle will be controlled via uplink telemetry. This two-axis rotational control shall keep the UV detectors within their peak response regions. Once per second, the control subsystem will measure the UV irradiance and will transmit a data packet to the ground over the serial HASP interface. The electrical, mechanical, and software systems are described in more detail in the following sections.

2.2 Electrical Systems

UV Measurement Sensors

In order to measure UV irradiance in the atmosphere, SURMA will house four individual UV photodiodes (UVA, UVB, UVC, and broadband UV total). The team is currently considering the SG01 series photodiodes from Boston Electronics.

Figure 5: Image of an SG01 series UV photodiode

UV Photodiodes are usually connected in a reverse-biased configuration, as shown below. All PN junctions are sensitive to incident electromagnetic radiation. If a photon strikes a PN junction it creates a free electron within the junction. The built-in field of the depletion region applies a force on the free electron and sweeps it across the junction. This movement of charge is called a 'photocurrent', and is the basis of operation for light detection photodiodes [6]. The photodiodes for this project are composed of Gallium Nitride or Aluminum Gallium Nitride semiconductor PN junctions that are highly sensitive to sub-400 nm wavelengths. They will be connected as shown below.

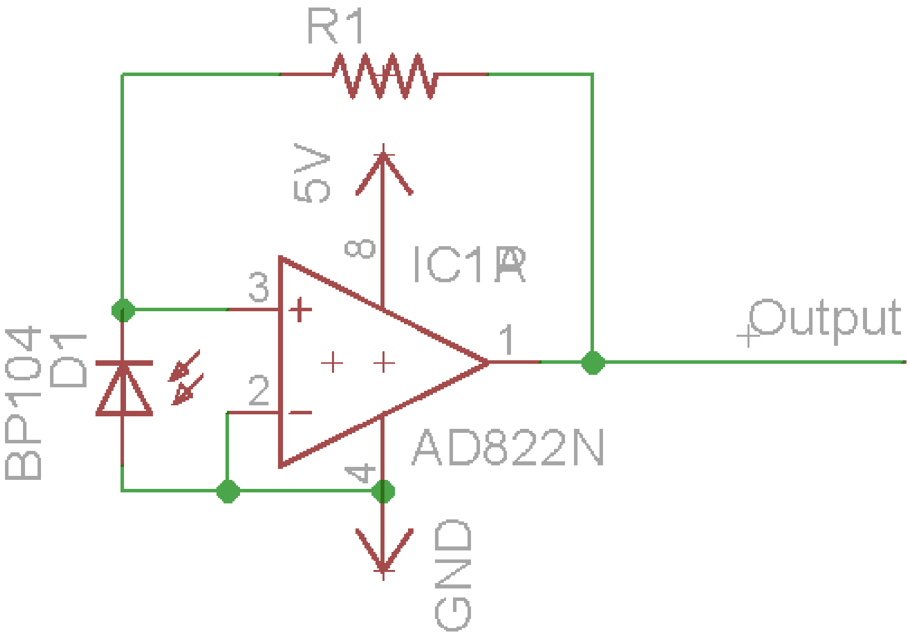

Figure 6: Amplifier schematic for SURMA photodiodes.

This circuit creates a measurable voltage across R1 as photocurrent is pulled through photodiode D1. Each UV photodiode will require its own amplifier circuit. The exact amplifier gain values (i.e. value of resistor R1) will be determined through sensor testing and calibration. Additional output filtering may be required to overcome Johnson dark current noise; this will also be determined through system testing and calibration [7].

Additionally, the URUA payload noticed an unexpected hysteresis effect in the recorded data. On URUA, the UV photodiodes output different results when rotating into view of the Sun as opposed to when rotating out view of the Sun. Photodiodes have a known temperature dependence, and it is theorized that the photodiode PN junction was slightly warmed while pointing at the sun, causing a difference in output. Although the team expects SURMA to point at the sun for the majority of the flight (thus limiting the perceived hysteresis), the team plans to mount a temperature sensor on each UV photodiode in an effort to detect subtle temperature differences and correlate recorded data with the hysteresis effect.

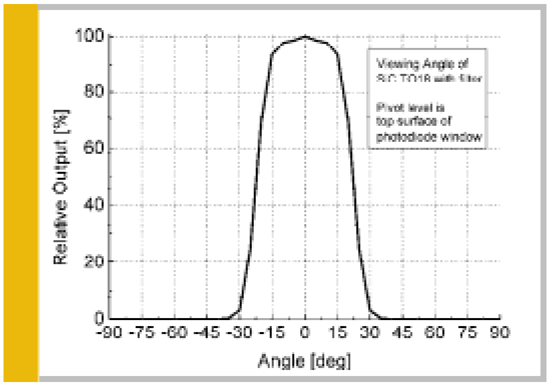

Figure 7: Actual UVC photodiode directional characteristics. Note the narrow peak viewing angle (~ ±15° for this photodiode).

One of the primary technical challenges associated with this project is that UV photodiodes typically have a narrow peak viewing angle. In order to measure UV irradiance through the entire flight, the UV sensors must be pointed at the sun. This necessitates the use of a solar tracking system.

Solar Tracking System

SURMA must be able to track the azimuthal position of the Sun with respect to the payload, and must be able to compensate for the rotation of the HASP gondola. SURMA will have a pair of broadband EM sensitive photodiodes. They operate in a similar manner to the UV photodiodes, and will use the same amplification circuit. As detailed below, the two solar tracking photodiodes will be mounted at a 90° angle from each other (and 45° off-centered from the payload). In this configuration, each solar tracking photodiode receives light at a different angle. When the HASP gondola is perfectly pointed at the Sun, each solar tracking photodiode outputs the same value. As the platform rotates, the pair of photodiodes create a differential signal, the magnitude of which increases with increasing angle away from the Sun. The flight computer needs to monitor this differential signal and make corrective turns to keep SURMA pointed in the right direction. The elevation angle of the payload will be controlled via uplinked commands from the ground station.

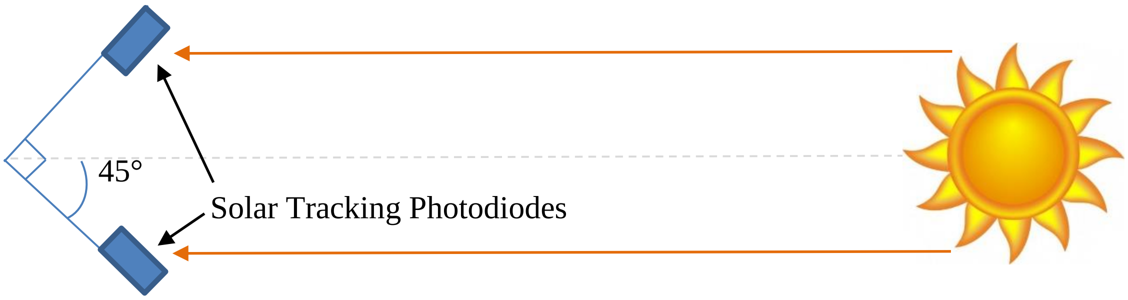

Figure 8: Conceptual diagram of the Solar Tracking System

Figure 9: Image of the OSRAM SFH 206K.

The team is currently considering OSRAM SFH 206K photodiodes, shown to the left. Its detector is sensitive to 400-1100 nm wavelength light (visible + infrared) with a peak response at 850 nm (close to the peak wavelength of the Sun).

In addition to its broadband response characteristics, the SFH 206K has a fairly linear response with respect to angle. Due to the fact that the sensor will be mounted at a 45° angle, it needs to be able to detect solar output from that direction. As shown below, the photodiode meets this need.

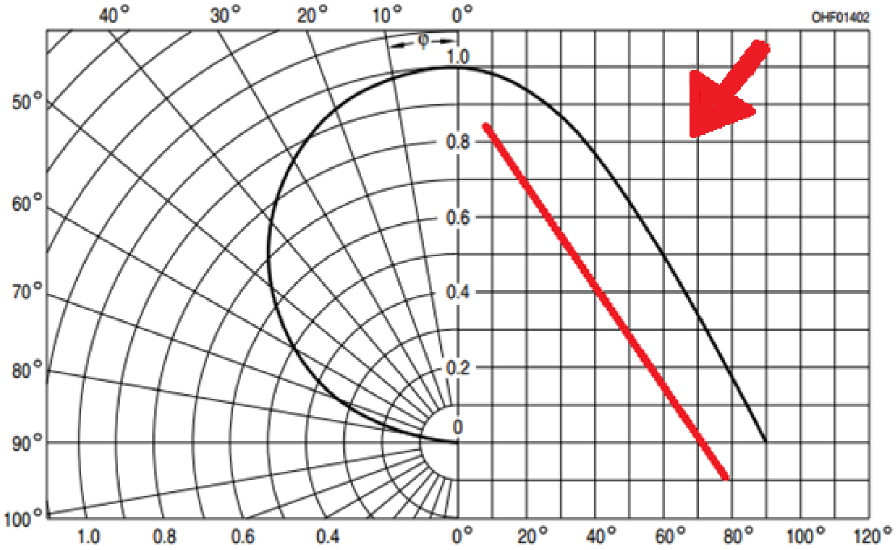

Figure 10: Broadband EM photodiode directional characteristics. Note the fairly broad, linear response as a function of incident angle, which makes this photodiode a good candidate for off-nominal solar detection.

Onboard Storage

As described in Section 4.4: *Telemetry*, the team expects to transmit 21-byte data packets once per second using the HASP telemetry downlink. These packets will also be recorded in backup onboard storage. SURMA will store data into an SD card housed within the electronics bay. For 15 hours of data collection (daytime collection only) at a rate of 1 data packet per second, SURMA will need roughly 1.1 MB of storage space. This required capacity is easy to obtain with an SD card.

Rotation Motors

There will be two control servo motors on SURMA: the azimuth control motor and the elevation control motor. Each servo will operate off of a digital PWM signal generated by the flight computer. The PWM signal will correspond to the desired motor control arm angle. The azimuth control motor must be able to spin 360° in order to observe the entire sky during flight, and must be capable of rotating the payload at least 20° per minute. This motor will be controlled by the flight computer in response to the solar tracking system. The elevation control motor will need to rotate less than 180° throughout the flight, and will be controlled by the flight computer in response to ground station commands.

Flight Computer

The SURMA flight computer is a single Arduino Mega. During the flight, it will perform the following actions:

- Monitor the azimuthal rotation of the HASP gondola and make corrective maneuvers
- Measure and record UV irradiance
- Transmit data packets to the HASP gondola via the DB9 serial connector
- Respond to commands issued by ground control

Arduino Mega was chosen because it can perform the required actions in a relatively small footprint at a relatively low cost. Arduino Megas have sixteen 10-bit ADC channels, which is enough to monitor all UV and solar tracking photodiodes, as well as temperature and rotational sensors. Arduino Megas have native digital PWM control, which will be used to control the servo motors. The Arduino IDE also has built in libraries for interfacing with SD cards, which will be used for onboard data storage.

The Flight Computer will connect to the SURMA daughterboard, which will house all of the required sensor signal conditioning and power regulation circuits.

Power Regulation

SURMA must be able to handle a nominal 30V from the HASP gondola. The voltage will decrease from ~33V to ~29V through the duration of the flight, thus the power system must be tolerant of a range of input voltages. This voltage must be regulated and made available to the individual electronic systems. The team is currently considering the Delta Electronics S36SE12001NRFB Isolated DC-to-DC converter, shown below, to step the voltage down to a manageable 12V. The 12V will be passed to subsystem-specific linear regulators to provide the proper operating voltages for the components.

Figure 11: Image of Delta Electronics S36SE12001NRFB Isolated DC-to-DC converter

The DC-to-DC converter outputs a constant 12V DC from an input voltage range of 18-75V. It is capable of delivering 1.3A DC and has built in over-current protection. It also has a small footprint, measuring 1.1” x 0.96” x 0.34”.

The servo motors will require 4.5-6V. The Arduino can either run off of a filtered 5V or through its own 9-15V input linear regulator. The amplifier networks can be powered by up to 15V, but shall be properly conditioned to output 0-5V based on the expected range of irradiance inputs.

2.3 Mechanical Structure

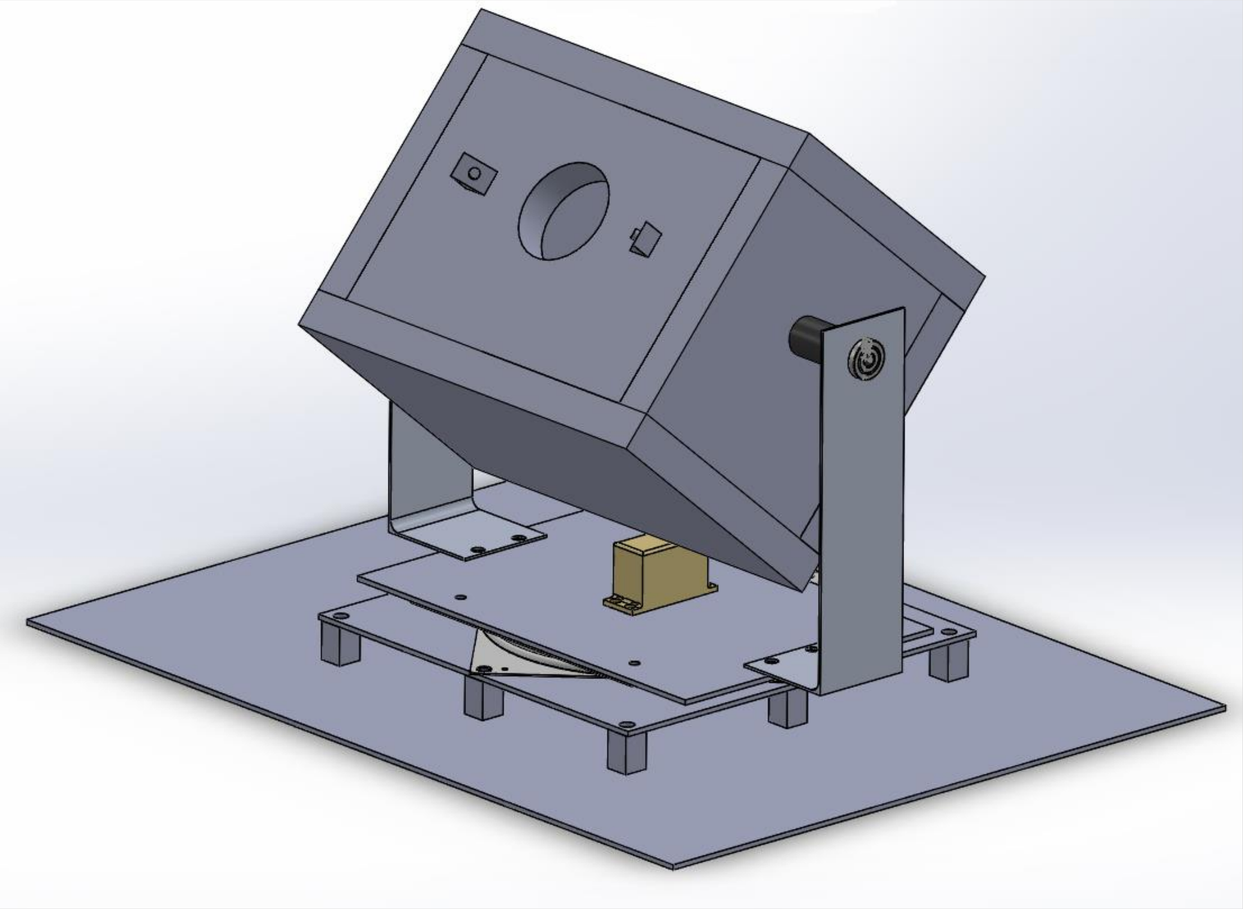

Figure 12: 3D rendering of SURMA, shown on a large HASP mounting plate for reference.

The payload has two main mechanical systems: the electronics bay and the mounting/orientation hardware. The electronics bay is composed of Foamular foam box overwrapped with an Econokote thermal finish. As shown below, it will provide the internal electronic components with support and thermal protection. The internal electronics will be mounted to PVC paneling to prevent the components from shifting during flight. A servo motor will be mounted on the inside of the electronics bay box to provide elevation angle control. Additional support for this motor may be required, and will be determined thorough system testing. The UV detection photodiodes will be mounted in a recessed area on the front face of the electronics bay. Solar tracking photodiodes will be mounted on 45° extrusions on the exterior of the electronics bay.

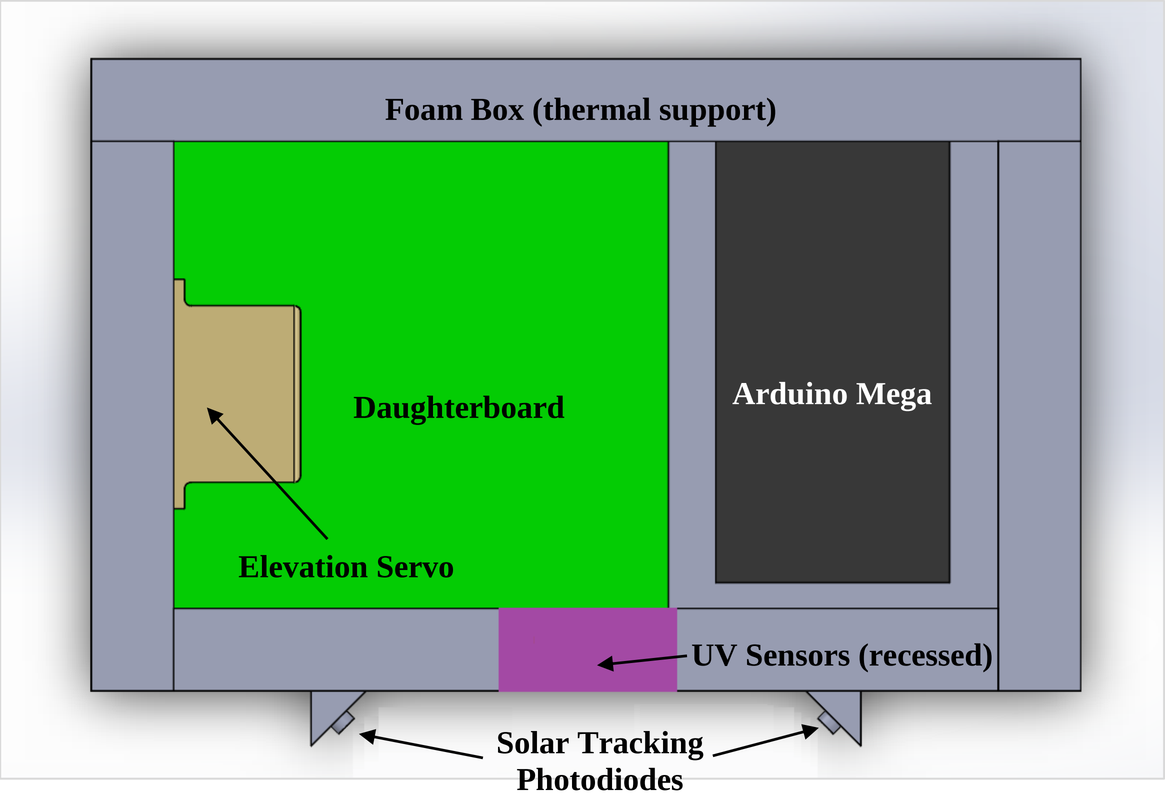

Figure 13: Layout of the SURMA electronics bay interior.

The electronics bay will be attached to a mounting and orientation structure via two vertical members attached to top support plate. The top support plate is to be mounted on top of an aluminum lazy susan, and will allow the electronics bay to rotate azimuthally. A second servo motor is fixed to the support plate. Its control arm will be passed through the center of the rotation platform and will be fixed onto the bottom support plate. This motor will provide the azimuthal rotation authority.

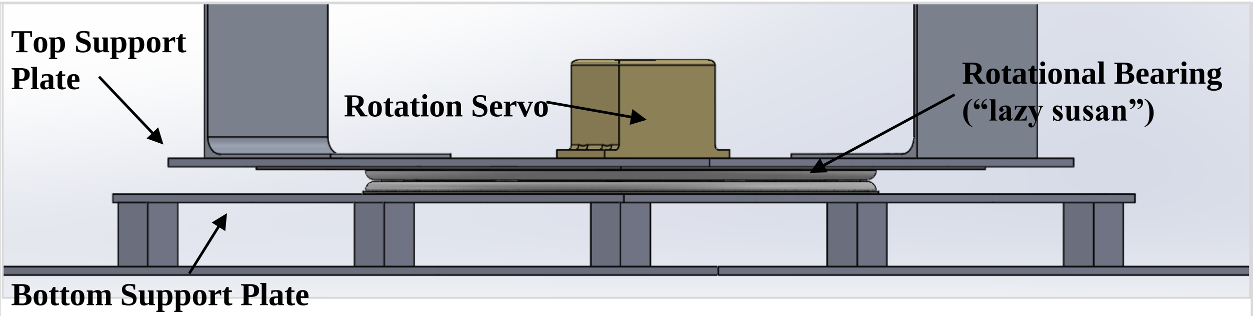

Figure 14: Detail of the azimuthal rotation structure. Primary payload rotation and support is provided by a 6” aluminum lazy susan. Rotational control is provided by a plate-mounted servo motor (highlighted in gold).

The rotation platform is fixed to the HASP mounting plate with eight 0.5” tall aluminum standoffs. The standoffs provide enough height for the rotational servo control arm to be attached to a fixed plate. Detailed mechanical drawings can be found in Section 4.1: *Preliminary Drawings*.

2.4 Software Design

The software will continually monitor the two solar tracking photodiodes via onboard ADCs. When the difference between the two sensor values is above a certain threshold, the flight computer will command the servo motors to initiate a small corrective turn in the required azimuthal direction. The threshold will be determined during testing, and will be based on the maximum allowable angle away from the sun and mechanical constraints (i.e. how precise can the sensors be mounted and how much tolerance is there on a given servo rotation). Elevation will be controlled periodically via telemetry from the ground.

The software is also responsible for recording and transmitting sensor values. The software will need to use the onboard ADCs to digitize the UV photodiodes and temperature sensors. These values will be transmitted through the HASP gondola using the telemetry packet format described in Section 4.4: *Telemetry*. Data transmission will occur at a rate of 4800 Baud (default serial interface data rate for a large payload). After transmitting the values, the software will record the telemetry packet into onboard storage. The onboard storage will be used in the event of transmitter failure or transmission interference during flight.

3.0 Team Organization

Team Orion is a team of four Undergraduate Engineering students attending Louisiana State University. Victor Fernandez-Kim is leading the project, managing mechanical design, and materials procurement. Joshua Collins shall be focused on electrical hardware and system design, power subsystems, and sensor subsystems. Stephen Harb shall work on developing software code for integrating the electrical and mechanical components. He will also create the software necessary to successfully collect data throughout the flight profile. Equipped with experience in project management, electrical design, and mechanical design, Brian Stutzman will be serving as an assistant to all sections.

3.1 Team Positions and Responsibilities

Name	Positions	Responsibilities
Victor Fernandez-Kim Mechanical Engineering	Project Manager Mechanical Design Manager Procurement Manager	• Liaison between the team and HASP Management • Set and leads team meetings • Coordinate task completion • Manage project time allocation • Design, construction, and testing of the mechanical systems • Communicate with HASP Management to order, track, and maintain components required for the project • Manages project monetary budget
Brian Stutzman Electrical Engineering	Assistant Project Manager Mechanical Section Member Electrical Section Member Software Section Member	• Assist design, construction, and testing of mechanical, electrical, and software systems • Serve as interim Project Manager when the Project Manager is unavailable
Joshua Collins Electrical Engineering	Electrical Design Manager Version Control Manager Report Manager	• Design, construction, and testing of the electrical systems • Maintain version control of all files • Organization and formatting of documents
Stephen Harb Computer Engineering	Software Design Manager Testing Manager	• Design, construction, and testing of the software system • Coordinate system tests and experiments • Create testing procedures for experiments • Leads system tests and experiments • Records results of tests and experiments

Table 3: Detailed breakdown of team positions and responsibilities

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Table 4: Team and Advisor Contact Information

3.3 Timeline

SURMA's mission goal is to observe UV irradiance at optimal angles from the sun as a function of altitude. As a result, a large amount of project development and testing will be devoted to the solar tracking system. The team anticipates that three students (Victor, Joshua, and Stephen) will participate in integration at the CSBF, and that no students will be present for flight operations at Ft. Sumner.

Date (2015)	**Description of Work**
January	Development of detailed SURMA mechanical, software, and electrical designs. Work on Preliminary Design Report (PDR)
January 25	**PDR document due**
February	Work on Critical Design Report (CDR). Begin SURMA materials and hardware acquisition. Begin testing solar tracking hardware/software.
March	Complete CDR, UV sensor calibrations, solar tracking system testing.
March 20	**CDR document due**
April	Complete individual system testing, begin system integration, and work on PSIP document.
April 24	**Preliminary PSIP document due**
May	Complete SURMA construction, begin SURMA system testing.
June	Continue system testing and design revisions. Revise and finalize PSIP document
June 26	**Final PSIP document due**
July	Complete SURMA system testing and design revisions, work on FLOP document
July 30	**Final FLOP document due**
August 3-August 7	Payload Integration at CSBF
August	Correction issues found at integration if necessary
August 29 - September 11	**HASP launch, recovery, packing, return**
October	Begin data analysis and science report
November	Completion of data analysis and final science report
December 11	**Submit Final Flight/Science Report**

Table 5: Anticipated Timeline of Major Project Events

4.0 Payload Specifications

The payload is designed to fit within the large size HASP payload footprint. As currently designed, it is expected to weigh roughly 1.6 kg (~3.5 lbs) and use roughly 5.625 W at 0.75 A.

4.1 Preliminary Drawings

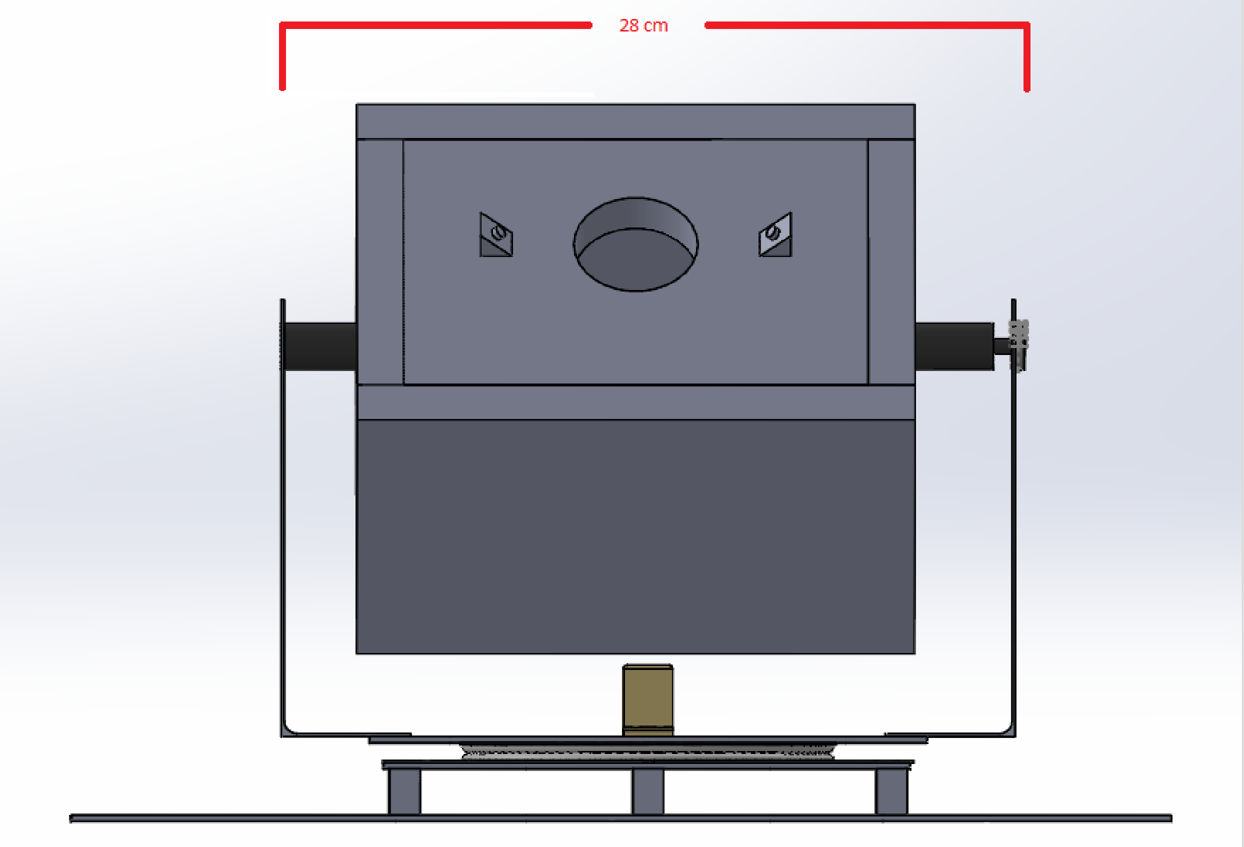

Figure 15: 3D rendering of SURMA front side. Payload front is 28 cm at its widest point, which is smaller than the maximum allowed 38 cm width. The payload is shown mounted on the HASP mounting plate for reference.

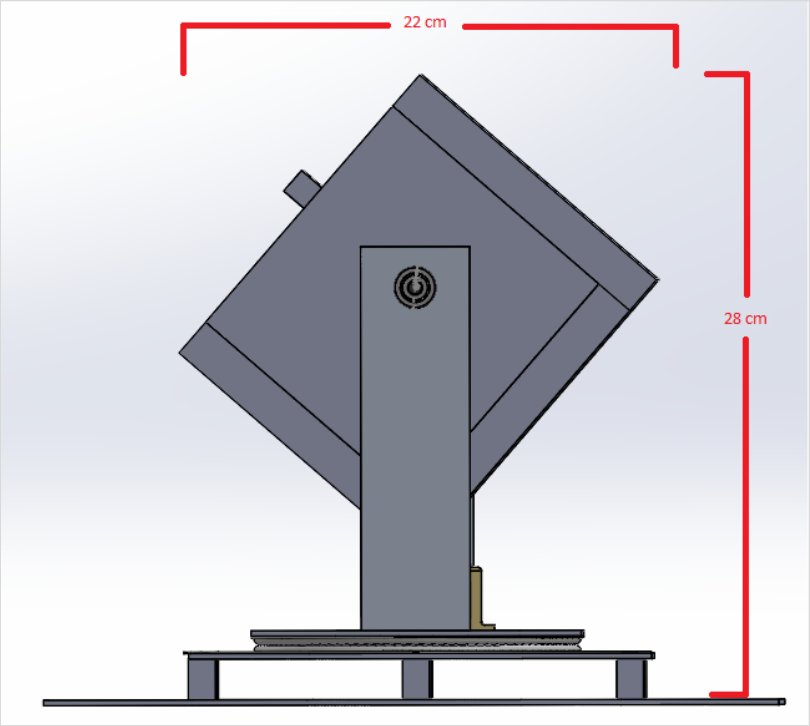

Figure 16: 3D rendering of SURMA right side. SURMA is a maximum of 28 cm tall x 22 cm deep (both depend on payload elevation, shown is worst case payload footprint). This is smaller than the allowed 30 cm x 30 cm. The payload is shown mounted on the HASP mounting plate for reference.

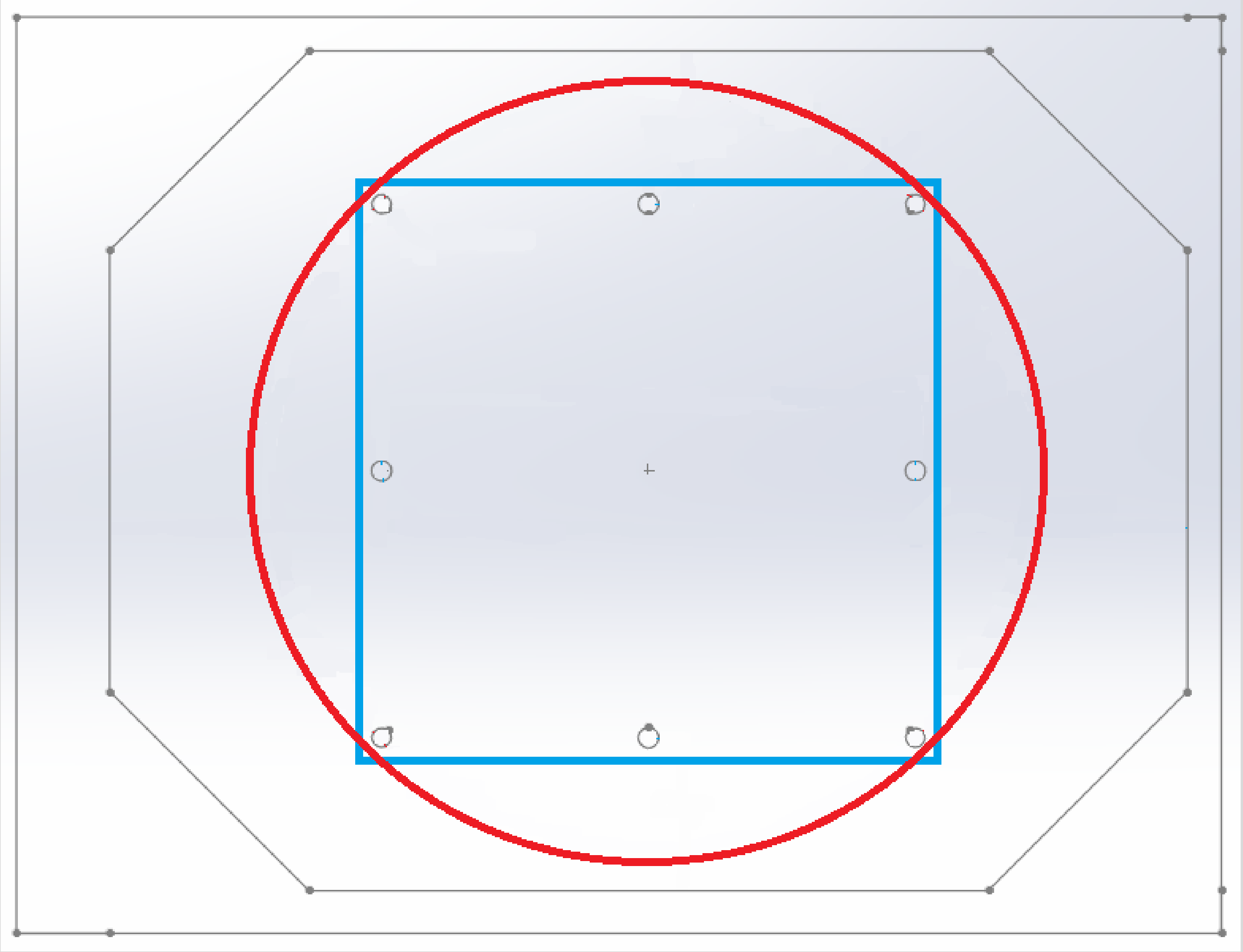

Figure 17: Anticipated SURMA footprint on the HASP mounting plate. Static footprint (i.e. mounting hardware that does not move) shown in blue, maximum dynamic footprint (i.e. rotational platform components) shown in red. At the closest point, SURMA will be 0.6” away from the keep out area

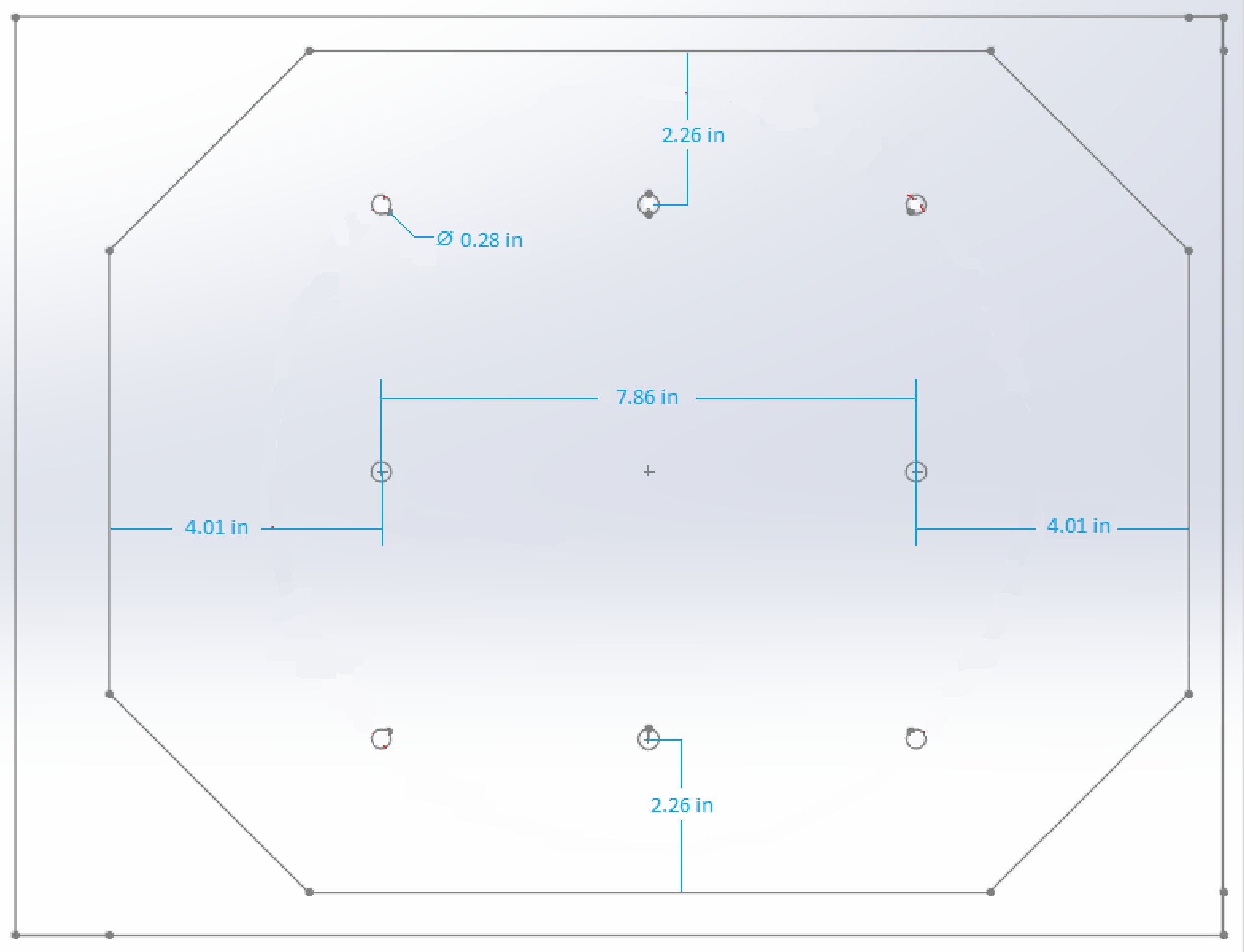

Figure 18: Anticipated HASP mounting plate modifications. Eight holes will be drilled, forming a 7.86” x 7.86” square. Holes will be 0.28” in diameter. Holes on the port and starboard sides are 2.26” away from the keep out area, while holes on the bow and stern sides are 4.01” away.

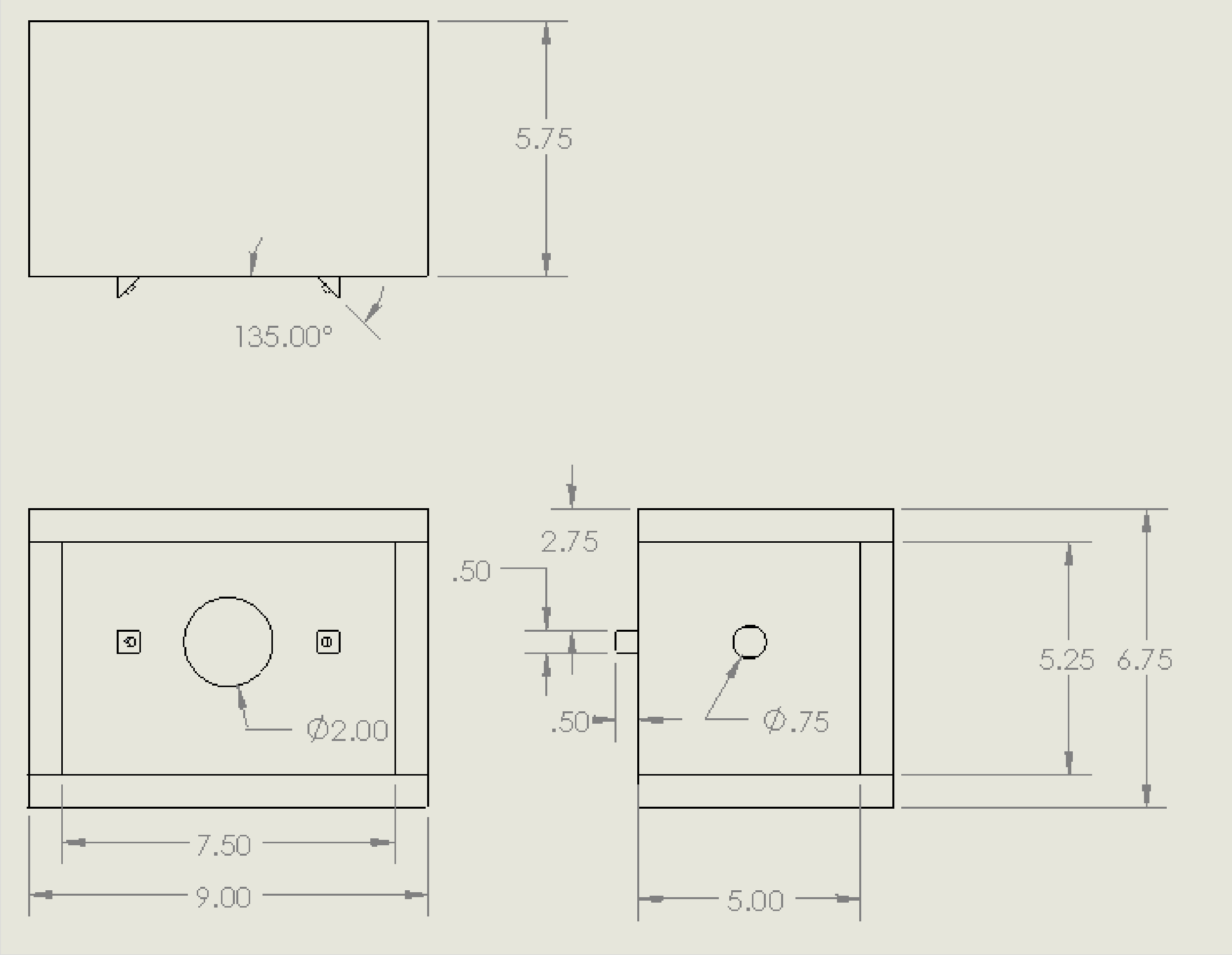

Figure 19: Electronics Bay detail with dimensions. The electronics bay is primarily composed of 0.75” thick Foamular insulation. All dimensions in inches.

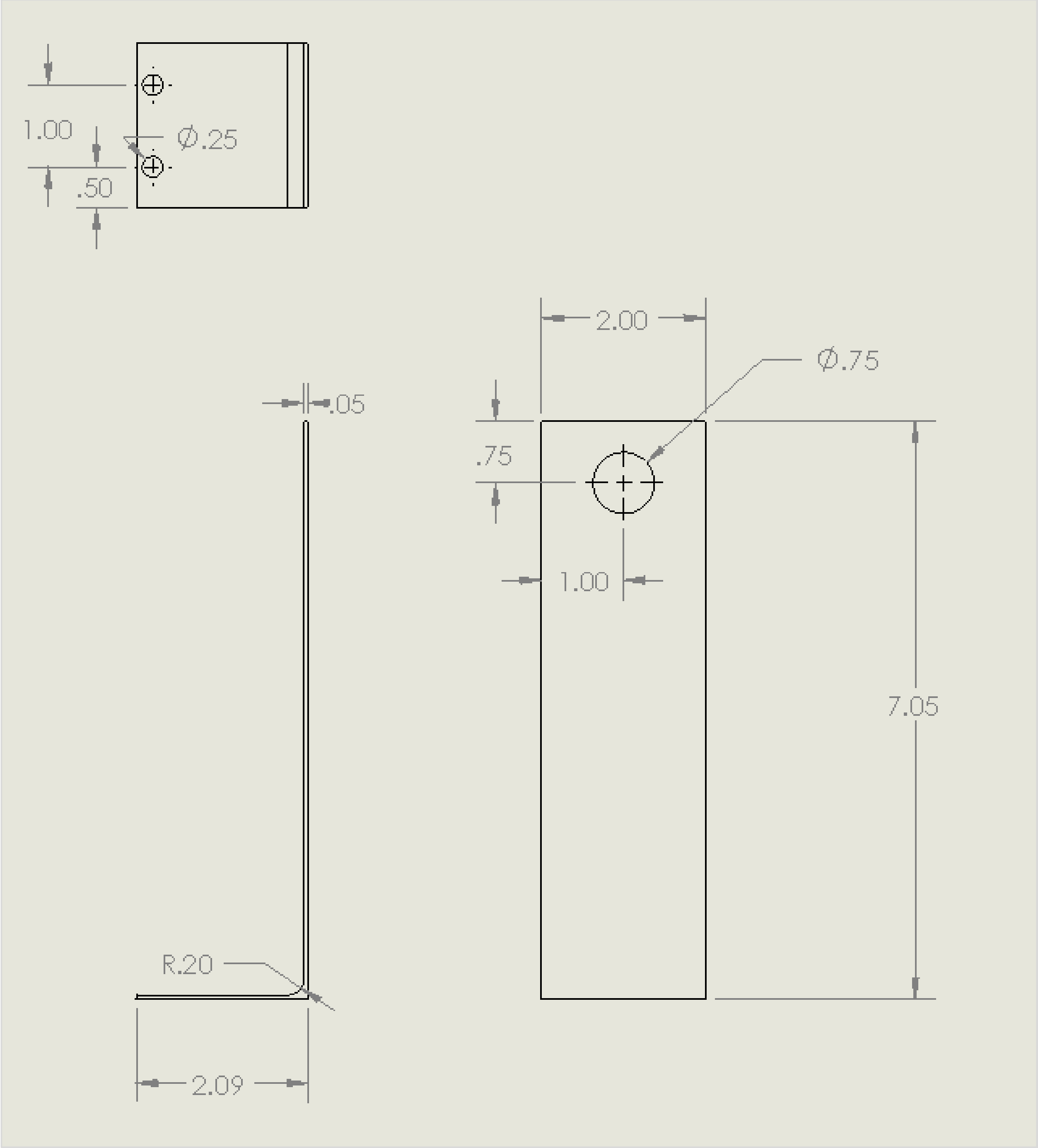

Figure 20: Electronics Bay Mounting Brace detail with dimensions.
Material: 6063 aluminum, all dimensions in inches.

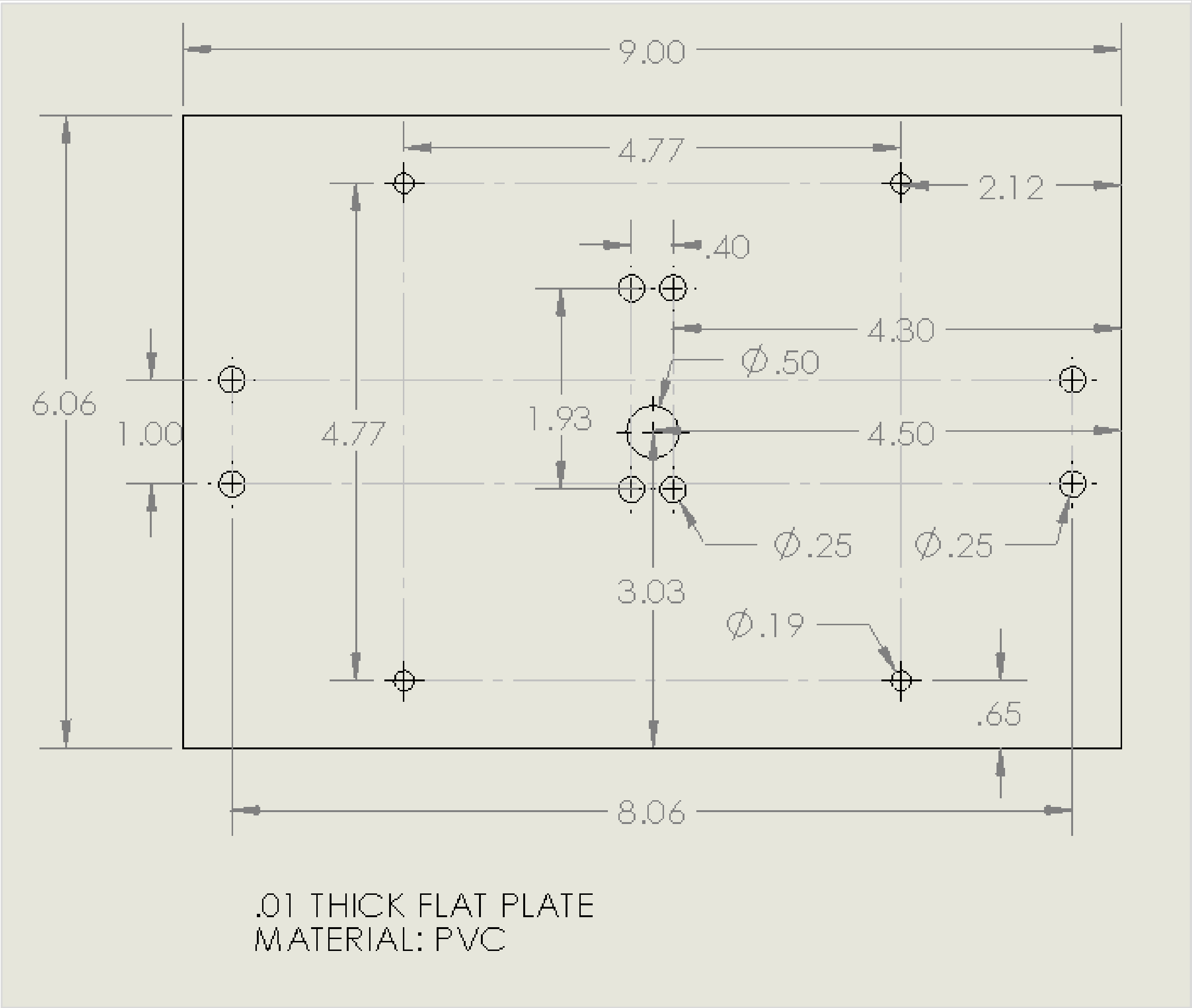

Figure 21: Top support plate detail with dimensions, all dimensions in inches.

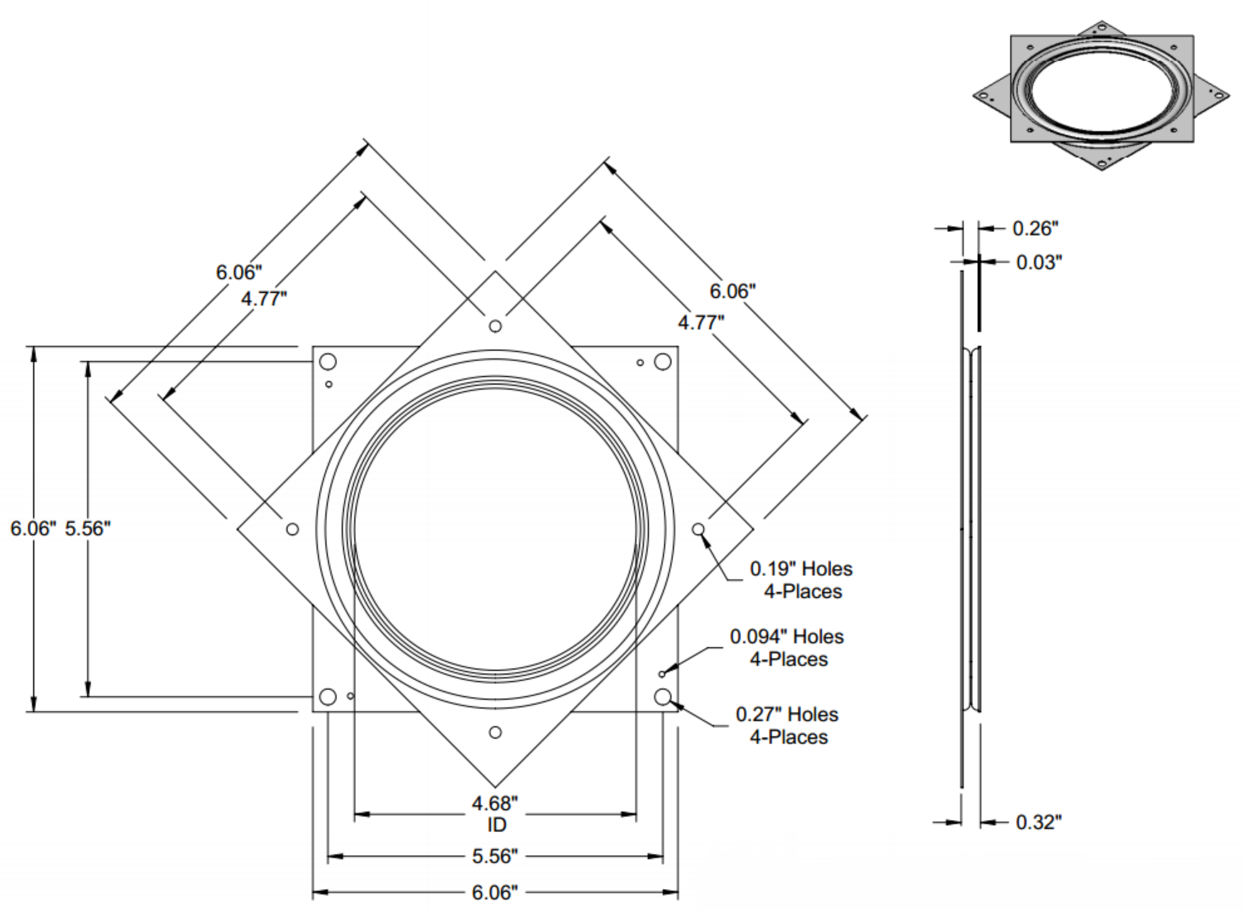

Figure 22: Aluminum rotational bearing detail, all dimensions in inches. [8]

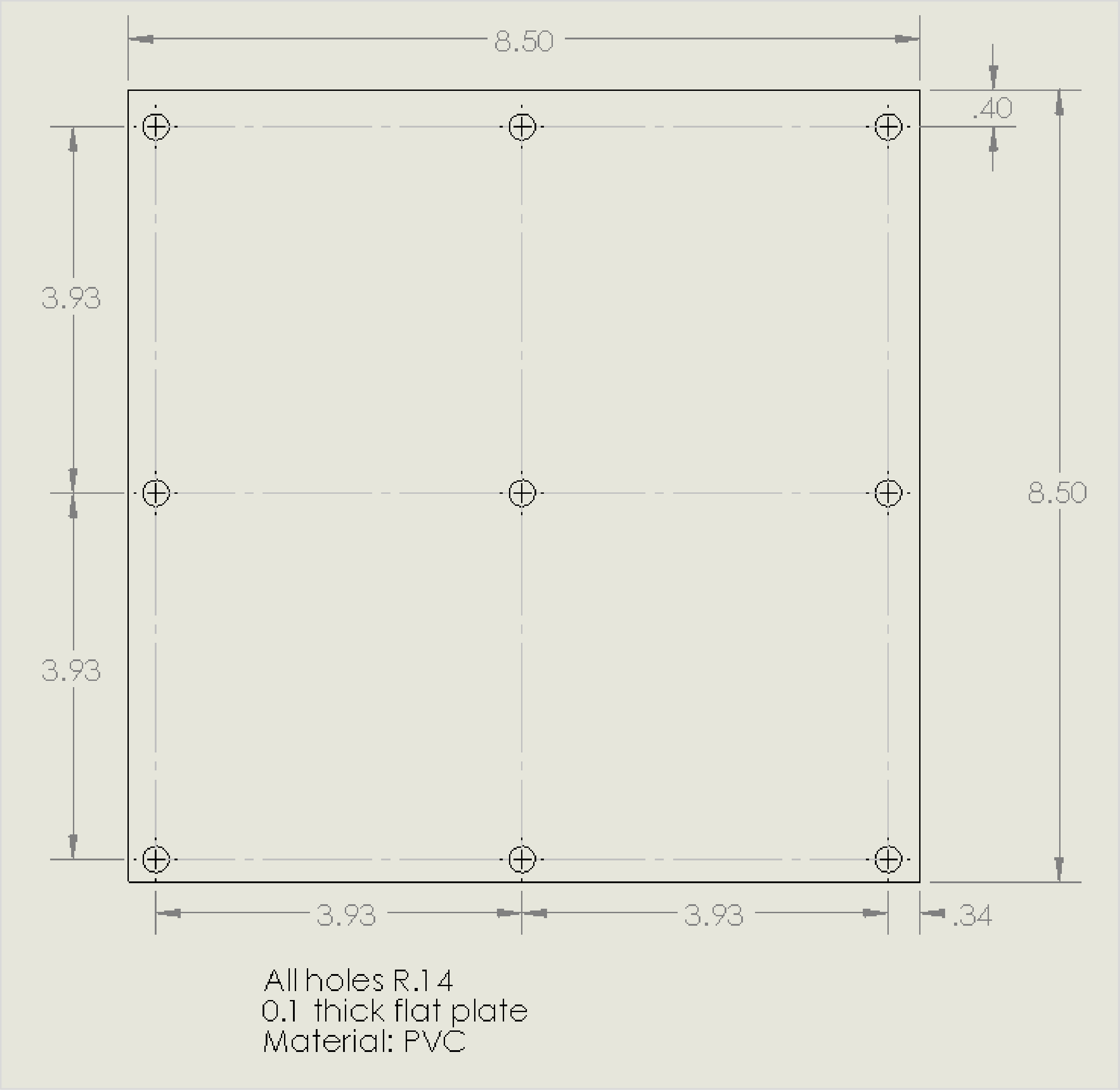

Figure 23: Bottom support plate detail, all dimensions in inches.

4.2 Weight Budget

Component	Material	Mass (g)	Mass Uncertainty (±g)
Electronics Bay Insulation	2.3 sqft. x 0.75" Foamular Foam + Econokote Thermal Barrier	150	25
Electronics Bay Support	74" x 0.5" 6063 Aluminum L Beams	30	10
Servo Motors	2x Generic High Torque Servo	150	10
Elevation Rotation Bearing	0.75" Type 316 Stainless Steel Bearings	180	40
Azimuthal Rotation Bearing	6" x 6" Aluminum Lazy Susan	50	10
Flight Computer	Arduino Mega	35	1
Daughterboard	4.5" x 4.25" x 1.57 mm FR4 (or eq.) PCB	50	10
Mounting and Support	350 cm^3 - Aluminum / PVC base + mounting screws, bolts	1000	500
Sensor Package	6x Photodiodes, 6x Temperature Sensors	15	0.5
	Total	**1660 g**	**606.5 g**

Table 6: Preliminary weight budget

4.3 Power Budget

The SURMA payload has three primary electrical systems: flight computer (Arduino Mega), servo motors for pointing and orientation, and UV and solar tracking photodiodes. The expected power requirements for these systems are listed below.

Component	Part Description	Current (mA)	Power (W)	Power Uncertainty (±W)
Flight Computer	Arduino Mega	50	.225	.025
Servo Motors	2x Generic High Torque Servo	500	3	1
Sensor Package	6x Photodiodes, 6x Temperature Sensors	200	2.4	1
	Total	**750 mA**	**5.625 W**	**2.025 W**

Table 7: Preliminary Power Budget

As shown above, the payload will require 5.625 W of power, and a continuous 750 mA of current. This is less than the maximum allowed ratings for a large size payload.

4.4 Telemetry

Byte	Title	Description
1	Header	Indicates beginning of data record
2-3	Status	Provides basic error code reporting
4-5	Millis	Number of Milliseconds since payload powered on
6-10	UV	4x10 bit ADC Values of the UV Photodiodes (UVA, UVB, UVC, broadband UV)
11-12	Solar	2x8 bit ADC Values of the solar tracking Photodiodes
13-16	UV_Temp	Temperatures of UV Photodiodes
17	EB_Temp	Interior temperature of electronics bay
18	S1_Temp	Temperature of azimuthal servo
19	S2_Temp	Temperature of elevation servo
20	Checksum	Checksum of bytes 2-16 (ignore header + footer)
21	Footer	Indicates end of complete data record

Table 8: Anticipated downlink data record, to be transmitted once per second using a 4800 Baud serial connection.

The team does not anticipate using either the analog downlink channels or the discrete commands. The team does anticipate sending a single two-byte command to the payload once per hour to adjust the elevation angle of the UV sensors.

4.5 Risk Assessment

SURMA does not have any pyrotechnics, radioactive materials, pressure vessels, high voltage, or separate radio transmitters onboard. The rotating mechanical structure poses the greatest risk to operators. However, the team does not anticipate using high speed or high torque servo motors, therefore the risk is fairly minimal.

4.6 Payload Location and Orientation

The payload must occupy one of the four large size payload positions (positions 9-12), however its science goals do not depend on a specific physical location or orientation on the HASP gondola.

5.0 References

[1] http://en.wikipedia.org/wiki/File:Ozone_altitude_UV_graph.svg
[2] http://hps.org/hpspublications/articles/uv.html
[3] http://solarphysics.livingreviews.org/open?pubNo=lrsp-2007-2&page=articlesu8.html
[4] http://rredc.nrel.gov/solar/models/smarts/relatedrefs/smarts295_users_manual_pc.pdf
[5] http://laspace.lsu.edu/Marslife/Payloads/smith/smith.php
[6] https://www.princeton.edu/~achaney/tmve/wiki100k/docs/Photodiode.html
[7] http://en.wikipedia.org/wiki/Photodiode/
[8] http://www.mcmaster.com/#cadinlnord/null/=v2zu97