Colorado Space Grant Consortium

University of Colorado at Boulder
Colorado Space Grant Consortium
520 UCB
Discovery Learning Center, Room 270

Dr. T Gregory Guzik
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364 Nicholson Hall
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Baton Rouge, LA 70803-4001

Dear Dr. Guzik

Thank you for taking the time to read our proposal and for considering our payload for the 2013 HASP platform. We look forward to hearing from you. The results from the University of Colorado at Boulder's HASP 2012 (HELIOS) team have given us cause to conduct further research into high altitude observatories. This year's HASP team has re-designed HELIOS and offers the opportunity to fly an improved mission (HELIOS II) to observe the sun in hydrogen-alpha wavelengths and to improve balloon based pointing systems. The HASP platform is the most suitable method to test our redesigned imaging systems in a high altitude environment and to compare our results to orbital and ground based imaging systems. Thank you for providing this opportunity for student research.

Sincerely the 2013 team,

Rishav Banerjee Gabe Frank Jonathan Sobol Kristen Hanslik

Jorge Cervantes Dan Nowicki Jack Swanson Caleb Lipscomb

Daniel DeWolf Anthony Lima Star Pais Ashley Zimmerer

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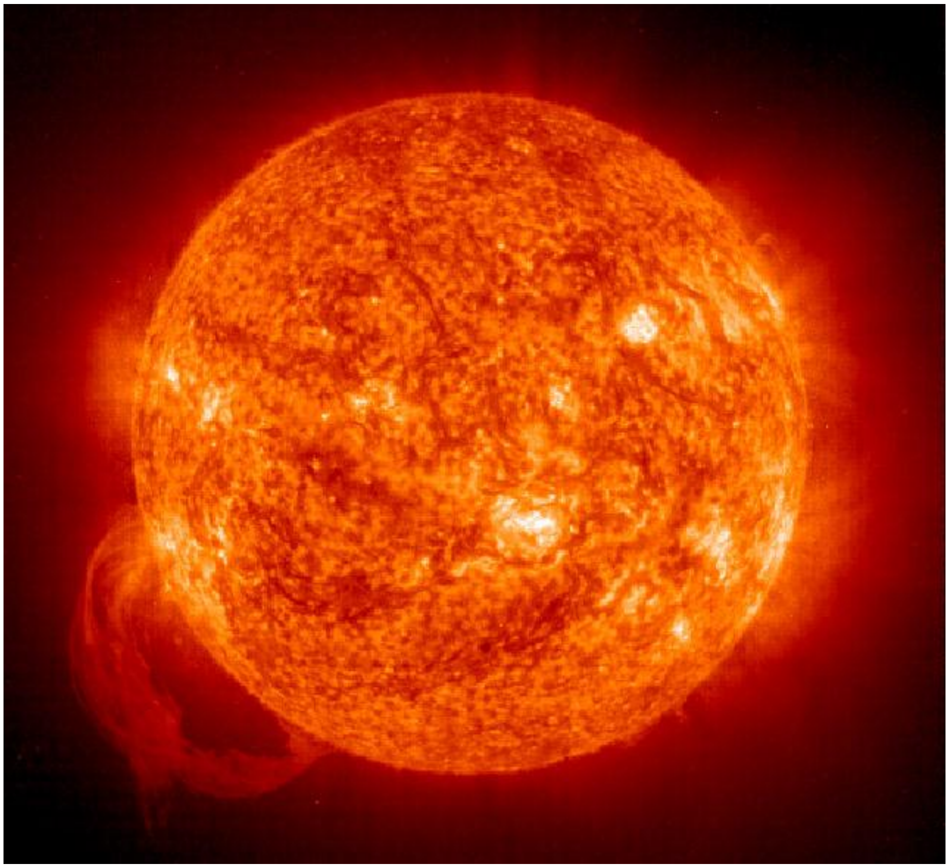
HELIOS II

Hydrogen-Alpha Exploration with Light Intensity Observation Systems II



Project: HELIOS II

Project Advisor: Chris Koehler

Project Manager: Caleb Lipscomb

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ADCS Lead: Rishav Banerjee

Command and Data Handling Lead: Star Pais

Electrical Power System Lead: Jorge Cervantes

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1.0 Mission Objective

Project HELIOS II (Hydrogen-Alpha Exploration with Light Intensity Observation System) shall design and construct a Solar Wavelength Imaging System (SWIS) to view the sun in the Hydrogen Alpha wavelength and capture both high and low resolution images in that wavelength using an Attitude Determination and Control System (ADCS) to locate the Sun and orient the SWIS towards the sun on-board a HASP flight. In addition, team HELIOS II shall design and use a standard BUS consisting of a standardized Electronic Power System (EPS) and Command and Data Handling System (C&DH) that can be connected to any scientific payload on future HASP missions.

Mission Objectives:

1. Observe and capture images of the Sun in Hydrogen Alpha wavelength using the SWIS system.
2. Design and implement an ADCS system to locate the Sun in the sky and orient SWIS towards the sun.
3. Prove the viability of high altitude balloon solar observation during a Colorado Space Grant Consortium (COSGC) sponsored HASP flight.
4. Design and implement a standard BUS capable of connecting with any scientific payloads.

1.1 Mission Premise

Currently, the majority of solar observations are performed using ground or orbit based telescopes. These two methods of observing the Sun have many drawbacks. Ground observations face issues with interference from atmospheric filtering; effectively lowering the quality of solar images and reducing the ability to gather accurate scientific data from those images. Orbiting observatories have a high cost, limiting the quantity of such solar imaging missions in space. The lower quantity of orbital missions causes reduced access to the solar images taken by orbital observatories. With these restrictions in mind, an alternative method to image the sun is through the use of high altitude balloon observatories. High altitude balloons are a relatively inexpensive platform. The HASP platform shall travel above 99.5% of earth's atmosphere, mitigating the effect of atmospheric interference during solar observations.

The Colorado Space Grant Consortium (COSGC) at the University of Colorado at Boulder (CU) has a history of high altitude observatory experiments. DIEHARD (2008) determined the viability of high altitude observatories by collecting diurnal and nocturnal images of celestial bodies to determine atmospheric turbulence and light intensity due to residual particles in the atmosphere. This was done using photometers mounted 45-degrees from the horizon. BOWSER (2009) further determined the practicality of high altitude observatories by examining certain wavelengths of cosmic light and took corresponding diurnal images and light intensity readings of the sky. BOWSER also measured platform stability in order to determine the conditions in which future HASP missions will fly. SPARTAN-V (2010) worked towards the goal of supporting precise photometry from balloon based pointing systems and telescopes.

SPARTAN-V focused on characterizing atmospheric scintillation and extinction to support the practicality of observing exo-planets from a high altitude balloon.

In 2012, the University of Colorado Boulder HASP team, HELIOS, flew a similar mission to test the viability of solar observation on a high altitude balloon platform. However, there mission was hindered by several issues. The HELIOS team was unable to finish the design and testing of the ADCS. The team also had outgassing causing fogging of the camera lenses. Additionally, the team experienced a power issue causing the payload to overdraw current which subsequently disabled all systems. To address these issues, Team HELIOS II shall perform the following:

1. A new ADCS shall be designed, assembled, and tested in order to orient SWIS cameras towards the sun.
2. HELIOS II shall perform outgas testing of the payload's entire structure and all components in a thermal vacuum chamber before launch in order to prevent outgassing from occurring during the flight. In addition, HELIOS II shall practice clean building procedures in the construction of all components of the HELIOS II payload, including the use of Colorado Space Grant Consortium's clean room for final assembly.
3. To mitigate the current overdraw issues, an external protection circuit shall be used to interrupt power to the electronic systems should an error occur. In addition, the electronic power system shall have the ability to reset in order to clear and solve any errors that may occur.

Further, members of HELIOS I shall serve as advisors to the HELIOS II team to give the experience and knowledge gained from the 2012 HASP mission to the HASP 2013 mission. This is to ensure that all previous failures will be rectified as quickly and completely as possible.

1.2 Photometry

The Solar Wavelength Imaging System (SWIS) shall image in Hydrogen-Alpha (656.3 nm) and shall maximize image quality. What is considered "visible light" can be separated into two categories. One: light that is seen with the naked eye and appears in images as white light. Two: the filtered spectrum of this white light, which can narrow down specific wavelengths. This filter system is used to observe details of the Sun that would otherwise be more difficult in white light pictures.

H-Alpha filters allow the camera to detect only red light at a wavelength of 656.3 nm. These wavelengths are emitted when a high-energy electron makes a transition to a lower energy state. However surrounding wavelengths typically drown them out, becoming "etiolated" in unfiltered cameras. Due to the chemical make-up of the Sun, Hydrogen is in abundance.

Therefore, Hydrogen-Alpha imaging of the Sun provides incredible amounts of comprehensive data to be taken on solar activity. [1]

The atmosphere of the Earth has shifting air pockets, which distort the view of ground telescopes despite scientific advancements in telescope design. The atmosphere also absorbs and blocks certain wavelengths of radiation before they can reach the Earth. The best way to examine stellar objects like the Sun is from studying it in all wavelengths it emits. New ground telescope technology has been able to correct for the atmospheric distortion to some extent but there is not a way of seeing the wavelengths blocked by the atmosphere. HELIOS II will ascend above 99.5% of Earth's atmosphere, which will allow SWIS to observe in these wavelengths. [2]

2.0 Requirements

In order to complete all mission goals, Team HELIOS II shall abide by all requirements specified by HASP, in addition to all requirements derived from mission objectives. The success or failure of HELIOS II shall be incumbent upon the adherence to and verification of the following statements.

Level	Requirement	Derived
0.1	Observe and capture images of the Sun in Hydrogen Alpha Wavelengths	Objective
0.2	Design and implement an ADCS (Attitude Determination and Control System) to locate the Sun in the sky and orient SWIS (Solar Wavelength Imaging System) toward the Sun	Objective
0.3	Prove the viability of high altitude balloon solar observation within a COSGC (Colorado Space Grant Consortium) sponsored HASP flight	Objective
0.4	Design and implement a standardized BUS capable of connecting with any scientific payload	Objective

Level	Requirement	Derived
0.1.1	SWIS shall implement an infrared filter allowing imaging of 656.28 nm wavelengths	0.1
0.1.2	SWIS shall implement a camera capable of gathering high resolution Hydrogen-Alpha images	0.1
0.1.3	SWIS shall allow for storage of captured infrared images	0.1

[1] *Cool cosmos*. (n.d.). Retrieved from http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/sun.html

[2] Eisenhamer, J. (2012, March 02). *Hubblesite*. Retrieved from http://hubblesite.org/the_telescope/hubble_essentials/

0.1.4	One barrel of SWIS shall have a large field of view with low resolution	0.1
0.1.5	One barrel of SWIS shall have a small field of view with high resolution	0.1
0.1.6	SWIS shall be insulated and isolated from all other systems' thermal footprint	0.1
0.1.7	SWIS data storage system shall be capable of connecting to primary control computer	0.1

Level	Requirement	Derived
0.2.1	ADCS shall monitor changes along theta and phi axes	0.2
0.2.2	ADCS shall utilize a motorized system to orient SWIS in the direction of the Sun	0.2
0.2.3	SWIS shall be capable of orienting 360 degrees and 90 degrees on theta and phi axes respectively in order to maintain solar focus	0.2
0.2.4	ADCS shall be designed with consideration to thermal effects on materials	0.2

Level	Requirement	Derived
0.3.1	HELIOS II shall comply with all HASP requirements outlined in RFP	0.3
0.3.2	HELIOS II shall comply with all budget and schedule constraints dictated by COSGC and HASP	0.3
0.3.3	HELIOS II shall maintain temperatures required for proper operation of all systems	0.3

Level	Requirement	Derived
0.3.1.1	Payload volume shall not exceed 38x30x30 cm	0.3.1
0.3.1.2	Payload shall resist the effects of up to 10 g vertical force and 5 g horizontal force	0.3.1
0.3.1.3	Payload shall utilize a twenty-pin EDAC 516 interface to HELIOS II system power and analog downlink channels	0.3.1
0.3.1.4	Payload shall not draw more than +30 VDC or 2.5 amps and shall split the provided +30 VDC to voltages necessary to operate payload	0.3.1
0.3.1.5	Payload shall enable six discreet command functions from HASP using EDAC 516-020 interface.	0.3.1
0.3.1.6	Payload shall allow serial downlink functioning at 4800 baud	0.3.1
0.3.1.7	Serial up-link shall allow for 2 bytes per command	0.3.1
0.3.1.8	Payload shall use a DB9 connector, RS232 protocol, with pins 2, 3 and 5	0.3.1
0.3.1.9	Payload shall transmit data packages showing health statuses utilizing unique header identification	0.3.1
0.3.1.10	Payload shall be incorporated into existing HASP platform mounting design	0.3.1

Level	Requirement	Derived
0.3.2.1	All receipts and proofs of purchase shall be retained	0.3.2
0.3.2.2	Schedule shall include weekly deadlines for each phase of design, assembly, and integration process	0.3.2
0.3.2.3	Schedule shall include all design document revisions; including relevant	0.3.2

	presentations	
0.3.2.4	Schedule shall include all weekly team meeting dates and times	0.3.2

Level	Requirement	Derived
0.3.3.1	SWIS structure shall be insulated to minimize thermal footprint of other systems	0.3.3
0.3.3.2	All internal components of all systems shall remain within operating temperatures within the range of -80 to 60 °C	0.3.3
0.3.3.3	All systems shall utilize heat sinks to mitigate thermal footprint effects on SWIS	0.3.3

Level	Requirement	Derived
0.4.1	BUS shall include effective electrical power systems to support science, ADCS, and tertiary systems throughout flight	0.4
0.4.2	BUS shall include a Command and Data Handling system able to oversee and control all systems	0.4
0.4.3	BUS shall include an Electronic Power System to provide power to all systems	0.4

Level	Requirement	Derived
0.4.1.1	HELIOS II shall be powered by HASP platform during entire flight duration	0.4.1
0.4.1.2	HELIOS II shall use no more than +30 VDC at 2.5 amps to provide power to systems	0.4.1
0.4.1.3	HELIOS II shall use sufficiently sized gauge wire for power transfer on different bus lines for system power	0.4.1
0.4.1.4	HELIOS II shall have a twenty-pin EDAC 516 interface to HASP system power and analog downlink channels	0.4.1
0.4.1.5	Pins A, B, C, and D shall be designated as power	0.4.1
0.4.1.6	ADCS, SWIS and tertiary systems shall be connected to pins A, B, C, and D for power.	0.4.1
0.4.1.7	Pins M, T, U and X shall be designated as ground	0.4.1
0.4.1.8	Pins F and N shall be designated for discrete commands	0.4.1
0.4.1.9	Pins K, L, M and R shall be designated as analog downlink to HASP command. K and M operate as signal, while M and R act as respective returns	0.4.1
0.4.1.10	Pins 2, 3 and 5 shall be designated as received, data, transmitted data, and signal ground respectively	0.4.1
0.4.1.11	Shall utilize the RS232 protocol (8 bits, no parity bit, 1 stop bit, no control flow)	0.4.1

Level	Requirements	Derived
0.4.2.1	Command and Data Handling system shall monitor and implement ADCS function	0.4.2

0.4.2.2	Command and Data Handling system shall allow control of the payload	0.4.2
0.4.2.3	HELIOS II shall be capable of turning payload on and off	0.4.2
0.4.2.4	HELIOS II shall be capable of communication with ADCS and SWIS, including discrete commands	0.4.2
0.4.2.5	Electronic Power System shall accept and distribute power to all systems as needed	0.4.2

3.0 Design Overview

HELIOS II includes the Solar Wavelength Imaging System (SWIS), an Attitude Determination and Control System (ADCS), an Electronic Power System (EPS) and a Command and Data Handling system (C&DH). SWIS is a two camera array with which images of the Sun are captured in Hydrogen-Alpha in a high and low resolution camera. The ADCS is a two-axis control system. The ADCS shall adjust the azimuth elevation of the SWIS; the imaging system is mounted on a circular plate with a full 360-degree range of rotation. The combination of these two elements shall allow SWIS to track the Sun and ensure the Sun is kept within the field of view of the SWIS. The EPS system shall provide power to all other systems on HELIOS II. The C&DH system shall control all other systems and monitor the health and status of those systems. The C&DH and EPS shall be located underneath SWIS, separated from the ADCS system. All of these separate sections shall be connected through the machined aluminum structure that shall maintain the structural integrity of HELIOS throughout launch, float, and landing. The design of HELIOS II is most suited for a large 20 kg payload, situated in any of the four large payload spots. Refer to figure 3.0.1 for a depiction of the HELIOS II payload.

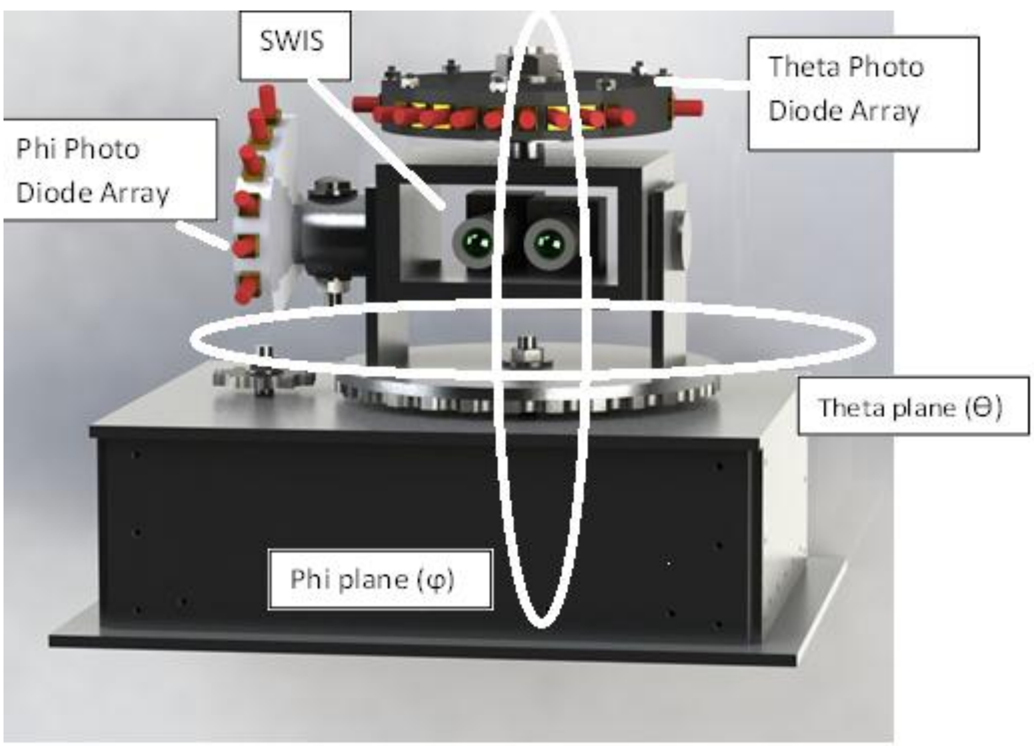


Figure 3.0.1

3.1 Solar Wavelength Imaging System (SWIS)

The objective of SWIS is to capture images of the Sun and filter the incoming radiation into the Hydrogen-Alpha wavelength. The system shall successfully: filter out unwanted EM radiation using reflective narrow band-pass filters, use a neutral density filter and polarizers to decrease the intensity of incoming light, and use a baffled barrel design and a diffraction grating to filter out most scattered light and improve image clarity. SWIS consists of two DMK 51AUO2 Monochrome CCD cameras, which are fitted with barrels containing the baffled feature, grating, and filters. Two different barrel lengths shall be used: one long (Figure 3.1.3) and one short (Figure 3.1.2). This shall allow for one camera with a wide field of view and a low resolution while the other camera shall have a high resolution but a small field of view. The shorter camera shall be used to verify the effectiveness of the ADCS system by analyzing the location of the Sun in each image. The longer camera shall be used to produce high resolution images to be compared with those from ground-based observatories.

The cameras shall operate during the day float phase of the mission to minimize the movement of the balloon, subsequently the blurring of the image and to maximize exposure time to the sun, allowing for more images of the sun to be captured. This mission design consideration, along with the long focal length shall produce high-resolution solar images.

The two SWIS cameras shall be mounted on the rotating rig below the θ (theta) photodiode array. The φ (phi) array shall be alongside the camera rig. The cameras shall use 8.5mm x 6.8mm CCD sensors to capture the images (Figure 3.1.1). The shorter camera shall record images with a resolution minimum of 50 pixels for the diameter of the Sun. The longer camera shall record images with a resolution of at least 400 pixels for the Sun's diameter. These images shall be stored on a solid state drive using a USB connection. The resolution of the images shall be 1600 pixels by 1200 pixels. The collected images shall be compared with photos from current ground observatories to assess their relative quality.

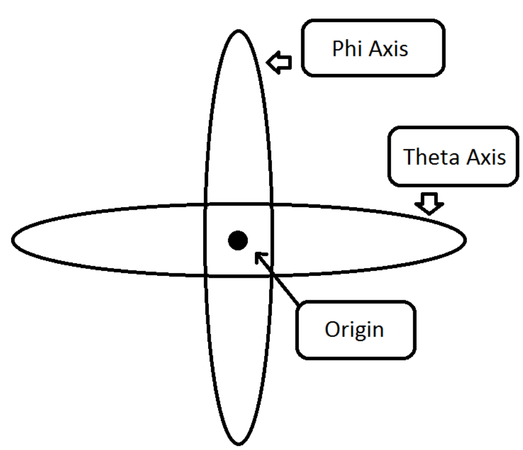


Figure 3.1.1

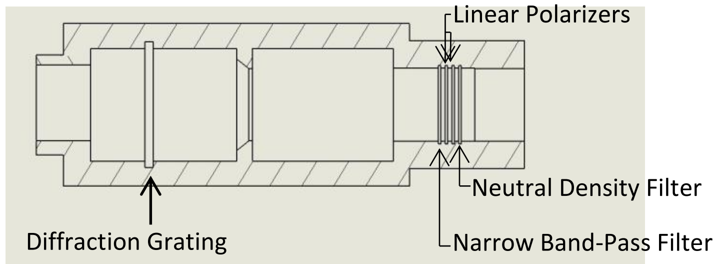


Figure 3.1.2

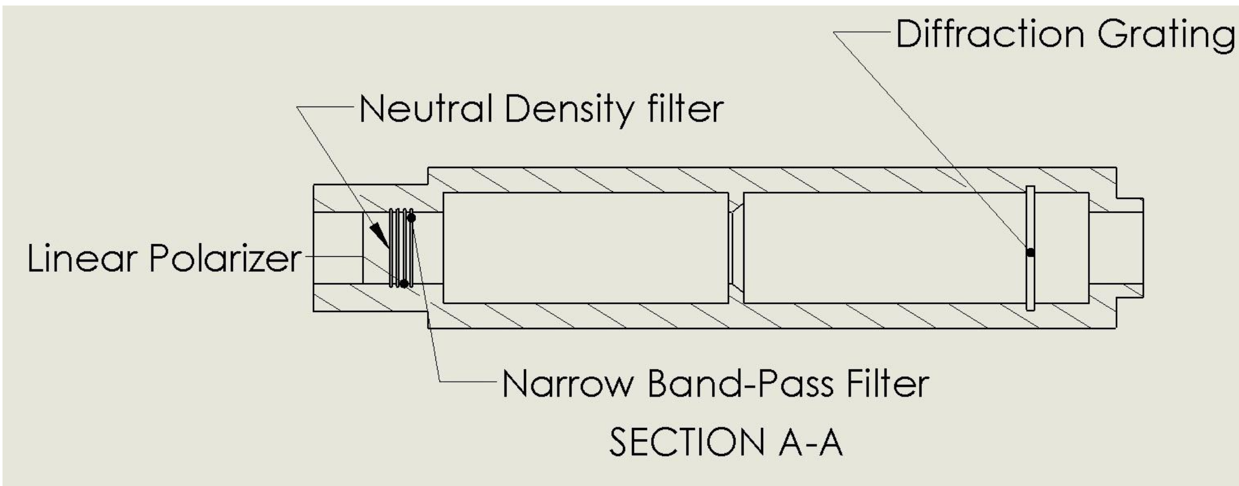


Figure 3.1.3

3.2 Attitude Determination and Control System (ADCS)

ADCS shall be responsible for maintaining the Sun within the field of view of the two-camera imaging system. This shall be accomplished via a two-axis photo-diode array system that shall use differing voltages to determine the corrections needed to allow for accurate imaging. The attitude determination shall depend on these two arrays to track the motion of the Sun as it takes into consideration the rotation and movement of the HASP balloon as well as tracking the Sun as it moves across the sky.

3.2.1 Solar Position Determination

A two-array system shall be used to maintain the sun within the field of view. The first, a theta plane array (ϴ), is a disk of a radius 15.2 cm with 14 photodiodes, 8 spaced clustered together within the forward 90 degrees and the other 6 spread out equally over the remaining 270 degrees (Figure 3.2.1, Figure 3.2.2). This spread out pattern optimizes the control and accuracy of the ADCS system. This array is to be mounted above the imaging system and shall rotate along with said system in the Theta-plane.

The second, a Phi-plane (φ), array is a semicircle with 6 photodiodes equally spaced within 105 degrees (with respect to the vertical). This shall be mounted to the side of the imaging system and shall also rotate in the Theta-plane with the imaging system (Figure 3.2.3, Figure 3.2.4). This is done so that when the imaging system is oriented in the Theta-plane, the Phi-Plane array is also oriented to face the sun.

The system shall have an external index sensor that shall act as the origin for the theta (ϴ) and phi (φ)

Detailed drawings of the Theta and Phi Plane arrays are given on pages 16 to 19.

Theta (Θ) Plane

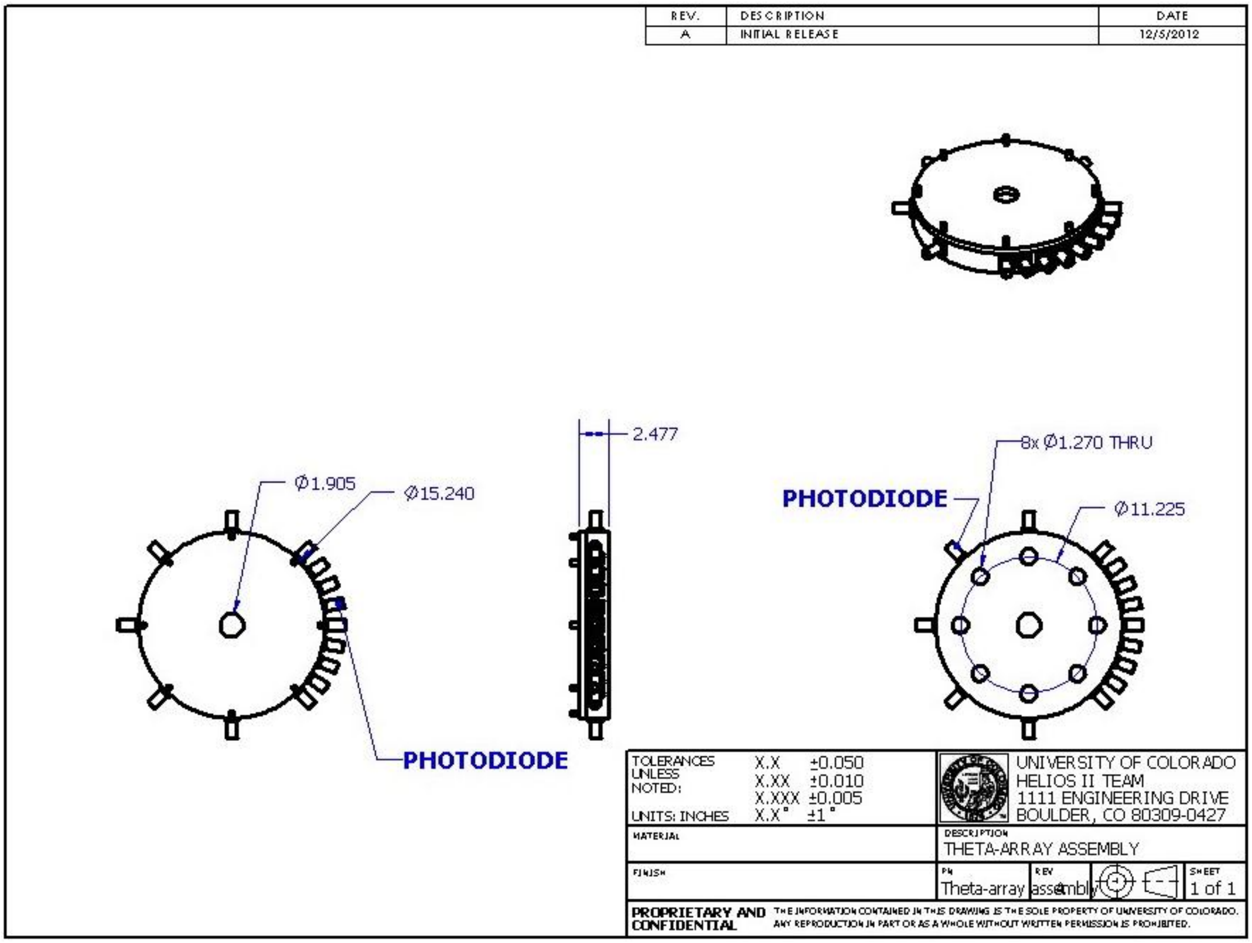


Figure 3.2.1

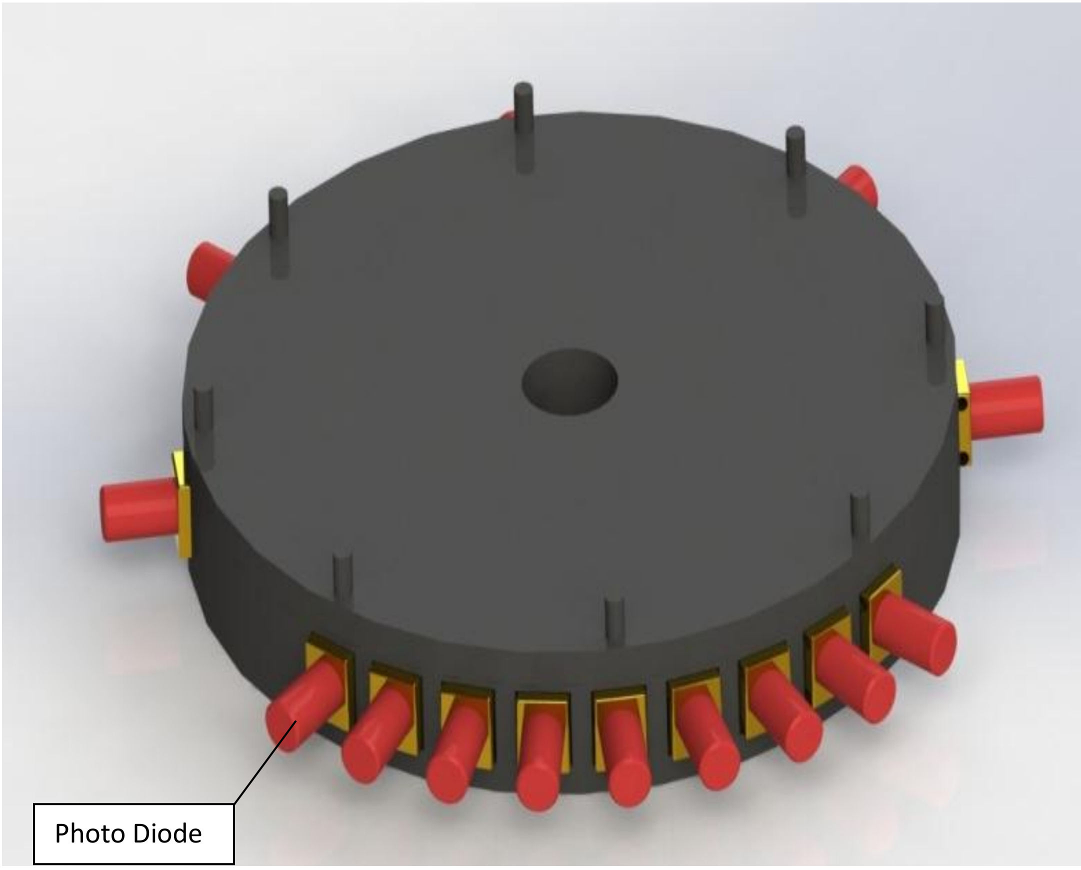
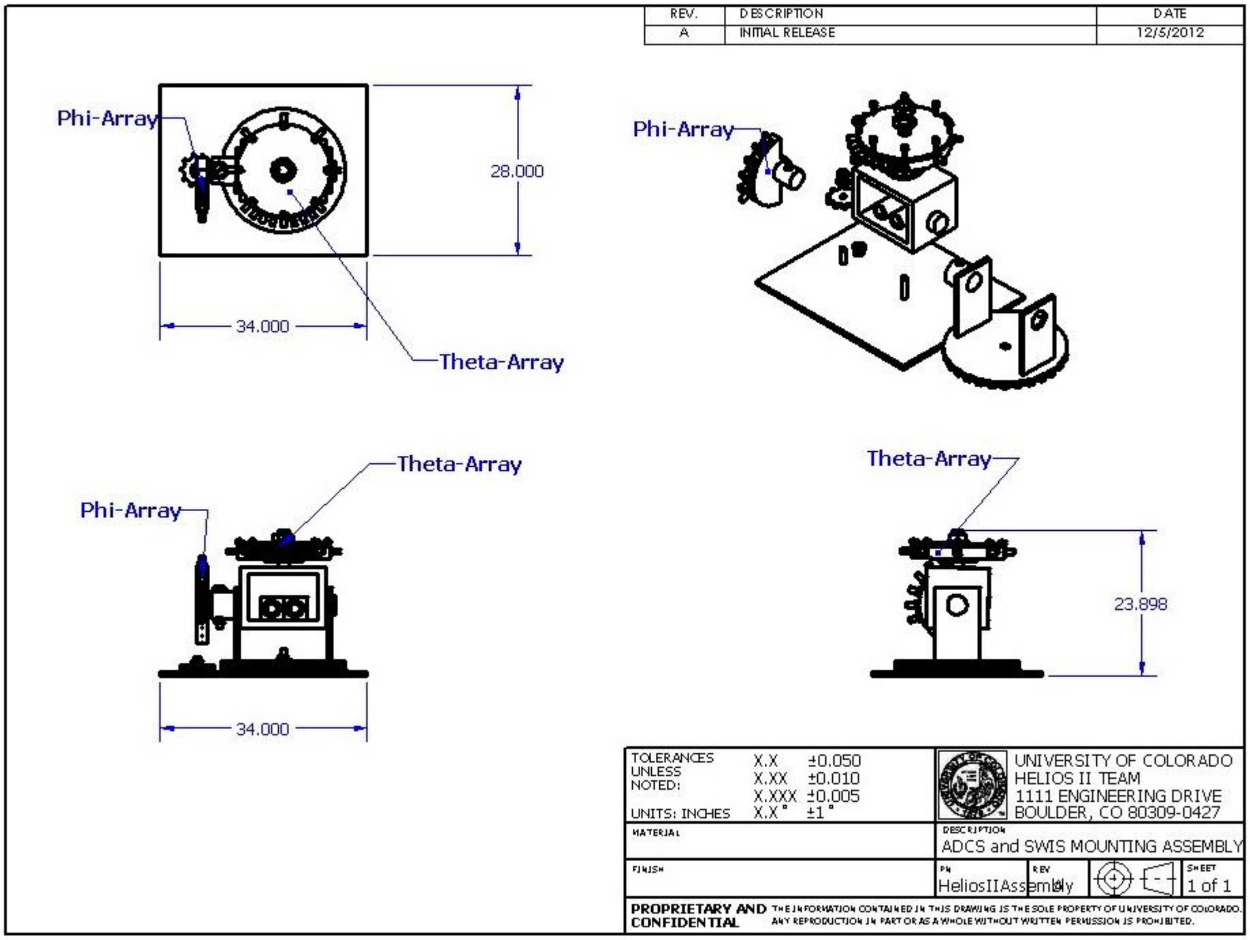


Figure 3.2.2

Phi (φ) Plane: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X.XXX ±0.005
UNITS: INCHES
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UNIVERSITY OF COLORADO
HELIOS II TEAM
1111 ENGINEERING DRIVE
BOULDER, CO 80309-0427
MATERIAL
DESCRIPTION
ADCS and SWIS MOUNTING ASSEMBLY
FINISH
PN
HeliosIIAssembly
REV
SHEET
1 of 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF UNIVERSITY OF COLORADO. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT WRITTEN PERMISSION IS PROHIBITED.

Figure 3.2.3

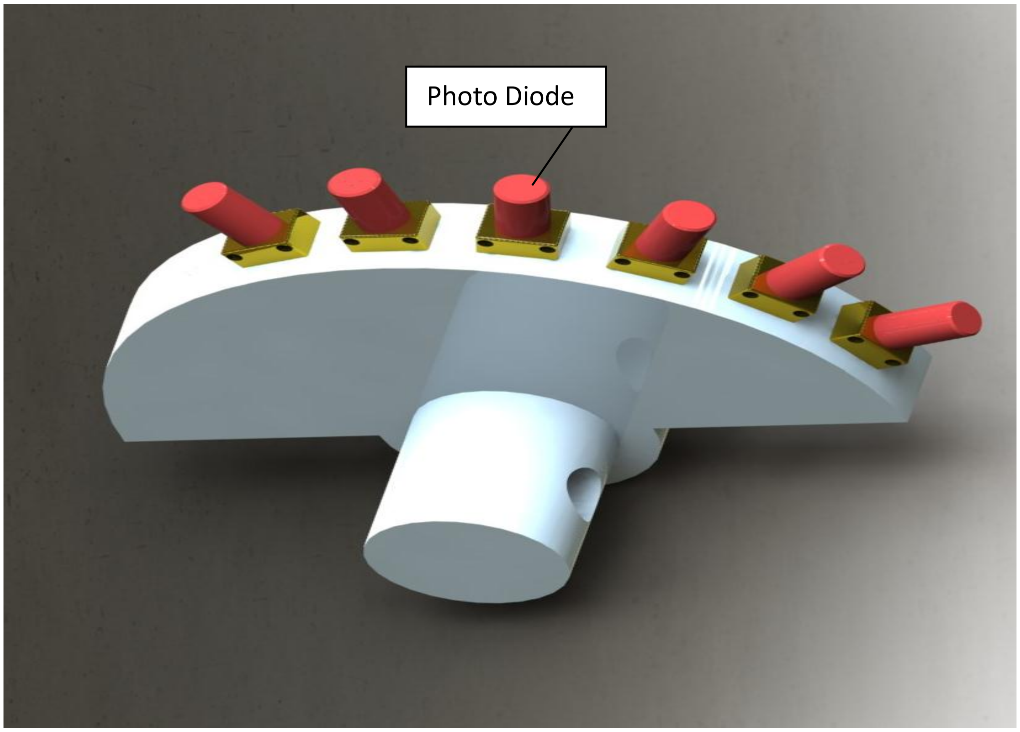


Figure 3.2.4

3.2.2 Rotation and Positioning

Two motor systems are used to rotate the imaging system, allowing it to focus on the Sun in a direction determined by the Theta-plane and Phi-plane arrays. One motor system is used to orient the system on the Theta-plane and the other motor system orients it along the Phi-plane. The system has an overall reaction time of 1-3 seconds, which varies depending on the degree of rotation. The system shall be able to respond fast enough to the platform rotating at a speed of up to 1.2 to 2 degrees per second.

Theta-Plane (ϴ) Motor System

The Theta-plane motor system orients the direction of the imaging system in the Theta-plane. The system is composed of a motor and a gear assembly. All components shall be toleranced and assembled to take into account thermal expansion/contraction due to varying temperatures following launch. The motor shall be a stepper motor with a small minimum step angle. This ensures that the motor is accurate in its rotation and stepper motors provide enough torque and control. The gear assembly consists of two gears on a flat plate attached with a tensioned chain. The imaging system along with sensor arrays are mounted to the larger of the two gears, while the motor is attached to the shaft of the smaller gear. The faster the imaging system rotates, the more likely it is for the ADCS to incorporate error in positioning. The gear assembly acts as a speed reducer for the motor so that maximum accuracy is maintained and motor torque is not compromised.

Phi-Plane (φ) Motor System

The Phi-Plane motor system orients the direction of the imaging system in the Phi-plane. This system is composed of a motor attached directly to the axis of Phi-Plane Array. The motor used in the Phi-Plane is identical to the motor used in the Theta-Plane Motor System.

3.2.3 Procedure of Operation:

ADCS shall work by processing the raw data from the arrays, taking into account every reading before choosing the photodiode exposed to the most intense light. The ADCS system shall then rotate in the direction on the most intense light readings. The ADCS shall then calculate the difference between the light intensity readings from the photodiodes in its current location and final location. This data shall be sent to the repositioning system to complete orientation before an image is taken. The orientation of the imaging system shall work in two steps.

1) The control system shall receive data from the Theta-Plane array and determine which of the photodiodes is receiving the most light. Then, the control system shall send the necessary commands to the Theta-Plane Motor System and orient the imaging system along the previously computed direction of most light, thus repositioning the system along the Theta-plane. This procedure is repeated twice to ensure accuracy and remove any instantaneous errors.
2) The control system receives data from the Phi-Plane array and the above process is repeated to position the system in the Phi-Plane. This ensures that the Phi-plane array shall never be affected by shadow from the structure, as the array shall be oriented towards the sun before any data is collected. This procedure is repeated twice to ensure accuracy and remove any instantaneous errors.

3.2.4 ADCS Test Procedures:

1) The solar position determination system shall be tested by positioning an intense light source simulating the Sun in different predetermined positions in a dark room. The responses from the photodiodes shall be recorded and checked for accuracy. The controls shall be corrected and restructured as needed to ensure minimum error.
2) The rotation and positioning system shall be tested in parallel with the solar position determination system. The accuracy with which the motors are able to position the SWIS shall be checked.
3) The ADCS system shall be subjected to extreme thermal conditions, simulating the thermal and environmental conditions that it shall operate in at high altitudes. The ADCS shall record accuracy of the solar position determination system and the repositioning system separately and as a whole.

3.3 Structural Design:

HELIOS II consists of two major substructures; each primarily constructed of 0.635 cm thick aluminum panels. The payload shall be a 30 cm x 38 cm x 0.635 cm PVC mounting plate. The first segment of the structure measures 30 cm x 38 cm x 10 cm (Figure 3.3.1 and 3.3.2), this shall contain the central computing and data storage (CDH) system, electronics, power board, the theta axis motor, and all wiring for the ADCS and SWIS systems. This substructure shall be thermally insulated, providing a thermal barrier between the heat-producing computing elements and the heat-sensitive imaging systems in the second substructure. The second substructure resides on top of the primary segment and is comprised of SWIS, the phi axis motor, the theta and phi photodiode arrays, and the tensioned gear system, all of which is mounted on a 26 cm X 34 cm X 0.635 cm PVC plate. The height of the array shall not exceed 20 cm above the top of the second substructure, ensuring that the project shall remain within volume requirements. Considerations have been taken to ensure that the structure shall remain sound despite the effects of thermal expansion. The entirety of the outer structure shall be painted white, to prevent interference from reflections in the photodiode arrays.

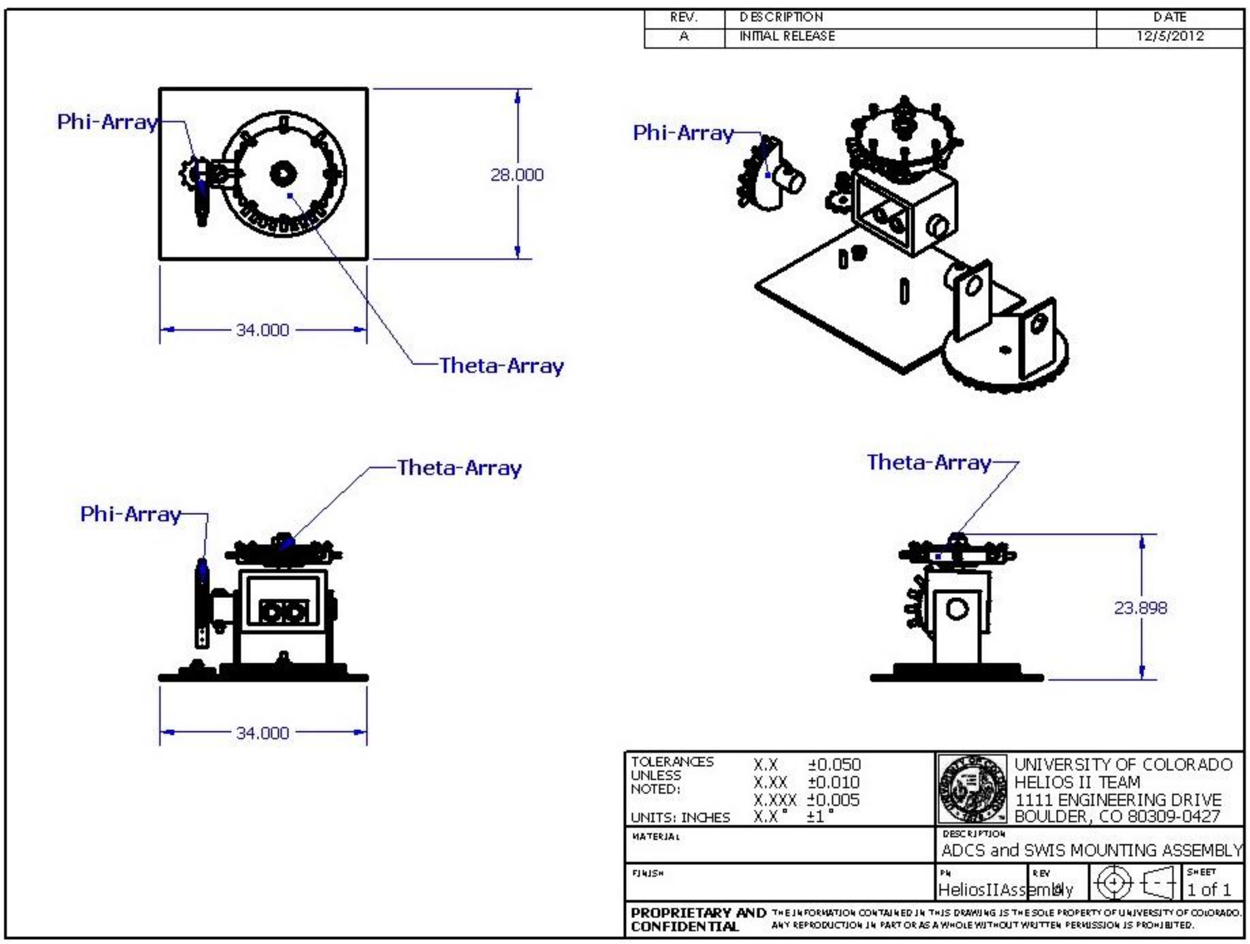


Figure 3.3.1

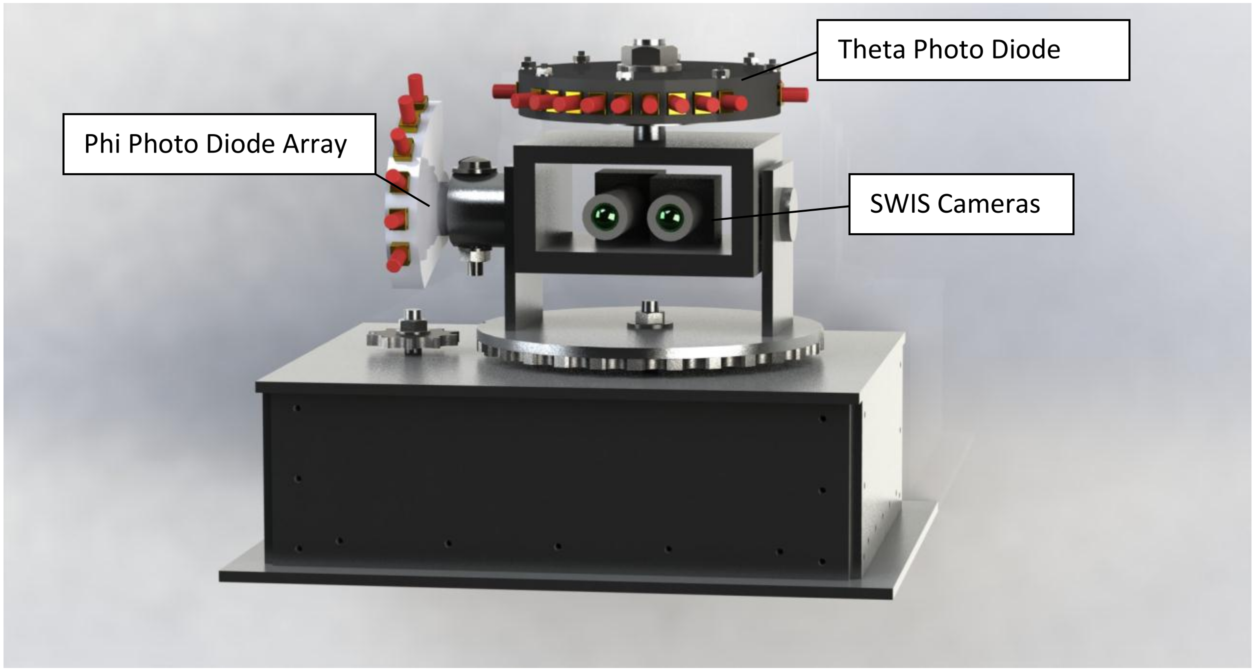


Figure 3.3.2

3.4 Command and Data Handling (C&DH):

The C&DH system onboard of HELIOS II shall include four main components: A flight computer, two microcontrollers, and a data storage system. HELIOS II's flight computer shall run a modified, low resource, Linux Kernel. This flight computer shall be used for all camera control and data handling, ground communication, and monitoring system health and status. An Arduino Due microcontroller shall be attached to the motherboard that shall be making all ADCS calculations and monitor SWIS system health. A second Arduino Uno microcontroller shall be used to collect environmental data of the flight and shall provide a reference for any anomalies that may occur. The last element of the C&DH system shall be a solid-state drive that shall be used for storage of all flight sensor data including captured images. The flight computer shall also be monitoring power draw of all electronics and shall implement external interrupts if necessary to ensure working stability of the payload. The flight computer shall interface to the HASP platform downlink/uplink communication lines to allow ground control of the payload. See the Functional diagram for EPS and C&DH on page 23 (Figure 3.4.1).

3.5 Electronic Power System (EPS):

HELIOS II is allotted 30 Volts DC from the HASP platform, redistributed between the different systems. The 30 V provided from the platform shall be directed to different components of the payload (Figure 3.4.1), as illustrated in the functional diagram on page 22. With the purpose of fulfilling mission of creating a standard bus for future HASP payloads, the voltage provided from HASP has been brought down to several different voltage values in the power card. HELIOS II shall be using only the 5 V and 9 V power sources.

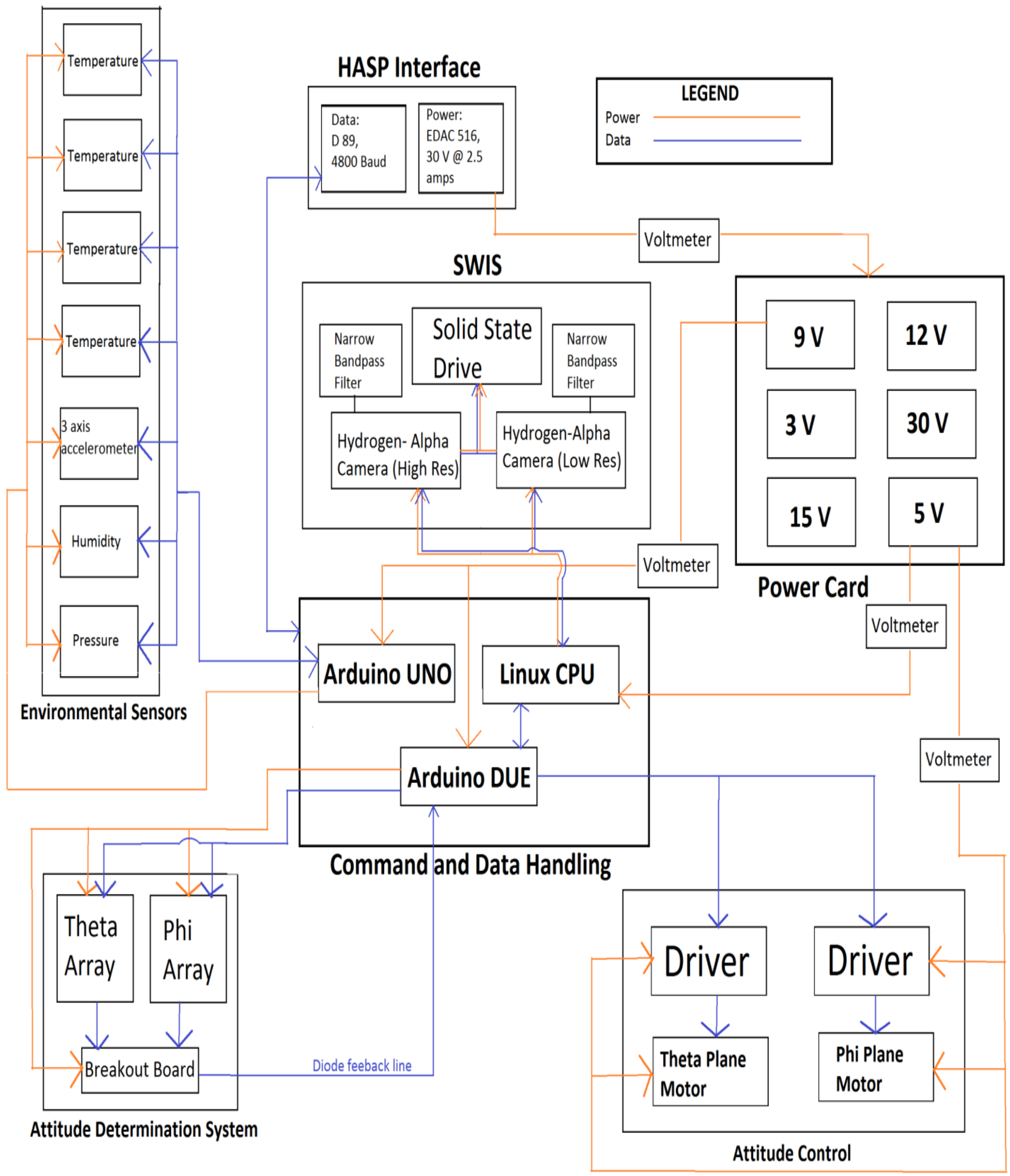


Figure 3.4.1

Power Budget

The following table depicts the estimated power required for each HELIOS II system during flight, as well as total power required for the entire payload at any given time. The power values displayed were calculated by using the maximum current and voltage values available for every component. HELIOS II will only use about 2/3 of the available 75 Watt power output. The HASP platform delivers the 30 VDC for approximately 270 Amp-hours. In the event that the duration of our flight is long, “up to 20 hours,” as stated in the call for proposal, HELIOS II would consume about 1071 Watt-hours, or approximately 1/8 of the available energy.

Instrument	**Voltage (V)**	**Current (A)**	**# of sensors/pins used at one time**	**Power (W)**
Arduino Uno	5	0.04	6	1.2
5 Volt Pin	5	0.05	1	0.25
3.3 Volt Pin	3.3	0.05	1	0.165
CPU	5	4	1	20
Cameras	5	0.5	2	5
Motors	5	1	1	5
Arduino Due	3.3	0.009	11	0.3267
5 Volt Pin	5	0.8	1	4
3.3 Volt Pin	3.3	0.8	1	2.64
Motor Drivers	5	3	1	15
Total Max Power Draw				53.59

Max Energy Draw (Whr)	= (Max Power Draw for up to ~20 hrs)	1071.63

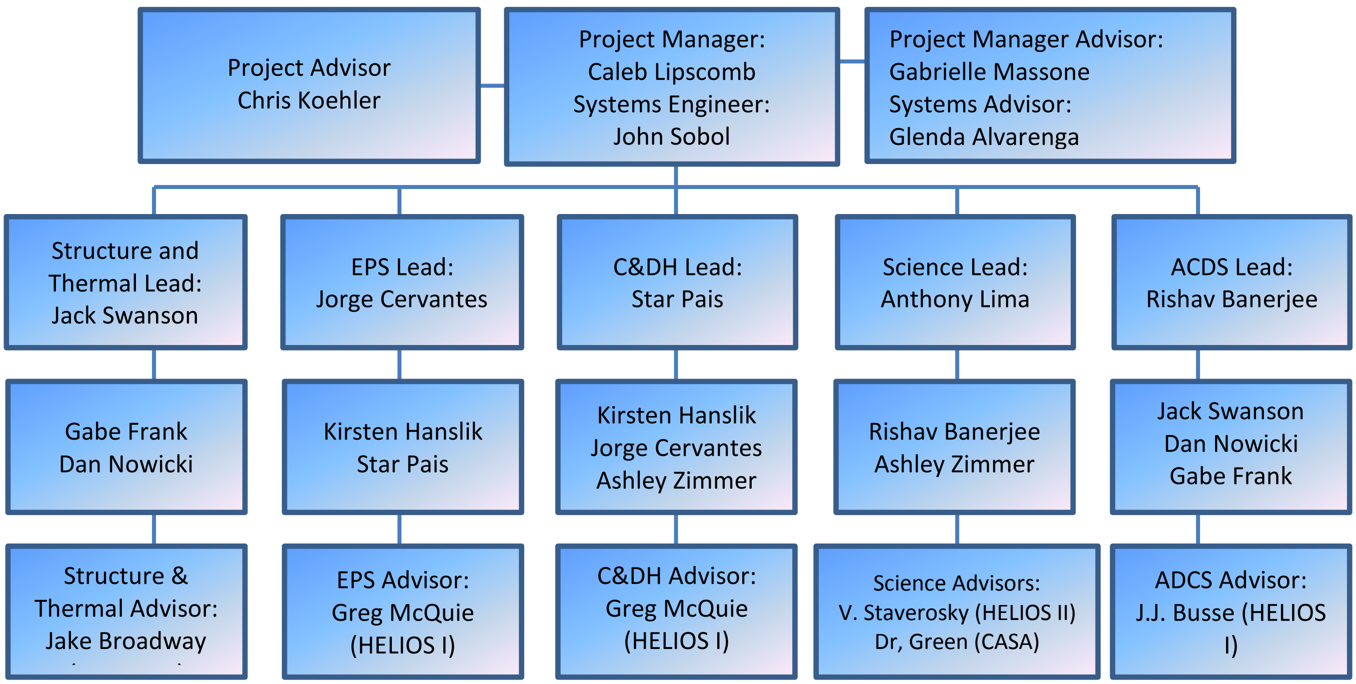
3.6 Thermal

Part of HELIOS II’s success depends on maintaining temperature within operational range of all systems. The heat given off from the processing unit, as well as the voltage regulators shall provide ample heating to the internal systems. The internal temperature may rise above operational limits, potentially leading to failure of internal systems. HASP shall reach an altitude of approximately 36,000 meters. At this altitude, the ambient pressure shall make convection impossible. In order to prevent failure due to overheating, heat sinks shall be applied to all systems using thermal epoxy. These heat sinks will then be applied directly to the HASP platform. In this way, the applied heat sinks shall directly conduct the thermal energy from the payload to the HASP platform, at which point it shall be radiated into the atmosphere. Heat sinks avoid reliance upon complex fluid cooling systems and shall function in the near-space environment the payload is exposed to. Therefore, the payload shall utilize the structure of the HASP platform to store and then distribute excess heat away from the processing system. In addition, the structure shall be painted white to reflect as much heat and light as possible. This process shall insure the payload against over-heating and system failure.

4.0 Management

HELIOS II consists of 12 members. Each member shall be in charge of a subsystem based on interest and/or experience with the subsystem. HELIOS II shall work with faculty advisors and members of the HELIOS I team to ensure the successful design and construction of the payload. The HELIOS I advisors shall work closely with the HELIOS II team in the subsystems of their expertise in order to give their knowledge and experienced gained from the 2012 HASP mission.

4.1 Organization Chart:



4.2 Scheduling

In addition to these scheduled meetings and conferences below, HELIOS II shall meet a minimum of once a week to accomplish project tasks and, along with weekly meetings with HELIOS II's faculty advisory, Chris Koehler. Throughout these meetings, team members shall discuss the current state of the project, and each system lead shall submit progress reports to the Systems Engineer and Project Manager. Each sub-section shall meet at their discretion and work on their system tasks. Reviews will be held with both HELIOS II's faculty and science advisors plus current and past COSGC students. A more detailed schedule is currently in development and incorporates lessons learned from HELIOS I.

	2012		2013											
Milestone	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**Notes**
Team Formed	▲													
Final Draft Proposal		▲												Ensure all of last year's problems have been addressed
Announcement of Student Payload Selection			▲											
Submit Selection Response			▲											Within two weeks of selection, a response to comments and
Preliminary Design Review			▲											
Critical Design Review			▲											Within two weeks of selection, a CDR will be presented to Space Grant and project affiliates
Teleconference				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
Preliminary PSIP document due						▲								Payload Specification and Integration Plan
SWIS Functionality						▲								Cameras and baffling system will be calibrated
Structure Functionality						▲								All structure machining and interfacing shall be completed
ADCS Functionality						▲								All control and determination systems will have gone through testing and be in proper working order
All System Integration							▲							All systems will be integrated and prepared for parallel testing of multiple systems
System Operations Testing							▲							Parallel testing of multiple testing
In-House Vacuum Testing							▲							Test all subsystems at Space Grant vacuum chamber and/or CASA (Center for Astrophysics and Space Astronomy) facility
Thermal/Vacuum Testing at Palestine,TX							▲							Test at CSBF in Palestine, Texas
Final PSIP document due								▲						Payload Specification and Integration Plan
Final FLOP document due									▲					Flight Operation Plan
HASP flight preparation										▲				
Target Flight Ready										▲				
Target Launch Date and Flight Operations											▲			
Recovery,packing and return shipping												▲		
Final Flight/Science Report Due														

5.0 Integration and Launch

Upon integration of HELIOS II into the HASP platform, all System Leads, the Systems Engineer, and the Project Manager, Caleb Lipscomb, shall ensure proper integration procedure is followed. A comprehensive checklist shall be used to confirm a successful integration of the HELIOS II payload. The System's Engineer, John Sobol, shall test all communication processes and equipment throughout integration to assure proper function.

5.1 Launch Procedures

The following is an approximation of flight times, altitudes, and events. Given in the leftmost column are estimated times in the hour-minute-second format. In the rows associated with each time are estimated altitudes, flight events, and system directives. The mission outline works on the assumption that the float time shall have 10 +/- 4 hours of sun visibility. Caleb Lipscomb is responsible for ensuring that all of the flight procedures are properly followed and completed. The team leads of each subsystem shall be responsible for ensuring that their respective subsystems successfully undergo integration into the HASP platform. During the flight, Star Pais and Rishav Banerjee shall be responsible for controlling all discrete commands to the HELIOS II payload on the HASP Platform.

Est. Time	Est. Alt (m)	Flight Event	System Event	Event Sub-Tasks
T – 1 day	0	N/A	Pre-Launch Check	Verify all systems
T – 1 day	0	HASP Integration	HASP Integration	
T – 01:00:00	0	N/A	Flight Line Setup	
T = 00:00:00	0	Launch	N/A	
T + 01:00:00	36,576	Max Altitude	All systems on	
T + 01:30:00	36,576	Float	Begin ADCS solar location loop	Record ADCS attitudes and behavior
T + 01:45:00	36,576	Float	Enable SWIS	Collect images
T + 20:00:00+	36,576	Before Descent	Disable Systems, Power Down	
T + 20:00:00+	36,576	Begin Descent		
T + 20:00:00+	0	Landing		

6.0 Conclusion

The goal of HELIOS II is to determine the feasibility of using a high altitude balloon platform as a solar observation platform. HELIOS II shall show that it is possible to take high quality images of the sun in the Hydrogen Alpha wavelength using a high altitude balloon platform. In addition, HELIOS II shall fly two different camera barrels, one with a high resolution and a small field of view and a second with a large field of view and a lower resolution. HELIOS II shall compare the images taken by HELIOS II with test images from a ground station as well as images taken using orbital telescopes to see if the balloon observation platform can produce comparable images of the Sun. Should the HELIOS II mission prove successful, it could offer much greater access to high quality solar observation by providing a cheaper alternative to multi-million dollar orbital solar observatories, and by eliminating the atmospheric interference experienced by ground-based solar observatories.

7.0 Appendix:

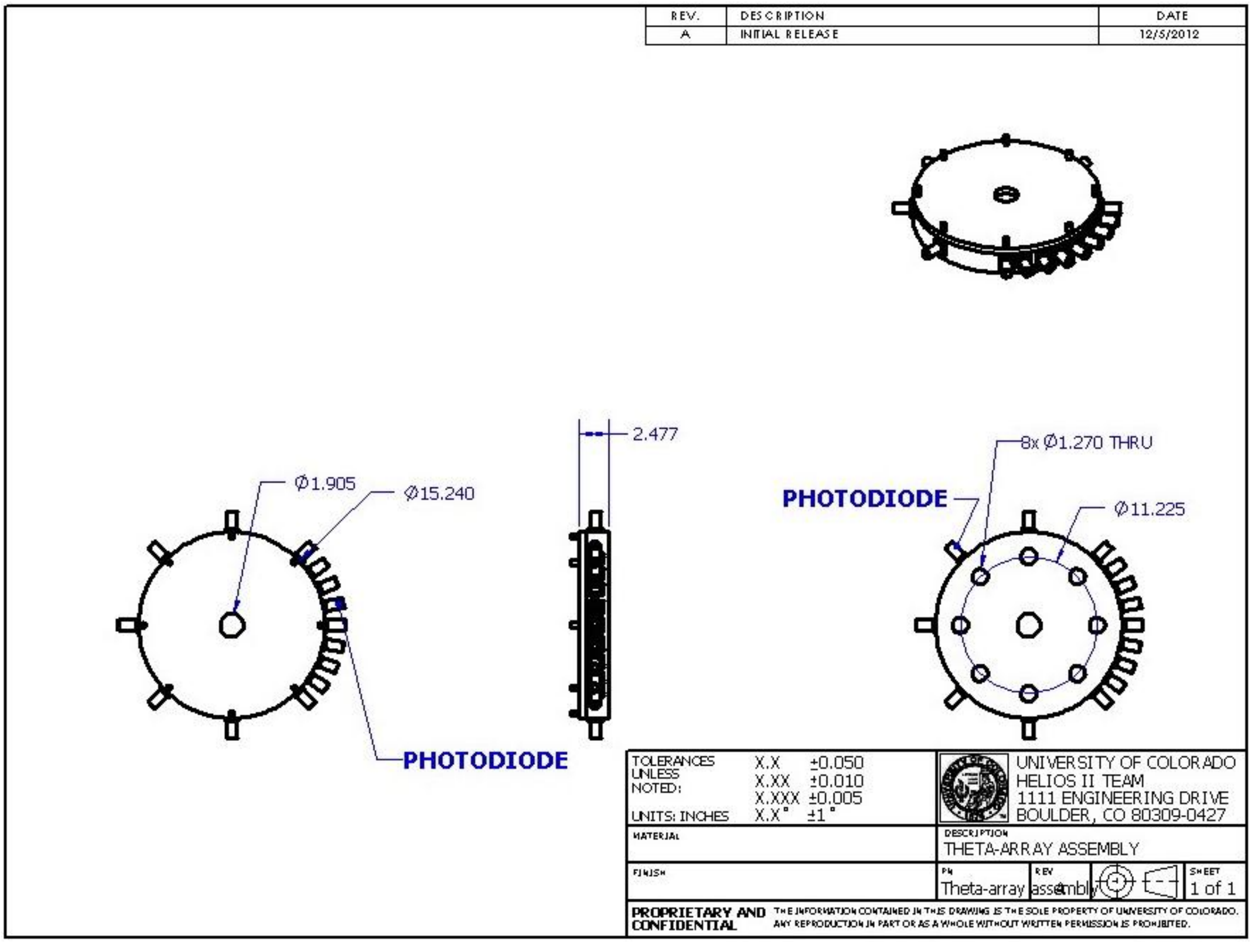
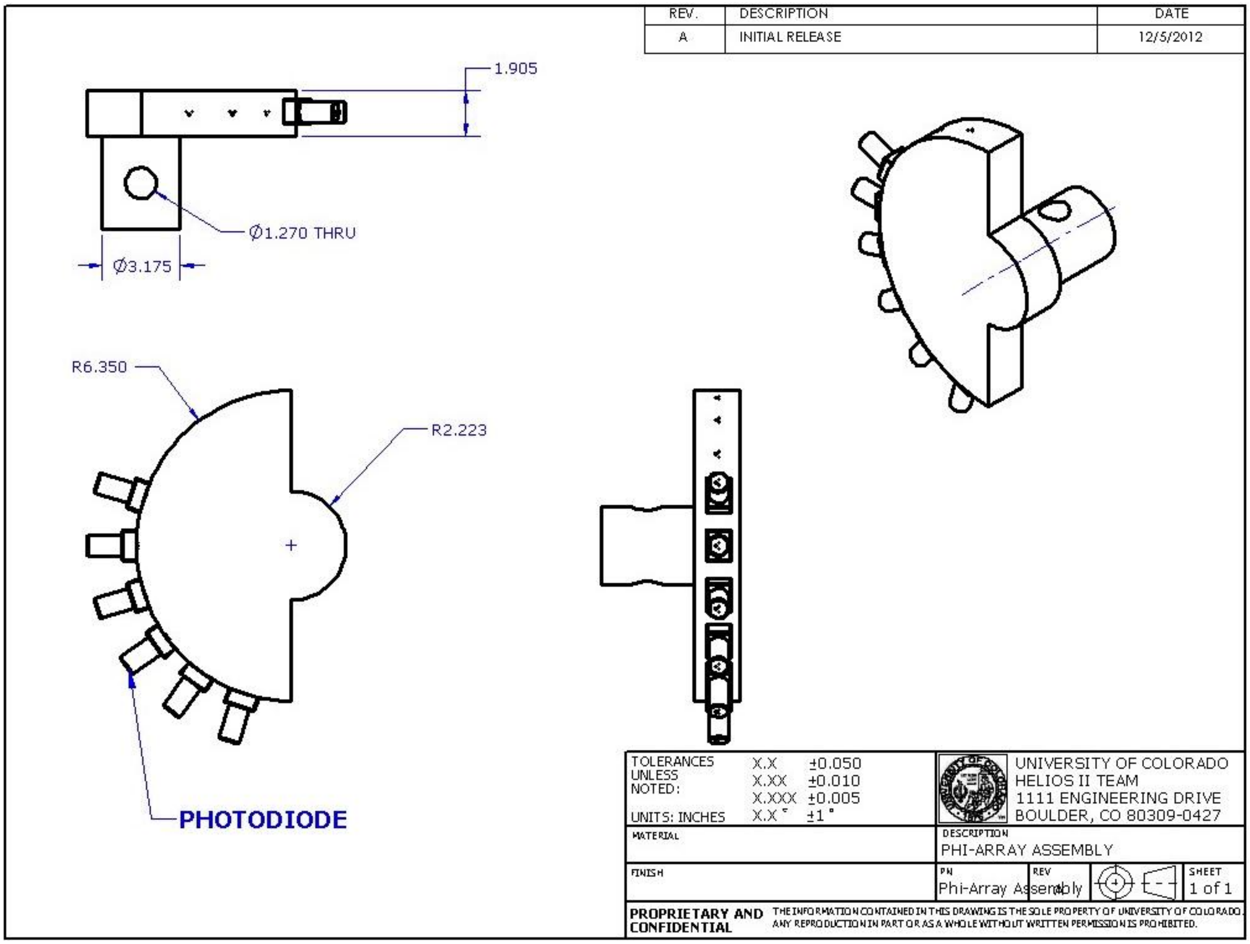


Figure 3.2.1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X.XX ±0.010
X.XXX ±0.005
UNITS: INCHES
X.X° ±1°
UNIVERSITY OF COLORADO
HELIOS II TEAM
1111 ENGINEERING DRIVE
BOULDER, CO 80309-0427
MATERIAL
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PHI-ARRAY ASSEMBLY
FINISH
PN
Phi-Array Assembly
REV
SHEET
1 of 1
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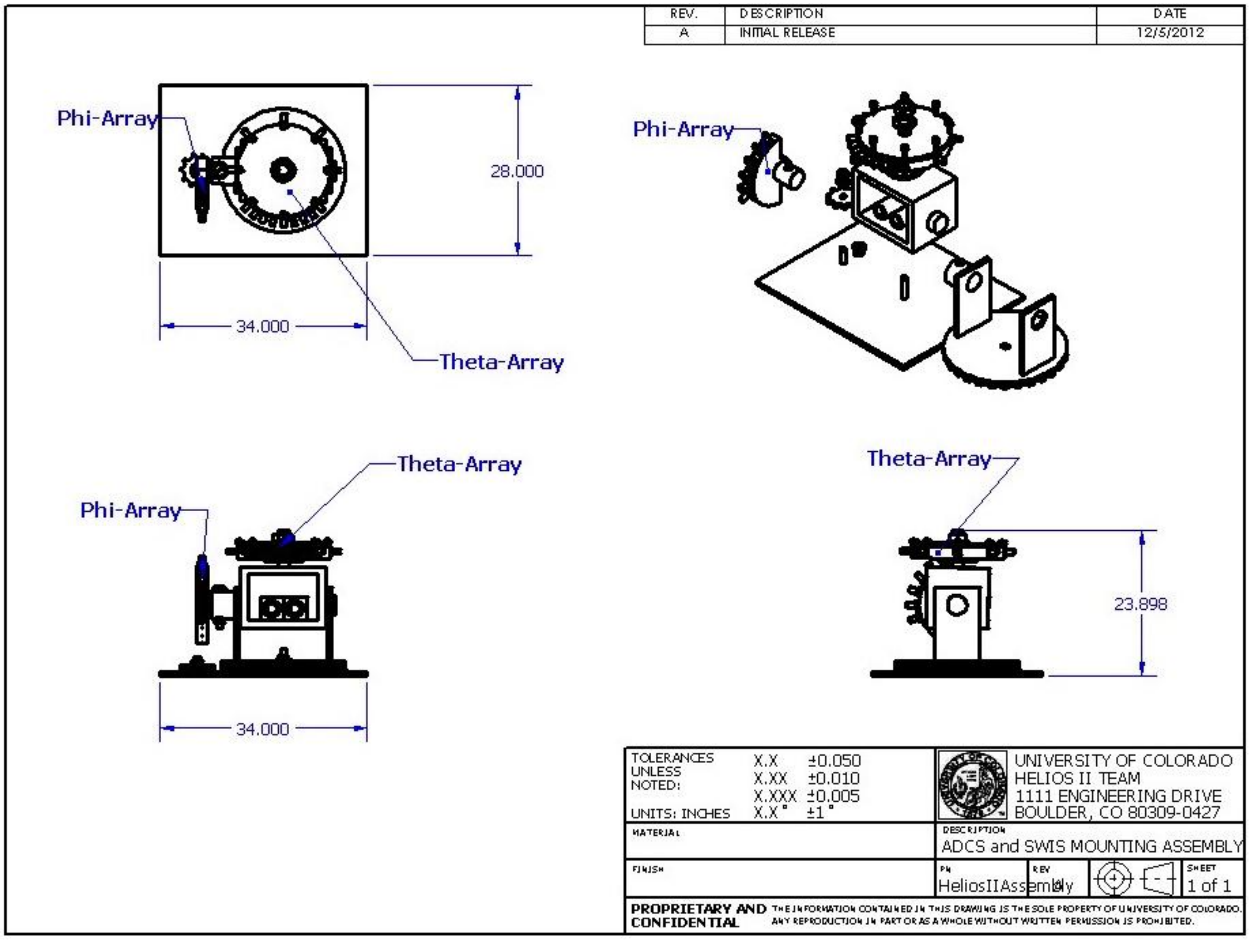
Figure 3.2.3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UNITS: INCHES
UNIVERSITY OF COLORADO
HELIOS II TEAM
1111 ENGINEERING DRIVE
BOULDER, CO 80309-0427
MATERIAL
DESCRIPTION
ADCS and SWIS MOUNTING ASSEMBLY
FINISH
PN
HeliosIIAssembly
REV
SHEET
1 of 1
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Figure 3.3.1