HASP Student Payload Application for 2023

Payload Title: Sol Seeker

Institution: College of the Canyons

Payload Class: LARGE	Submit Date: 01/06/2023

Project Abstract:

The Sol Seeker payload will use a telescope mounted on a set of motors to identify, lock on, and track the sun as the balloon maneuvers in the upper atmosphere.

The telescope system will include a low-resolution camera, with a lens pairing that will allow it to correctly identify the sun among other stars that will be visible from the platform. There will also be a high-resolution camera used to take images of the sun and detect sunspots. A computer will be used to control and process images from the cameras, and a microcontroller will be used to run a pair of motors that can rotate the telescope, as well as read temperature data from a pair of temperature sensors, and determine the position of the telescope relative to its starting position. Data will be saved to a pair of onboard SD cards, mounted on each of the controllers, at regular intervals and data snippets via downlink will be monitored during flight.

Team Name:	Team or Project Website:
Sol Seeker	https://teresaciardi.wixsite.com/cocast

	Student Leader Contact Information:	Faculty Advisor Contact Information:
Name:	Melissa Rocha	Teresa Ciardi
Department:	Mathematics/Psychology	Physical Sciences/Astronomy
Mailing Address:	26455 Rockwell Canyon Rd	26455 Rockwell Canyon Rd
City, State, Zip code:	Santa Clarita, CA 91355	Santa Clarita, CA 91355
e-mail:	mrocha1@my.canyons.edu	teresa.ciardi@canyons.edu
Telephone:	(661) 857-6913	(661) 313-6015

The signature below indicates that the student lead and faculty advisor have read and understood the HASP CFP and Student Payload Interface manual, commit to providing the required HASP deliverables by the indicated due dates and agree to respond to HASP management inquires in a timely manner.

Commitment Signature:	*Melissa Rocha*	

Flight Hazard Certification Checklist

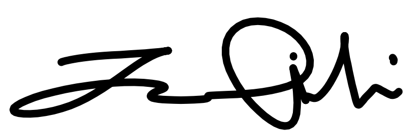
NASA has identified several classes of material as hazardous to personnel and/or flight systems. This checklist identifies these documented risks. Applying flight groups are required to acknowledge if the payload will include any of the hazards included on the list below. Simply place an (x) in the appropriate field for each hazard classification. **Note:** Certain classifications are explicitly banned from HASP and the remaining hazards will require additional paperwork and certifications. If you intend to include one of the hazards, you must include detailed documentation in section 3.8 of the application as required by the HASP Call for Payloads.

This certification must be signed by both the team faculty advisor and the student team lead and included in your application immediately following the cover sheet form.

Hazardous Materials List		
Classification	**Included on Payload**	**Not Included on Payload**
RF transmitters		X
High Voltage		X
Lasers (Class 1, 2, and 3R only) Fully Enclosed		X
Intentionally Dropped Components		X
Liquid Chemicals		X
Cryogenic Materials		X
Radioactive Material		X
Pressure Vessels		X
Pyrotechnics		X
Magnets less than 1 Gauss*		X
UV Light		X
Biological Samples		X
Non-Rechargeable Batteries		X
Rechargeable Batteries		X
High intensity light source		X

* Magnets greater than 1 gauss are banned.

Student Team Leader Signature: _______*Melissa Rocha*_____________________________

Faculty Advisor Signature: 

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1. Payload Description

The College of the Canyons Aerospace and Sciences Team Payload titled Sol seeker will be an automated telescope system that will track and image the Earth's sun. The Sol seeker shall be looking for sunspots on the Sun using a white filter. Once the Sun is no longer visible the telescope will then track the next brightest object in space, which is most likely going to be the moon.

1.1 Payload Scientific/Technical Background

The Sol Seeker payload will track the location of the Sun relative to the payload's position by capturing the Sun's light footprint with a camera and lens pair. The camera and lens pair are mounted on a set of motors designed to apply rotational movement of the camera and lens. Both the camera and the lens are controlled by a Raspberry Pi computer, which will take the input of the low-resolution camera and send movement commands to the motors, via the Teensy through a Serial channel, to adjust the rotational position of the telescope system accordingly. A high-resolution camera will capture images of the sun to detect sunspots. There will be one Teensy 4.1 (an Arduino-based microcontroller) to control the motor system, read the thermistor sensors, and construct and send downlink data.

1.1.1 Mission Statement

The purpose of the experiment is to track the location of the Sun across the sky by focusing on sunspots while the High-Altitude Student Platform (HASP) rotates during its flight in the stratosphere. As the HASP platform and balloon oscillate about 10 degrees/min it creates a stabilization challenge which this experiment seeks to solve. As the platform (HASP) the payload is mounted on moves, rotates, and rattles, the telescope will constantly need to adjust its position to keep itself pointed towards the target. This may be difficult if there are other bright light sources in the sky, as the telescope will need to differentiate between the Sun and any other light sources. The camera and lenses will be mounted on motors that rotate to counter the rotational motion the Sol seeker payload will endure during HASP's flight and will adjust for variations in the platform's position. The use of motors will counteract the rotation of the platform to track the sun.

The experiment also serves as a testbed for a potential upgrade for a future iteration of the project. Once the mechanical aspect of the tracking portion of the experiment is deemed a success, a more advanced camera may be used to provide further tracking options of other celestial objects. One notable possibility for a potential future upgrade would be using a thermal camera, instead of a solar lens and a standard camera.

1.1.2 Mission Background and Justification

Sunspots are areas where the magnetic field disrupts energy flow as kinks in the magnetic field emerge from the photosphere to create the sunspots. The kinks in the Sun's magnetic field are about 2,500 times stronger than Earth's magnetic field, and the strength of the magnetic field detected in these kinks is much higher than anywhere else on the Sun. Sunspots tend to occur in pairs where the north and south ends of the kinks in the magnetic field emerge and re-enter the photosphere of the Sun. Sunspots appear dark because energy is disrupted in this region causing a difference in temperature as compared to the rest of the photosphere (the surrounding surface of the Sun).

Sunspots are associated with solar flare activity which can affect Earth. Solar flares are plumes of solar material that initially follow the kinks in the magnetic field and then break away from the Sun. Solar flares emit x-rays and can result in a burst of solar particles that bombard the Earth as geomagnetic storms. Solar flares can disrupt radio transmission, affect power grids, and damage sophisticated electronics in satellites. The number of sunspots peak every 11 years and sunspots are currently increasing in number. By monitoring the current sunspot activity, an analysis can be made of the statistical probability of solar flare activity (National Weather Service, n.d.).

The Sol Seeker payload will demonstrate a low-cost method for detecting sunspots and monitoring solar activity because relatively low-cost parts for the scaffolding will be used.

Stage lighting yokes used in the Beijing Olympics were used as an inspiration for the scaffold to hold the telescope (Harman, 2008).

1.1.3 Mission Objectives

- Prove that maintaining alignment of a telescope with the sun is possible from a rotating platform
- Use collected data to determine number of sunspots detected by the Sol seeker payload and compare Sol Seeker data to current NASA data
- Ensure successful operation of Sol Seeker payload including flight computers, electronics, and mechanical operation for duration of flight

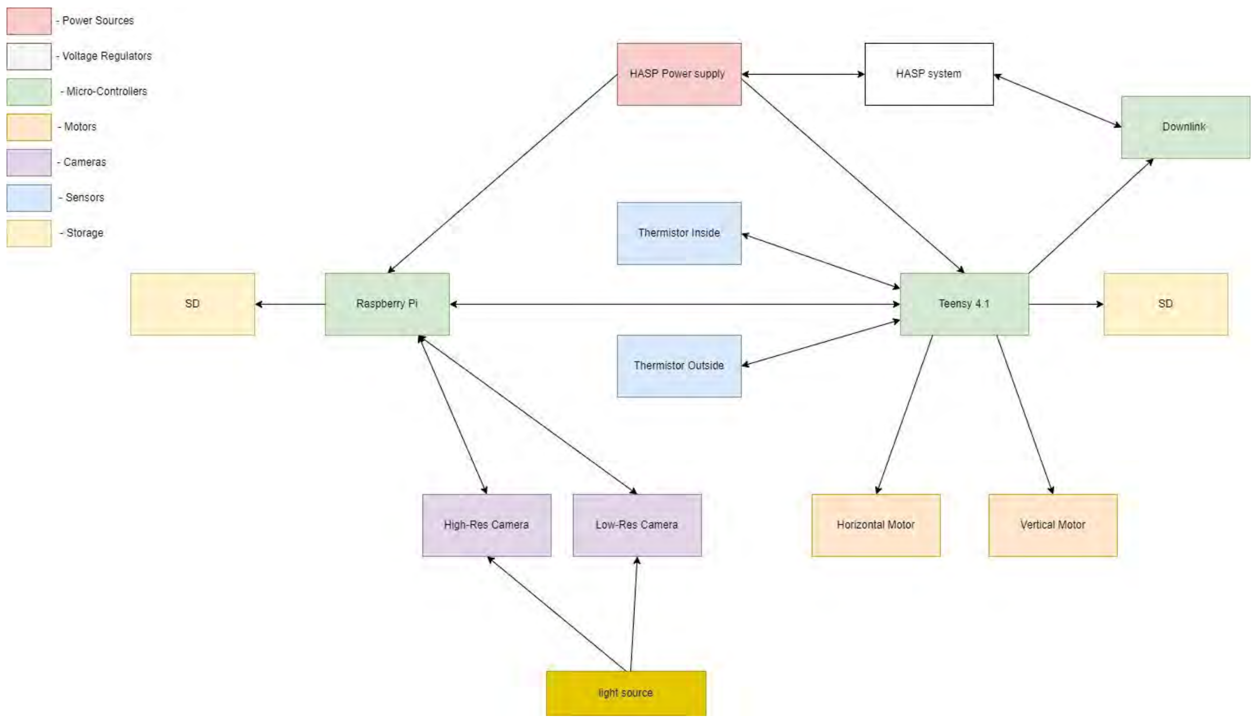
1.1.4 Scientific Relevance to the HASP Platform

Sol seeker is a telescope-camera system that will operate best without the hindrance of atmosphere conditions such as seeing atmospheric window limitations, and the hindrance of light pollution. A near space environment is optimal for solar observations and imaging. The HASP platform will provide a rotating system against which the Sol Seeker system can be tested, indicating the viability of a sunspot seeking system on a rotating platform.

1.2 Payload Systems and Principle of Operation

The experiment will have 2 major parts:

- Telescope composed of a pair of cameras and a telescope lens, managed by a Raspberry Pi computer
- Set of rotating motors, controlled by a Teensy 4.1, an Arduino-based micro-controller



Principle of Operation Diagram

One of the cameras is a CMOS Imaging Camera and will have a ZWO Mini Guide Scope attachment. The other camera is a 4K Webcam and will be used to assist the imaging camera find the brightest light. Both will have a white solar filter mounted on them to filter out the incoming light from the environment properly in order to easily identify the sun from the rest of the elements in the sky.

4K Webcam *CMOS Imaging Camera*

White Solar Filter

Mini Guide Scope

The HASP power supply will run through a 5V regulator supplying the Raspberry Pi and Teensy 4.1 with adequate power. The Teensy will control the movement of the cameras, while the Raspberry Pi will control the operation of the cameras. The 2 stepper motors will each be provided with a 12V regulator in order to supply correct power to the motors. There will be a pair of thermistors connected to the Teensy 4.1 to track the temperature of the electrical components. One will be positioned inside the enclosure of the two controllers, and one will be positioned on the outside. The Raspberry Pi will also have a single serial communication line to the Teensy 4.1, to provide the Teensy with its current image status and position. This information will be used to determine whether the images from the camera are still being saved properly and to indicate if the telescope needs to be moved. The Teensy 4.1 will also be reading the thermistor temperature data, as well as keeping track of the motors' movements, and will send both of data points, along with the telescope image status through the serial downlink which is connected to HASP via the RS232 connector.

The telescope will have a search algorithm that will scan as much of the visible sky as possible, by rotating the telescope until it identifies the brightest source of light. This will be triggered every time the telescope has not identified a target, which would be at the start of the experiment, and every time it loses track of the sun.

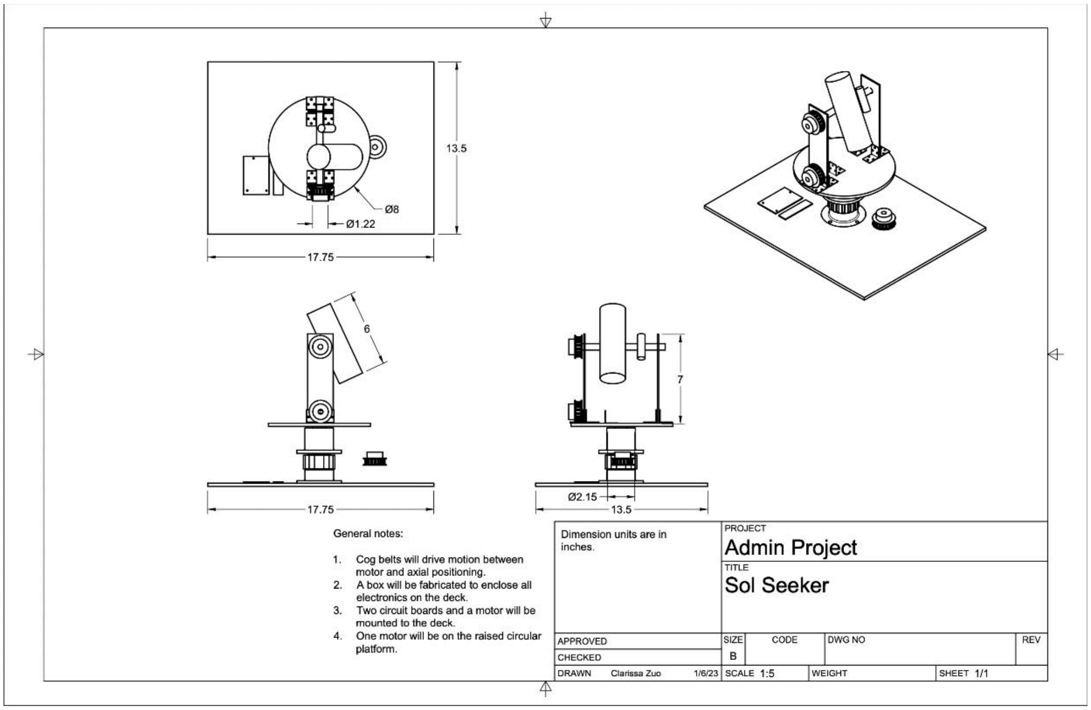
1.3 Major System Components

The Raspberry Pi computer is responsible for managing the cameras, it will process data from the cameras, determine whether the camera angles need to be adjusted to maintain alignment with the sun, and send any movement commands to the Arduino-based micro-controller.
The Teensy 4.1 (an Arduino-based micro-controller) will then run the motors for the required amount of time in the desired directions, to achieve the desired camera angles.

The relative rotational positions of the motors and the temperature readings from the thermistor sensor will be saved at regular intervals to an on-board SD card on the Teensy 4.1 microcontroller while also sending regular intervals of data snippets via the downlink to track the functioning of the Sol Seeker payload during flight. The Raspberry Pi will store image data on its SD card to be analyzed upon the experiment's conclusion.

1.4 Mechanical and Structural Design

The telescope stand will consist of a flat plate, with both cameras mounted on a vertical holder that will have motors on it.



Design sketches of Telescope stand

The payload's electrical system will be housed in an enclosure, off to the side of the plate, with wiring for the telescope system and motors exiting the enclosure through a small hole. Standard insulated wiring needed to control the telescope system will be harnessed in a manner that ensures wiring will not be strained in any way as the motors rotate the system. There will be enough slack given to the wires to prevent entanglement and secured to the chassis where applicable to allow enough flexibility during telescope adjustment. A physical stop made of cap head screws will limit the maximum horizontal rotation to less than 700 degrees and minimize the risk of the cables being damaged. An inhibit in the code will limit the maximum vertical rotation to less than 90 degrees. The motors will be lubricated with Dicronite, a tungsten disulfide (WS_2) solid lubricant coating. Its lamellar structure will allow the motors to move with very low resistance.

White insulated wire

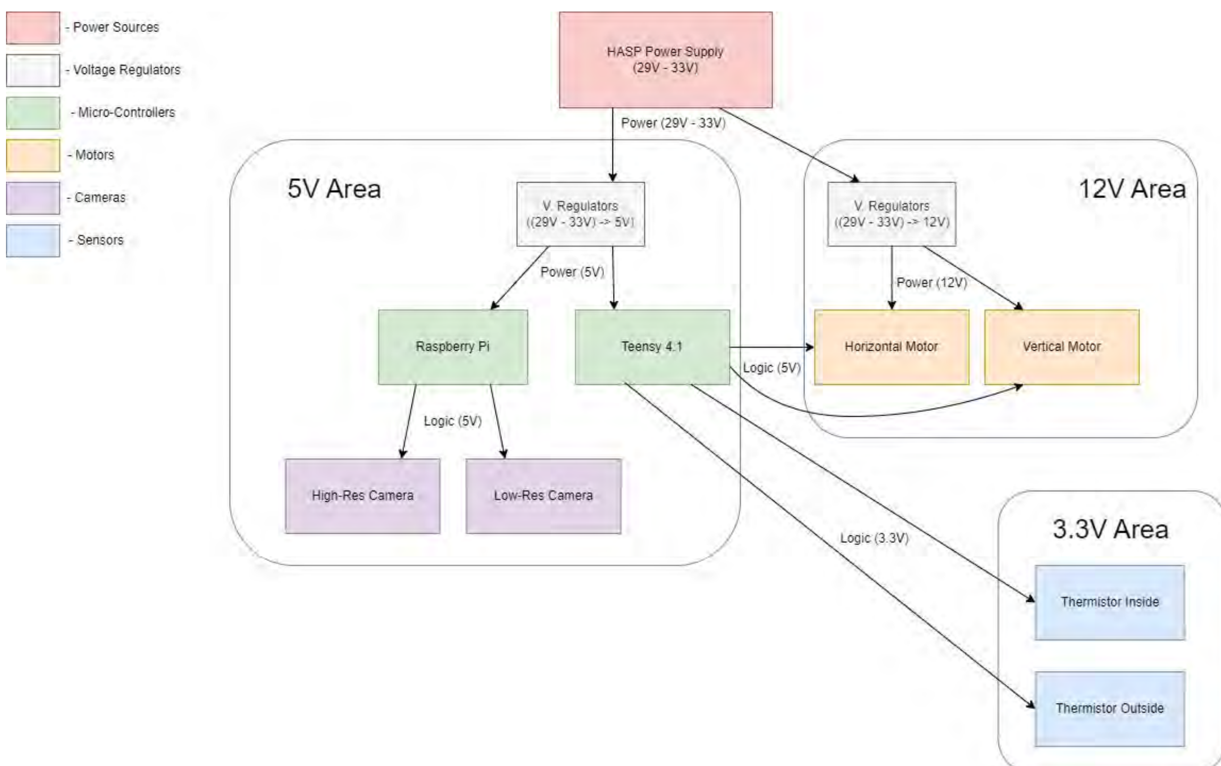
6061 aluminum

Solid State Lubricant

1.5 Electrical Design

The experiment will be branching the 30V input power from HASP into 3 separate power areas:

- 12V area, for running each one of the motors
- 5V area, for running the Raspberry Pi and the Teensy 4.1 controllers
- 3.3V area, for running the thermistor sensors

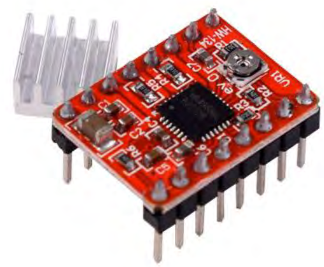


Abstract electrical diagram

Out of the power areas listed above, only 2 will be created with the use of voltage regulators, the 12V and the 5V area. They will use the 7812T and 7805T regulators respectively. The 3.3V area will be powered by the 3.3V output pin on the Teensy 4.1.

Both motors used to adjust the telescope's position will be Nema 17 stepper motors and will be run using the A4988 motor driver chips. Each one of these driver chips will take a 12V input for the motors, and a 5V input for the logic. The motor will have a software inhibit using a 1/4 or 1/8 step configuration, to achieve a higher degree of refined vertical movement.

Nema 17 Stepper Motor



A4988 Motor Driver chip

1.5.1 Controllers

A Raspberry Pi 4 8Gb, which will be controlling the two cameras by enclosing a loop with the following functions:

1) Take an image from the Low-Resolution camera
2) Detect any light patches present in the image
3) Isolate the largest light patch, if there is one
4) Send any required movement commands to the Teensy 4.1, to keep the camera pointed towards the largest light patch
5) Take & save the image from the High-Resolution camera to the SD card

The other controller will be a Teensy 4.1, an Arduino-based micro-controller, which will control the direction of the cameras by controlling the horizontal and vertical motors, as well as read the temperature data from the thermistor sensors and send downlink data.

Raspberry Pi 4 (8 GB) computer

Teensy 4.1 (Arduino-based micro-controller)

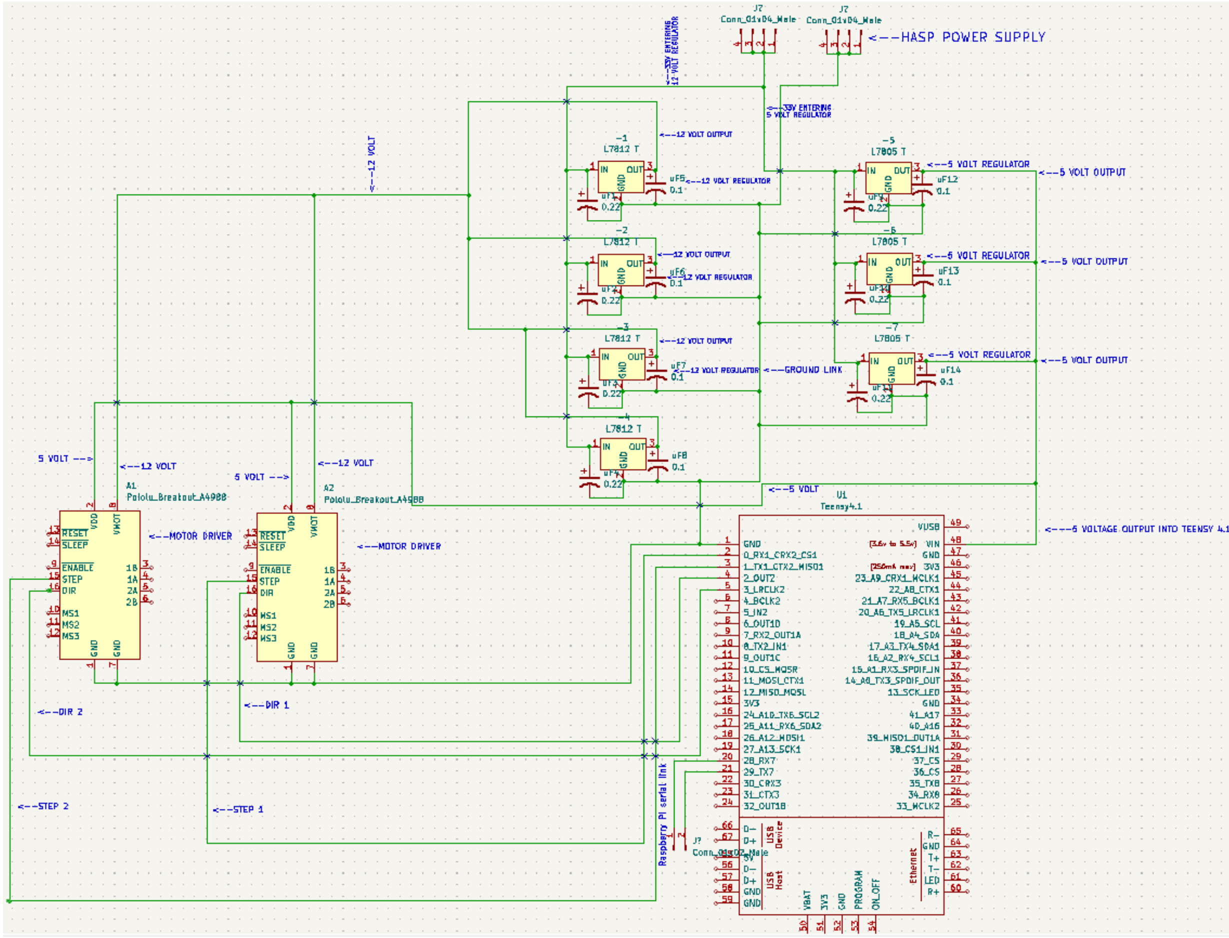
1.5.2 Storage

An SD card will be mounted on both the Raspberry Pi and the Teensy 4.1. The SD card onboard the Raspberry Pi will contain the images from the High-Resolution camera, while the one onboard the Teensy 4.1 will contain the occasional snippets of the current angles of the telescope, as well as the temperature readings. Downlinked data from Teensy 4.1 will be stored on at least two team members' computers and the Advisor’s computer to ensure redundancy.

400 GB SD card

1.5.3 Power Supply System

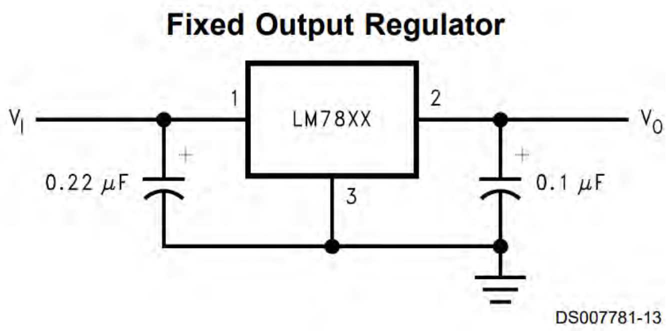
The 30V power will be supplied by HASP and stepped down by a series of 7812T and 7805T voltage regulators. For both the 12V and 5V power areas, there will be multiple regulators placed in parallel, for redundancy. There will be four 12V Regulators, and three 5V Regulators.



Electrical schematic

Each one of the regulators will have its own small dedicated circuit, as per the design specifications of the 7812T and 7805T.

7812T Voltage Regulator *7805T Voltage Regulator*



78XX Regulator dedicated circuit (according to the datasheet)

1.6 Thermal Control Plan

The payload is expected to encounter temperatures of -80C to +50C. The 6061 aluminum that will be used to construct the flat plate, electronics housing, and telescope mounting is proven to withstand the expected temperature range. The electronics enclosure will be insulated with Mylar Blankets, to lessen the effects of temperature extremes on the Raspberry Pi computer and Teensy 4.1 microcontroller.

Mylar Blankets

2. Team Structure and Management

2.1 Team Management

The Sol Seeker team is a subdivision of the Aerospace and Sciences Team (AST) which is headed by the Astronomy and Physics Club (APC). The club advisors, Teresa Ciardi and Gregory Poteat, create an environment for students to build and conduct science experiments in near space conditions. They provide support, encouragement, and the opportunity for scientific exploration. Professor Teresa Ciardi is the main driving force of the HASP Sol Seeker team. She holds advanced degrees in physics and astrophysics, is the Lead Faculty for Astronomy and Physical Science at College of the Canyons (COC), Chair of COC's Professional Development Committee, Co-Chair of COC Global – Comprehensive Internationalization Committee, the Principle Advisor for APC, Co-Lead of the STEM Equity Alliance, Co-Investigator on a 1.5 million 6-year S-STEM NSF Grant, as well as the Principle Investigator/Advisor/Mentor for NASA HASP, NASA RockSatX, NASA Rock-On, and NASA GLEE projects. Professor Ciardi continually shares all her leadership experience and scientific knowledge by volunteering 900+ hours annually for students to participate in NASA projects and interact in club activities. She provides access to the MakerSpace facility where the team meets every Sunday afternoon, with additional hours during the week as needed (what is COC's MakerSpace). Most importantly, she provides general science mentoring and facilitates project success by allowing team leads to plan agendas, all the while directing the workflow and helping individual program managers stay on track. She continually stresses the importance of planning, fundraising, materials acquisition, budgeting, team cohesiveness, communication, respect, and acknowledgment of individual achievement. She also directly plans and oversees on-site NASA facility student trips, where students are given the opportunity to enhance networking, professionalism, and troubleshooting skills.

Adjunct Faculty Professor Gregory Poteat serves as the manufacturing and mechanical design advisor to the team. He spent 25 years as a machinist fabricating and installing instrumentation for flight research, followed by a decade+ managing the technology transfer program at the Armstrong Flight Research Center. He retired from his career at NASA in March of 2012, and currently teaches manual and CNC machining courses at College of the Canyons. He will oversee and guide the manufacturing and assembly of structural and mechanical components, while various student mentors and a community Local Astronomy Club consulting team advise current leads and team members on the designing and testing processes of the payload.

The Sol Seeker team is comprised of various students from high school, community college, and university representing an array of STEM disciplines, as well as alumni student mentors and a community consulting team comprised of current or retired engineers in various fields. The project manager, Melissa Rocha, is a COC student studying mathematics and psychology. Her responsibilities include establishing a collaborative and inclusive environment, guiding the engineering and marketing/media sub-teams, coordinating sub-team tasks by developing a timeline to achieve defined milestones and complete the payload, ensuring all deliverables are completed and submitted on time specified by HASP management and included in the timeline below, attending meetings with HASP Program Directors, managing budget and inventory, as well as providing a bill of materials for procurement.

The mechanical systems lead, Clarissa Zuo, is a High School student and a COC student studying Physics. She is responsible for leading the mechanical sub-team and delegating tasks in order to draft the mechanical structures by creating drawings for machining, addressing electrical system needs, and completing the hands-on fabrication of the structure. The electrical systems lead, Derek Peraza, is a COC student studying electrical engineering. He is responsible for leading the electrical sub-team and delegating tasks to design the flight computer by choosing the electrical components, working with the mechanical team to ensure the payload structure meets the electrical system needs, working closely with the software team to ensure the code supports the electrical components, as well as the assembly and integration of the electrical system. The software lead, Drake Lovelady, is a COC student studying electrical engineering. He is responsible for leading the software sub-team and delegating tasks to write code and ensuring it supports electrical and mechanical needs.

The student mentoring team is comprised of alumni HASP participants that are dedicated to the success of the experiment and developing the leadership skills of newer team members. Sarah Boyer is a COC student studying mechanical engineering with experience as a mechanical & electrical lead. She is an innovative designer and lends inspiration and advice to the new team leads. Shaun Ford is a COC and CSUN student with vast knowledge of mechanical, electrical, and software engineering. He has assisted in the mechanical and electrical designs for multiple missions and is adept at sharing his wealth of knowledge with all team members. Daniel Larimer is a student at Cal Poly- San Luis Obispo studying Mechanical Engineering and is part of the Structures and Mechanisms team for Cal Poly's CubeSat Laboratory. He advises the mechanical and electrical team with expectations he previously encountered as the integration team lead. Andrew Nowakowski holds degrees in business management and computer science and has extensive knowledge in electrical design and software troubleshooting. Svarun Soda is a COC Alumni and CSUN student who assisted in every aspect of designing, building, troubleshooting, and data analysis of multiple payloads. He shows his leadership by continually being a team player and being involved in everything from marketing to team building, and documentation.

The consulting team is a collective group of individuals from the Local Group Astronomy Club of Santa Clarita Valley, Santa Clarita, California many of whom are current or retired engineers. They are a community-based group that has been providing educational outreach since 1984 and are a California non-profit corporation public charity (lgsvc.org). The Sol Seeker team reached out to the Local Group Astronomy Club for advice on solar filters and lenses. During the meeting, many of those in attendance were extremely interested in the HASP project. They decided to create a consulting team to collaborate with COC's HASP team and meet regularly to discuss the Sol Seeker payload design. Dave Flynn has a master's in electrical engineering and spent the first 10 years of his career designing, testing, and flying spacecraft at TRW and Martin Marietta. He then worked at Walt Disney Feature Animation Studios doing IT Systems Engineering. He is now an IT Systems Engineering Lead at IPAC on the Caltech campus, which is responsible for gathering, processing, and archiving imagery from ground, air, and space telescopes worldwide. Glenn Basore is a retired design CAD drafter from Medtronic Minimed who worked on insulin pumps and tested support equipment for production engineering. Abhishek Khanna has a master's in computer science and is a Lead Product Manager, Analytics for DIRECTV. He has experience working with the immense amount of data available through Astrophotography and finding cost-effective ways to render viable data. Robi Mukherjee is a Mechanical Engineer/Prototype Machinist with over forty years of experience. He started as a Machinist at Raytheon in 1980 working on missile and radar systems. He has been working at Dynaroll/Providien in the medical device field since 1992. He retired from the Army National Guard in 2006 where he worked as a small arms repairman and tank mechanic. He has an avid interest in the history of technology, including ancient and medieval astronomical and scientific instruments. Vahid Talaie is a Senior Principal Engineer at Baxter with extensive knowledge of software. All of the members of the consulting team plan to stay through completion of the payload build.

The fundraising, recruitment, and awareness efforts are led by the dedicated Marketing and Media team for COC's Astronomy and Physics Club (APC), which is the parent group of the Aerospace and Sciences Team (AST). Flyers are posted around campus, and the club participates in various events led by the Associated Student Government that give exposure to the NASA experiments conducted by the AST. The director of the Math, Engineering, and Science Achievement (MESA) Program at COC also assists in recruiting new members and spreading information about the opportunities the various NASA projects have to offer (what is MESA). Through a collective effort of each member of the APC, a substantial amount of funds were raised during the previous flight season for the various COC NASA projects. This includes $9,890 in community donations, $4,000 from LA County Supervisor 5th District, Kathryn Barger, $3,000 College of the Canyons Foundation mini-grants, $16,400 from College of the Canyons for RockSatX and RockOn rocket launch fees, as well as $48,000 in student re-engagement funds awarded by College of the Canyon's Chancellor for students to travel to various NASA sites with their student-designed and constructed science experiments. An $8,000 CADENCE grant was also secured for Professors Teresa Ciardi and Gregory Poteat for an externship. The team has various social media accounts, including Facebook, Instagram, and TikTok to engage with the community, and holds a letter fundraiser throughout the year that reaches various businesses in the greater Los Angeles area. The Marketing/Media team also maintain a website for the Aerospace and Sciences Team, that includes a description of all the NASA projects the team is engaged in, as well as photos of the team and a donation link (https://teresaciardi.wixsite.com/cocast). Additionally, Advisor Teresa Ciardi was recently awarded a $10,000 grant from Lockheed, a $1,500 grant from Aerojet Rocketdyne, and $3,000 in mini-grants from the College of the Canyons Foundation specifically designated for parts. Through the success of various projects, as well as student and advisor efforts, COC's NASA projects have become a recognized non-instructional program and this program is eligible to request district funding for the first time for the 2023/2024 academic year. Additionally, the administrators for the Applied Technologies Department will be designating an area of MakerSpace to be the hub for all future HASP/RockSatX projects.

NASA HASP non-instructional program budget 2023/2024	
Description	**COST**
Materials - electronic components and raw metal	$5,000.00
Flights to NASA CSBF for testing and integration of payload - 2 Faculty Advisors and 4 students	$3,385.00
Travel costs (hotel, rental vehicle, meals for Advisors) while at NASA CSBF for testing and integration of payload - 2 Faculty Advisors and 4 students	$2,755.00
Total	$11,140

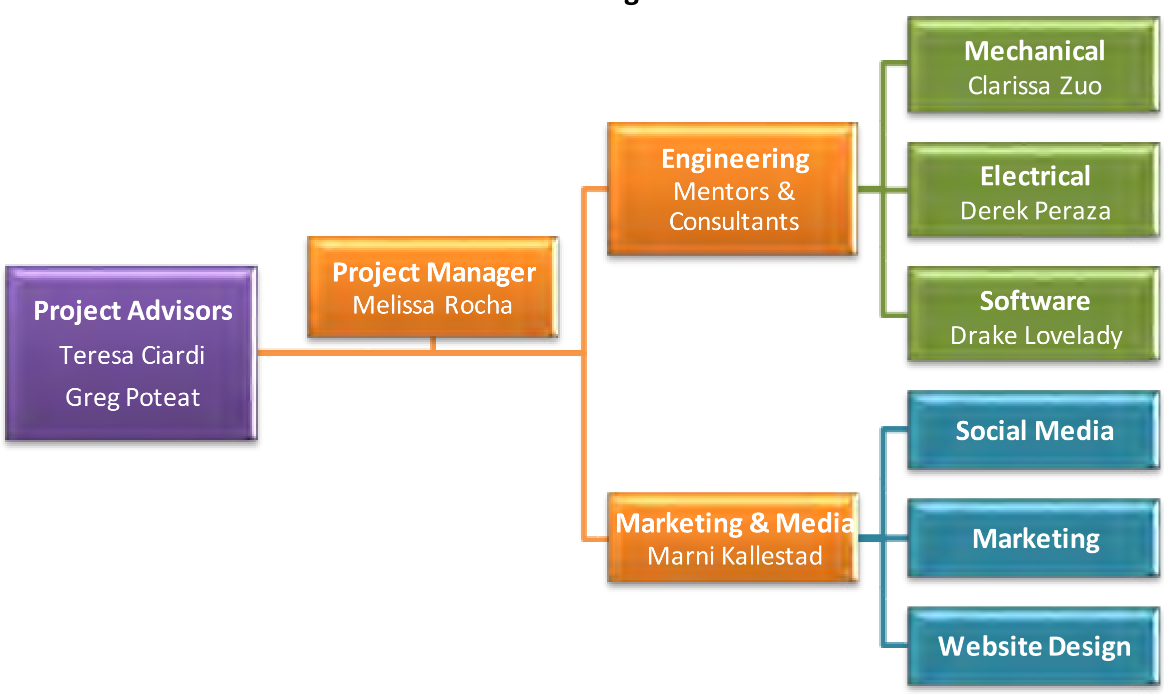
2.1 Advisor Statement

Advisor Teresa Ciardi provides guidance and laboratory access to complete all NASA projects. Annually, Ciardi volunteers upwards of 900 hours of mentorship, actively participating in all aspects of design, research, machining, construction, testing, planning, fundraising, budgeting, ordering, and building student leadership skills. Teresa Ciardi guides the students to create an action plan with due dates for each stage of the process to ensure students complete their project and have a successful mission, and to ensure that specific deliverables are met. She has instituted a contract this academic year with a required code of conduct to participate in the club and NASA projects, as well as expectations for each lead role. Ciardi also seeks and manages all finances including grant writing, fundraising, program review, and monitoring parts order budgets.

Advisor Greg Poteat volunteers approximately 500 hours coordinating with the student team to focus on the functional, mechanical and structural aspects of the design in concurrence with the Local Astronomy Group. As design elements are determined he helps recommend the specific structural requirements of the design based on his years of experience in developing and building similarly complex projects for NASA flight research. He then works with the students in the Fab Lab and MakerSpace to fabricate and assemble components into a functional payload as well as coordinates the testing of structural integrity.

2.2 Team Organization and Roles

Sol Seeker Team Organizational Chart



Sol Seeker Team Member Role and Contact Information

Name	Role/Academic Year	Email	Phone
Project Management			
Teresa Ciardi	Logistics & Science Faculty Advisor	teresa.ciardi@canyons.edu	661-313-6015
Greg Poteat	Machining Faculty Advisor	gregory.poteat@canyons.edu	661-670-9108
Amy Foote	Recruitment MESA Director	amy.foote@canyons.edu	661-904-2001
Melissa Rocha	Project Manager Undergrad	mrocha1@my.canyons.edu	661-857-6913
Maranda Laws	Assistant Project Manager Undergrad	mrlaws@my.canyons.edu	661-803-9188
Engineering Team			
Clarissa Zuo	Mechanical Lead High School/ Undergrad	clarissa.y.zuo@my.canyons.edu	925-368-0541
Derek Peraza	Electrical Lead Undergrad	derek.peraza@my.canyons.edu	818-634-0303
Drake Lovelady	Coding Lead Undergrad	drake.lovelady@my.canyons.edu	661-607-1560
Miguel	Mechanical Team Member Undergrad	mpazx@my.canyons.edu	818-564-1253
Marketing/Media			
Marni Kallestad	Marketing Lead Undergrad	marni.kallestad@my.canyons.edu	661-878-4955
Gabriel Jimenez	Marketing Co-Lead Undergrad	gmjimenez1@my.canyons.edu	818-805-4762
Arely Castillo	Marketing/Media Team Member Undergrad	Acastillo5@my.canyons.edu	747-273-4510
Mentor Team			
Sarah Boyer	Mechanical/ Electrical Mentor Undergrad	krokulyte@gmail.com	661-993-5400
Shawn Ford	Mechanical/ Electrical/ Software Mentor Undergrad	shawn.ford@my.canyons.edu	661-860-1966

Daniel Larimer	Mechanical/ Electrical Mentor Undergrad	daniel.larimer11@gmail.com	661-904-0143
Andrew Nowakowski	Electrical/Software Mentor Bachelor's Business Management & Computer Science		661-505-3973
Svarun Soda	Software/Electrical Mentor Undergrad	ssoda@my.canyons.edu	818-852-3202
Consulting Team	The Local Group Astronomy Club of Santa Clarita Valley, California		
Dave Flynn	Lead Engineering Consultant	dave.flynn@lgscv.org	661-644-0708
Glenn Basore	CAD design Consultant	gpb91384@icloud.com	
Abhishek Khanna	Astrophotography Consultant	shekenastro@gmail.com	818-441-8517
Robi Mukherjee	Mechanical Consultant	pax@g741.org	
Vahid Talaie	Software Consultant	vtalaie@live.com	661-645-7896

Sol Seeker Team Photo

Left to right: Vahid Talaie, Gregory Poteat, Svarun Soda, Drake Lovelady, Melissa Rocha, Glen Basore, Clarissa Zuo, Derek Peraza, Abhishek Khanna, Miguel Paz, Teresa Ciardi, Robi Mukherjee, Dave Flynn

2.3 Timeline and Milestones

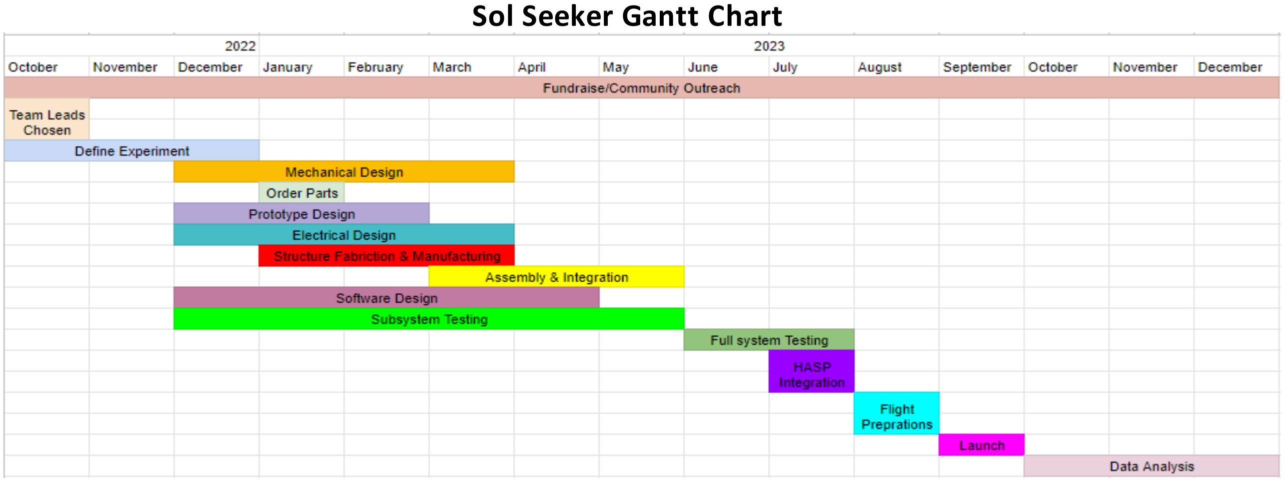
Sol Seeker Tentative Schedule

Month of 2022	**Tasks**
October	Fundraise
8th	Team Leads Applications Due
13th	Fundraise & Recruiting at Homecoming Tailgate
16th	Advisors Announce Team Leads
23rd	Finalize New Experiment Idea
28th	Fundraise & Recruit at Bi-Annual Star Party
November	Fundraise
6th	Discuss Preliminary Parts to Evaluate & Order
10th	Community Outreach
13th	Research Parts
14th	HASP Q & A
19th	Team Building-Potluck with Lockheed Internship Recruiter
20th	Mechanical Design Discussion
27th	Discuss payload title & overall mission goals
28th	Meeting with The Local Group Astronomy Club of Santa Clarita Valley, to further discuss science experiment idea
December	Fundraise
1st	Community Outreach
2nd	Notice of Intent Due
4th	Prototype of electrical design built with rudimentary parts & software
11th	Inventory of Parts Ordered Complete
16th	HASP Application Development Teleconference
18th	Further Discussion of Design & Parts/Preliminary Mechanical Drawings Complete
30th	Preliminary Component Selection
Month of 2023	
January	Fundraise/Community Outreach
6th	HASP Application Due
8th	Review Inventory for parts selection
15th	Complete PCB design
22nd	Finalize parts list for procurement
27th	Anticipated announcement of student payload selection
29th	Order parts and begin manufacturing of testing rig and components
February	Fundraise/Community Outreach
3rd	Monthly Teleconference
5th	Begin fabrication of payload prototype & computerized simulation of structural integrity
12th	Redesign prototypes if necessary
19th	Begin work on electrical and flight computer systems

24th	Monthly Status Report Due
26th	Begin PSIP & NASA Integration Security Documentation
March	Fundraise/Community Outreach
3rd	Monthly Teleconference
5th	Finalize payload structural design
12th	Preliminary thermal-vacuum testing on select components
19th	Finalize electrical design
24th	Monthly Status Report Due
26th	Integrate electrical subsystems
April	Fundraise/Community Outreach
2nd	Continue testing select subsystems
7th	Monthly Teleconference
9th	Preliminary PSIP & NASA Integration Security Documentation first draft due (internal due date)
16th	Finalize software design
23rd	Address changes to Preliminary PSIP
28th	Preliminary PSIP & NASA Integration Security Documentation due Monthly Status Report Due
30th	Finalize manufacturing & assembly
May	Fundraise/Community Outreach
5th	Monthly Teleconference
7th	Test final version of software
14th	Full subsystem testing
21st	Revise PSIP Documentation if necessary
26th	Monthly Status Report Due
28th	Begin testing fully integrated payload
June	Fundraise/Community Outreach
2nd	Monthly Teleconference
4th	Address changes to payload if necessary
11th	Final PSIP first draft due (internal due date) NASA Flight On-Site Security Documentation due (*not attending)
18th	Address changes to PSIP & troubleshoot payload if necessary
25th	Begin FLOP Documentation
30th	Final PSIP & NASA Flight On-Site Security Document due Monthly Status Report Due
July	Fundraise/Community Outreach
2nd	FLOP First Draft due (internal due date)
7th	Monthly Teleconference
9th	Payload Flight Ready/ Complete FLOP Documentation
16th	Address any changes that need to be made to documentation/payload
21nd	Final FLOP Documentation due

24th – 28th	Student payload integration at CSBF, Palestine, TX
28th	Monthly Status Report Due
August	Fundraise/Community Outreach
4th	Monthly Teleconference
6th-20th	HASP Flight Preparation: troubleshoot payload if necessary, prepare schedule for flight monitoring
25th	Monthly Status Report Due
27th	Ship payload to CSBF, Ft. Sumner, NM if necessary
September	Fundraise/Community Outreach
1st	Monthly Teleconference
3rd	HASP 2023 Target flight ready date
4th	Target launch date & flight operations
6th – 10th	Target recovery, packing, & return shipping dates
10th	Await return of payload & begin post flight analysis
17th-24th	Preliminary Data Analysis
29th	Monthly Status Report Due
October	Fundraise/Community Outreach
1st	Set up Final Flight/Science Report template
6th	Monthly Teleconference
8th-22nd	Continued Data Analysis
27th	Monthly Status Report Due
29th	Further develop mission goals for next experiment
November	Fundraise/Community Outreach
3rd	Monthly Teleconference
5th-12th	Complete Data Analysis
17th	Monthly Status Report Due First Draft of Final Flight/Science Report due (internal due date)
December	Fundraise/Community Outreach
8th	Final Flight / Science Report due

Sol Seeker Gantt Chart



2.4 Anticipated Participation in Integration and Launch operations

Team Sol Seeker plans to attend integration at the Columbia Scientific Balloon Facility (CSBF) in Palestine, Texas with a fully functioning payload. All subsystem team leads will be present, including faculty advisors. The integration team will consist of 3-4 students, as well as 1-2 advisors. The integration team will arrive at CSBF front offices to check in with security personnel at 8 am sharp to undergo safety training (if necessary) and retrieve on-site badges. The team shall be present in the designated hanger for thermal/vacuum testing daily at the time specified by the directors of the HASP program and participate in the activities planned for the day. The integration team does not include any members who are foreign nationals at this time. All requested participant information shall be included in the NASA Integration Security Documentation for CSBF, Palestine, Texas.

The NASA Flight On-Site Security Documentation for CSBF, Ft. Sumner, New Mexico will not be submitted because the payload is to be built in such a way that team members do not need to be physically present for pre-launch operations in order to have a successful mission. A detailed Flight Operation Plan shall be submitted by the due date so that the Sol Seeker payload may be integrated onto the HASP platform by CSBF/HASP personnel. A hang test, launch, and flight monitoring schedule will be created in order to ensure that 1-2 team members are monitoring the payload remotely for the duration of pre-flight and flight operations.

3. Payload Interface Specifications

3.1 Weight Budget

Item	Mass	Uncertainty	Comments
3.0 Monochrome CMOS Imaging Camera	0.090 kg	0.002 kg	Weight provided by highpointscientific.com
3D printed Telescope Scaffold components	0.7345 kg	0.002 kg	Provided through Fusion 360
Aluminum Telescope Scaffold components	2.6920 kg	0.0020 kg	Provided through Fusion 360
ZWO Mini Guide Scope	0.25 kg	0.002kg	Weight provided by astronomy-imaging-camera.com
Wiring	0.03 kg	0.002 kg	
Raspberry Pi (8GB RAM)	0.046 kg	0.001 kg	Weight provided by versus.com
Teensy 4.1	0.013 kg	0.0002 kg	
Nema 17 Stepper motor	0.287 kg	0.002 kg	Weight provided by amazon.com
Nema 17 Stepper motor	0.287 kg	0.002 kg	Weight provided by amazon.com

2 x 400 GB SD card	0.0090 kg	0.00005 kg	Weight provided by amazon.com
2 x (thermistors)	0.0003 kg	0.000004 kg	Weight provided by www.vishay.com
4 x (12 V regulators)	0.00632 kg	0.0006 kg	Weight provided by amazon.com
3 x (5 V regulators)	0.0036 kg	0.0006 kg	mouser.com
7 x (0.22 capacitors uF)	0.192 kg	0.001 kg	Weight provided by amazon
7 x (0.1 capacitors uF)	0.192 kg	0.001 kg	Weight provided by amazon
SolarLite Solar Filter Film	0.022 kg	0.0002 kg	Weight provided by www.amazon.com
Fasteners	0.025 kg	0.005 kg	
Logitech Brio 4K Webcam	0.3345 kg	0.0002 kg	Weight provided by www.amazon.com
Belt Pulley	0.07044 kg	0.002 kg	Weight provided by www.amazon.com
Mylar Blankets	0.0566 kg	0.02 kg	Weight provided by www.amazon.com
TOTAL	5.34126 kg	0.045854 kg	

The total mass of the payload is well under the allotted weight maximum of 20kg. The payload is estimated to be 5.34126 kg. This number was derived from the examination of Fusion 360's model analysis, and through the weights specified on individual parts online.

3.2 Power Budget

Item	Voltage	Current	Power	Comments
Raspberry Pi (8GB RAM)	5V	885 mA	4.43 W	values provided by manufacturer
Teensy 4.1	5V	100 mA	0.5 W	values provided by manufacturer
NEMA 17 stepper motor	12V	2 A	24 W	values provided by manufacturer
NEMA 17 stepper motor	12V	2 A	24 W	values provided by manufacturer
2 x (thermistors)	0V	80 mA	0 W	values provided by manufacturer
4 x (12 V regulators)	0V	4 A	0 W	values provided by manufacturer
3 x (5 V regulators)	0V	3 A	0 W	values provided by manufacturer

3.0 Monochrome CMOS Imaging Camera	5V	150 mA	0.75 W	values provided by manufacturer
Logitech Brio 4K Webcam	5 V	150 mA	0.75 W	values provided by manufacturer
TOTAL	30V	1.814 A	54.43 W	

The components that are going to be drawing power are the two controllers, the two cameras, the two motors, and the two thermistors. The controllers and the cameras are each going to be drawing power from the 5V regulators, while the motors are going to be drawing power from the 12V regulators. The thermistor sensors are going to be drawing power from the 3.3V pin on the Teensy 4.1. The experiment will have a transient current flow because of the motors being used, as they will only draw the full amount of current if they are being run at full speed.

Utilizing Watt's Law, the running voltage was multiplied by the current for each component to find the power. The power for each component was summed to find the total power of 54.34 W. The uncertainty will be ± 10% watts based off the equipment specifications.

3.3 Downlink Serial Data

The Sol Seeker payload will be sending occasional data packets via the Serial Downlink, for mid-flight monitoring by the team. The sent data packets will include a starting character (1 byte), the current angular positional data of the telescope (12 bytes, 3 numerical readings), the current temperature data from the thermistor sensors (8 bytes, 2 numerical readings), a status bit for the Telescope (1 bit) and an ending character (1 byte). The total size of the Downlink data packets will be 184 bits. The data rate will be ~3-5 times per minute.

Bits	Space Used	Data Type	Purpose
1 - 9	1 byte (8 bits)	Character	Starting Symbol
10 - 42	4 bytes (32 bits)	Integer	Telescope Angle X (Roll)
43 - 75	4 bytes (32 bits)	Integer	Telescope Angle Y (Pitch)
76 - 108	4 bytes (32 bits)	Integer	Telescope Angle Z (Yaw)
109 - 141	4 bytes (32 bits)	Integer	Temperature Inside
142 - 174	4 bytes (32 bits)	Integer	Temperature Outside
175	1 bit	Bit	Telescope Status Bit
176 - 184	1 byte (8 bits)	Character	Ending Symbol

Downlink packet structure diagram

3.4 Uplink Serial Commanding

The payload will not be receiving any Uplink commands.

3.5 Analog Downlink

The payload will not be using Analog Downlink, only Serial Downlink.

3.6 Discrete Commanding

The payload will not be making use of Discrete Commanding.

3.7 Payload Location and Orientation Request

The Sol Seeker team requests position 9 on the HASP platform. It is a spot previously flown and is a large payload position which provides more room to house the electrical components of the experiment. This would allow for optimal thermal regulation and the ability to create a larger mount for the telescope. It would also allow for more effective positioning of the telescope cameras and motors, to allow for a more efficient mechanical design which will result in less movement stress being applied on the motors as the telescope angles are moved throughout the flight.

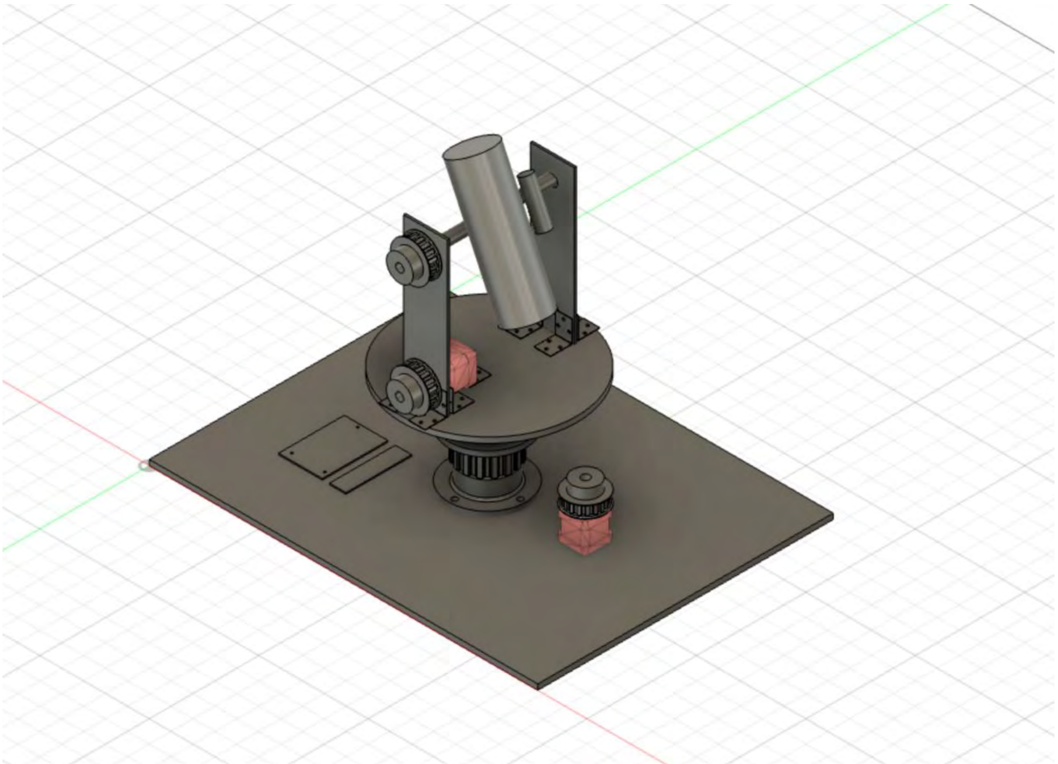
If position 9 is not available, any of the other large payload positions would be optimal for the Sol Seeker experiment. A large payload is not essential to the success of the mission; however, a larger surface area is preferable for the mount and motors of the telescope. The experiment design may be reconfigured for a smaller payload if needed.

If a position that houses small payloads is all that is available, position 8 is preferable. It is a position that was previously flown and is well within the HASP camera view. If position 8 is not available, any of the other small payload positions will still allow the experiment to be successful.

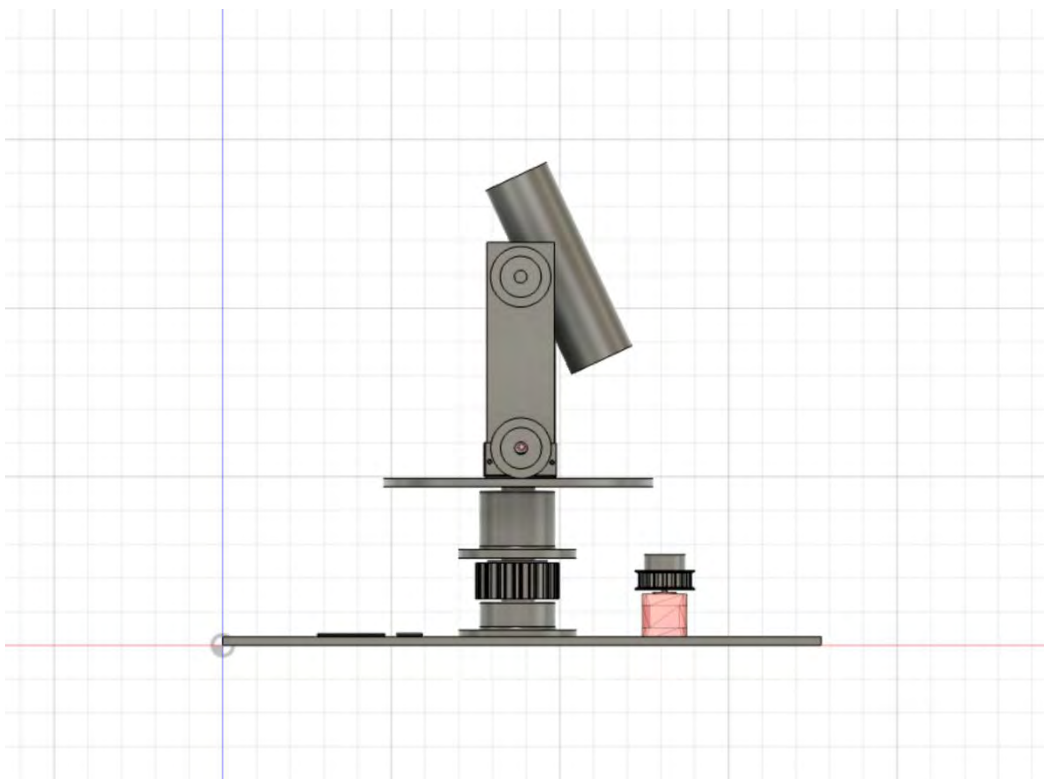
3.8 Special Requests

No special requests.

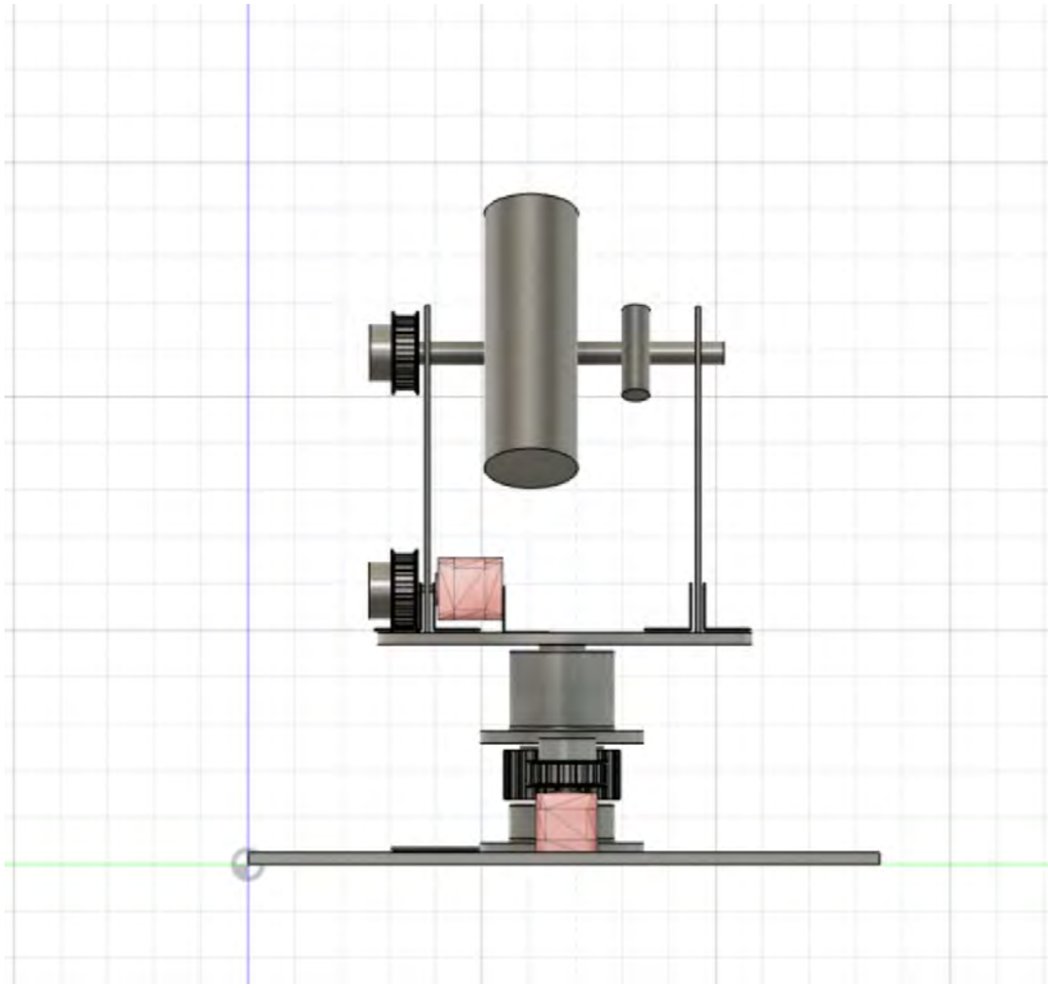
4. Preliminary Drawings and Diagrams



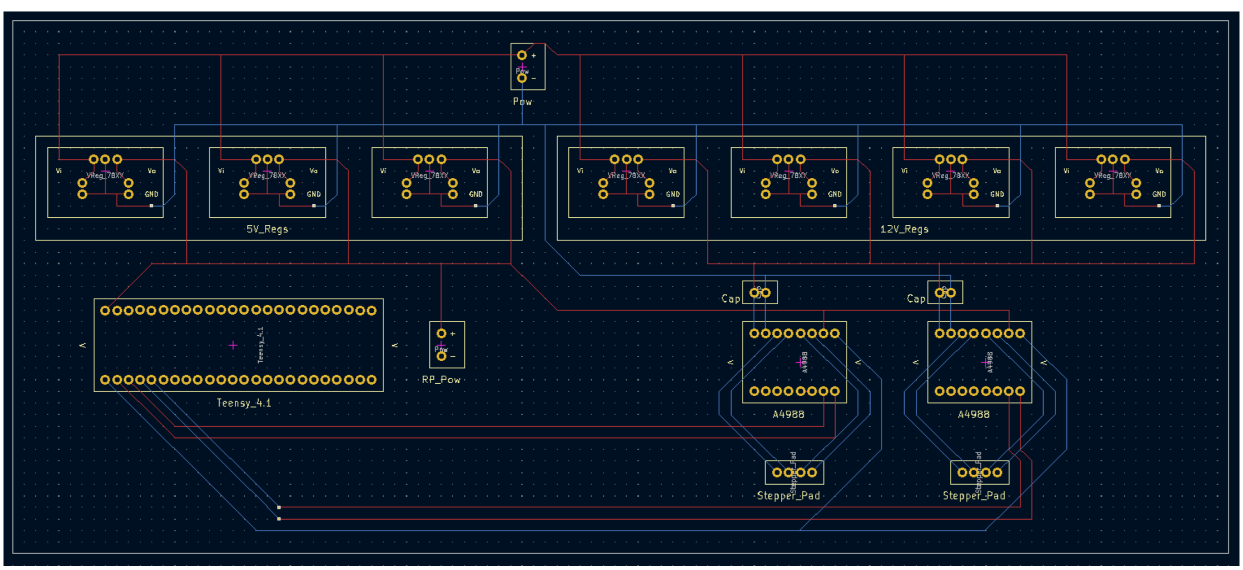
Perspective view of Telescope stand model



Side view of Telescope stand model



Front view of Telescope stand model



Tentative PCB design

Appendix A: NASA Hazard Tables

Appendix A.1 Radio Frequency Transmitter Hazard Documentation

HASP 2022 RF System Documentation	
Manufacture Model	N/A
Part Number	N/A
Ground or Flight Transmitter	N/A
Type of Emission	N/A
Transmit Frequency (MHz)	N/A
Receive Frequency (MHz)	N/A
Antenna Type	N/A
Gain (dBi)	N/A
Peak Radiated Power (Watts)	N/A
Average Radiated Power (Watts)	N/A

Appendix A.2 High Voltage Hazard Documentation

HASP 2022 High Voltage System Documentation	
Manufacture Model	N/A
Part Number	N/A
Location of Voltage Source	N/A
Fully Enclosed (Yes/No)	N/A
Is High Voltage source Potted?	N/A
Output Voltage	N/A
Power (W)	N/A
Peak Current (A)	N/A
Run Current (A)	N/A

Appendix A.3 Laser Hazard Documentation

HASP 2022 Laser System Documentation			
Manufacture Model		N/A	
Part Number		N/A	
Serial Number		N/A	
GDFC ECN Number		N/A	
Laser Medium		N/A	
Type of Laser		N/A	
Laser Class		N/A	
NOHD (Nominal Ocular Hazard Distance)		N/A	
Laser Wavelength		N/A	
Wave Type		*(Continuous Wave, Single Pulsed, Multiple Pulsed)* N/A	
Interlocks		*(None, Fallible, Fail-Safe)* N/A	
Beam Shape		*(Circular, Elliptical, Rectangular)* N/A	
Beam Diameter (mm)	N/A	**Beam Divergence (mrad)**	N/A
Diameter at Waist (mm)	N/A	**Aperture to Waist Divergence (cm)**	N/A
Major Axis Dimension (mm)	N/A	**Major Divergence (mrad)**	N/A
Minor Axis Dimension (mm)	N/A	**Minor Divergence (mrad)**	N/A
Pulse Width (sec)	N/A	**PRF (Hz)**	N/A
Energy (Joules)	N/A	**Average Power (W)**	N/A
Gaussian Coupled (e-1, e-2)		*(e-1, e-2)* N/A	
Single Mode Fiber Diameter		N/A	
Multi-Mode Fiber Numerical Aperture (NA)		N/A	
Flight Use or Ground Testing Use?		N/A	

Appendix A.4 Battery Hazard Documentation

HASP 2022 Battery Hazard Documentation	
Battery Manufacturer	N/A
Battery Type	N/A
Chemical Makeup	N/A
Battery modifications	*(Must be NO)* N/A
UL Certification for Li-Ion	N/A
SDS from manufacturer	N/A
Product information sheet from manufacturer	N/A