HASP Student Payload Application for 2021

Payload Title: **OreSat1B - Environmental Testing of OreSat Subsystems**	
Institution: **Westview High School & Portland State University**	
Payload Class (Enter SMALL, or LARGE): **Small**	Submit Date: **Jan 8th, 2021**

Project Abstract:
The failure rate of university-built CubeSats has historically been high, with around half of missions failing within 60 days of deployment. Often, a lack of proper testing on various subsystems and components results in such failures. In 2016, Portland State University along with several other universities and industry partners submitted the 2016 NASA CSLI Application, aiming to build and launch Oregon's first CubeSat, OreSat. OreSat is a 2U CubeSat planned to be launched in Q2 of 2022 from the International Space Station. One of OreSat's primary missions is to collect data on high altitude (> 12 km) cirrus clouds with the Cirrus Flux Camera (CFC) instrument. Additionally, several technology readiness demonstration projects will be pioneered on OreSat, including a long-distance S-band telemetry link using off-the-shelf components ("DxWiFi'') and an open-source CubeSat "kit" called the OreSat bus. The OreSat1B test system seeks to test these three subsystems for extended periods in a space-like environment: the thermal performance of shortwave infrared Cirrus Flux Camera instrument, the long-distance performance of the "DxWiFi'' S-band radio link, and the OreSat CubeSat system. OreSat1B also serves as a STEM Outreach component for OreSat, as students at Westview High School will lead in the assembly, integration, and flight of the payload.

Team Name: **OreSat**	Team or Project Website: https://www.oresat.org/

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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 (gray-filled items on the table below) and the remaining hazards will require additional paperwork and certifications. If you intend to include one of the hazards, you must include detailed documentation in section 3.8 of the application as required by the HASP Call for Payloads.

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

Hazardous Materials List		
Classification	**Included on Payload**	**Not Included on Payload**
RF transmitters	X	
High Voltage		X
Pyrotechnics		X
Lasers		X
Intentionally Dropped Components		X
Liquid Chemicals		X
Cryogenic Materials		X
Radioactive Material		X
Pressure Vessels		X
Magnets		X
UV Light		X
Biological Samples		X
Li-ion Batteries		X
High intensity light source		X

Student Team Leader Signature: [signature]

Faculty Advisor Signature: [signature]

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1. Payload Description

OreSat is set to be Oregon's first small satellite, a 2U CubeSat being built by the Portland State Aerospace Society (PSAS), an interdisciplinary team of undergraduate and graduate students at Portland State University. Various partner institutions, including Oregon State University, University of Oregon, and some high schools, are helping with the project. OreSat was accepted into the 2017 NASA CubeSat Launch Initiative (CSLI) and is scheduled to be launched in Q2 of 2022 from the International Space Station. As described by the 2016 CSLI Proposal [1], OreSat holds three mission objectives: provision space-based STEM outreach experiences to students in Oregon, map the global distribution of high altitude cirrus clouds, and demonstrate several innovative open-source CubeSat technologies (Figure 1).

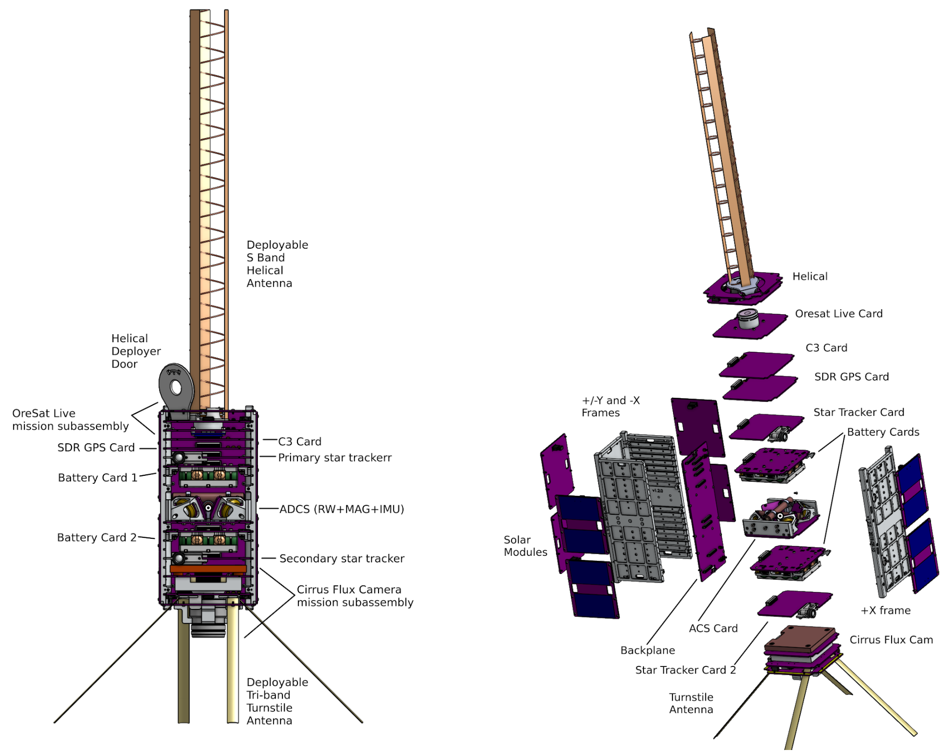

Figure 1. OreSat 2U CubeSat. Left shows the card-cage structure, right shows an exploded view of the aluminum frame and cards.

OreSat1B will test these systems in the unique near-space environment that the 2021 High Altitude Student Payload (HASP) can provide (Figure 2). The long duration near-vacuum and thermal environment of a HASP payload are as close to testing in space as possible; testing and demonstrating the operation of OreSat's critical subsystems will ensure future mission success in orbit. We are proposing to test three main subsystems of OreSat:

OreSat's primary mission is to provide a unique space-based STEM outreach to students across the state of Oregon with the "OreSat Live" mission. The OreSat Live payload transmits live images of the student's location down to the students. Students receive the video on an inexpensive receiver called the Oresat Live Handheld Ground Station. Oresat1B will test three critical parts of the OreSat Live mission: The camera, the radio link, and the ground station. Video and images will be gathered from the innovative 3 cm Schmidt Cassegrain telescope lens and camera system. These will be transmitted on the innovative open-source "DxWiFi" S-band radio system, which uses commercial-off-the-shelf WiFi hardware to create a long-distance WiFi link under an amateur radio license. This signal will then be received on the ground using prototypes of the OreSat Live Handheld Ground Station.

The secondary mission of OreSat is to study the global distribution of high-altitude cirrus clouds which have a profound impact on building accurate climate models. In collaboration with faculty and students at the University of Maryland Baltimore County and University College London, the Cirrus Flux Camera (CFC) instrument has been developed to provide an inexpensive system to gather multi-band shortwave infrared (SWIR) image data reflected off of high altitude (> 12 km) cirrus clouds. OreSat1B will gather images and thermal performance data from the CFC instrument on the HASP flight, proving its operation in a near-space environment.

The tertiary mission of OreSat is to demonstrate an open-source CubeSat "bus" (technology infrastructure) called the OreSat bus. This includes an onboard computer, amateur radio telemetry system, a star tracker, inertial measurement unit, and magnetometer system. OreSat1B will provide an invaluable near-space long-duration test for these systems.

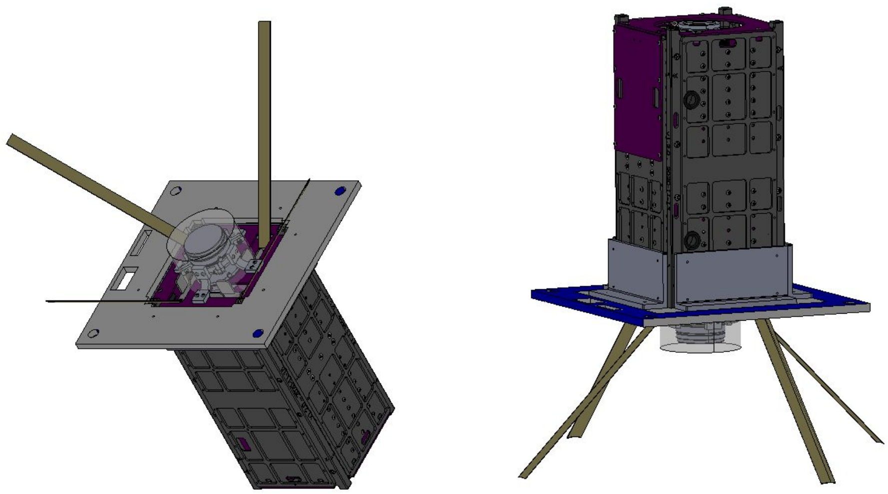

Figure 2. Proposed OreSat1B payload for 2021 HASP flight consisting of the OreSat frame, the OreSat Live mission, the Cirrus Flux Camera, and a subset of the OreSat CubeSat bus.

1.1 Payload Scientific / Technical Background

1.1.1 Mission Statement

OreSat1B is a simplified configuration of the OreSat 2U CubeSat, designed to test OreSat's mission and bus subsystems in the unique near-space environment provided by a HASP flight. OreSat1B will demonstrate and provide performance data on OreSat's "OreSat Live" mission, Cirrus Flux Camera mission, and the open-source OreSat CubeSat bus.

1.1.2 Mission Background and Justification

CubeSats designed and launched by academia have a history of high failure rates. Between 2003 and 2017, the mission success rates of CubeSats from academia stands at an average of 45% [2]. Integration testing and poor thermal design are hypothesized to be the main culprits in the high failure rate. The HASP payload opportunity provides an incredible opportunity to do integration testing, operational assessment, and measure the thermal performance of the CubeSat in a space-like environment. OreSat is also Oregon's first satellite, and the first CubeSat missions have a notoriously high failure rate. HASP will provide invaluable training to the OreSat team as it provides a direct match to a CubeSat mission: assembly, test, integration, launch, and ground operations. And unlike a CubeSat mission, HASP has the unique advantage that hardware can be recovered for a post-mortem on the mission.

OreSat1B will be configured similar to the current flight configuration of OreSat to provide the most accurate data. Several subsystems, most notably the Gallium Arsenide solar cells, Lithium-Ion battery cards, and the reaction-wheel and magnetorquer-based attitude control system, will be removed from the system. Further, deployable antennas will be pre-deployed, custom firmware will be written to autonomously run performance tests during flight, and high resolution thermal and mission performance data will be stored on-board the satellite for recovery after the flight.

1.1.3 Mission Objectives

<u>OreSat Live Mission System</u>

Demonstrate video acquisition and compression from the OreSat Live camera system. Demonstrate transmission of the data over the S-band DxWiFi radio system to both a commercial ground station and the OreSat Live Handheld Ground Station. Demonstrate system operation in a space-like environment to a ground station with a line-of-site distance of > 100 km.

- ❑ Successful onboard capture of images and short video segments from the OreSat Live Schmidt-Cassegrain lens and camera.
- ❑ Reception of video and data from the DxWiFi S-band telemetry link using the OreSat Live Handheld Ground Station from > 100 km line-of-sight distance with low bit error rates (BER < 10^{-5}).

- ❏ Reception of video images and data from the DxWiFi S-band telemetry link on the ground using COTS high gain antennas and receivers from > 100 km line-of-sight distance with low bit error rates (BER < 10^{-5}).
- ❏ Depending on ground station location (altitude), vehicle flight path, and system performance, attempt to break the world record for WiFi transmission of 430 km.

<u>Cirrus Flux Camera Mission System</u>

Demonstrate image acquisition and thermal management of the Cirrus Flux Camera Shortwave InfraRed camera system in a space-like environment.

- ❏ ≥ 100 image captures from the shortwave IR camera to local flash memory.
- ❏ Obtain continuous measurements of thermal performance of the camera system under operation
    - ❏ Without thermal control
    - ❏ Demonstrate thermal control of the SWIR sensor to < -8 °C for five separate 10 minute periods at altitudes above 30 km if the temperature rises above 8 °C.
- ❏ After the flight, compare actual thermal performance compared to the Thermal Desktop models.
- ❏ Process captured images to confirm SWIR lens performance, system ground resolution at flight altitude.
    - ❏ Possibly identify cirrus clouds in images if local weather conditions are favorable for cirrus cloud formation during flight.

<u>OreSat CubeSat Bus</u>

Demonstrate continuous, error robust operation for the full duration of the flight.

- ❏ Demonstration of continuous operation of the C3 onboard computer and telemetry radio despite thermal conditions.
- ❏ Hourly functionality and performance tests of OreSat's subsystems, including the SDR GPS card, image captures from the star tracker card, and data captures from the IMU and Magnetometer card.

1.2 Payload Systems and Principle of Operation

Figure 3 shows the OreSat1B block diagram.

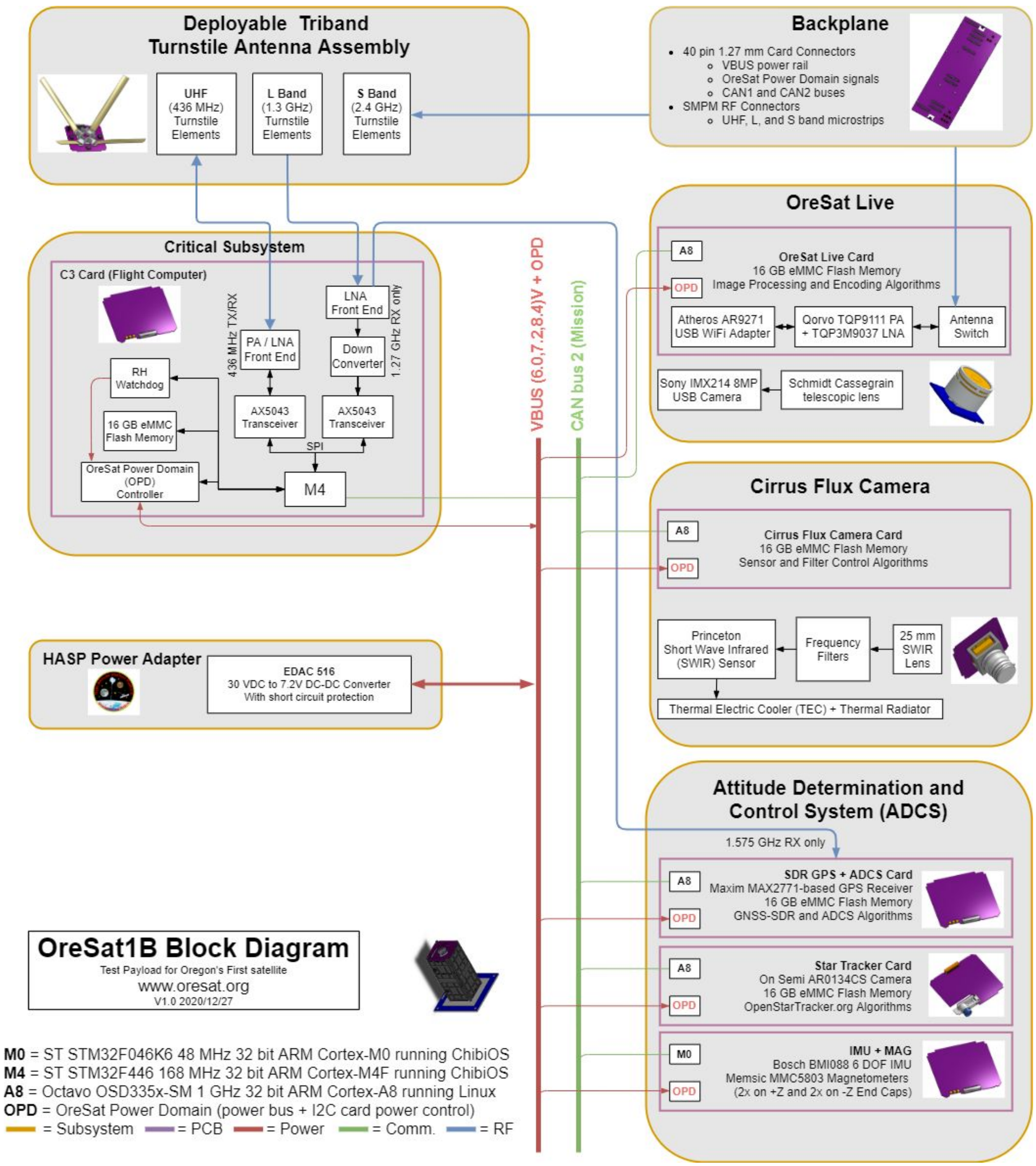

Figure 3. System-level block diagram of the OreSat1B

The principles of operation of OreSat1B will follow a CubeSat launch, deployment, and operational phases.

Pre-Launch
The OreSat team will choose a local with a few km of the balloon launch site to set up a ground station camp. A commercial ground station will be set up, along with several OreSat Live Handheld Ground Stations. The ground station teams will coordinate with the launch team using cellphones and amateur radios.

Launch
OreSat1B will be powered off for launch, and be powered on by the HASP vehicle after launch either 30 minutes after launch or at altitude, whichever is first (and whichever is possible). OreSat runs off of a 7.2 V internal power bus; OreSat1B will convert the HASP's 30V at 0.5 A power supply using a DC-DC converter mounted on the unused solar array area down to 7.2 V at 2A. On power-up, OreSat1B will immediately begin autonomous high-resolution temperature recording and begin beaconing on its 1W UHF (436 Hz) amateur radio system. The beacon has truncated temperature and performance data that the ground teams will receive and process live.

Operations
After 30 minutes of simple beaconing operations, OreSat1B will begin autonomously testing mission subsystems.

- The C3 onboard computer will power up the OreSat Live mission subsystem, which includes its own processor and memory system. Images will be continuously captured from the camera system and transmitted over the DxWiFi system via the omnidirectional 4 element turnstile antenna system. The ground station will pick up these transmissions on both the commercial and hand-held ground stations, measuring link budget through bit error rates and overall performance by successful frames per second.
- The C3 onboard computer will power up the Cirrus Flux Camera, which includes its own processor and memory system. The CFC will run a continuous series of automated tests to capture SWIR images and test the thermal performance of the passive and active thermal control system.
- The C3 onboard computer will continue to beacon on the UHF radio once a minute. Every hour, the ground team will connect to the C3 using the Engineering Data Link (L band uplink, UHF band downlink) and perform a series of data captures and operational status checks.
- Once an hour, the C3 onboard computer will sequentially powerup and test other CubeSat subsystems, including the SDR GPS receiver, star tracker, IMU, and magnetometers. Each subsystem will capture and store its own data, while the C3 will record the thermal state of each system.

Recovery
The system will be powered down on or before the descent. Upon recovery, the system will be carefully housed for a careful teardown analysis looking for any damage or thermal effects. Then as each subsystem is removed, its high-resolution data will be read off the various flash memory systems and uploaded to the OreSat shared drive for safekeeping and future analysis.

1.3 Major System Components

OreSat1B will be testing all of the main systems of the OreSat CubeSat, with the exception of the solar arrays, battery packs, antenna deployers, reaction wheels, magnetorquers, and the high gain S-band helical antenna.

1.3.1 OreSat 2U Frame and Backplane

The OreSat frame and card cage is an open-source design by Portland State University students. The system is designed to provide maximum modularity to independent student teams by using a common card architecture and hardware and software APIs. The 6061-T6 Aluminum frame provides the structure for the CubeSat, in addition to a non-electrical thermal connection from the cards to the frame using an innovative wedge and triangle "clamp" system. The card clamping system compresses type 2 anodized aluminum surfaces onto large copper surface runs along the edge of each card, allowing for a thermally conductive but electrically insulating path. Wedges and triangles are located on the +X, -Y, and +Y sides of the frame.

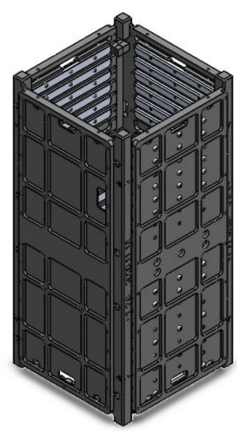

Figure 4. V1.2.0 configuration of the OreSat Frame Assembly

The backplane of OreSat1B, located on the inner -X side of the frame, allows for the cards of each of the subsystems with power, data, and RF connectors. Each card can connect to the main 24 pin connector, 20 pin auxiliary connector, and 3 RF connectors. These connectors allow the cards to interface with CAN1 and CAN2 buses, VBUS power rail, OreSat Power Domain signals (which allow each card to be powered up independently), and the U/L/SL band microstrips.

Figure 5. *OreSat Backplane Assembly*

1.3.2 C3 On-board computer card

The OreSat C3 onboard computer provides critical telemetry and control of the system. Based on an STM32F439 microcontroller with an external radiation-tolerant watchdog circuit, the C3 is in charge of radio beacons, engineering data link communication passes, powering individual subsystems, and monitoring the general health, state, and status of the various systems over the Controller Area Network (CAN) busses on the backplane which connect to all subsystems.

The C3's radio system is an L-band (1.265 GHz) receiver that is the primary uplink, and a UHF (436 MHz) transceiver that is the primary downlink. In an emergency, the system can do half-duplex communication on the UHF transceiver's UHF receiver.

1.3.3 Triband Four Element Canted Turnstile Antenna

OreSat1b uses a triband four-element canted turnstile antenna system for omnidirectional reception of L band, bi-directional UHF communication, and bi-directional S-band communication. Each element is a small (~ 7 cm) fiberglass tape spring with three copper elements, one for each band. The elements are mounted on the -Z face of the CubeSat (towards the ground).

Usually, the OreSat Live / DxWiFi system uses a highly directional and thus high gain helical antenna; for OreSat1B, this system will just use the omnidirectional turnstile antenna.

Since the turnstile antenna will be pre-deployed and should face down towards the Earth, a request has been made to exceed the dimensions for the small payload classification. It is expected that the turnstile antenna will deploy at a 45-degree angle from the payload, with a length of 7 cm. Based on available drawings and images of past HASP payloads, the turnstile antenna is not expected to interfere with other payloads on HASP.

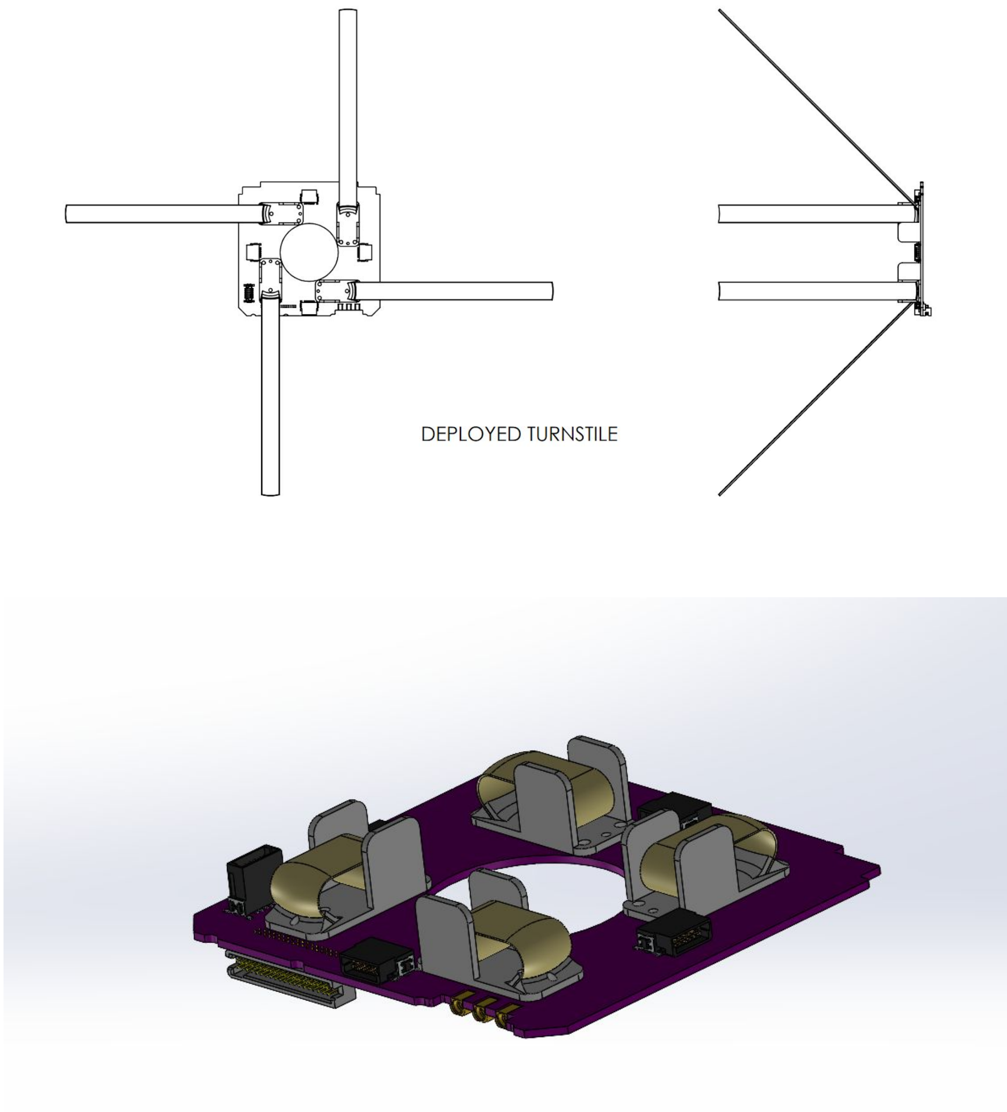

Figure 6. *Above, deployed turnstile showing the 4 fiberglass elements.*
Below, the pre-deployed turnstile assembly

1.3.4 OreSat Live System

The OreSat Live system consists of three parts:

- The OreSat live camera system, which has an innovative 3 cm wide hand-ground Schmidt Cassegrain telescope lens and a high-resolution Sony CMOS image sensor.
- The OreSat Live card, which contains an Octavo SM processor running Linux from an eMMC flash disk. This card controls the camera, processes the video, and controls the wireless system.
- DxWiFi radio system on the OreSat Live Card, which is an Atheros AR9721 802.11b USB to WiFi adapter IC. This commercial, off the shelf WiFi adapter, is attached to a bi-directional amplifier which includes a 1W power amplifier in order to get a long-distance WiFi system. The RF signal is then broadcast from the turnstile antenna.

1.3.5 Cirrus Flux Camera System

The Cirrus Flux Camera (CFC) is a ShortWave IR (SWIR) imaging multiband science instrument. It consists of several parts:

- The CFC processing card, which contains an Octavo SM processor running Linux with an eMMC flash disk. This card controls the camera and stores the raw images taken from the sensor.
- The sensor card, which holds the Princeton SWIR imaging sensor that has its own built-in thermoelectric cooler (TEC), and a large copper thermal mass.
- A Navitar 25mm SWIR lens is mounted via the lens mount, to be fastened to the sensor card. Additionally, the thermal lens strap mounted to the -Z end card serves to not only dissipate heat from the Navitar SWIR lens but also to provide structural support.

Since the Cirrus Flux Camera is currently in development, there is a high likelihood that various components will change in their design. Most notably, the design of the thermal lens straps and the copper thermal mass is likely to change as the OreSat thermal team models the subsystem. Changes are not likely to significantly affect the mass or power budget for OreSat1B.

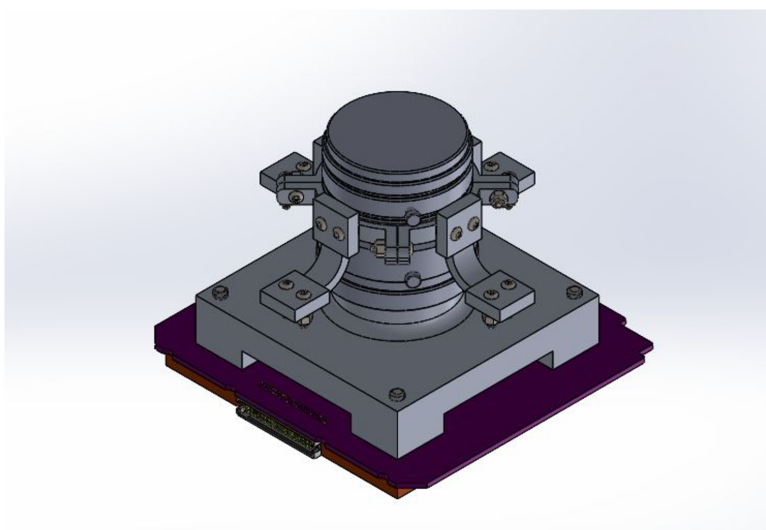

Figure 7. Assembled CFC assembly as of 12/26/20 for OreSat1B payload. The assembly includes the lens mount, thermal lens straps, CFC card, Navitar 25mm SWIR lens, and copper thermal mass. The thermal strap design is likely to change before the final flight.

1.3.6 Altitude Determination System

The attitude determination and control system, or ADCS, of the space-bound OreSat is designed to orient and maneuver the satellite in the environment of space. Since OreSat1B will not be in orbit, the control systems (magnetorquers and reaction control wheels) will not be flown. However, the two-star tracker cards, software-defined radio GPS Card, and IMU/Magnetometer cards will be flown and tested. Data from these systems will be stored locally.

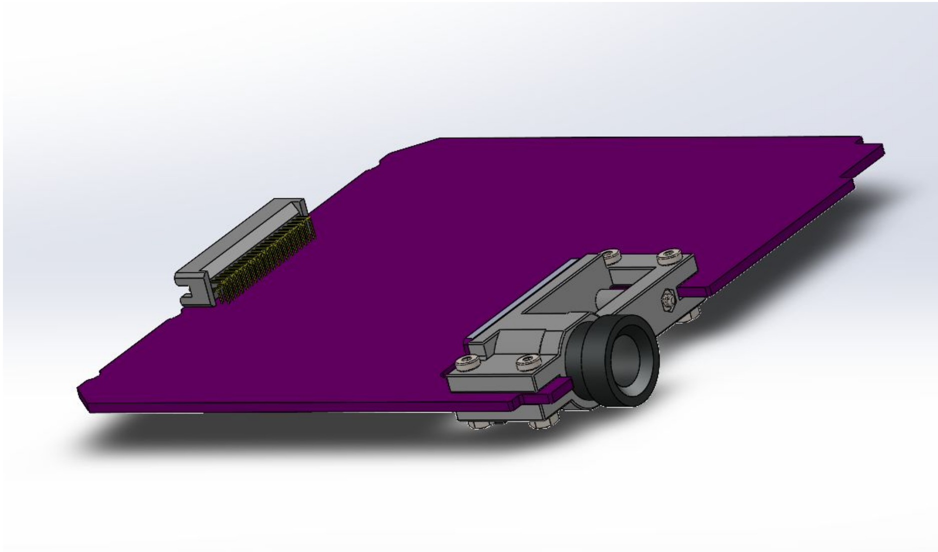

Figure 8. *Assembled OreSate Live "card" for the OreSat Live Mission*

1.3.7 OreSat Live Handheld Ground Station

Although not technically an OreSat1B component, the Handheld Ground Station is built by students from a kit and allows them to receive live video from space from the OreSat Live system. The Handheld Ground Station is composed of several 3D printed parts, a helical antenna, a Raspberry Pi Zero, a PCB, and Atheros 9721 receiver module. Data transmitted by the OreSat Live system on OreSat1B will be received by the handheld ground station, which will be connected to a laptop. Data will be collected and analyzed by the teams at Portland State Aerospace Society after the flight.

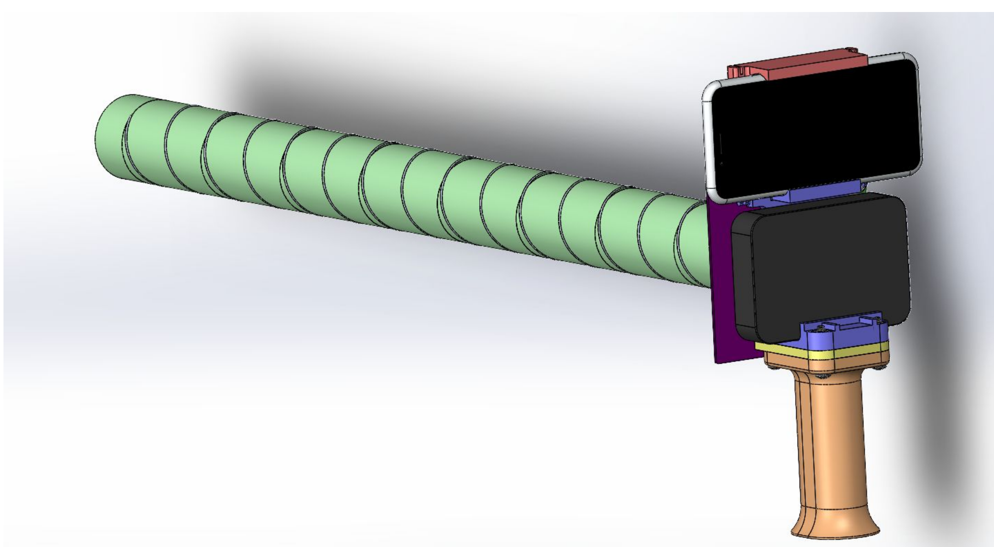

Figure 9. *Assembled Handheld Ground Station for the OreSat Live Mission*

1.4 Mechanical and Structural Design

The structure to be flown on OreSat1B payload will be that 2U configuration of the open-source OreSat frame. The frame of OreSat is made of 6061-T6 Aluminum with type 2 anodization, manufactured to the specifications as represented in the drawings in the "Preliminary Drawings and Diagrams" section. Each "card" will slide into a slot of the card cage and connect to its respective connectors on the 2U backplane. Cards will be held down using a triangle-wedge system, thermally connecting each card to the frame.

OreSat1B will be attached to the payload plate via 4 L-brackets on each side of the frame. Each L-bracket is mounted to the frame of OreSat1B with 4 fasteners, which is then mounted to the HASP mounting plate with 2 fasteners and nuts. The L-brackets will be machined out of aluminum, providing the required strength for the 5g horizontal and 10g vertical shock tests. The OreSat1B payload is not expected to have any stresses other than the impact of the landing of the payload. Therefore, the design of the mounting mechanism is purely designed for the expected 5g horizontal and 10g vertical shock.

1.5 Electrical Design

OreSat1B is a simplified version of the OreSat 2U CubeSat. Detailed technical information on the OreSat 2U CubeSat can be found at https://www.oresat.org/satellites/oresat and https://www.oresat.org/technologies/cubesat-subsystems.

OreSat1B will include the following OreSat 2U CubeSat subsystems:

- C3 on-board flight computer with onboard amateur L-band (1.265 GHz) receiver and UHF (436 MHz) 1W transmitter
- Attitude determination systems: optical star tracker, inertial measurement unit, magnetometers, and an SDR GPS receiver.
- OreSat Live camera and DxWifi S-band (2.422 GHz) receiver and 1W transmitter
- OreSat Backplane
- Cirrus Flux Camera system (a short-wave IR camera subsystem)

Schematics of these subsystems can be found on our various Github repositories pointed to by https://www.oresat.org/technologies/cubesat-subsystems. Full schematics of the entire OreSat CubeSat system in PDF form are available by request.

The OreSat1B mission would specifically leave out:

- Solar panels
- Battery packs
- Attitude Control System (magnetometers and reaction wheels)
- The OreSat Live highly directional, the high-gain helical antenna will be replaced by an S-band patch antenna with hemispherical propagation.

For power, OreSat1B will use HASP-provided 30V @ 0.5A power. We will replace one of our external solar panels with a 30V to 7.2V DC-DC converter mounted on a solar panel PCB: the input will be a 1ft cable to an EDAC 516-020-000-301 connector, and the output will be the standard OreSat solar connector which interfaces with OreSat's electrical main bus. The detailed schematic can be found on https://github.com/oresat/oresat-testing in the OreSat1B folder.

1.6 Thermal Control Plan

Region	Expected Temperature (°C)	In Operating Range? (Y/N)
Launch Site (Ft. Sumner, NM)	0 to 40°C	Y
Crossing tropopause	-55 °C	Y
Float	-30 °C	Y
Recovery Site	0 to 40°C	Y

Table 1. Expected temperatures to be experienced by OreSat1B and if in operating range of components

The OreSat1B payload will utilize the same hardware design for the space-bound OreSat mission. All of the components onboard OreSat1B are designed to operate in the "Automotive" temperature range, at -40 to 105 °C. Therefore, the payload will be within the operating range and will be within the operating temperature at all stages of the flight.

One area where additional thermal control exists is in the Cirrus Flux Camera (CFC) subsystem. Although the Princeton IR SWIR sensor has a temperature range of -40 to 70 °C, the operating range must be kept below -8 °C. This may require additional cooling, so the CFC instrument has a built-in thermoelectric cooler (TEC) and copper thermal mass. This will ensure the sensor is kept within the operating temperature range. Below is an image of the CFC subsystem, including the copper thermal mass.

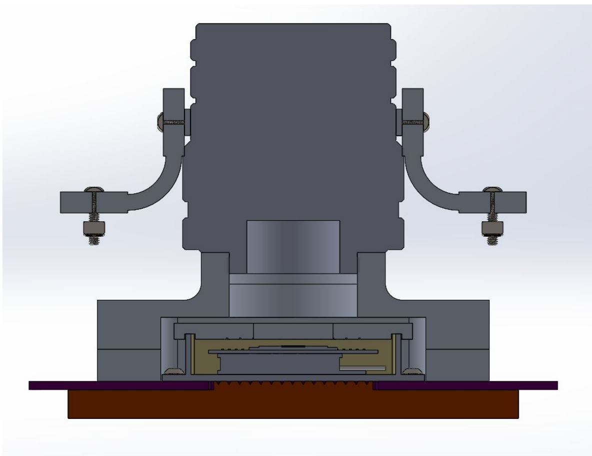

Figure 10. Cross-section of the Cirrus Flux Camera subsystem to be flown on the OreSat1B payload. The Princeton IR SWIR sensor is actively cooled with a Thermoelectric Cooler (TEC) with thermal dissipation by a copper thermal mass.

2. Team Structure and Management

2.1 Team Organization and Roles

The OreSat test payload will be constructed and operated by a student team led by Marvin Lin, with collaboration from students from both Westview High School and Portland State University. The OreSat teams at the Portland State Aerospace Society (PSAS) will be responsible for the development of the various subsystems for OreSat1B, while the team at Westview will be responsible for payload integration and testing.

Marvin Lin is a current high school Junior and member of PSAS/OreSat at PSU. He will be responsible for the management of the team, the submission of monthly reports and attendance of teleconferences, and the development of hardware for the HASP Payload. Marvin is also responsible for the mechanical design of the Cirrus Flux Camera and will be working on various mechanical aspects of the OreSat1B payload development.

Emma Levy is an undergraduate student at Portland State University and a member of the Portland State Aerospace Society. She will serve as the primary PSU point of contact for the student lead. Andrew Greenberg is an adjunct professor at Portland State University and is the faculty advisor for the Portland State Aerospace Society (PSAS) and thus OreSat. Andrew will provide the needed support for the development of the OreSat1B payload. Derek Yoshikane is the CTE Manufacturing Lead at Westview High School, in addition to being the faculty advisor of the Westview Aerospace Club.

The OreSat team will also assist in the development of the OreSat test payload. Since most of the subsystems flying in the OreSat1B payload will be identical to those flying to space on OreSat, development of the subsystems will occur concurrently. While all OreSat teams will be involved in the development of the core subsystems of the OreSat1B payload, several are of particular interest to the HASP payload. The OreSat Cirrus Flux Team is responsible for the design and development of the Cirrus Flux Camera (CFC), which is the primary system being tested on OreSat1B. The OreSat Structure team is responsible for the design of all structural components on OreSat, including but not limited to the frames, thermal analysis, and more. Lastly, OreSat PREP is the team responsible for the electrical design of OreSat.

The students at Westview are responsible for the integration of the existing OreSat design into the requirements for the HASP Payload. This includes assembly of the OreSat1B payload, design of the mounting system, and attendance at environmental testing. The students at Westview High School will primarily serve as a STEM outreach component of OreSat, as they will be learning about the process of designing a small satellite and having hands-on experience with assembling and testing the payload. Marvin Lin, a current Westview Student and Student Lead, will be responsible for establishing the STEM outreach component at Westview High School.

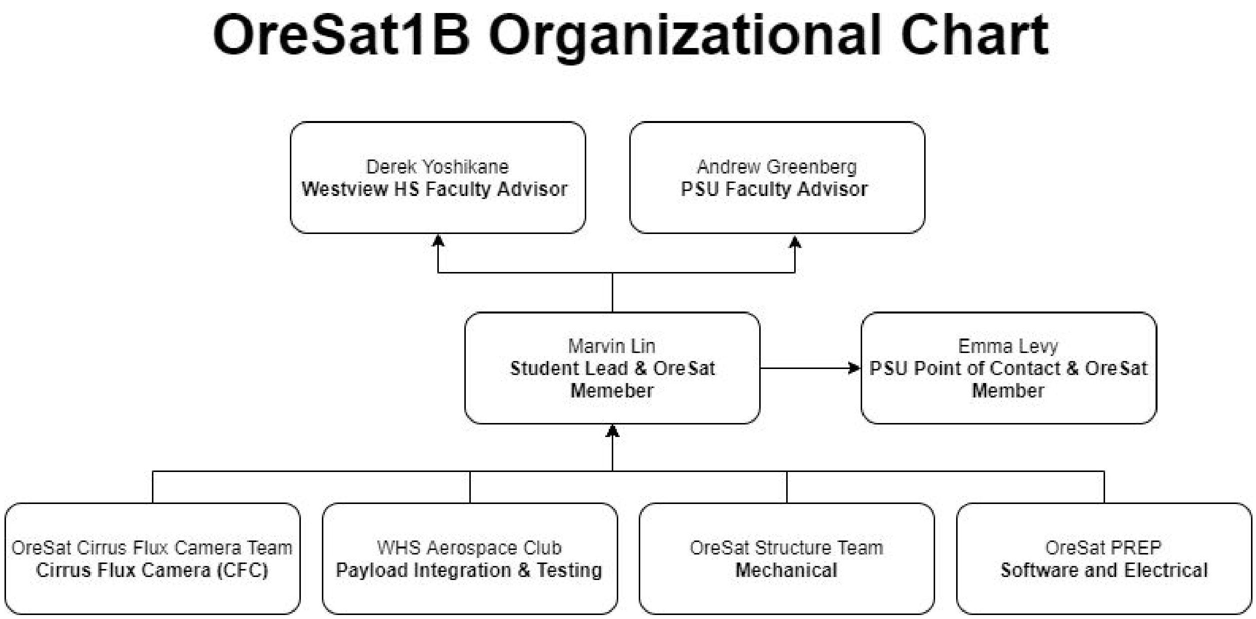

Figure 11. Organizational chart for the development of OreSat1B

Project Manager /Student Lead	Marvin Lin *High School Junior and PSAS/OreSat Member*	15487 NW Andalusian Way Portland, OR 97229	marvin.j.lin@gmail.com 971-297-9480
PSU Point of Contact	Emma Levy *Undergraduate Student at Portland State University*	Portland State University 1930 SW 4th Ave Suite 500 Portland, OR 97201	el36@pdx.edu 907-885-8622
Faculty Advisor	Andrew Greenberg *Adjunct Professor at Portland State University*	Portland State University 1930 SW 4th Ave Suite 500 Portland, OR 97201	adg4@pdx.edu 503-708-7711
Faculty Advisor	Derek Yoshikane *CTE Manufacturing Instructor at Westview HS*	Westview High School 4200 NW 185th Ave Portland, OR 97229	derek_yoshikane@beaverton.k12.or.us 503-356-3020

Table 2. Area of responsibility, academic year, mailing address, and contact information of key personnel

2.2 Timeline and Milestones

Below is a list of key milestones for the OreSat1B payload. The Gantt timeline organized by major WBS elements can be found in the appendix.

Date	**Description**
January	Reconciliation of existing OreSat hardware available for HASP payload use. **Additional fundraising will take place for the required components.**
February - March	**Continued development on various subsystems of OreSat1B**, including but not limited to OreSat Live, Cirrus Flux Camera, C3 Flight Computer, Startracker, DxWiFi + Turnstile Antenna, and GPS/ADCS card.
April	**Finalization of OreSat Test Payload design.** Integration and testing of various components will also occur. Most components should be manufactured and boards should be “stuffed” by April or May.
April 30th	**Preliminary PSIP document and NASA Integration Security document are due.**
May	**Full system integration and testing.** This will be the first time the entire system is integrated and powered on.
June	**Preliminary environmental testing of the full OreSat Test payload**, including thermal and vibrational.
June 25th	**Final PSIP document and NASA Flight On-Site Security Document due.**
July - August	Finalize operating procedure by FLOP deadline. **Final testing and integration of all subsystems.**
July 23	**Final FLOP document due.**
July 26th - 30th	OreSat1B integration with HASP at CSBF to get Payload Integration Certification (PIC).
August	Fix any issues with integration; final systems testing.
September 5th - 7th	**Launch of payload at Ft. Sumner**. The student leads and faculty advisor set up ground stations and conduct tests of the DxWiFi communications system from nearby the launch facility.
September - November	Analysis of data collected by OreSat1B. **Writing and completing the Final Flight Report will also occur**.
December 10th	**Final Flight/Science Report Due.**

Table 3. Preliminary timeline for OreSat1B to be flown on the 2021 HASP system

2.3 Anticipated Participation in Integration and Launch operations

It is anticipated that the project manager, a faculty advisor, and 3-4 students will attend payload integration at CSBF in July. The project manager, a faculty advisor, and 1-2 additional students are anticipated to attend the flight operations at Ft. Sumner. Attendance at the flight operations is primarily for the test of the DxWiFi system of OreSat1B.

3. Payload Interface Specifications

3.1 Weight Budget

The payload will be a stripped configuration of the 2016 CSLI Application OreSat mission. Table 3 outlines the preliminary mass budgets for each component, organized by subsystem. Changes will be made to the components as development on various subsystems continues. However, significant changes to the overall mass are unlikely. Since the space-bound OreSat configuration is estimated to be under 3kg, it is highly unlikely that OreSat1B configuration will exceed the weight budget, as several subsystems have been removed (ie. Battery cards, solar panels, etc).

Subsystem	Qty	Component	Mass (g)	Ext. Mass (g)	Notes
Structure				**1023.83**	
	1	+X aluminium frame	167.73	167.73	Calculated with material properties in Solidworks
	1	-X aluminium frame	164.18	164.18	Calculated with material properties in Solidworks
	2	+Y aluminium frame	129.69	259.39	Calculated with material properties in Solidworks
	n/a	Card Wedges, triangles, and frame fasteners	119.19	119.19	Calculated with material properties in Solidworks
	n/a	Payload fasteners + Mounting plate	277.08	277.08	Calculated with material properties in Solidworks
	1	+Z End Cap	17.75	17.75	Calculated with material properties in Solidworks
	1	-Z End Cap	18.53	18.53	Calculated with material properties in Solidworks
OreSat Bus				**180.17**	
	1	LGR turnstile antenna assembly	49.46	49.46	Calculated with material properties in Solidworks
	1	OreSat Backplane	80.71	80.71	Calculated with material properties in Solidworks

	1	OreSat1B Power Delivery Card	50	50	Estimated with calculations from Solidworks + components (PCB = 39.06)
OreSat Live				**155.66**	
	1	C3 (Flight Computer)	50	50	Estimated with calculations from Solidworks + components (PCB = 39.46)
	1	OreSat Live Camera & Lens	28.08	28.08	Calculated with material properties in Solidworks
	1	Cassegrain Lens	27.58	27.58	Calculated with material properties in Solidworks
	1	DxWiFi Card	50	50	Estimated with calculations from Solidworks + components (PCB = 36.44)
ADCS				**195.16**	
	2	Startracker Card + Camera Assembly	47.58	95.16	Calculated with material properties in Solidworks
	1	GPS/ADCS Card	50	50	Estimated with calculations from Solidworks + components (PCB = 38.87)
	1	IMU/Magnetometer	50	50	Estimated with calculations from Solidworks + components (PCB = 38.87)
Cirrus Flux Camera				**346**	
	1	Navitar 25mm SWIR Lens	53.43	53.43	Calculated with material properties in Solidworks
	1	CFC Card (Sensor) + Princeton IR SWIR Sensor	58.8	58.8	Calculated with material properties in Solidworks
	1	CFC Card (Components)	50	50	Estimated with calculations from Solidworks + components (PCB = 39.06)
	1	Lens mount + copper thermal mass + thermal straps	183.77	183.77	Calculated with material properties in Solidworks
Total Mass				**1900.82**	Determined from CAD model of OreSat1B + estimate of component masses

Table 4. Preliminary weight budget for the OreSat1B payload totals to around 1.9kg, well under the 3kg limit for the small payload classification.

3.2 Power Budget

The following power budget was determined from testing of existing components and predictions from spec sheets. The following power budget shows the maximum power to be drawn from the payload, with most predictions with the system at 100% duty cycle.

Component	mA	Duty Cycle	Effective mA	Eff. mW @ 7.2V	Notes
C3 Card (180 mA - 250 mA)	150	100%	150	1080	Doing ADS, ACS, capturing and streaming video
SDR GPS	100	100%	100	720	Streaming raw GPS IQ data
IMU + MAG	17	100%	17	122	Streaming data to FC
DxWiFi transmitter + PA	500	85%	425	3060	Streaming video over DxWiFi
OreSat Live Camera	40	100%	40	280	Streaming video to FC
Cirrus Flux Camera (CFC)	100	100%	100	720	Sending images to FC
CFC TEC (thermal mgmt)	750	100%	750	5400	Cooling the CFC
TOTAL				**11382**	

Table 5. Preliminary maximum power budget for the OreSat1B payload with both the CFC and OreSat Live online. The HASP payload will be providing 30V at 0.5A, stepped down to 7.2V. HASP provides a maximum of 15 W which is well above OreSat1B's maximum draw of 11.3 W.

3.3 Downlink Serial Data

The OreSat test payload will not be using the downlink serial data provided by the HASP Payload. All of the data from the mission will be collected onboard the payload.

3.4 Uplink Serial Commanding

The OreSat test payload will not be using the uplink serial command provided by the HASP Payload. All operations of the payload will occur autonomously.

3.5 Analog Downlink

The OreSat test payload will not be using the analog downlink provided by the HASP Payload. All of the data from the mission will be collected onboard the payload or through the downlink from the DxWiFi/C3 telemetry.

3.6 Discrete Commanding

The OreSat test payload will not be using the discrete commanding outside of power on/off provided by the HASP system. All operations of the payload will occur autonomously.

3.7 Payload Location and Orientation Request

There is no preference for the location of the OreSat test payload. All locations for the small classification are acceptable.

3.8 Special Requests

The OreSat1B payload is seeking to fly two separate RF transmitters:

- C3 telemetry system: A 1W amateur radio transmitter on the UHF band (436.00 MHz) that transmits a telemetry beacon once a minute using Automatic Packet Reporting System (APRS) and G3RUH protocol. This system has been extensively tested for EMI at PSU's RF chambers and has already been extensively tested for use.
- DxWiFi: A project pioneered at Portland State University that utilizes a long-distance, WiFi-based (802.11b) 2.422GHz amateur radio link to establish a 1 Mbps bidirectional data link. The DxWiFi Communication System on OreSat1B will utilize a commercial, off the shelf IEEE 802.11b (1 Mbps BPSK) WiFi transceiver using the Atheros 9721 chipset, a 30dBm (1W) power amplifier, and the omnidirectional turnstile antenna.

The integrated triband turnstile antenna will require a waiver. The turnstile antenna will protrude from under the mounting plate and the antennas will be extending outside the keep-out region on the bottom side of the mounting plate. The antennas are constructed from fiberglass tape with embedded copper antenna elements. The antenna will function normally if in contact with non-conductive surfaces. Based on drawings and online images of the HASP system, we do not believe the turnstile elements will interfere with HASP operations. Since the elements are flexible, the antenna elements can also be bent to be constrained within the payload area. Below are CAD models of the deployed turnstile elements.

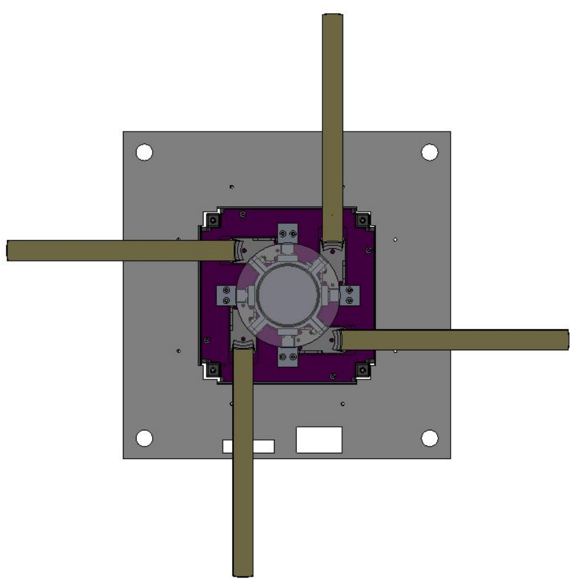

Figure 12. (1/2) CAD model of deployed turnstile antenna elements with the mounting plate. The angle of the antennas can be adjusted to prevent contact with the HASP system boom mounting arms.

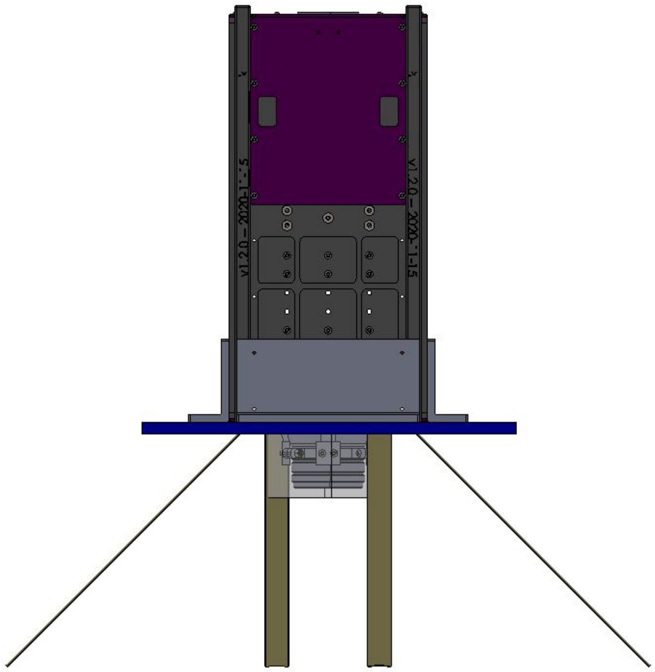

Figure 13. (2/2) CAD model of deployed turnstile antenna elements with the mounting plate. The angle of the antennas can be adjusted to prevent contact with the HASP system boom mounting arms.

4. Preliminary Drawings and Diagrams

The following are preliminary drawings for the OreSat1B payload. Many of the following drawings were made for the OreSat mission, however are applicable for OreSat1B. Note that only key drawings have been included. Additional CAD models and drawings can be found at https://github.com/oresat/oresat-dxwifi-hardware and the OreSat1B folder in https://github.com/oresat/oresat-testing GitHub repositories. Electrical schematics can also be found in the various repositories on https://github.com/oresat.

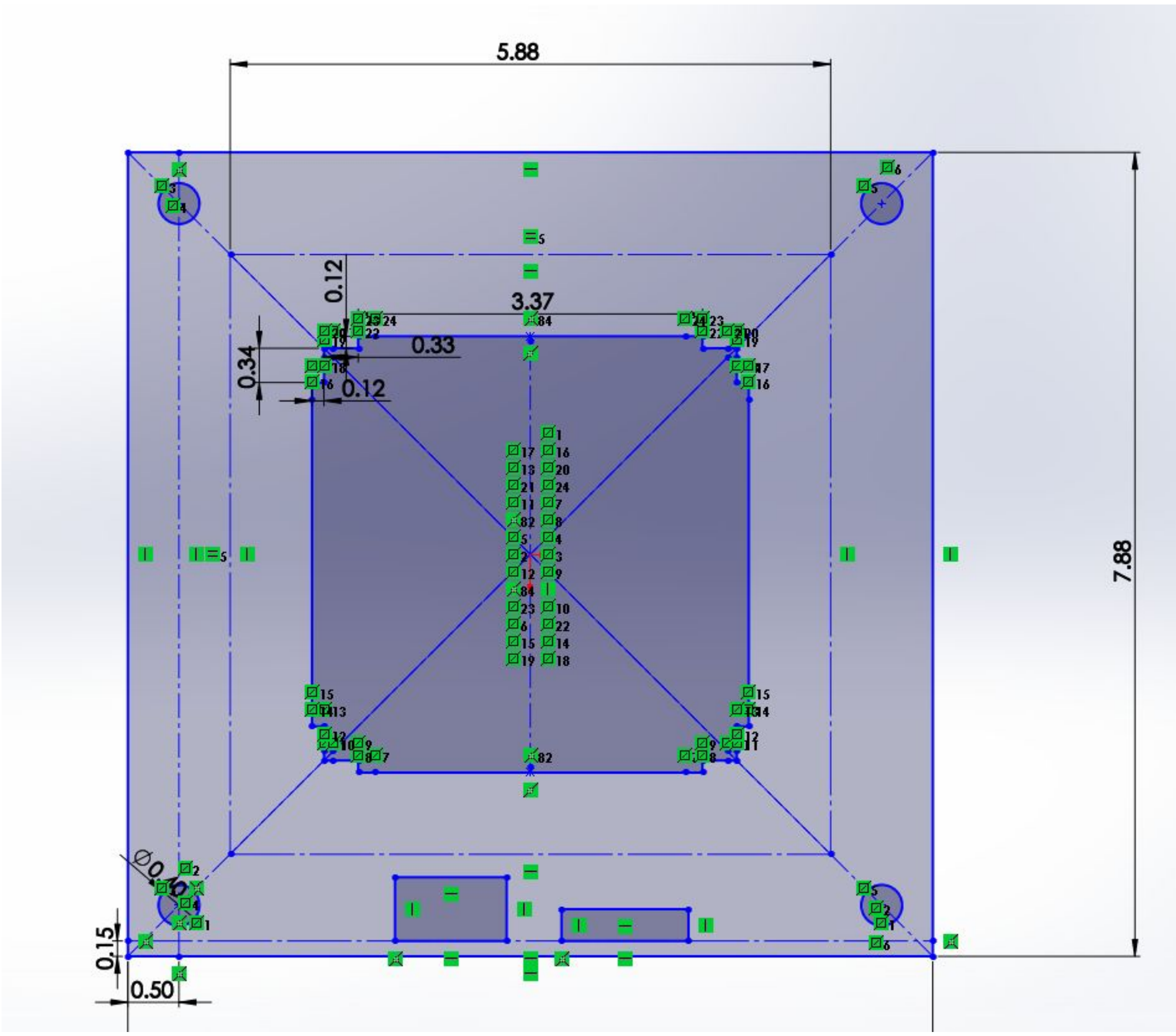

Figure 14. Dimensioned drawing of the mounting plate for OreSat1B. The payload will be mounted on the existing solar panel mounting points. The additional cutout allows the bottom of OreSat1B to slide through the mounting plate.

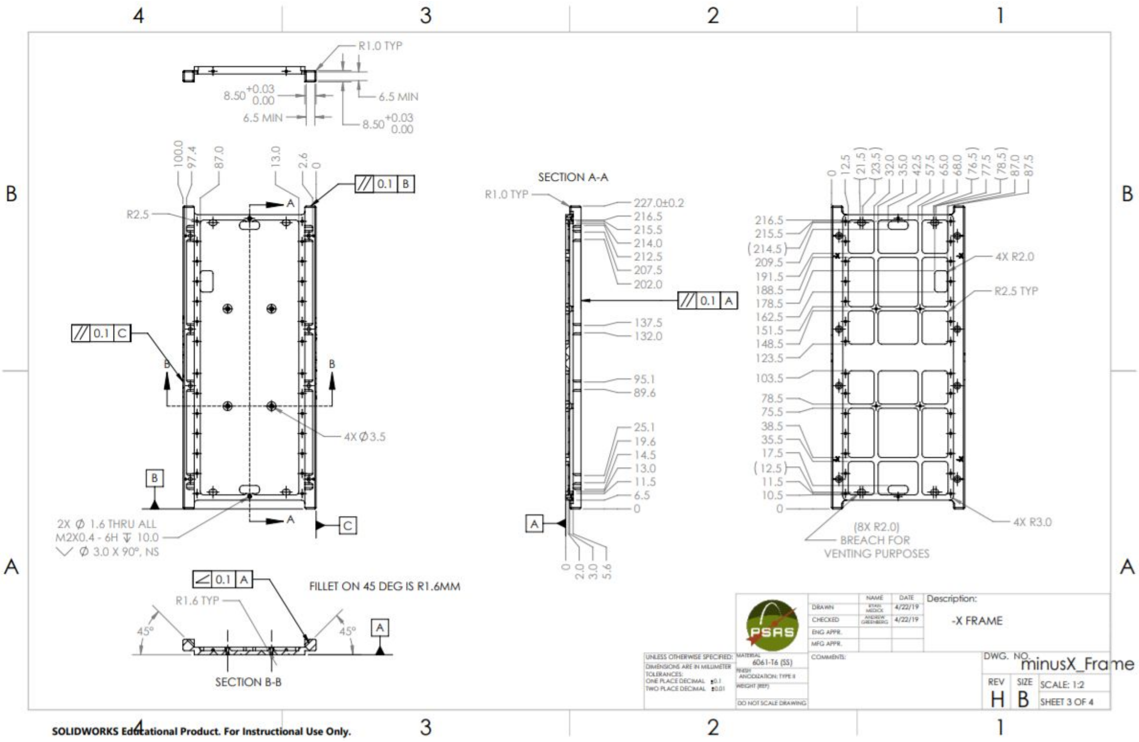

Figure 15. 1 of 3 Dimensioned Drawing of the minus X OreSat Frame

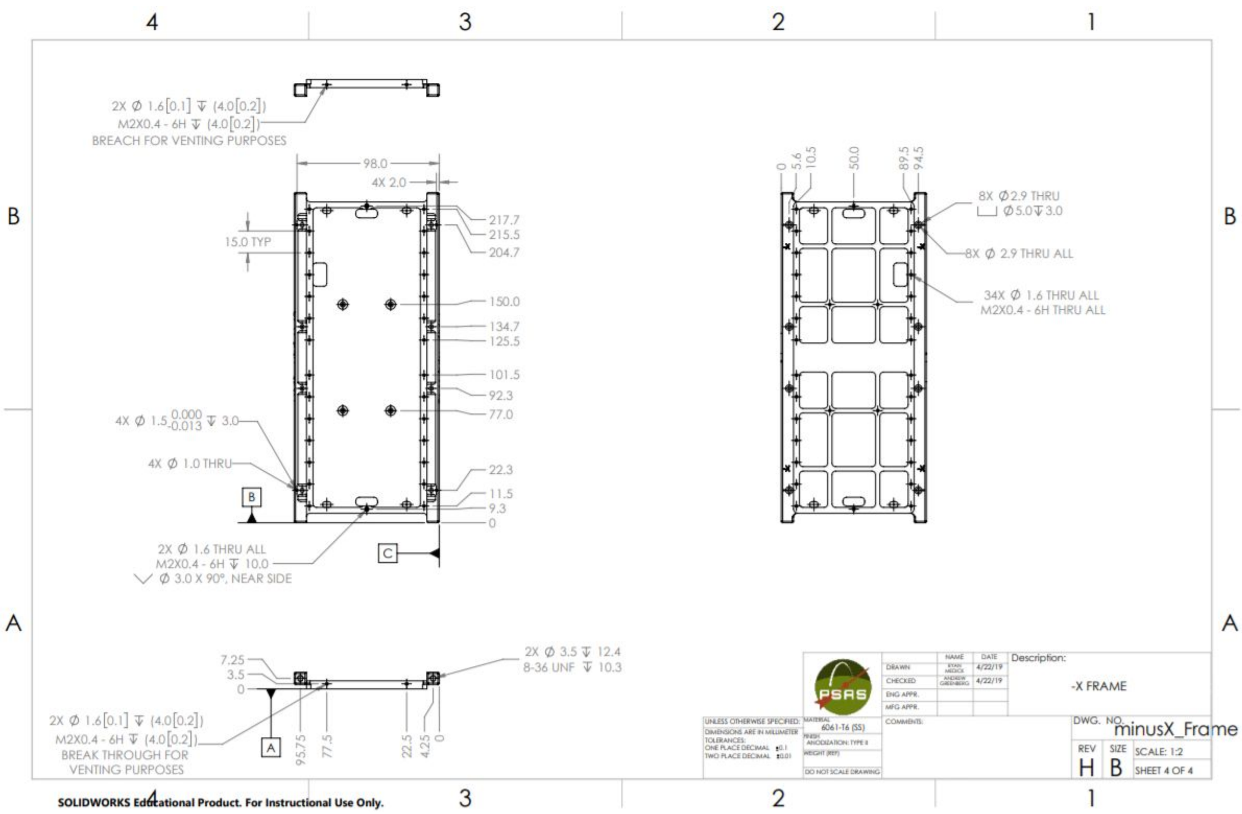

Figure 16. 2 of 3 Dimensioned Drawing of the minus X OreSat Frame

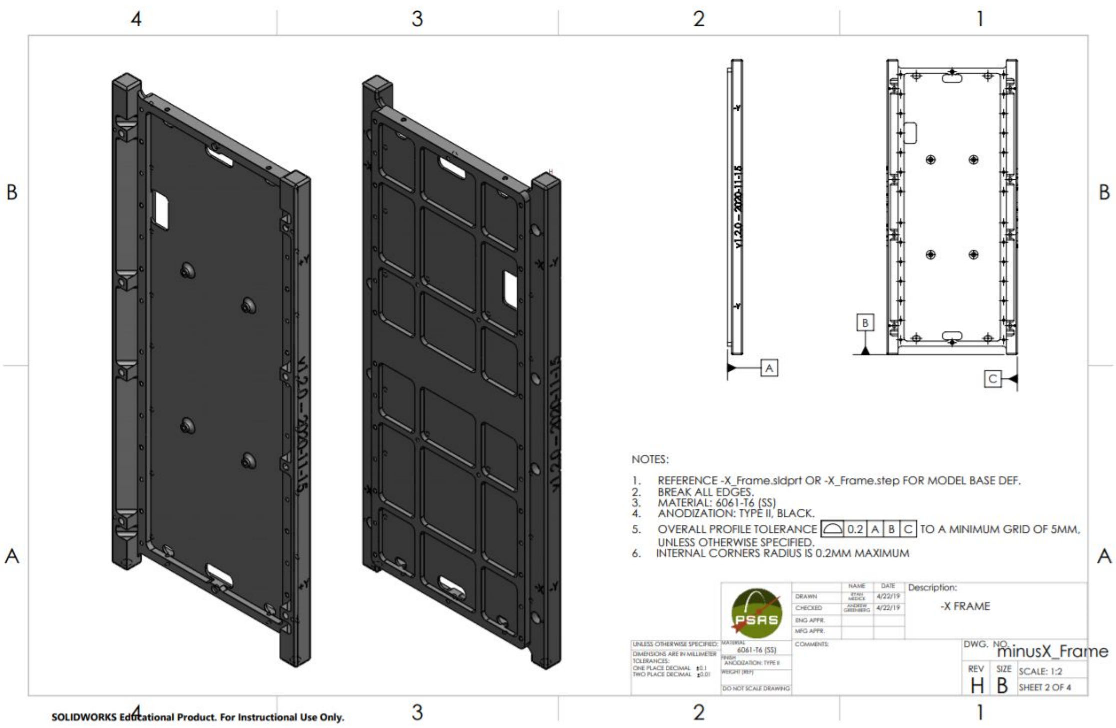

Figure 17. 3 of 3 Dimensioned Drawing of the minus X OreSat Frame

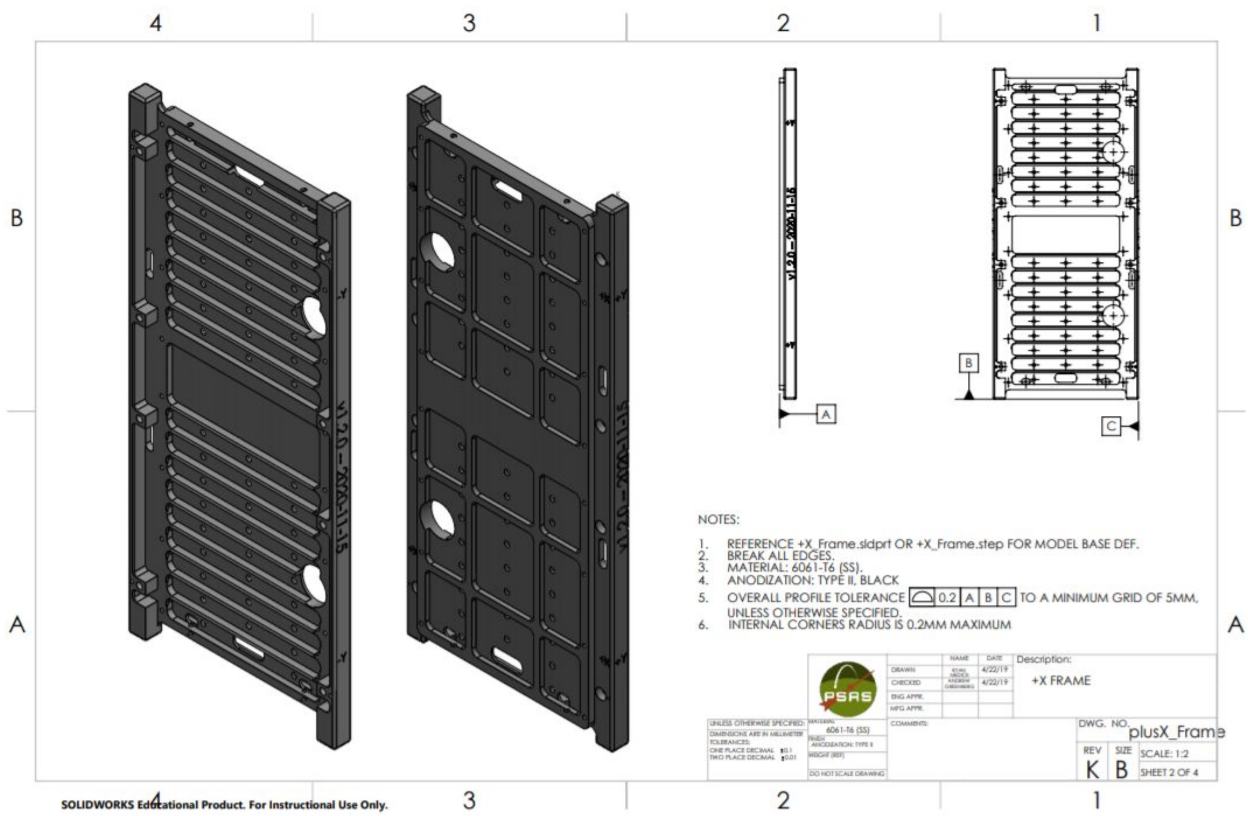

Figure 18. 1 of 3 Dimensioned Drawing of the plus X OreSat Frame

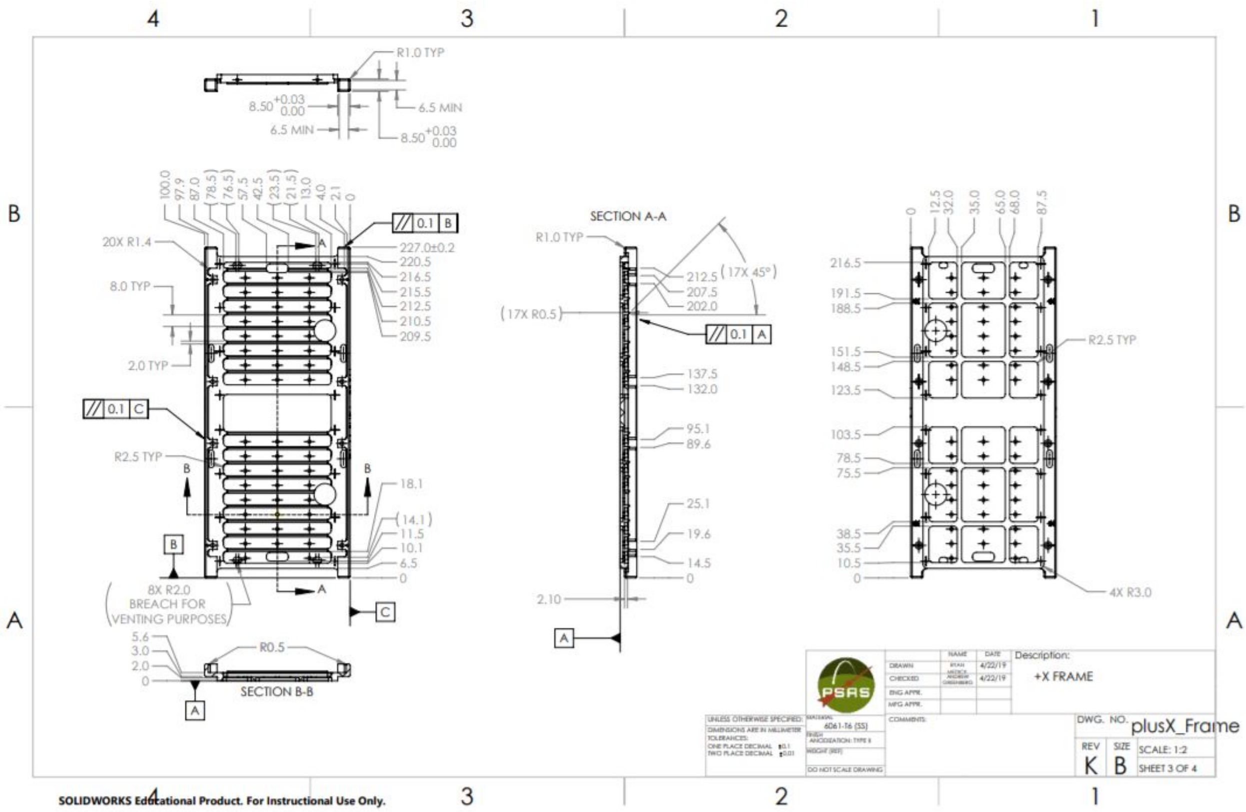

Figure 19. 2 of 3 Dimensioned Drawing of the plus X OreSat Frame

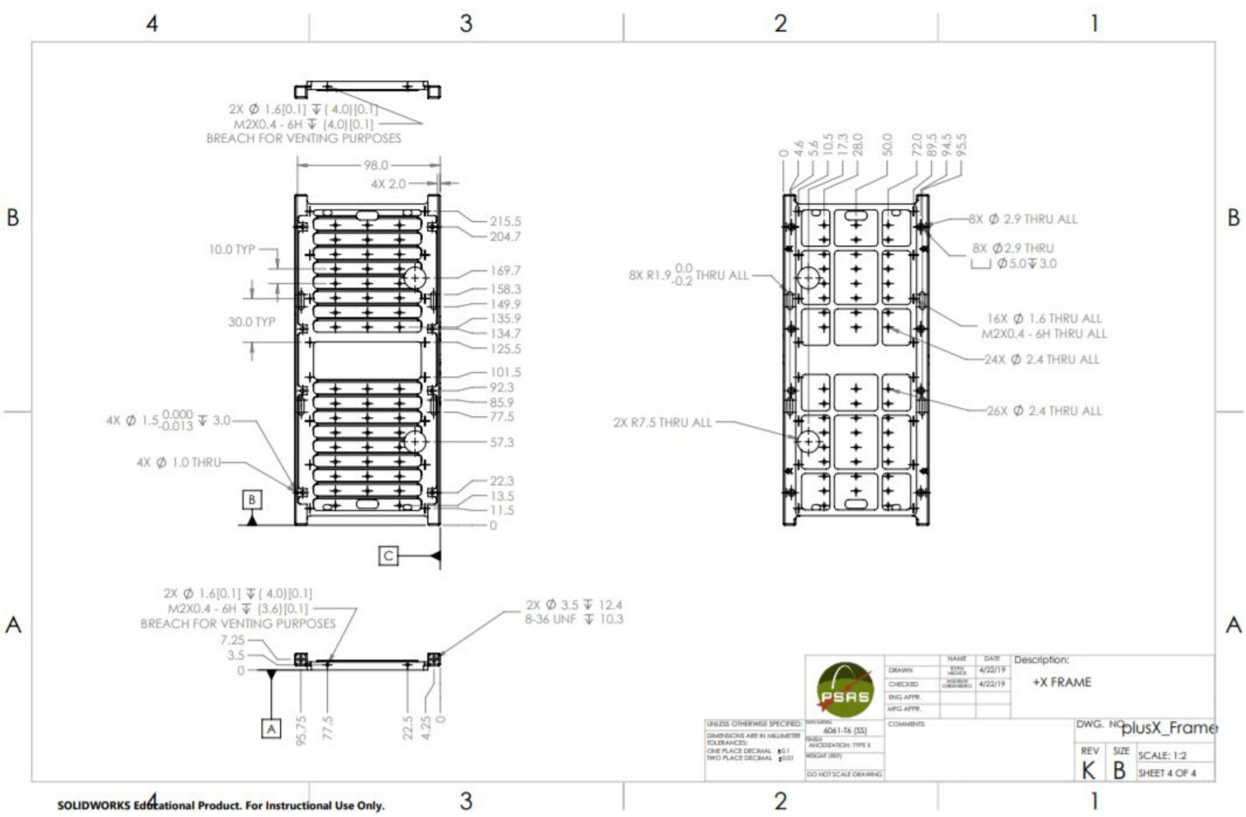

Figure 20. 3 of 3 Dimensioned Drawing of the plus X OreSat Frame

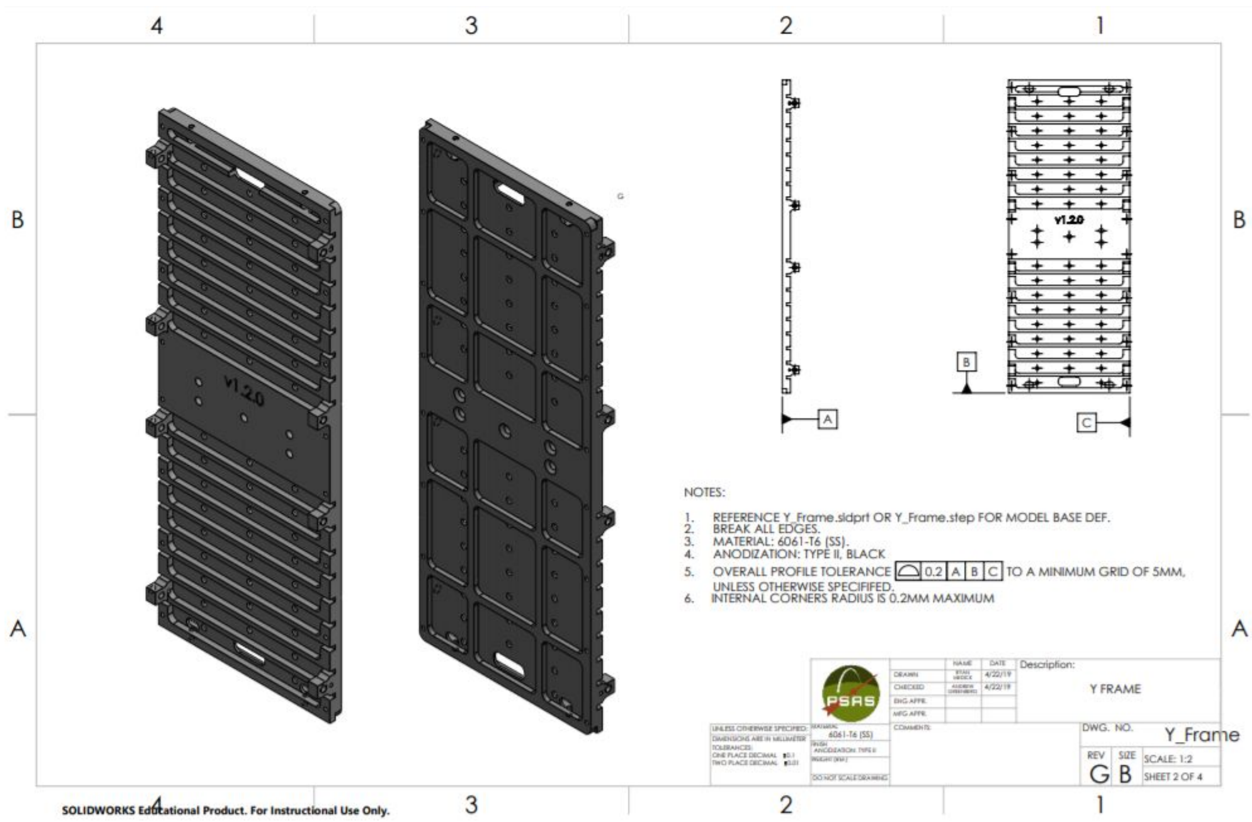

Figure 21. 1 of 3 Dimensioned Drawing of the Y OreSat Frames

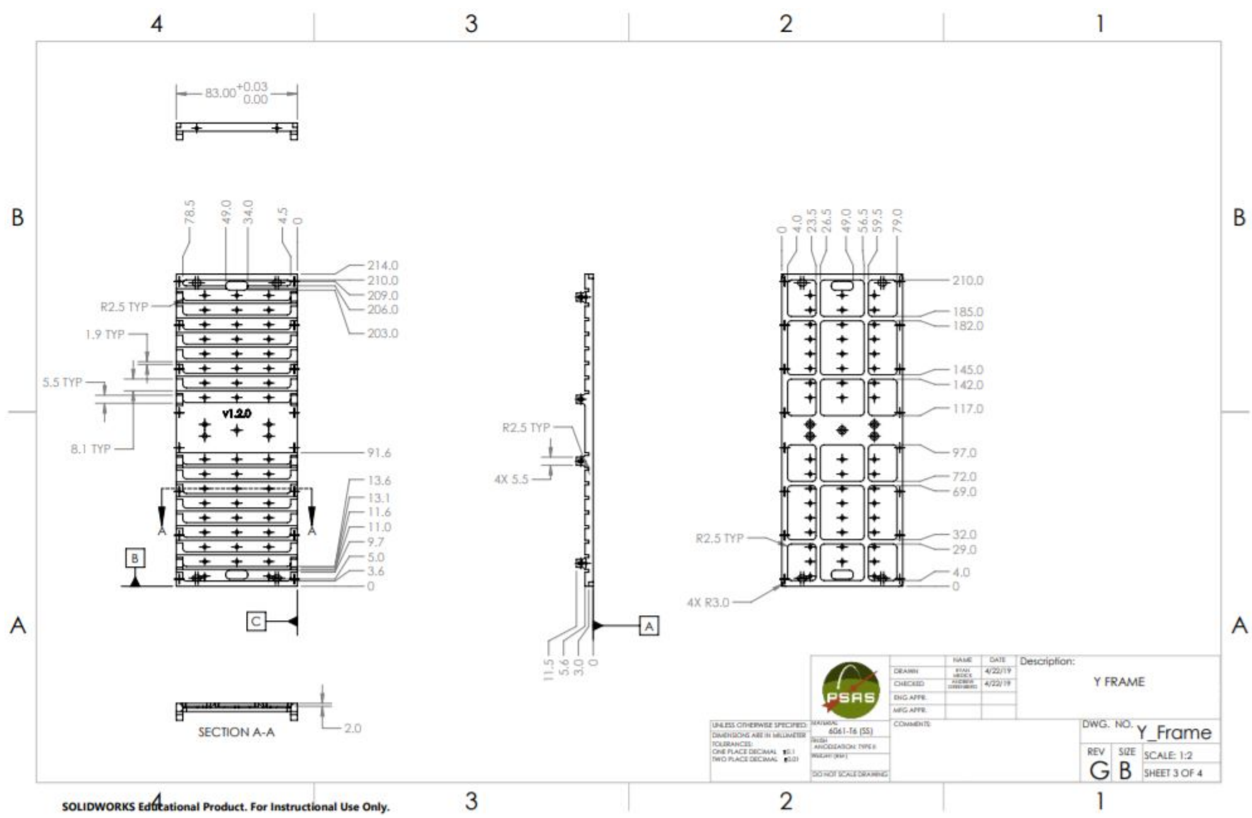

Figure 22. 2 of 3 Dimensioned Drawing of the Y OreSat Frame

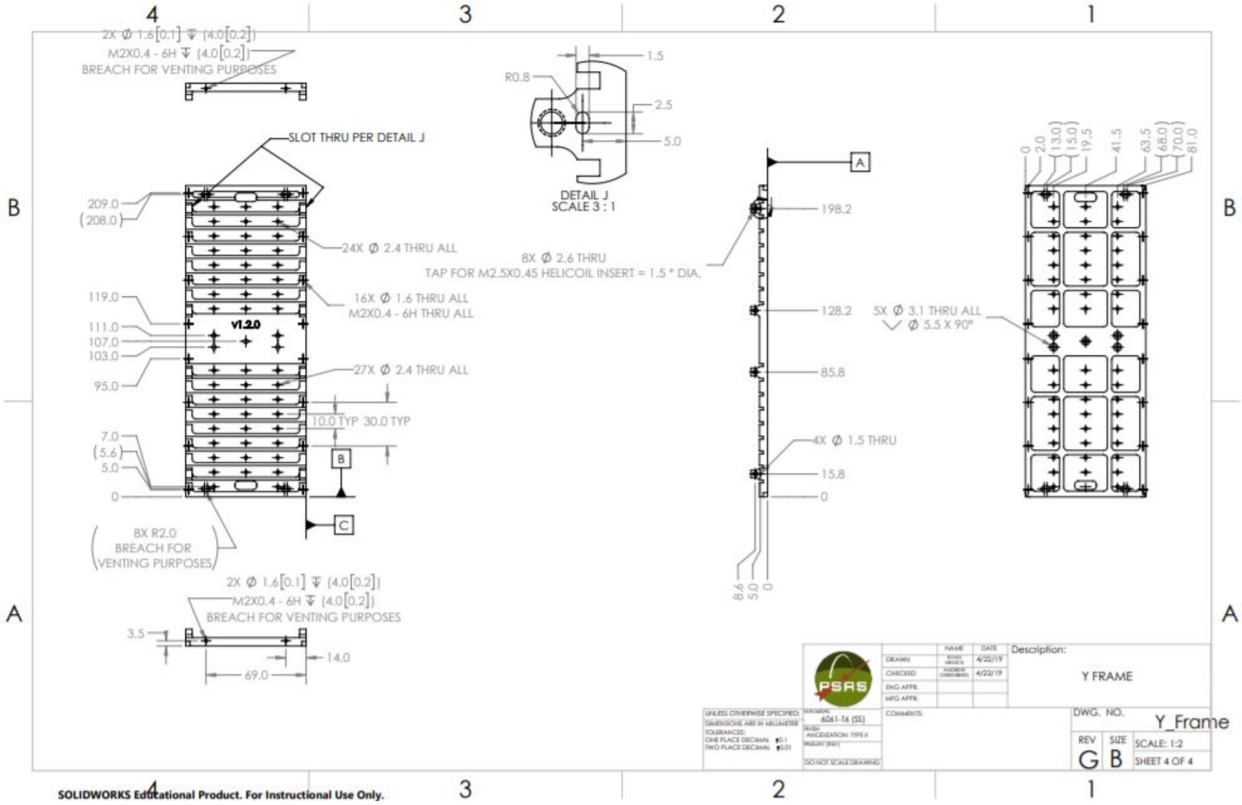

Figure 23. 3 of 3 Dimensioned Drawing of the Y OreSat Frame

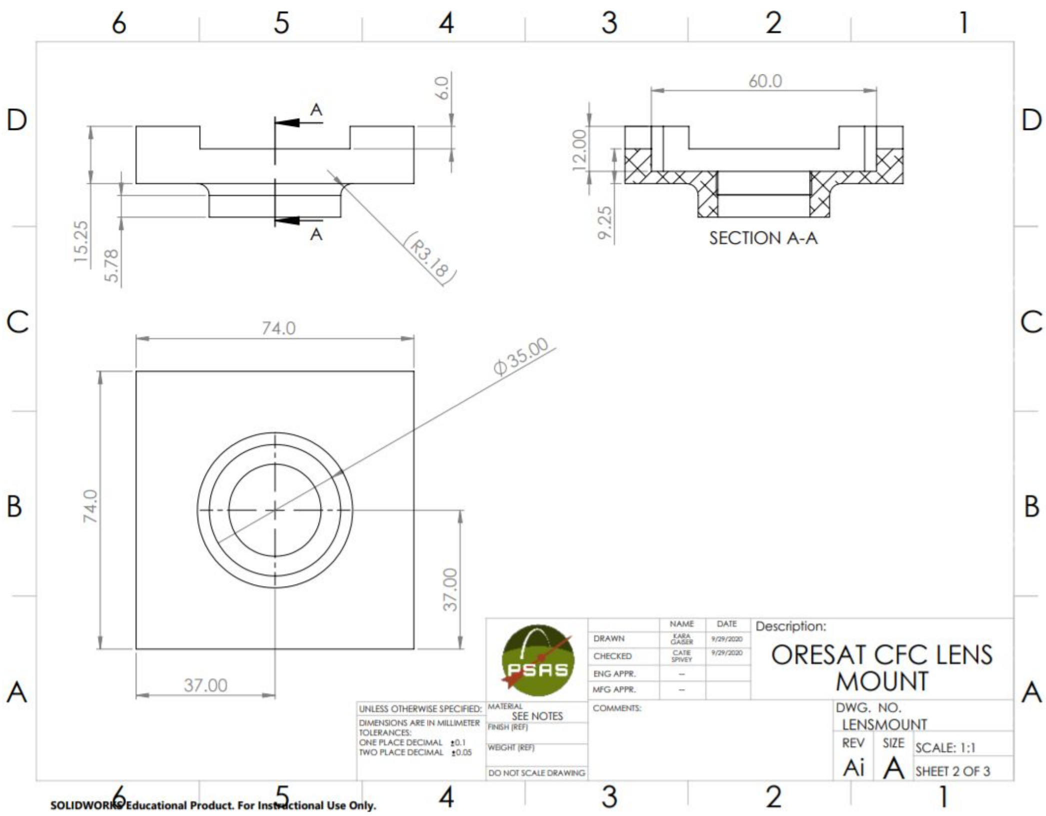

Figure 24. 1 of 2 Dimensioned Drawing of the OreSat CFC Mount

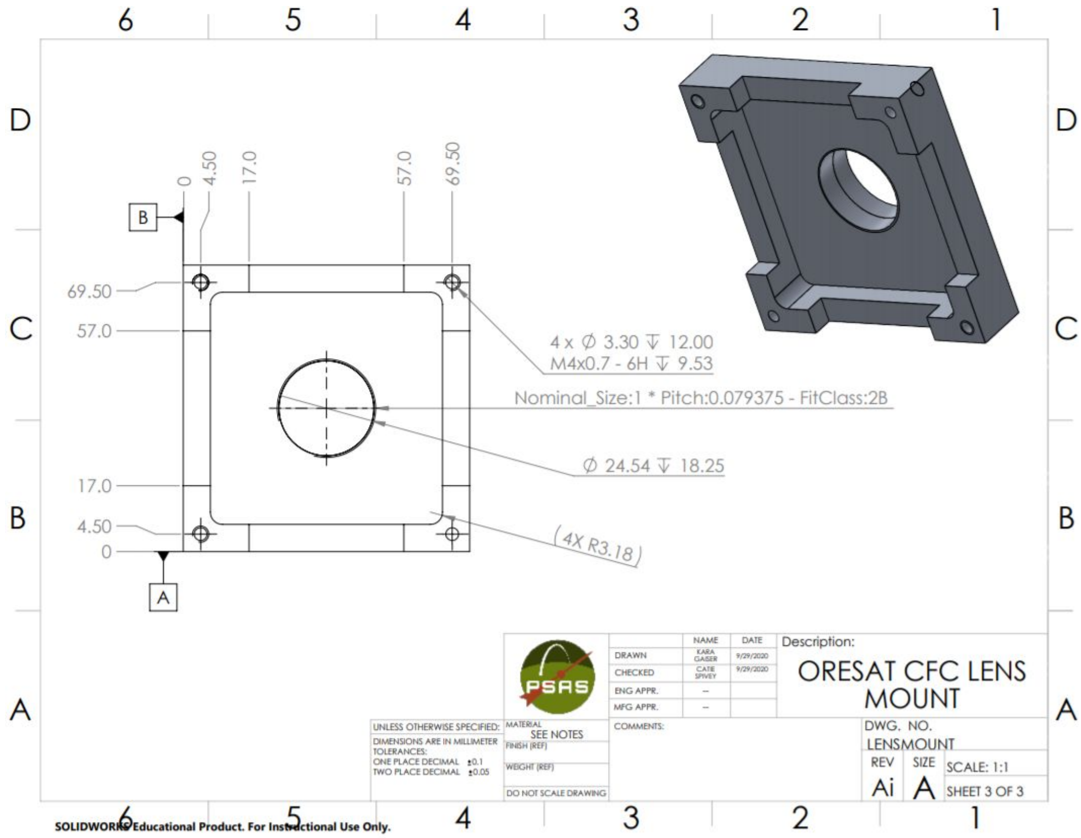

Figure 25. 2 of 2 Dimensioned Drawing of the OreSat CFC Mount

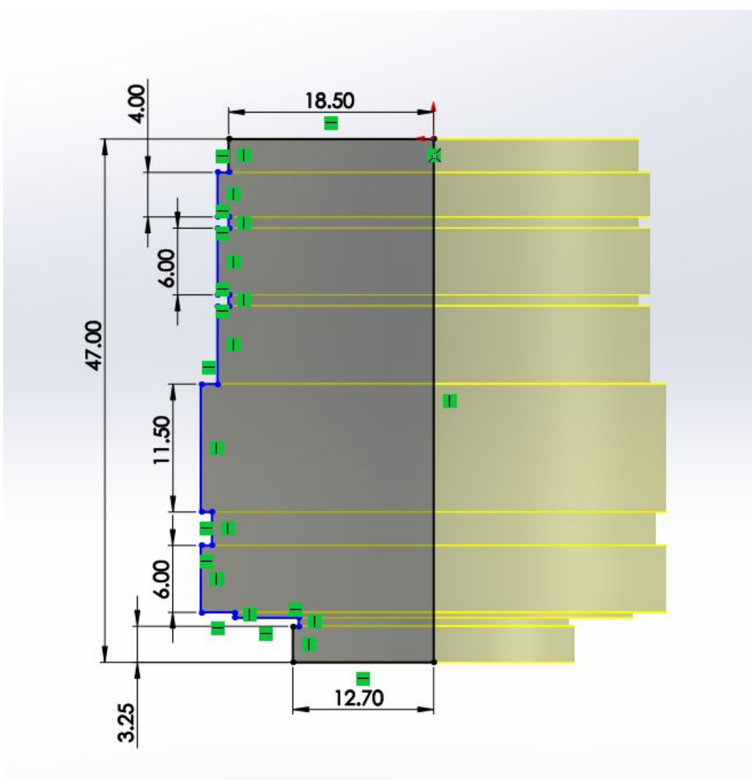

Figure 26. Dimensioned Drawing of the Navitar 25mm SWIR Lens for the Cirrus Flux Camera

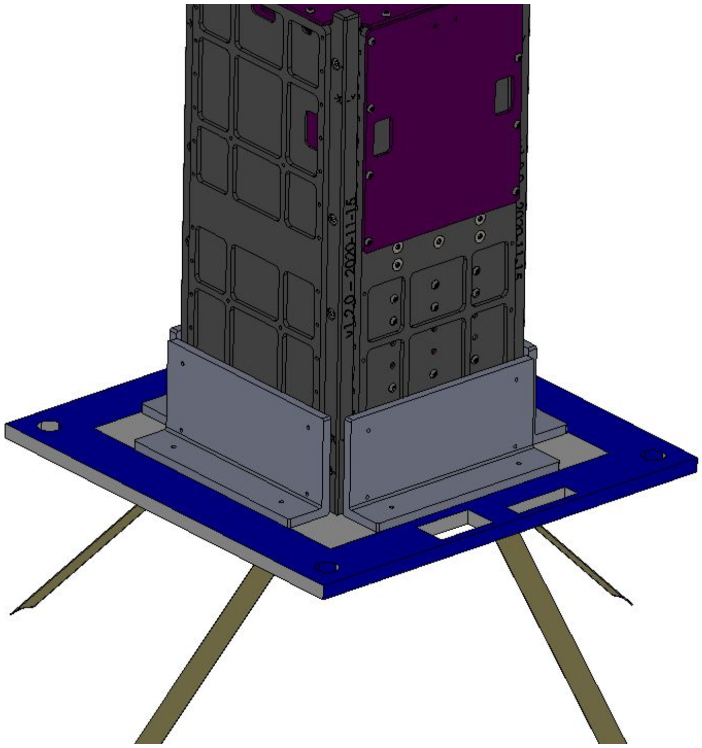

Figure 27. Preliminary CAD model of the OreSat1B payload

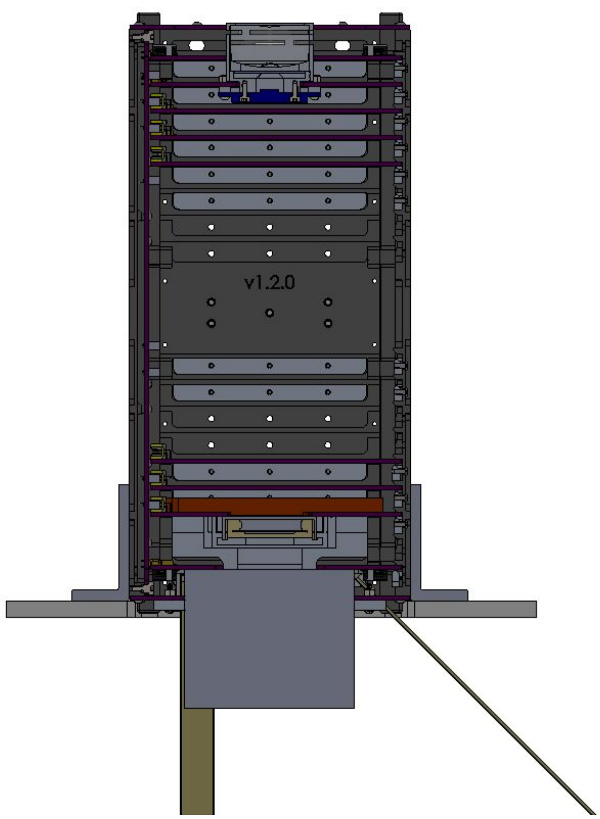

Figure 28. Section view of preliminary CAD model from -Y side

5. References

1. OreSat 2016 CSLI Application. (n.d.). Retrieved December 28, 2020, from https://drive.google.com/file/d/0B_LcfbAtlfiZVzgzM2FCbDV0RFE/view

2. Venturini, C. C. (2017, June 12). Improving Mission Success of CubeSats. Retrieved December 28, 2020, from https://www.nasa.gov/sites/default/files/atoms/files/improving_mission_success_of_cubesats_-_tor-2017-01689.pdf

Appendix

The following sections include the detailed Gantt timeline organized by major WBS elements and additional images of existing components. Additional PCB schematics/layouts, CAD drawings can all be found at https://github.com/oresat.

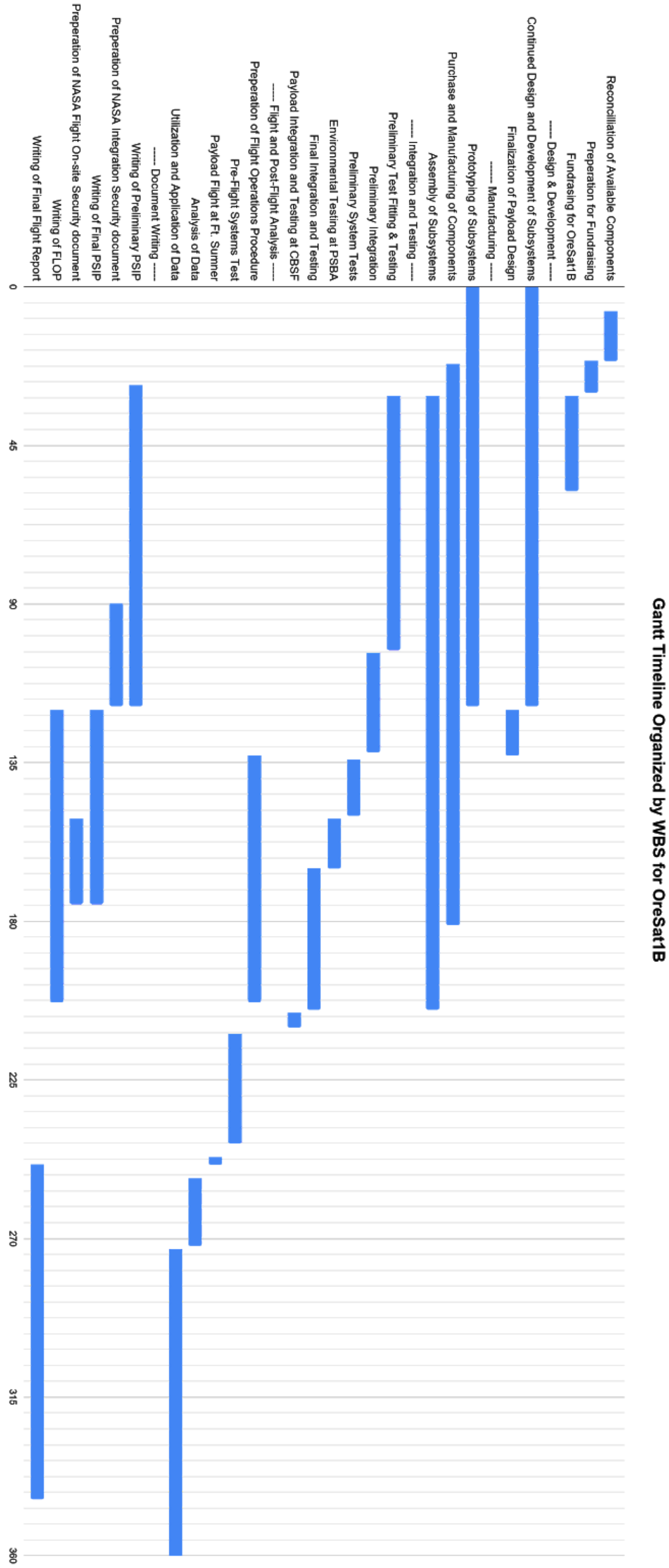

Figure 29. Gantt timeline organized by major WBS elements

Figure 30. 3D printed model of the Cirrus Flux Camera subsystem mission

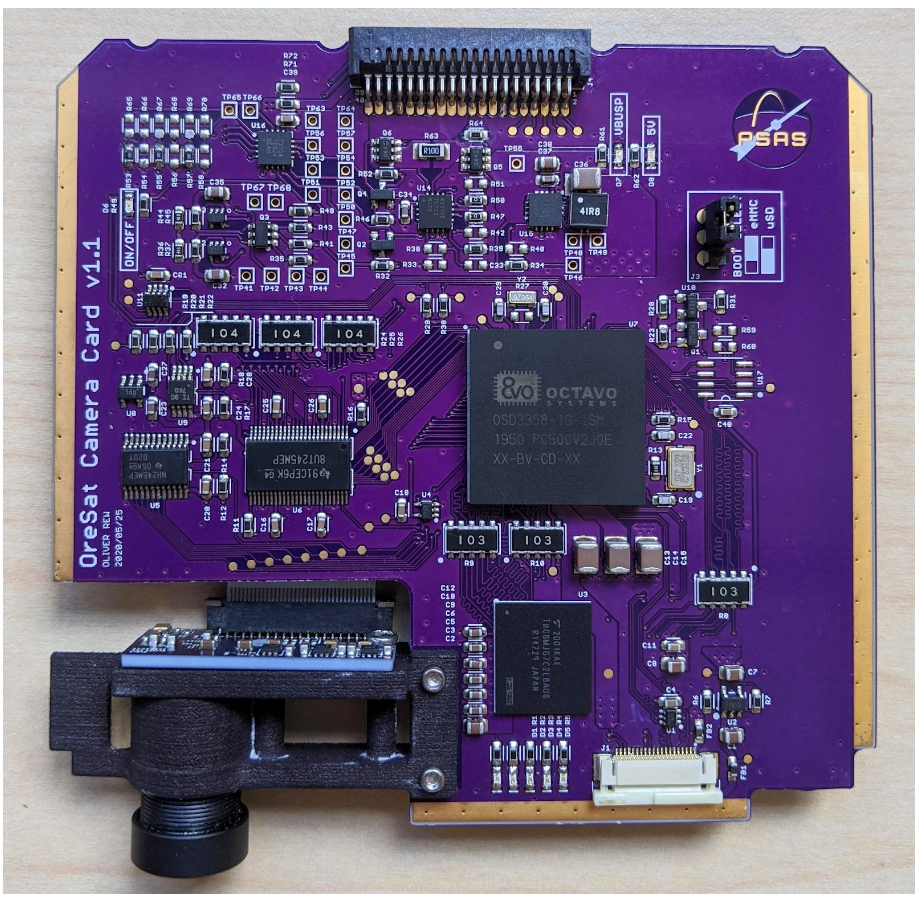

Figure 31. V1.1 of the OreSat Startracker “card”

Figure 32. Existing anodized aluminum frames for OreSat

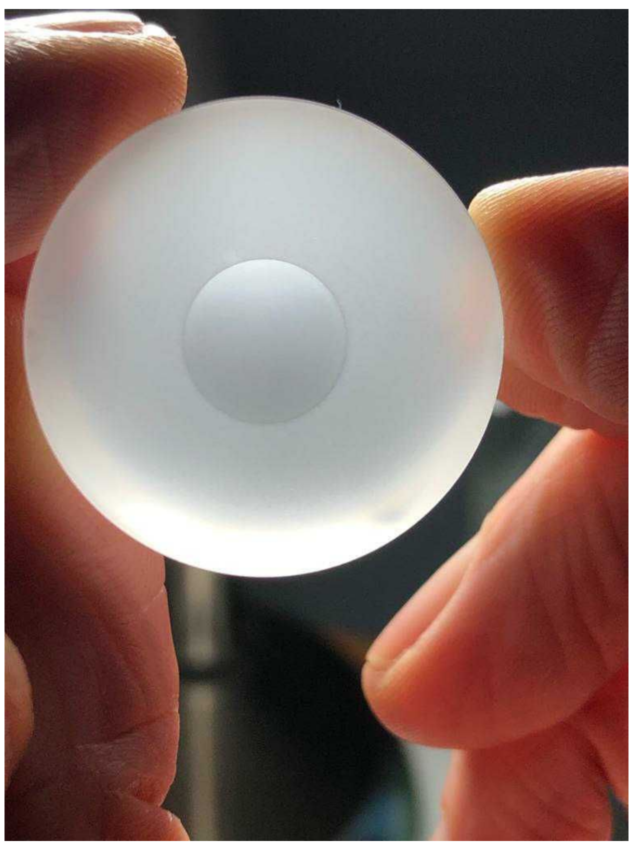

Figure 33. Artisanally crafted OreSat Live Schmidt-Cassegrain lens

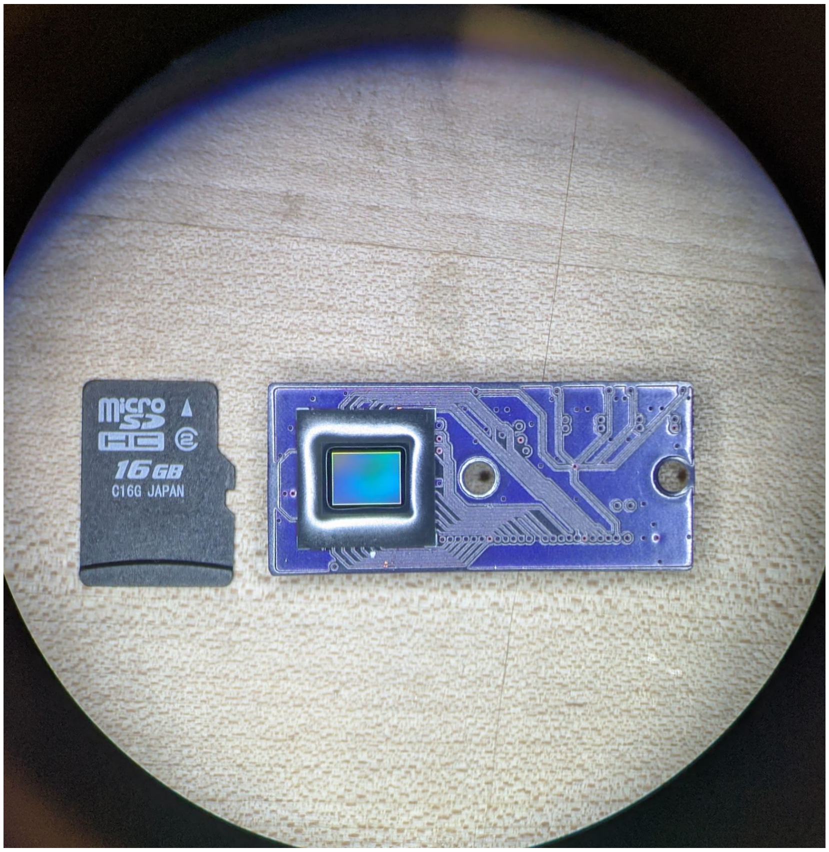

Figure 34. Sensor and board for the OreSat Startracker "card"

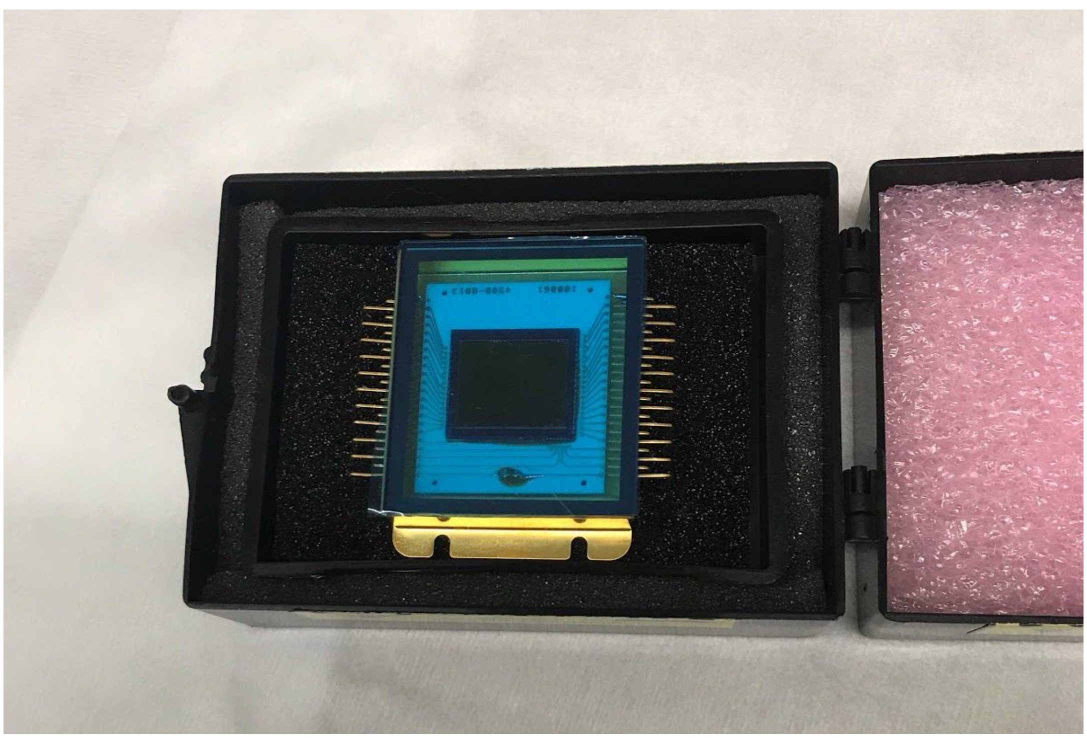

Figure 35. Princeton Shortwave IR Sensor for the Cirrus Flux Camera mission