HASP Student Payload Application for 2010

Payload Title:
OSIRIS Lite (OLite)

Payload Class: (check one)	Institution:	Submit Date:
☒ **Small** ☐ **Large**	The Pennsylvania State University	12/18/09

Project Abstract

OSIRIS Lite (OLite) is being developed by students at The Pennsylvania State University's Student Space Programs Laboratory (SSPL) as a technology demonstration for the OSIRIS CubeSat. Ultimately, the technologies demonstrated by OLite will make up the spacecraft bus for the OSIRIS satellite, designed to investigate the effects of space weather on the ionosphere. As the challenges for developing student satellite hardware are significant, a precursor balloon flight will provide the necessary heritage to enable a more costly and complex project.

OLite is demonstrating the communications, guidance, navigation and control and power subsystems which are in the critical path for the development and subsequent flight of the OSIRIS CubeSat. These demonstrations take advantage of the near space environment provided by a balloon flight to verify the systems will operate in their desired manor when the CubeSat is launched (expected in 2013).

The team currently consists of more than 20 undergraduate students from many disciplines across the university including computer science, physics, and aerospace, mechanical, computer and electrical engineering.

OLite conforms to all the requirements specified in the Call for Proposals. Additionally, OLite will require clearance below the interface panel for an antenna operating at in the 400 MHz and 900 MHz bands and support for a ground station requiring a 10A 120 V AC circuit.

Team Name:	Team or Project Website:
OLite	http://sspl.psu.edu

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OSIRIS Lite (OLite) Proposal for the High Altitude Student Platform (HASP), 2010

OSIRIS Lite, 2010

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REVISION HISTORY

Version	Date	Author	Description
001	12/18/09	Allen Kummer	Initial Release

RELEVANT DOCUMENTS

Doc. Number	Title	Rev
N/A	HASP CFP 2010	v2
N/A	HASP Interface Manual	v21709

*Relevant documents are available on the SSPL web server when available

OSIRIS LITE (OLITE) PROPOSAL FOR THE HIGH ALTITUDE STUDENT PLATFORM (HASP), 2010

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1.0 Mission Description

1.1 Mission Statement

OSIRIS Lite (OLite) will demonstrate key communication, navigation, and power generation technologies for the OSIRIS satellite using the low-cost HASP balloon platform in a relevant near-space environment.

1.2 Technical Objectives

1) The guidance, navigation and control experiment shall demonstrate the OSIRIS satellite attitude sensors and determination algorithm in a relevant near-space environment.
2) The power experiment shall demonstrate the efficiencies of the photovoltaic power supply system and the effect of Indium Tin Oxide on system efficiency in near-orbit solar conditions.
3) The communications experiment shall demonstrate the link budget that serves as a model for the end-to-end communications system between the OSIRIS satellite and the SSPL ground station.

1.3 Success Criteria

1.3.1 Comprehensive Success Criteria

1) The project shall calculate and return the attitude solution of the OLITE system in the form of Euler Parameters (unit quaternions) and the corresponding raw data every 10 seconds for a minimum of 10 hours.
2) Characterize the I-V curve for each of two solar panels; one covered by ITO and one uncovered and lock on to the peak power point of each for 20 evenly spaced measurements between sun elevations of 0 and 60 degrees.
3) The Project shall measure and return received signal strength and bit error rate once every 10 seconds for the first 2.5 hours of flight from both the payload and the ground station.

1.3.2 Minimum Success Criteria

1) The project shall calculate and return the attitude solution of the OLITE system in the form of Euler Parameters (unit quaternions) and the corresponding raw data every 10 seconds for a minimum of 1 hour during the float phase.
2) Characterize the I-V curve for each of two solar panels, one covered by Indium Tin Oxide and one uncovered, and lock on to the peak power point of each panel for at least 10 evenly spaced measurements between sun elevations of 0 and 60 degrees.
3) The project shall provide a measure of received signal strength once every 10 minutes for the first 2.5 hours of flight at both the payload and the ground station.

1.4 Mission Justification

OSIRIS Lite is a low-cost, medium-risk test flight to demonstrate new technologies critical to the success of the future OSIRIS satellite mission. The HASP environment provides a cost-effective method for reducing risk to the OSIRIS mission by allowing for the development of new technology and demonstrating its successful operation in a relevant environment. The OLITE mission also provides a near-term launch opportunity that will continue to motivate students in the years before the OSIRIS launch.

The OSIRIS CubeSat mission will provide *in situ* measurements of the spatial and temporal characteristics of stimulated (heated) ionosphere, which will be correlated with ground-based measurements to better understand variable space weather conditions and phenomena such as ionospheric irregularities. As its primary objectives OSIRIS will 1) provide *in situ* measurements of the stimulated (heated) ionosphere produced by ground-based heaters; 2) correlate *in situ* heated ionosphere measurements with ground-based measurements including incoherent scatter radars and ionosondes; and 3) investigate spatial and temporal characteristics of the heated ionosphere by measuring plasma properties as the satellites gradually separate. The use of ionospheric heaters such as HAARP, Arecibo, and EISCAT will allow the OSIRIS mission to mimic natural ionospheric irregularities at defined locations and times, as well as perform research on active experiments. The OSIRIS mission is a constellation of three CubeSats, each carrying a Hybrid Plasma Probe (HPP), which consists of a combination Langmuir probe (LP), plasma frequency probe (PFP), fixed biased probe (FBP), and Druyvesteyn fast temperature probe (FTP).

The OLite 2010 mission is the first of two demonstration missions the second building on the lessons learned from the first. This fist mission is a functional demonstration and thus constrained primarily by the overall HASP constraints. The second flight in 2011 will conform to the CubeSat form factor and demonstrate the functionality of the subsystems as they would fly on the final satellite.

2.0 Payload Design and Operation

The OSIRIS Lite payload is designed to closely model the targeted satellite platform to demonstrate critical components for OSIRIS.

2.1 Guidance, Navigation and Control Experiment

The Guidance, Navigation and Control (GNC) experiment flying on OLite consists of sun sensors, a magnetometer, and the algorithms necessary to determine attitude from these sensors. Five sun sensor units are located on the faces of the payload, as seen in Figure 2. One sun sensor is located on the top face of the payload and one sensor is mounted on each of the side panels. This gives the sun sensors the ability to track the sun as it moves across the sky and as the HASP gondola spins. A magnetometer, located under the top face of the payload, is used in combination with the sun sensors to provide a reference vector necessary in the calculation of the attitude solution. These sensors and the algorithm, after being demonstrated on a balloon flight, will be used to determine the attitude of the OSIRIS satellite

The HASP platform provides a unique environment for testing the sun sensors since the balloon will fly the payload well over the majority of the Earth’s atmosphere, thus providing access to direct and unscattered sunlight like what will be seen when the sensors are used on orbit.

2.2 Power Experiment

The power experiment takes advantage of the balloon's altitude to better simulate the solar environment that will be encountered on a satellite platform. The power experiment will be testing a solar panel assembly consisting of a coating of indium tin oxide (ITO), a transparent conductive material that is being evaluated for use on the OSIRIS platform to increase the current return path for plasma experiments on the satellite. The flight will demonstrate the effects of ITO on the overall performance of a solar panel by covering one string of solar sells with ITO and leaving another exposed directly to the sunlight.

Preliminary testing has shown approximately a 10% drop in solar cell efficiency with the ITO covering compared with solar cells without the ITO covering as show in Figure 1 below.

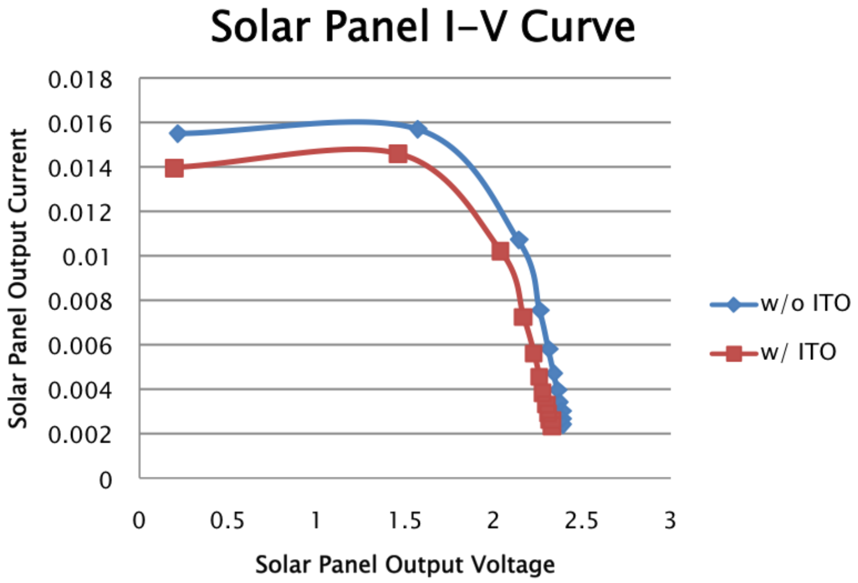


Figure 1 Solar Panel IV curve with and without ITO

Also being demonstrated during the flight will be the maximum peak power tracker (MPPT), a device designed to autonomously track the peak power point of a solar array over various lighting conditions and current loads. The MPPT allows the OSIRIS satellite to recover the most amount of power from its solar cells and use them at their most efficient point at all times.

2.3 Communications Experiment

The communications experiment is designed to demonstrate the communication system functionality and link budget model being used to design the OSIRIS satellite. The communication system contains two transceivers: the main radio and the beacon radio. Both have half-duplex transmit and receive capabilities. The main radio transmits and receives over a carrier frequency band of 902-928 MHz while the beacon operates over a carrier frequency band of 420-450 MHz. A dual band, crossed dipole antenna will be located approximately 50 cm below the HASP interface plate and used to transmit information to a ground station located at the launch site.

A ground station will be required at the launch site and is to be developed by the OLite team as well. This ground station will serve as the demonstration link to the OLite payload and will be used to confirm received signal strength and the transmitted bit error rate (BER). It will consist of a pair of directional antennas on a tripod that can be used to follow the balloon throughout the flight and a 2×2×3-ft equipment rack to house the radios, amplifiers and computer equipment to support the flight.

3.0 Subsystem Description

This section describes what HASP resources OLite will use and how OLite will fit within the HASP constraints.

3.1 Mechanical

The OLite payload must satisfy a number of requirements restricting it to a mass of 3 kg, a 15×15-cm footprint, a height of 30 cm, and ability to survive the landing loads.

With the mass of the OLite restricted, the total mass includes a 30% contingency on all current best estimates (CBEs) except where detailed models of the systems have been made. After calculating mass properties either by analysis or manufacturer's specifications, the total mass of the OLite payload, including contingency, is 2356 g, well under the mass budget. Table 1 provides the detailed mass budget.

OLite will be mounted to the interface plate with four bolts from below. Minor modifications are required to the interface plate in the form of a hole for each of the mentioned bolts, two pass throughs for the antenna connection and the addition of a PVC flange for the PVC antenna boom to attach to the underside.

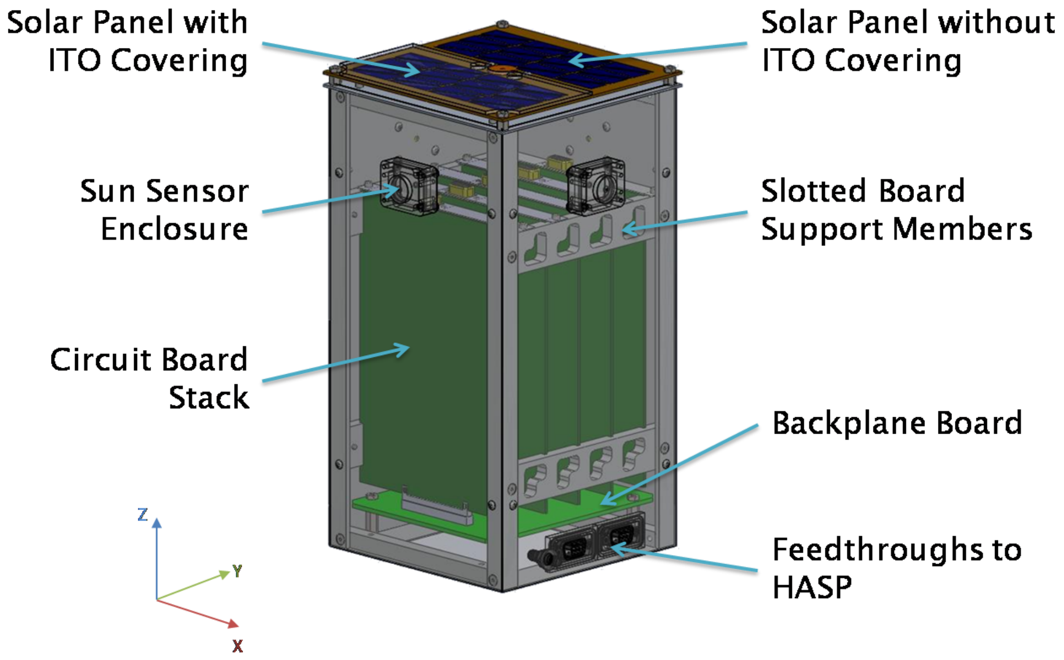


Figure 2 OLite Component Overview

Table 1 Payload Mass Budget

Item	CBE Mass	Contingency
GNC Experiment	179.36	30.00%
PWR Experiment	137.00	30.00%
PWR Subsystem	129.00	30.00%
CDH Subsystem	115.00	20.00%
COM Subsystem	426.50	15.00%
MECH Subsystem	1219.33	13.71%
SYS Backplane Board	150.00	30.00%
	Uncertainty Mass	521.70 g
	Total CBE	2356.19 g
	Margin	122.11 g

3.2 Command and Data Handling

Currently, OLite plans to use the serial telemetry downlink at the specified 1200-baud rate for all of its data. The current design uses the extra analog downlink channels to monitor the operation of the CDH system, one channel each for current and voltage housekeeping sensors requiring a slow sampling rate (<<1 Hz) and course resolution (~8 bits). There is presently no plan to use the HASP discrete command lines.

OLite is planning on using the HASP provided GPS signal at a frequency of 1 Hz. This signal acts both as an input for the GNC algorithm as well as synchronization of the internal clock to account for clock drift.

3.3 Downlink Data Format

The data transmitted to HASP is a modified telemetry matrix. It will use 10 bits per word with one subframe ID word and three IRIG standard sync words. The general format can be seen in table below. The OLite system will be slightly different from a normal telemetry matrix because it will not have one set format. Because of the low data rate, the wide range of sample rates and the face that some experiments are off for half the mission, a single, fixed telemetry matrix is unfeasible. Because of this, four separate frame formats will be developed and tailored for specific subsystems' data. The four are Housekeeping, Camera Pictures, Communications and Power/GNC. The different formats will be differentiated from each other with an embedded identifier word in the matrix. This frame format eliminates the ability to subcommutate words though the option to supercommutate is still available, but is probably unnecessary.

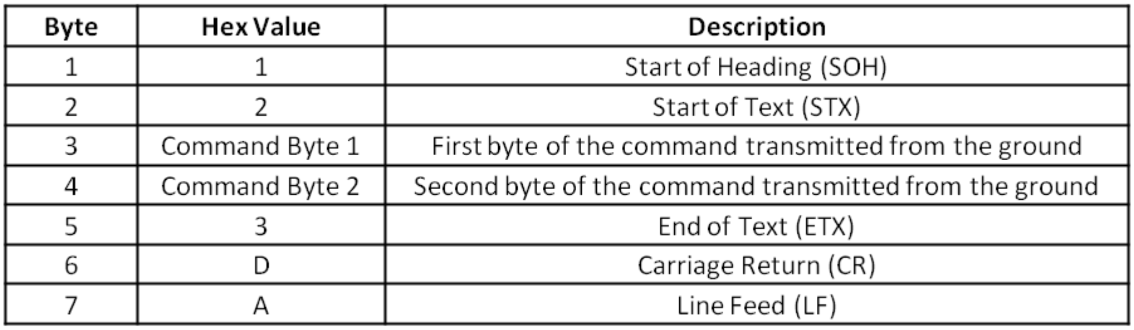
Table 2 Telemetry Matrix Format

Word	**1**	**2**	**3**	**4**	**5**	**6**	**7-TBD**	**TBD+1**	**TBD+2**	**TBD+3**
Name	SFID	Time1	Time2	Time3	Time4	ID	Data	SYNC1	SYNC2	SYNC3
Descr	1 2 .. TBD	Timestamp with resolution down to the second which gives second, minute, hour, day, month, year				H P G C	Housk Picture GNC/P COM	First 10 bits of sync	Second 10 bits of sync	Last 10 bits of sync

3.4 Uplink Commands and Data Format

OLite is designed to operate autonomously throughout the flight, however, as this is a prototype, there may be a need to force the instrument into different modes or turn components on and off remotely. In the event that this is required, commands will be issued infrequently (every 1-2 hours) and do not have a required uplink data rate-OLite can adjust to the resources the HASP system has available. The planned uplink format is described in Table 3 below with the built in commands listed in Table 4 below.

Table 3 Command Uplink Packet Definition



Byte	Hex Value	Description
1	1	Start of Heading (SOH)
2	2	Start of Text (STX)
3	Command Byte 1	First byte of the command transmitted from the ground
4	Command Byte 2	Second byte of the command transmitted from the ground
5	3	End of Text (ETX)
6	D	Carriage Return (CR)
7	A	Line Feed (LF)

Table 4 Uplink Command List

ID:	Size (bits):	Description:	Type:
0x00	8	GNC Experiment On	General
0x01	8	GNC Experiment Off	
0x02	8	Power Experiment On	
0x03	8	Power Experiment Off	
0x04	8	COM RSSI Experiment On	
0x05	8	COM RSSI Experiment Off	
0x06	8	COM BER Experiment On	
0x07	8	COM BER Experiment Off	
0x08	8	Patch Heater On	
0x09	8	Patch Heater Off	
0x0A	8	Reset Magnetometer	GNC
0x0B	8	Sun sensor 1 On	
0x0C	8	Sun sensor 2 On	
0x0D	8	Sun sensor 3 On	
0x0E	8	Sun sensor 4 On	
0x0F	8	Sun sensor 5 On	
0x10	8	Sun Sensor 1 Off	
0x11	8	Sun Sensor 2 Off	
0x12	8	Sun Sensor 3 Off	
0x13	8	Sun Sensor 4 Off	
0x14	8	Sun Sensor 5 Off	
0x15	8	Reset 3.3-V Power Line	COM

0x16	8	Reset 5V Power Line	
0x17	8	Transceiver - RSSI Mode	
0x18	8	Transceiver - Transmit Mode	
0x19	8	Transceiver - Receive Mode	
0x1A	8	Power Cycle C&DH	Power
0x1B	8	Power Cycle GNC	
0x1C	8	Power Cycle COM	
0x1D	8	Ascent Mode	C&DH
0x1E	8	Float Mode	
		Change Config Files - Last 4 bit : data (0 - 15)	C&DH Config Files
0x2[0]	8	Change HK Interval (seconds)	
0x3[0]	8	Change Camera Ascent Interval (Minutes)	
0x4[0]	8	Change Camera Float Interval (Minutes)	

3.5 Configuration

The OLite payload will be completely contained within the allocation set forward in the Call for Proposals. The solar panel will be pointed vertically up from the OLite payload and should be kept clear, although minor obstructions should not significantly affect the validity of the demonstration results. About a half meter of clearance is required below the interface plate for an antenna assembly, and metal obstruction should be kept to a minimum for approximately a meter surrounding the antenna to minimize the effect on the antenna radiation pattern. Based on illustrations of previous integrated HASP instruments on the program website, any small payload location will be suitable for OLite. Illustrations of the full instrument and its interface to HASP can be found in the Mechanical section (3.1) above or the **Error! Reference source not found.** section 7.0.

3.6 Power

OLite will use two DC/DC converters to convert the nominal 30±2 V supplied by HASP to regulated 3.3-V and 5-V supplies for payload use. The payload power and CDH systems will be on for the entirety of flight, while CDH can be used to turn off the other experiments within the payload. Table 5 below shows the estimated power budget detailing the consumption of each assembly in the HEMI system.

3.7 Thermal

From previous experience with high altitude balloons and the HASP platforms, the payload thermal design has been identified as a major concern. At present, the OLite team plans to conduct extensive thermal testing in the SSPL thermal vacuum chamber. These tests will be used to determine proper placement of temperature sensors and heaters to ensure adequate temperature monitoring and control.

4.0 Operational Modes

The OLite payload has three operational modes that it can be in throughout flight. The payload will autonomously switch into these modes through a scheduler built into the CDH system, although there will be the option to uplink commands through HASP to set the operational mode manually during flight. The flight con-ops is shown in Figure 3 and Table 5 below. The payload will begin on the ground in safe mode for the preflight checkout, entering communications experiment mode when HASP is cleared for launch. After a half hour at the float altitude, the payload will switch from communications experiment mode to the float experiment mode for the remainder of the flight.

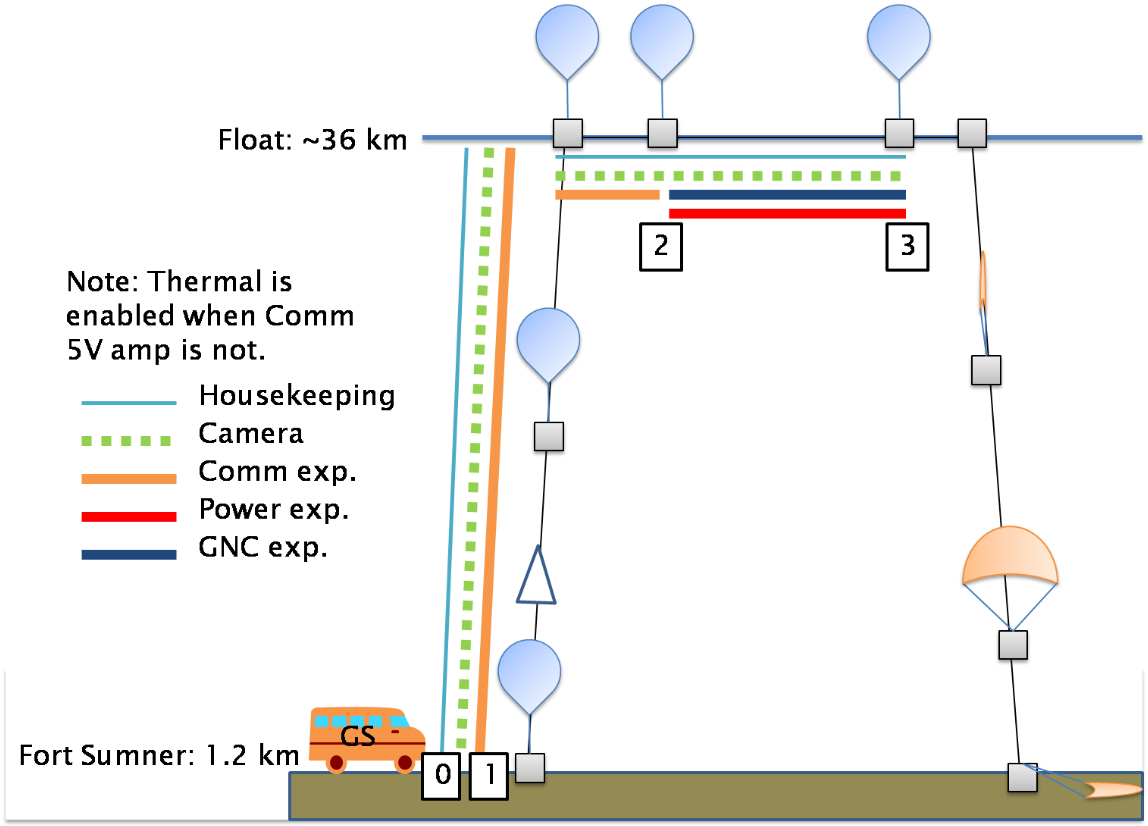


Figure 3 OLite Con-Ops

Table 5 Flight Con-ops Modes

Mode	Description
0	Safe Mode – Payload preflight checkout
1	Communications Experiment
2	Float Experiment
3	Shutdown – Payload Shutdown by HASP

4.1 Safe Mode

In safe mode, CDH and housekeeping are the only systems on continuously. This mode is entered to monitor the condition of the payload both before flight and in the event of an anomaly during flight. In this mode total power draw, broken down in Table 6 Safe Mode Power Budget, is 5.7W leaving a margin of approximately 4.8W after considering power regulation inefficiencies. Data volume in this mode will vary, and is dependant on the conditions for reverting to safe mode though at all times the data volume will remain within the HASP constraints.

Table 6 Safe Mode Power Budget

Subsystem	Power Allocation (W)
GNC Experiment	0
PWR Experiment/Subsystem	0
CDH Subsystem	1.5
COM Experiment	0
Thermal Subsystem	2
Housekeeping	0.5
Sub-Total:	4
Contingency (43%)	1.72
TOTAL:	5.72
Margin:	4.78

4.2 Communications Experiment Mode

OLite is in the communications experiment mode during the assent and first 30 minutes of float. In this mode the communications experiment will be the only active experiment due to its large power draw. Table 7 summarizes the power budget for this mode with OLite drawing approximately 10 W with a .5 W margin. While in the communications experiment mode, data will be collected and transmitted from the experiment and housekeeping and transmitted to the HASP system on a continuous basis. Table 8 summarizes the data budget including framing and contingency for a telemetry matrix formatted data link.

Table 7 Communications Mode Power Budget

Subsystem	Power Allocation (W)
GNC Experiment	0
PWR Experiment/Subsystem	0
CDH Subsystem	1.5
COM Experiment	4.8
Thermal Subsystem	0
Housekeeping	0.5
Sub-Total:	7.05
Contingency (43%)	3.03
TOTAL:	10.08
Margin:	0.42

Table 8 Communications Mode Data Budget

Communications Experiment Total Downlink Data	327.13 bps
+ 7% Framing	22.9 bps
+ 30% Contingency	140.67 bps
Total Downlink Rate	490.7 bps
OSIRIS Lite Data Allocation	1200 baud
Data Margin	709.31 bps

4.3 Float Experiment Mode

OLite is in the float experiment mode beginning after 30 minutes of float and until the eventual cut down to terminate the flight. In this mode the GNC and power experiments will be running resulting in a total power draw of about 7 W with a 3.5 W margin. Table 9 summarizes the power budget for this mode. While in the float experiment mode, data will be collected and transmitted from the experiments and housekeeping and transmitted to the HASP system on a continuous basis. Table 10 summarizes the data budget including framing and contingency for a telemetry matrix formatted data link.

Table 9 Float Experiment Mode Power Budget

Subsystem	Power Allocation (W)
GNC Experiment	0.25
PWR Experiment/Subsystem	0.33
CDH Subsystem	1.5
COM Experiment	0
Thermal Subsystem	2
Housekeeping	0.5
Sub-Total:	4.83
Contingency (43%)	2.08
TOTAL:	6.91
Margin:	3.59

Table 10 Float Experiment Mode Data Budget

Float Experiment Total Downlink Data	327.13 bps
+ 7% Framing	22.9 bps
+ 30% Contingency	140.67 bps
Total Downlink Rate	490.7 bps
OSIRIS Lite Data Allocation	1200 baud
Data Margin	709.31 bps

5.0 Testing and Integration Procedures

5.1 Testing at Penn State

The OLite payload will require environmental testing for both instrument calibration and flight system validation. This project will assume environmental extremes from temperature data provided by the HASP Call for Proposals document, illustrated in Figure 4 below.

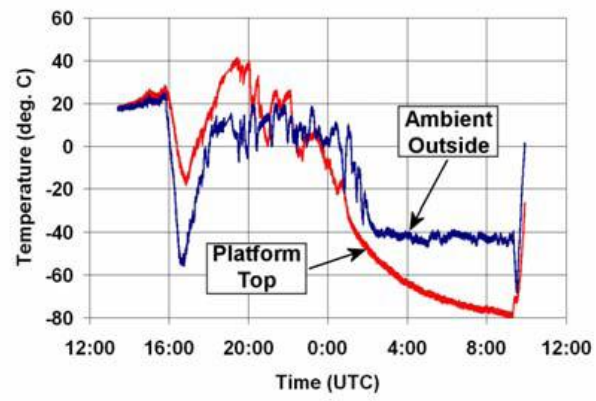


Figure 4 HASP Flight Temperature Profile (source)

For engineering analyses and test, the following procedures will be performed at Penn State:

- Thermal–Vacuum Test: To validate the thermal analysis in a simulated environment

  A physical model of the experiment will be fabricated to test within a thermal–vacuum chamber at Penn State University. The chamber will simulate calculated hot/cold environments, and sensors placed around the model will be used to create a temperature profile around the model that can be compared with data from the mathematical model.

- Vibration/Structural Analysis:

  To ensure that the OLite instrument is mechanically robust to survive all phases of the HASP flight (vibration test is not warranted given the funding levels and requirements of the project)

5.2 HASP Testing and Integration

SSPL will conduct significant preliminary testing at Penn State prior to integration. Therefore, the instrument-level validation will already be complete by integration at Ft. Sumner. The procedures remaining for Ft. Sumner will be a validation of successful interfaces between OLite and HASP. Specifically, we will validate:

- the command telemetry interface to ensure we can both transmit and receive data
- the mechanical interface to ensure a reliable mounting and clearances
- power interface to ensure electromagnetic compatibility

5.3 Additional Resources

As planned, the OLite payload will not require additional resources beyond those allocated in the HASP Call for Proposals and the HASP Student Payload Interface Manual. OLite will however require space below the payload to hang the antenna for the communications experiment. Increased data volume will always enhance the data return, but is not required. Accommodation for a ground system will be required at least 100 meters away from the launch site with a single 10A 120 V power source being required.

6.0 Team Organization

6.1 Management

This project will operate under the auspices of the Student Space Programs Laboratory (SSPL) at The Pennsylvania State University. The lab is managed and lead by a core group of students under its Director, Dr. Sven Bilén, and advised by a group of faculty members and representatives from industry. This project will be a project under the SSPL Flight Program, and will have the support of the lab's resources.

The primary focus of the SSPL is the integration of real-world space-systems project work with the traditional curriculum to better educate students and prepare them for careers in space science and engineering. SSPL is integrated into the engineering curriculum, giving its students many ways of receiving credit and recognition for their efforts. SSPL projects provide senior capstone projects, independent study projects, undergraduate honors theses, and graduate theses. SSPL student present the results of these projects at national and international conferences.

SSPL enriches the students' experience by introducing them to the resources, faculty, projects, opportunities, and other students that they otherwise might never meet. By participating in, and often leading in some way, the lifecycle of a complex project, students are better prepared for the challenges ahead, whatever field they may pursue. By creating an environment where creativity and independence is encouraged, and by giving students access to other experienced students and exciting projects to work on, the students can grow faster than in any classroom.

6.2 Project Organization

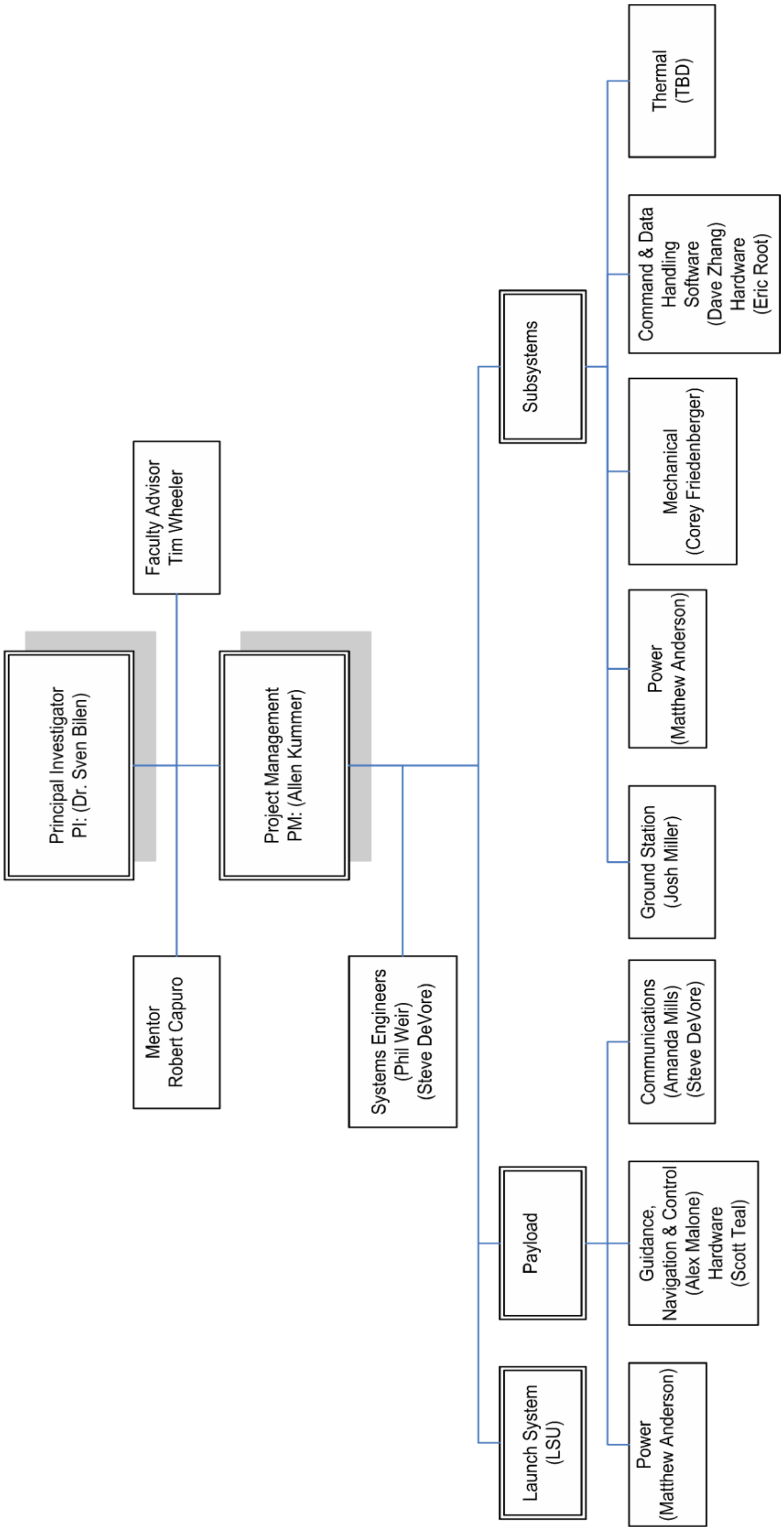


Figure 5 OLite Project Organization

Project Management:	Allen Kummer	*Student Project Manager*
	atk5025@psu.edu	(215) 622-8230
	Dr. Sven Bilen	*Faculty Advisor, PI*
	sbilen@psu.edu	(814) 865-1526

The administrative planning, organizing, directing, coordinating, analyzing, controlling, and approval processes used to accomplish overall project objectives, which are not associated with specific hardware or software elements. This element includes project reviews and documentation, and non-project owned facilities. It excludes technical planning, management, and delivering specific engineering, hardware and software products.

Systems Engineering: Phil Weir
psw5011@psu.edu

The technical and management efforts of directing and controlling an integrated engineering effort for the project. This element includes the efforts to define the project flight instrument and ground system, conducting trade studies, the planning and control of the technical project efforts of design engineering, software engineering, integrated test planning, system requirements writing, configuration control, technical oversight, control and monitoring of the technical project, and risk management activities. Documentation products include requirements documents, interface control documents (ICDs), and master verification and validation (V&V) plan.

Payload: Power: Matthew Anderson
mga5036@psu.edu

COM: Amanda Mills
acm210@psu.edu
Steve Devore
sud148@psu.edu

GNC: Alex Malone
atm5062@psu.edu
Scott Teal
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This element includes the equipment provided for special purposes in addition to the normal equipment (i.e., GSE) integral to the flight system. This includes leading, managing, and implementing the hardware and software payloads that perform the technology demonstration and data gathering functions placed on board the payload.

Subsystems Power: Matthew Anderson
mga5036@psu.edu

GS: Josh Miller
jim5166@psu.edu

CDH: Eric Root
ecr5039@psu.edu
Dave Zhang
dzz0615@psu.edu

THM: TBD

Mech: Corey Friedenberger
cwf5034@psu.edu

The subsystems serve as the platform for carrying the payload on the balloon to achieve the mission objectives. The included subsystems are: Command & Data Handling, Ground Station, Mechanical, Thermal, and Power. This element also includes all design, development, production, assembly, test efforts, and associated GSE to deliver the completed system for integration with the host balloon and detector instrument. This element does not include integration and test with payloads and other project systems.

6.3 Preliminary Schedule

The schedule for this project is illustrated in Figure 6, which illustrates the estimated dates for the mission phases leading up to integration with HASP and through flight operations and post-flight analysis. Based on past projects' experience with travel costs and student schedules, likely 4–6 students will support the integration with, and eventual launch of HASP in person. In addition, several students will likely support the integration and launch operations remotely from Penn State.

ID	Task Name	Start	Finish
1	**OSIRIS Lite Balloon 1**	**Tue 9/1/09**	**Fri 12/17/10**
2	**Phase A - Preliminary Design**	**Tue 9/1/09**	**Thu 10/22/09**
11	System Reqs Review/Mission Def. Review	Sun 10/25/09	Sun 10/25/09
12	**Phase B - Definition**	**Mon 10/26/09**	**Sun 12/6/09**
18	Preliminary Design Review	Mon 12/7/0	Mon 12/7/0
19	**Phase C - Final Design, Fab**	**Tue 12/8/09**	**Sat 1/30/10**
31	HASP Proposal Due	Fri 12/18/0	Fri 12/18/0
32	Selection Announcement	Fri 1/15/1	Fri 1/15/1
33	Critical Design Review	Sun 1/31/10	Sun 1/31/10
34	**Phase D - Final Assembly, I&T**	**Mon 2/1/10**	**Fri 4/23/10**
35	**Subsystem Testing**	**Mon 2/1/10**	**Fri 3/5/10**
38	System Integration Review\Test Readiness Review	Sun 3/14/10	Sun 3/14/10
39	**System Integration and Testing**	**Mon 3/15/10**	**Fri 4/23/10**
50	Prelim PSIP Due	Fri 4/23/1	Fri 4/23/1
51	Mission Readiness Review	Sat 4/24/1	Sat 4/24/1
52	Final PSIP Due	Tue 6/1/10	Tue 6/1/10
53	Final FLOP Document Due	Sun 8/1/10	Sun 8/1/10
54	Integration at CSBF	Mon 8/2/1	Fri 8/6/1
55	HASP Flight Prep	Sun 8/29/10	Thu 9/2/10
56	Target Flight Ready	Fri 9/3/1	Fri 9/3/1
57	**Phase E - Flight Operations**	**Mon 9/6/10**	**Sat 9/11/10**
58	Target Launch Date, Flight Ops	Mon 9/6/1	Mon 9/6/1
59	Recovery, packing and return shipping	Wed 9/8/1	Sat 9/11/1
60	**Phase F - Post Flight Analysis**	**Tue 9/7/10**	**Fri 12/17/10**
61	Post Flight Anaysis	Tue 9/7/10	Wed 12/15/1
62	Final Report Due	Fri 12/17/1	Fri 12/17/1

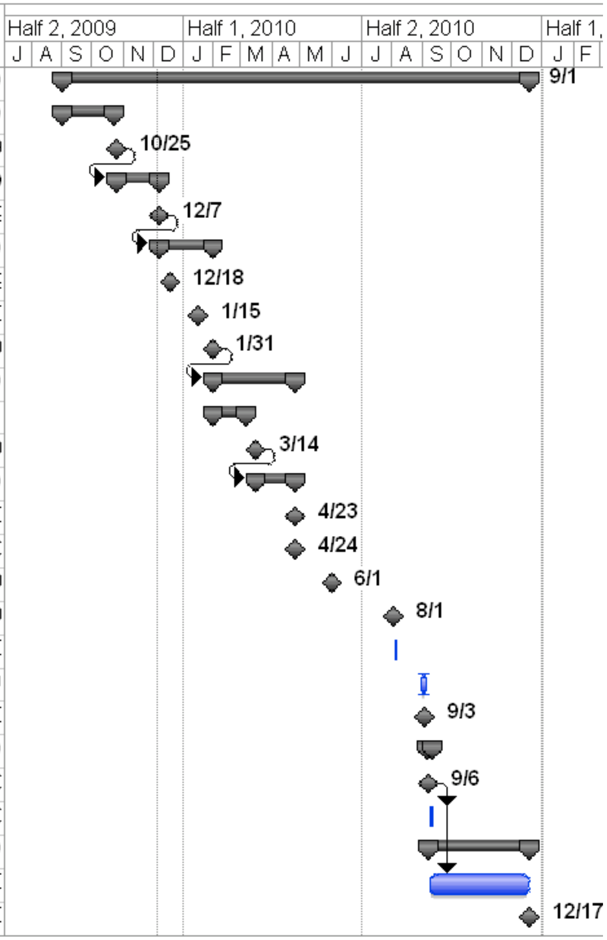

Figure 6 Preliminary Project Schedule

7.0 Preliminary Drawings

Below are preliminary drawings of the OLite payload mounted to the HASP base-plate. Section 3.1 above provides specific descriptions of the instrument configuration with HASP.

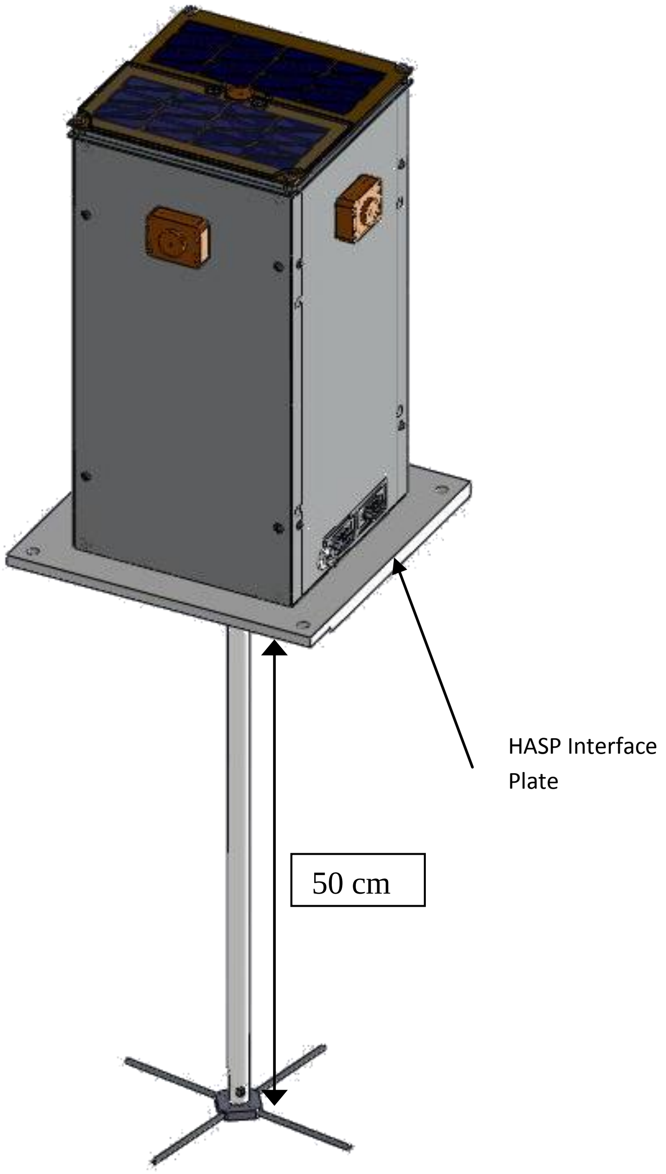

Figure 7 OLite Flight assembly

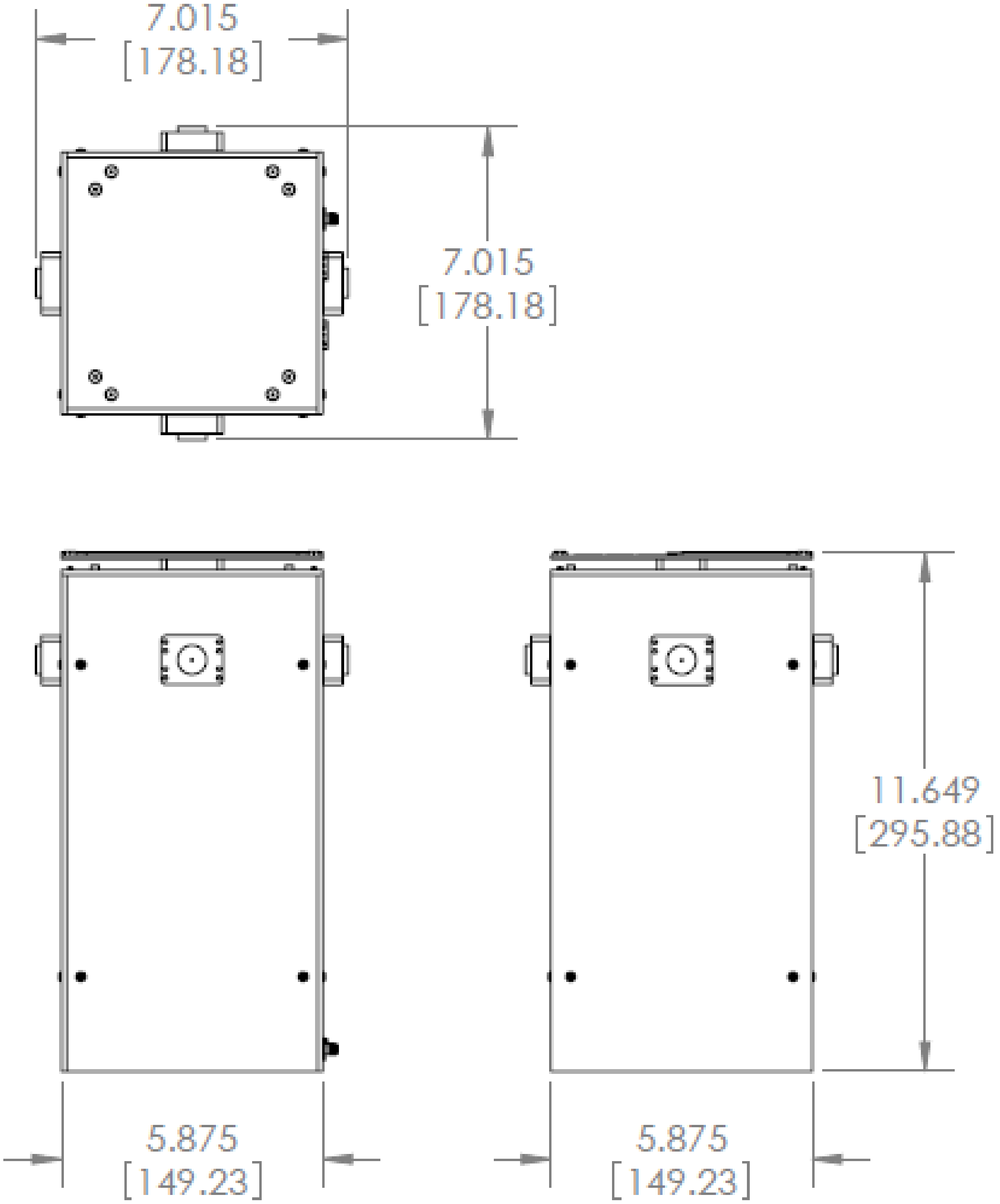

Figure 8 Overall OLite Dimensions (Inches [mm])

Appendix A Acronyms

BER	Bit Error Rate
CBE	Current Best Estimate
CDH	Command and Data Handling
COM	Communications
EISCAT	European Incoherent Scatter Scientific Association
FBP	Fixed Biased Langmuir Probe
FTP	Fast Temperature Probe
GNC	Guidance, Navigation, and Control
GS	Ground Station
GSE	Ground Support Equipment
HAARP	High Frequency Active Auroral Research Program
HASP	High Altitude Student Platform
HPP	Hybrid Plasma Probe
I&T	Integration and Test
ICD	Interface Control Document
IRIG	Inter-range Instrumentation Group
ITO	Indium Tin Oxide
LP	Langmuir Probe
MECH	Mechanical
MPPT	Maximum Peak Power Tracker
OLite	OSIRIS Lite
OSIRIS	Orbital System for Investigating the Response of the Ionosphere to Stimulation and Space Weather
PFP	Plasma Frequency Probe
PWR	Power
SSPL	Student Space Programs Laboratory
THM	Thermal
V&V	Verification and Validation