HASP Student Payload Application for 2011

Payload Title: OSIRIS Lite 2 (OLite 2)		
Payload Class: (check one) ☒ Small ☐ Large	Institution: The Pennsylvania State University	Submit Date: 12/17/10

Project Abstract

OSIRIS Lite 2 (OLite 2) 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 2 will make up the spacecraft bus for the OSIRIS satellite, designed to investigate the effects of space weather on the ionosphere. The 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). 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.

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 2 conforms to all the requirements specified in the Call for Proposals. Additionally, OLite 2 will require clearance for an antenna operating in the 430 MHz band, collaboration for RF interference testing and support for a ground station requiring a 10A 120 V AC circuit.

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OSIRIS Lite 2 (OLite 2) Proposal for the High Altitude Student Platform (HASP), 2011

OSIRIS Lite 2, 2011

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17 December 2010

OSIRIS LITE 2 (OLITE 2) PROPOSAL FOR THE HIGH ALTITUDE STUDENT PLATFORM (HASP), 2011

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1.1 Mission Statement

OSIRIS Lite 2 (OLite 2) will demonstrate key spacecraft bus technologies for the OSIRIS satellite using the low-cost HASP balloon platform in a relevant near-space environment.

1.2 Technical Objectives

- The communications subsystem shall data downlink over the main radio, beacon downlink, and data uplink in near satellite flight like conditions.
- The ground station subsystem shall demonstrate satellite-tracking capabilities including position and Doppler correction by maintaining link with the OLite 2 payload.
- The ground station subsystem shall demonstrate infrastructure to support amateur radio reception, decoding and reporting of beacon signals.
- The guidance and navigation subsystem shall demonstrate the OSIRIS satellite GPS operation, attitude sensors and attitude determination algorithm in a relevant near-space environment.
- The power subsystem shall demonstrate power generation, storage and supply for the satellite in near-space like conditions.
- The mechanical subsystem shall demonstrate antenna deployment in flight configuration in a laboratory environment.
- The thermal subsystem shall demonstrate modeling and operation of both passive and active heater control algorithms by maintaining temperature in the rarified gas high altitude balloon environment.
- The command and data handling subsystem shall demonstrate command handling through flight software and control of each subsystem throughout the flight.

1.3 Success Criteria

1.3.1 Comprehensive Success Criteria

- OSIRIS Lite 2 shall cycle through default mode and transmit mode continuously for the day period of the flight.
- OSIRIS Lite 2 shall transmit beacon packets to amateur radio operators and have them reported back to the OLite 2 team.
- The OSIRIS simulator shall operate exclusively from power generated onboard during daylight periods.
- The OSIRIS simulator shall actively maintain internal temperature to within OSIRIS operational temperature range.

1.3.2 Minimum Success Criteria

- OSIRIS Lite 2 shall maintain survival temperature throughout flight.
- OSIRIS Lite 2 shall generate sufficient power to meet the default mode requirements with an energy surplus.
- OSIRIS Lite 2 shall measure and report attitude and position once over the flight.
- OSIRIS Lite 2 shall complete one successful beacon transmission period.
- OSIRIS Lite 2 shall complete one successful main downlink period.

1.4 Mission Justification

OSIRIS Lite 2 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 developing new technology and demonstrating their successful operation in a relevant environment. The OLite 2 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 2 2011 mission is the second of two demonstration missions, the second building on the lessons learned from the first. This first mission was a functional demonstration and thus constrained primarily by the overall HASP constraints. The second flight will conform to the CubeSat form factor and demonstrate the functionality of the subsystems as they would fly on the final satellite.

2.0 System Design

The OSIRIS Lite 2 payload is designed to closely model the targeted satellite platform to demonstrate critical components for OSIRIS. To do so, the OLite 2 payload is broken into two subcomponents: the CubeSat Simulator (CSS) and the support box. The CSS is to emulate an actual CubeSat as accurately as possible: it maintains a CubeSat form factor and provides the housing for all electronics expected to be on the OSIRIS mission. All additional electronics, such as HASP interface circuitry, are being housed in the support box. The CSS is mounted on top of the support box at an angle with a mounting bracket as seen in Figure 1.

2.1 Mechanical

The OLite 2 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. The CSS must also meet the requirements defined in the CalPoly CubeSat Design Specifications (CDS).

With the mass of the OLite 2 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 2 payload, including contingency, is 1598 g, well under the mass budget. Table 1 provides the detailed mass budget.

The design of the OLite 2 payload includes several features that were found to be beneficial from the OLite 1 payload. Circuit boards in the CSS are slotted vertically into structure and mate with a backplane board. The design of the support box is a version of the OLite 1 structure that has been adapted to meet new requirements.

The OLite 2 assembly 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.

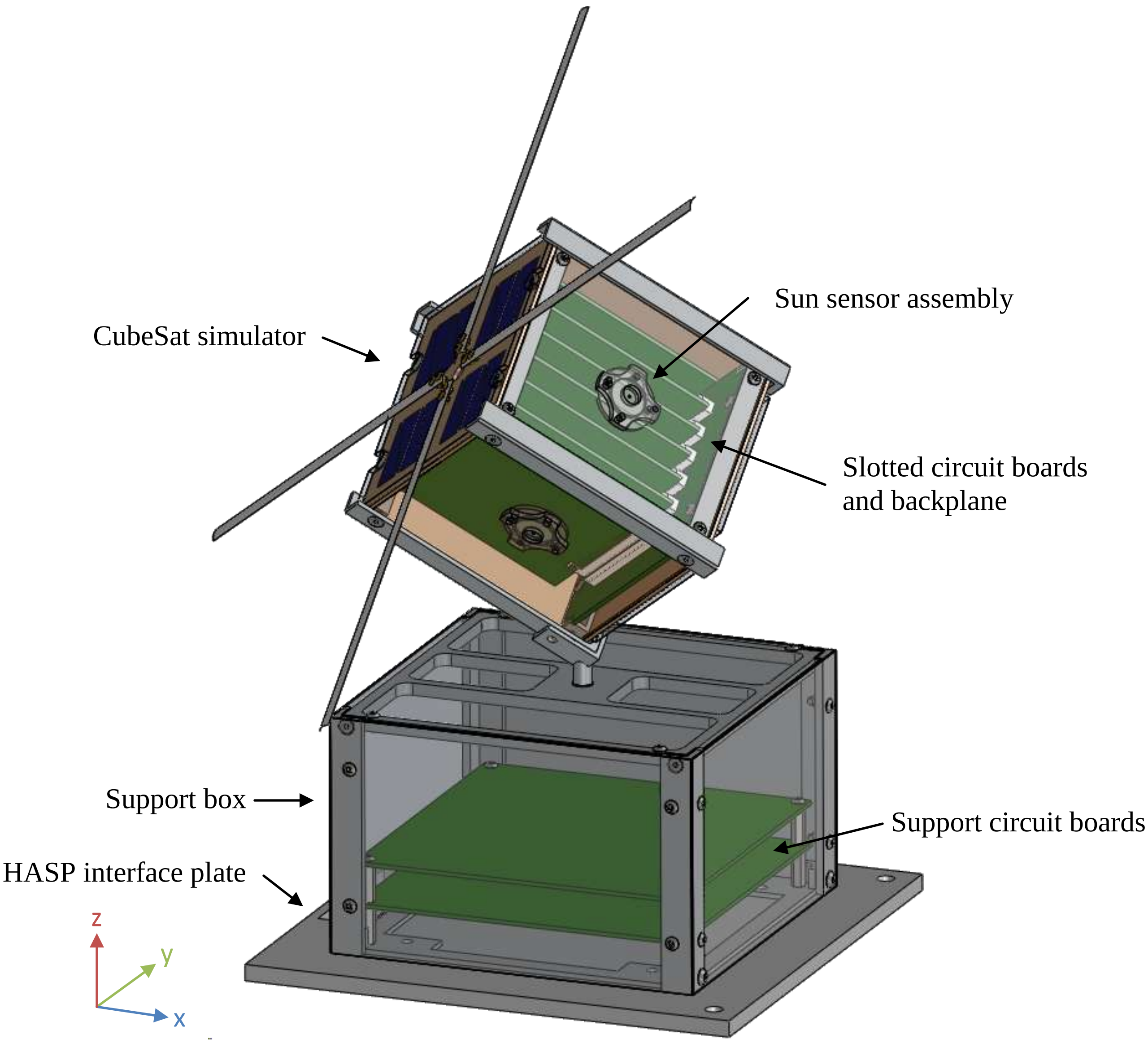

Figure 1 - The OLite 2 assembly with foreground panels transparent

Table 1 - Payload Mass Budget

Item	CBE Mass	Contingency Mass
GNC Subsystem	118.67 g	51.03 g
PWR Subsystem	470.89 g	202.49 g
CDH Subsystem	103.31 g	42.78 g
COM Subsystem	35.67 g	15.34 g
MCH Subsystem	377.91 g	113.37 g
THM Subsystem	46.40 g	19.96 g
	Uncertainty Mass	444.97 g
	Total CBE	2042.79 g
	Margin	957.21 g

2.2 Guidance, Navigation and Control Subsystem

The Guidance, Navigation and Control (GNC) subsystem flying on OLite 2 consists of sun sensors, a magnetometer, and the algorithms necessary to determine attitude from these sensors. Six sun sensor units are located on the faces of the payload, as seen in Figure 1. 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 on the backplane board, is used in combination with the sun sensors to provide body frame vectors 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 similar to what will be seen when the sensors are used in orbit.

GNC is also flying on OLite 2 a GPS receiver to determine the payload's position and velocity. This information is essential in producing reference vectors for the attitude solution as well as general housekeeping information. During the OSIRIS mission, position will be necessary to determine when the satellite has access to the ground station or is in a science region.

2.3 Power Subsystem

The ultimate goal of the OLite 2 Power Subsystem is to provide a stable power interface for all of the electrical and electromechanical devices in the system. Because there are varying requirements on power from the other subsystems, several different power bus interfaces must be provided, along with a software-controlled power distribution network. The Power Subsystem is also responsible for monitoring power quantity and quality at numerous points within the subsystem and reporting digital packets of this data to Command and Data Handling.

The power subsystem will take advantage of the HASP balloon flight above most of the atmosphere to simulate the solar radiance of an orbit thus allowing the power subsystem to validate the ability to generate power to support the eventual satellite. The power team builds off experience from the OLite payload developing solar panels and from preliminary testing of the indium tin oxide (ITO) coating over the solar panels leading up the OLite flight (now set for the spring). This experience is leading to the development of a new set of solar panels in the satellite form factor.

The power subsystem will also test the ability to convert solar power efficiently and store excess power on board with a lithium battery pack while supporting the satellite operations.

2.4 Communications Subsystem

The communications subsystem 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 in the 430 MHz amateur band. The communications system will transmit in both modes to demonstrate data rate and interfacing with the ground station and amateur stations in the area.

The team recognizes that the communications system operates close to the balloons command frequency and proposes to provide the HASP team a prototype radio and support interference testing as part of the integration process. Additionally, the downlink radio activities will be contingent on a "keep alive" signal being sent through the HASP command uplink signal at a rate sufficient to assure that if interference with normal HASP communications occurs, an absence of the keep alive signal will shut down the system.

A ground station will be required at the launch site and is to be developed by the OLite 2 team as well. This ground station will serve as the demonstration link to the OLite 2 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.

2.5 Command and Data Handling

OLite 2 will transmit data in accordance with the normal satellite concept of operations through the communications subsystem. This data will also be mirrored through a debugging interface with the support box. In instances where the radio has been turned off, the data will be echoed through the debugging interface as before but will not be sent to the radio. The support box will be responsible for buffering the data and converting it to the HASP serial downlink at 1200 baud. The support box will also archive the data on an SD card for recovery after the flight. The support box will also be responsible for taking commands in the HASP uplink format and converting them to the OSIRIS flight commands.

2.6 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 2 system will be slightly different from a normal telemetry matrix because it will not have one set format. Separate frame formats will be developed and tailored for specific subsystems' data. 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. The SFID will increment for data packets of the particular type for reconstruction on the ground. Table 3 breaks down the expected data downlink usage. After contingency the OLite 2 team maintains a 30% margin on the downlink steam at 1200 baud.

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 G	Housk GNC	First 10 bits of sync	Second 10 bits of sync	Last 10 bits of sync

Table 3 Downlink data budget

Data Type	Num of Sensors	Measurement Length (b/measurement)	Rate (Hz)	Total (bps)
Voltage	25	8	1.000	200.000
Current	25	8	1.000	200.000
Temperature	20	8	1.000	160.000
GPS	1	2088	0.017	34.661
Rotation Rate	1	16	0.017	0.266
Sun Vector	1	48	0.017	0.797
Mag Vector	1	48	0.017	0.797
			Total	594.9

CBE + 30%	850.7
Allocation	1200
Margin	349.3
% Margin	29%

2.7 Uplink Commands and Data Format

Olite 2 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 can adjust to the resources the HASP system has available. As a mode to prevent interference with the HASP communications system, a command will be uplinked at a frequency that will be determined with the HASP team to assure HASP communications robustness.

The planned uplink format is described in Table 4 below.

Table 4 – 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)

The command list will include individual commands to turn subsystems on and off, reset to a known state, transmit keep alive, housekeeping requests etc.

2.8 Configuration

The Olite 2 payload will be completely contained within the allocation set forward in the Call for Proposals. The solar panel and sun sensors will be facing perpendicular to the faces of the

OSIRIS simulator and should be kept clear, although minor obstructions should not significantly affect the validity of the demonstration results. Based on illustrations of previous integrated HASP instruments on the program website, any small payload location will be suitable for Olite 2. Illustrations of the full instrument and its interface to HASP can be found in the Mechanical section (2.1) above.

2.9 Power

Olite 2 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 data logging system in the support box will be on continuously to support the OSIRIS simulator. These systems and a supplementary thermal system account for the 3 W allocated to the support box. The support box is also capable of turning power on and off to the OSIRIS simulator to supplement what is being generated on the simulator. Table 5 below shows the estimated power budget detailing the consumption of each assembly in the Olite 2 system.

2.10 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 2 team plans to conduct extensive thermal testing in the SSPL thermal vacuum chamber. These tests in conjunction with COMSOL simulation will be used to determine proper placement of temperature sensors and heaters to ensure adequate temperature monitoring and control.

3.0 Operational Modes

The Olite 2 payload has two primary operational modes that it can be in throughout flight, as well as two secondary modes. The payload will autonomously switch into the primary modes through a scheduler built into the CDH system, although there will be the option to uplink commands through HASP and the beacon radio to set the operational mode manually during flight. The flight con-ops is shown in Figure 2 and Table 5 below. The payload will begin on the ground in safe mode for the preflight checkout, entering an hour-long loop consisting of eight to ten cycles of the default mode and zero to two cycles of the main downlink once HASP is cleared to take off. It will continue this hourly loop throughout flight.

GNC	Beacon TX	RX	Sleep	Main Downlink
1 min	1 min	1 min	3 min	6 min
repeat 8, 9, or 10 times				repeat 0, 1, or 2 times

Figure 2 Olite 2 Con-Ops

Table 5 Flight Con-ops Modes

Mode	Description
0	Safe Mode – Payload preflight checkout
1	Default Mode
2	Main Downlink

3	Shutdown – Payload Shutdown by HASP

3.1 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 dependent 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 Subsystem	0
PWR Subsystem	0
CDH Subsystem	1.5
COM Subsystem	0
Thermal Subsystem	2
Housekeeping	0.5
Sub-Total:	4
Contingency (43%)	1.72
TOTAL:	5.72
Margin:	4.78

3.2 Default Mode

Since Olite 2 operates as OSIRIS would on orbit, the OSIRIS con-ops was considered. Figure 3 shows the default con-ops for OSIRIS. In this mode, OSIRIS is looping every six minutes through determining attitude and position information, transmitting basic housekeeping data through the beacon, listening for a command uplink and then sleeping if not commanded to do otherwise after the uplink period. In this mode, data sent through the beacon is sent in Morse code so that amateur radio operators or HAM operators can easily decode the signals and upload the information back to the Penn State team through a web interface.

Adapted for Olite 2, the major change comes from the transmission. Olite 2 will supplement the data transmitted through the beacon with data sent through HASP.

HASP will provide 3W of power for the support box. While the OSIRIS simulator will run primarily off its own power, the support box will provide supplemental power to charge the batteries in case of failures. Table 7 details the worst-case power budget from HASP for this mode.

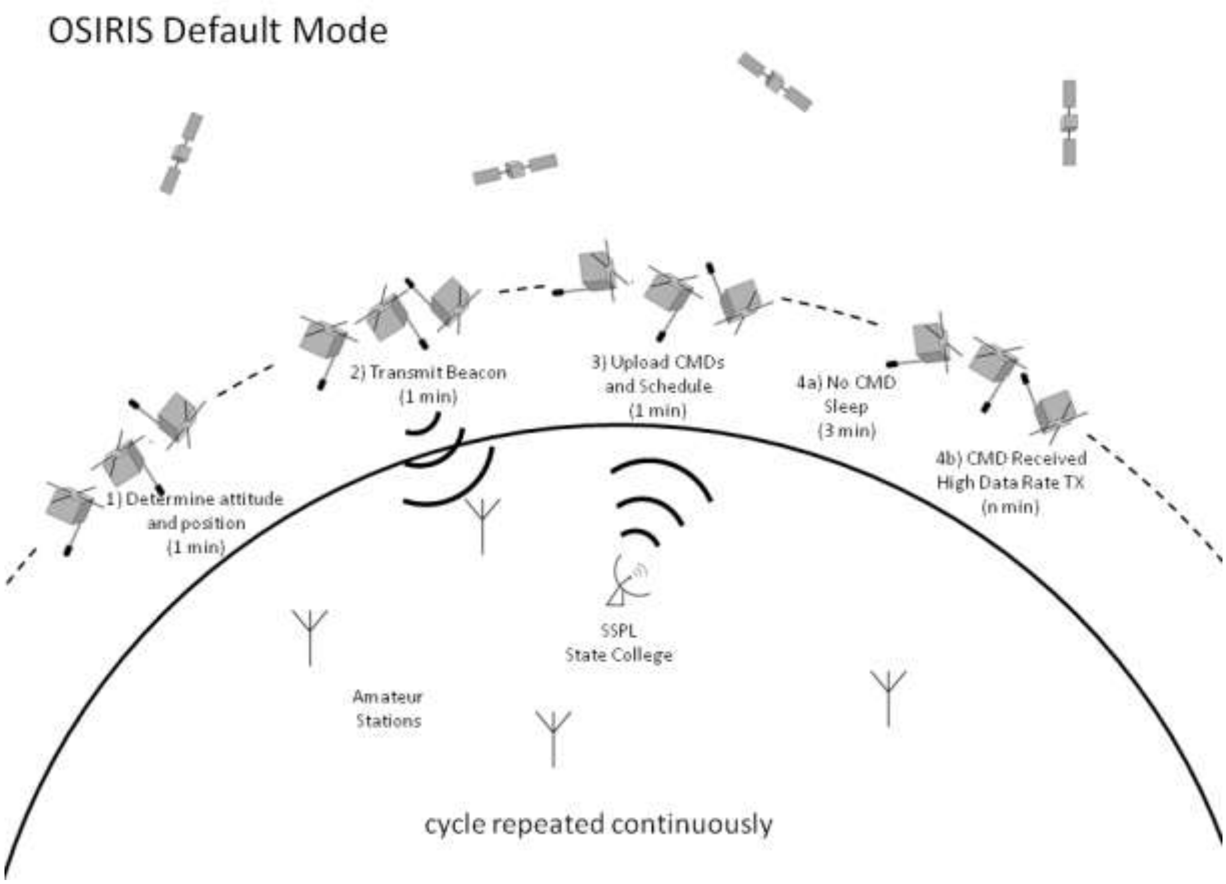

Figure 3 OSIRIS Default Mode Con-Ops

Table 7 Default Mode Worst Case Power Budget

Subsystem	Power Allocation (W)
Support Box	3
GNC	.226
PWR	.5
CDH	.25
COM	.6
Thermal	1
OSIRIS Simulator Subtotal	2.58
Sub-Total:	5.58
Contingency (30%)	2.4
TOTAL:	7.98
Margin:	7.02

3.3 Main Downlink Mode

When a command is uploaded during the receive period in the default mode CDH forces Olite 2 to transmit its detailed data packages down through the main downlink path. This downlink path will simulate an OSIRIS communications pass over the SSPL ground station in State College. This mode will be entered zero to two times per hour, depending on how many times the default mode is run and available power.

The limiting factor for main downlink events is the available power. Since Olite 2 is striving to demonstrate a satellite ready design, the power subsystem is supplying the satellite's power needs. This means that while operating on the balloon, Olite 2's functionality is limited by how much power the solar panels can generate.

Table 8 details the power budget for this mode.

Table 8 – Main Downlink Mode Power Budget

Subsystem	Power Allocation (W)
Support Box	3
Worst Case Supplemental Power	7
Sub-Total:	10
Contingency (30%)	4.3
TOTAL:	14.3
Margin:	.7

4.0 Testing and Integration Procedures

4.1 Testing at Penn State

The Olite 2 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.

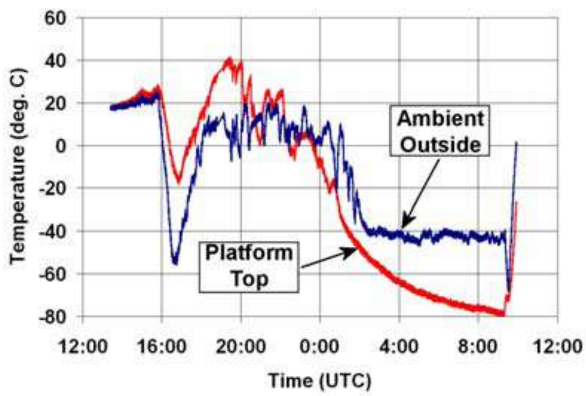

Figure 4 – HASP Flight Temperature Profile

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 2 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)

4.2 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 2 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
- interference free radio operations, including radio shutdown

4.3 Additional Resources

As planned, the Olite 2 payload will not require additional resources beyond those allocated in the HASP Call for Proposals and the HASP Student Payload Interface Manual. Olite 2 will however require a waiver for antennas extending beyond the envelope. 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.

5.0 Team Organization

5.1 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.

5.2 Project Organization

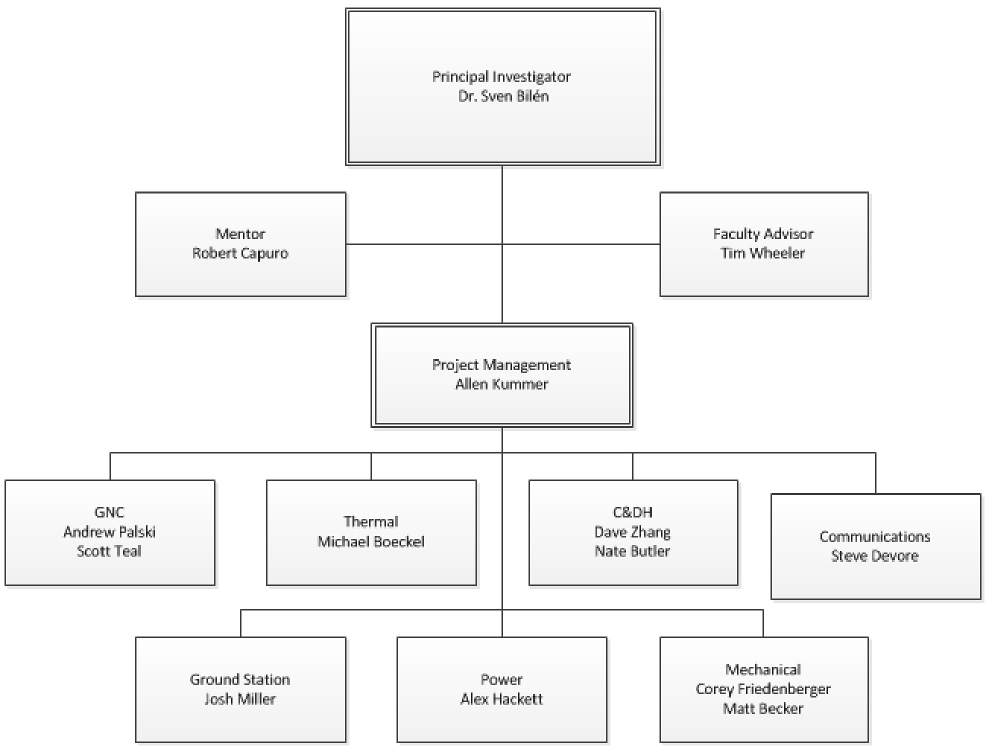

Figure 5 – Olite 2 Project Organization

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 Engineer: TBD

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.

Subsystems

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Support Box: TBD

The subsystems are the primary technology tested on the balloon. This includes leading, managing, and implementing the hardware and software payloads that perform the technology demonstration and data gathering functions placed onboard.

5.3 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.

A special note this year to assure status report guidelines are met, the updates for each subsystem will be reported by each lead at the weekly leads meeting as a function of the meeting. At the end of the month, these will be compiled to be sent to the HASP team. This will assure that the collective group is involved in the process instead of a single lead.

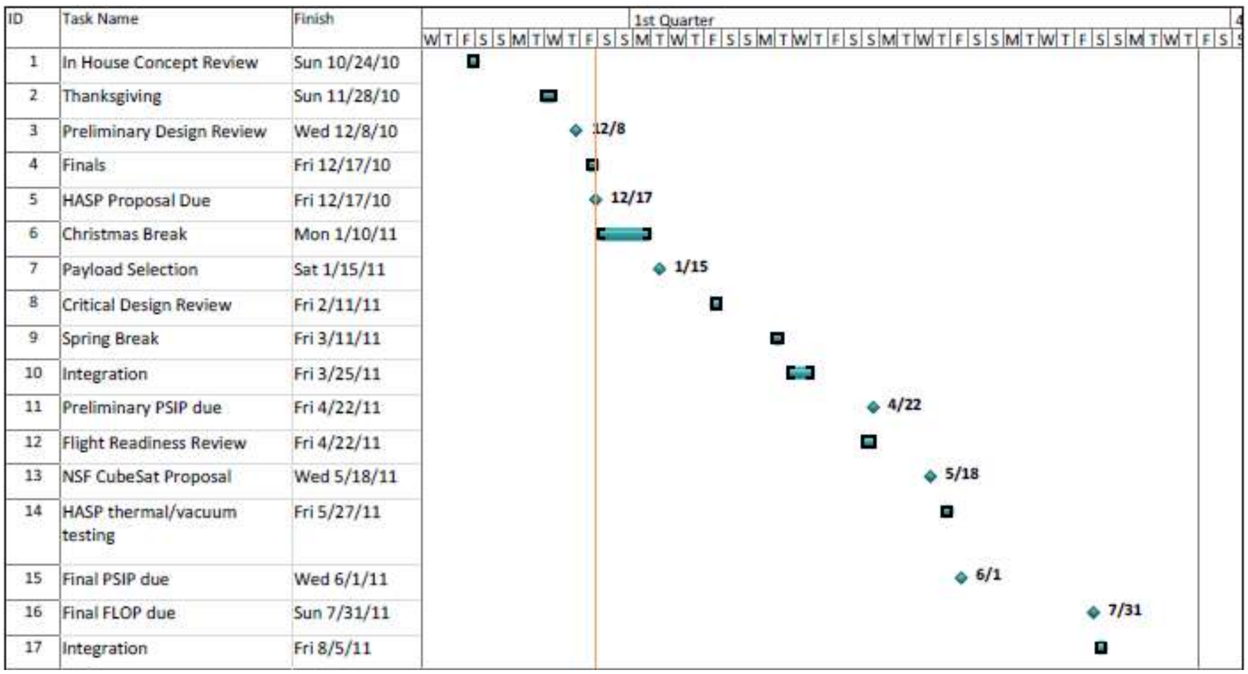

Figure 6 – Preliminary Project Schedule

6.0 Preliminary Drawings

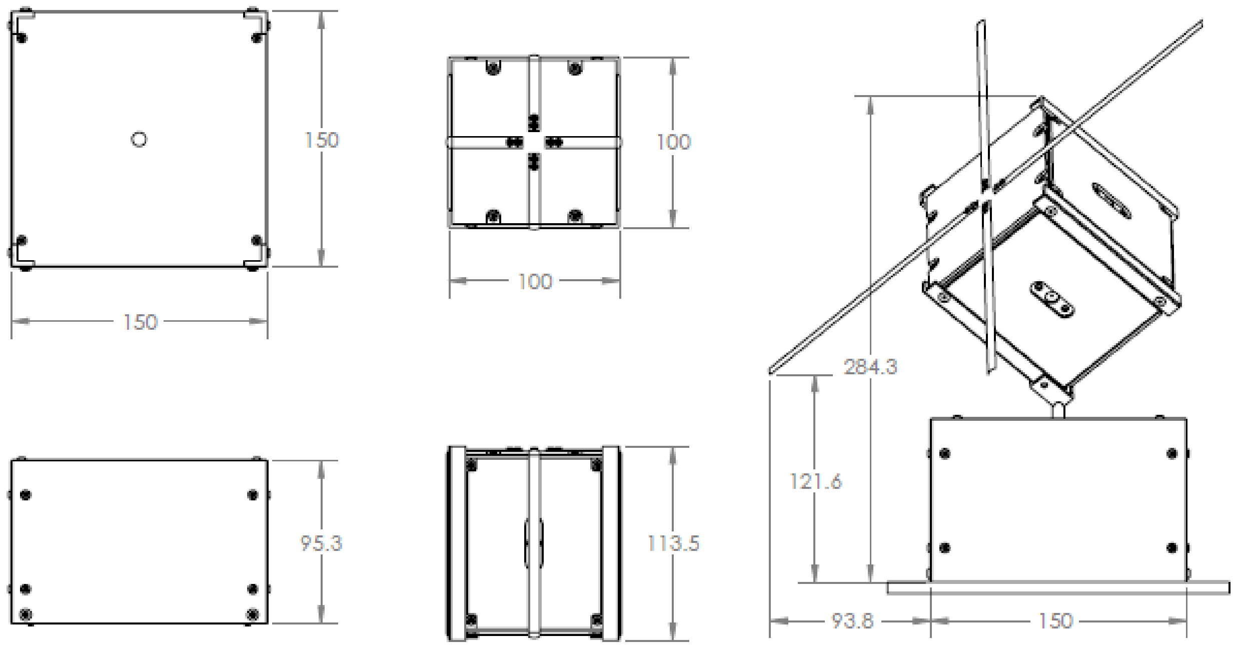

Figure 7 – Overall Olite 2 Dimensions (mm)

Appendix A: Acronyms

BER	Bit Error Rate
CBE	Current Best Estimate
CDH	Command and Data Handling
CDS	CubeSat Design Specifications
COM	Communications
CSS	CubeSat Simulator
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
MCH	Mechanical
MPPT	Maximum Peak Power Tracker
Olite 2	OSIRIS Lite 2
OSIRIS	Orbital System for Investigating the Response of the Ionosphere to Stimulation and Space Weather
PFP	Plasma Frequency Probe
PWR	Power
SFID	Sub Frame ID
SSPL	Student Space Programs Laboratory
THM	Thermal
V&V	Verification and Validation