HASP Student Payload Application for 2018

Payload Title: Miura II		
Institution: University of Colorado at Boulder		
Payload Class (Enter SMALL, or LARGE): LARGE		Submit Date: 2/16/18

Project Abstract: The Miura II payload shall demonstrate one possible application of a reusable, expandable soft-shell structure in a near space environment. The deployable structure will attempt to recreate thermal and barometric internal conditions that are livable for human's. Miura II will explore deployment and retraction methods for expandable habitats as well as materials that give the soft shell the required properties. HASP allows Miura II to test the viability of a thermally-insulated, pressurized, and reusable soft-shell structure in a harsh near-space environment where temperature, pressure, and other environmental factors are more accurately represented than during testing on the ground. The Miura II team will be comprised of undergraduate engineering students from the University of Colorado Boulder. The management and team breakdown will include a project manager, systems engineers, team lead engineers, and a faculty mentor from the Colorado Space Grant Consortium.

Team Name: Miura II		Team or Project Website: http://spacegrant.colorado.edu/boulderstudents/boulderprojects/hasp-home
	Student Leader Contact Information:	Faculty Advisor Contact Information:
Name:	Conner Shaver	Brian Sanders
Department:	Aerospace Engineering Colorado Space Grant Consortium	Colorado Space Grant Consortium
Mailing Address:	520 UCB	520 UCB
City, State, Zip code:	Boulder, CO 80309	Boulder, CO 80309
e-mail:	conner.shaver@colorado.edu	brian.sanders@colorado.edu
Office Telephone:	970-768-7522	303-492-5451
Mobile Telephone:	970-768-7522	303-258-6339

Miura II

Colorado Space Grant Consortium

HASP 2018 Proposal

Jaret Anderson Nicholas Bearns Ashkan Bafti Lindsay Cobb Madisen Frie
Raymie Fotherby Mary Hanson Shu-Yu Lin Jason Magno
Charles Puskar Lewis Redner Tristan Schoeman Conner Shaver
Griffin Van Anne Srikanth Venkataraman Lucas Zardini

Advisors: Brian Sanders Dawson Beatty

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1 Mission

The Miura II payload shall demonstrate one possible application of a reusable, expandable soft-shell structure in a near space environment. The deployable structure will attempt to recreate thermal and barometric internal conditions that are livable for humans. Miura II will explore deployment and retraction methods for expandable habitats as well as materials that give the soft-shell habitat the required properties. HASP allows Miura II to test the viability of a thermally-insulated, pressurized, and reusable soft-shell structure in a harsh near-space environment where temperature, pressure, and other environmental factors are more accurately represented than during testing on the ground. The Miura II team will be comprised of undergraduate engineering students from the University of Colorado Boulder. The management and team breakdown will include a project manager, systems engineers, team lead engineers, engineers, and a faculty mentor from the Colorado Space Grant Consortium.

1.1 Mission Statement

Miura II shall repeatedly expand, sustain, and contract a thermally-insulated, pressurized, soft-shell structure on the High Altitude Student Platform while monitoring and documenting the deployment process, internal pressure and temperature, and the material performance in order to evaluate the viability of a reusable, collapsible, soft-shell structure in a near-space environment.

1.2 Mission Objectives

1. Repeatedly expand, sustain, and contract a soft-shell structure in a near-space environment.
2. Pressurize and thermally-insulate the foldable soft-shell structure in a near-space environment.
3. Qualitatively monitor and record the expansion-contraction cycle of the soft-shell structure using high-quality visual data.
4. Capture high-quality visual data to analyze the material performance of the soft shell structure.

1.3 Mission Premise

1.3.1 Deployable Structures

Currently, most habitable space modules utilize a solid, hard-shell design. Although these designs have proven to be durable and resistant to the conditions of space, they are difficult to manipulate and expensive to launch. As world governments and industries seek to expand our reach further into the Solar System, a new, more flexible design is required. A soft-shell structure will be the more economical habitat deployment method that provides the solutions to the problems associated with a hard-shell design.

NASAs Advanced Exploration Systems, along with Bigelow Aerospace, has provided an initial solution to this problem via the Bigelow Expandable Activities Module (BEAM), which is currently deployed on the International Space Station. Most significantly, BEAM was recently deployed on its eighth SpaceX Commercial Resupply Service mission on April 8th, 2016, where it was filled with air to prepare the habitat for a two-year test period during which astronauts on board will conduct several tests to ensure the capability and practicality of a soft-shell space habitat.[1]

Deployable soft-shell structures hold many significant advantages to their solid counterparts when considering the economic feasibility. Expandable structures are lower-mass and lower-volume, which will potentially reduce the number of launches and overall mission costs for deep-space travel in the future. The structure will occupy a minimum volume during launch, but will expand to provide a comfortable living space for its occupants. In addition, the shell will provide adequate protection from debris, radiation, and other harsh environmental factors in space. One of the biggest advantages the soft-shell mechanism will have over a hard-shell habitat is its collapsible nature. After expansion, the design can be de-pressurized and collapsed down to its original compressed state and transported to a different location or stowed for future use. Project Miura II will study and improve the design of a folding soft-shell structure that can be retracted and reused. This technology could prove to be essential in the future of human space transportation.

1.3.2 Folding Mechanisms

The Bigelow BEAM has a fully-expanded to initially-compressed volume ratio of 400%. Miura II strives to improve upon the expansion ration of current soft shell structures while still preserve its advantages. The project is a successor to one based off of a folding technique called the Miura-Ori tessellation pattern. Due to constraints with pressurizing this structure, the team is transitioning to using a habitat that expands radially as well as vertically. This added expansion axis will create a figure that resembles an urn. This habitat will be contained using a metal frame which can move to expand with pressurization, meaning that there are no well-defined creases in the material of the soft-shell structure. This allows for greater structural integrity while the habitat is pressurized.

1.3.3 Need for HASP Platform

Although this structure can be tested on the ground, a high-altitude balloon platform such as HASP would provide the optimal environment for this experiment. Though certain environmental factors can be simulated in a laboratory, not all environmental factors can be simulated accurately at once. HASP will allow Miura II to remain at float altitude for an extended period of time in order to repeatedly test the pressurization and expansion mechanism and determine its viability in a harsh space environment.

1.4 Principle of Operations

Miura II shall have all of its systems verified prior to Integration and Launch with the HASP platform. All systems will be powered on prior to launch to set a baseline of atmospheric conditions. The soft-shell structure will begin its cycles once Miura II reaches float. During an expansion-contraction cycle, the pressurization system shall expand the soft-shell structure, sustain the fully-expanded state, then contract the structure to its original folded state in a span of 100 minutes. Prior to release, the soft-shell structure will finish its cycles and remain in a closed position for descent and recovery. The Principle of Operations is shown in Figure 1.

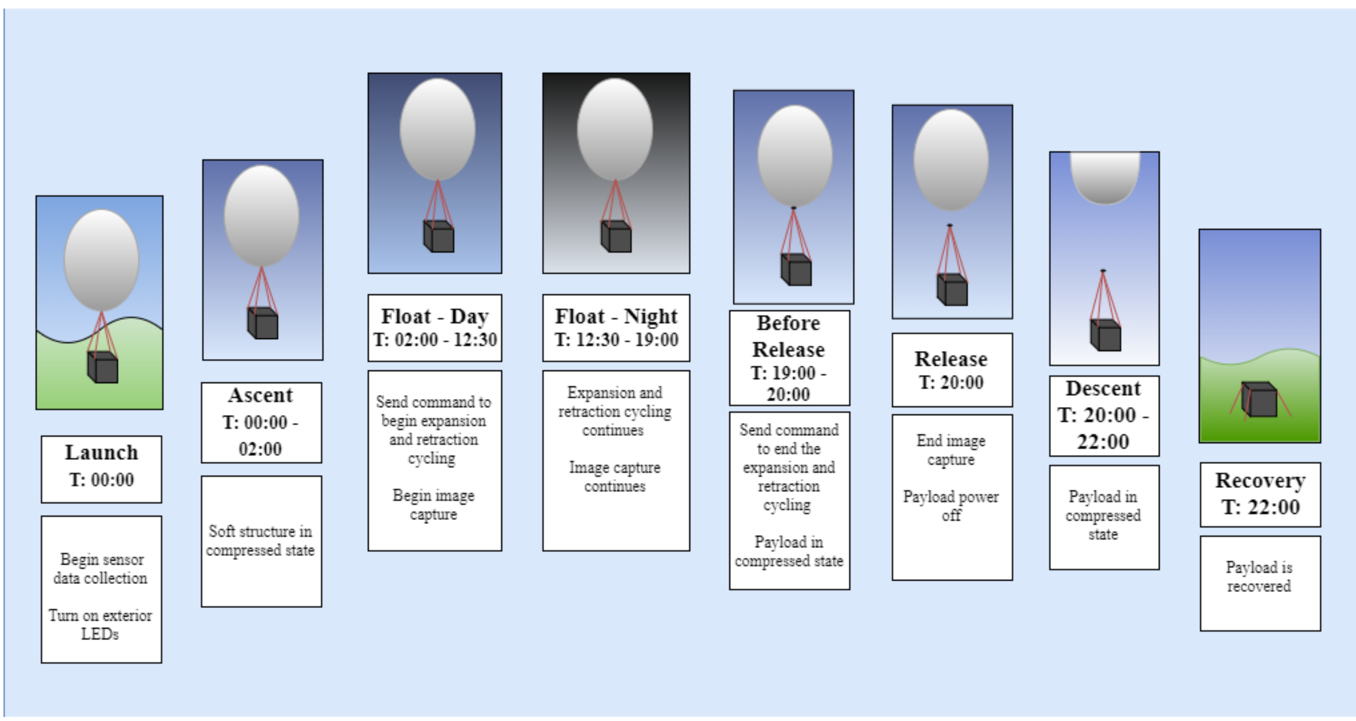


Figure 1: Principle of Operations Diagram

1.5 Concept of Operations

The soft-shell structure will begin its 100-minute cycle approximately two hours after the launch via a manual uplink command, or via an automatic backup five hours into the mission. In the first five minutes of a cycle, the soft-shell structure will pressurize to 0.75 atm. Then, the structure will retain its pressurization and extension to at least seven times the minimum volume for 60 minutes. An escape valve will release the pressure and contract the structure over a five minute window. Then, the structure will remain in its compressed state for 30 minutes. Throughout the entire cycle, two cameras shall record visual data from opposite sides of the payload for accurate post-flight analysis. The USB cameras shall also take pictures of the soft structure every second at a lower image quality for post-flight analysis and troubleshooting, if necessary. All environmental data (pressure, temperature, and humidity) will be recorded every second. The Concept of Operations diagram is shown in Figure 2.

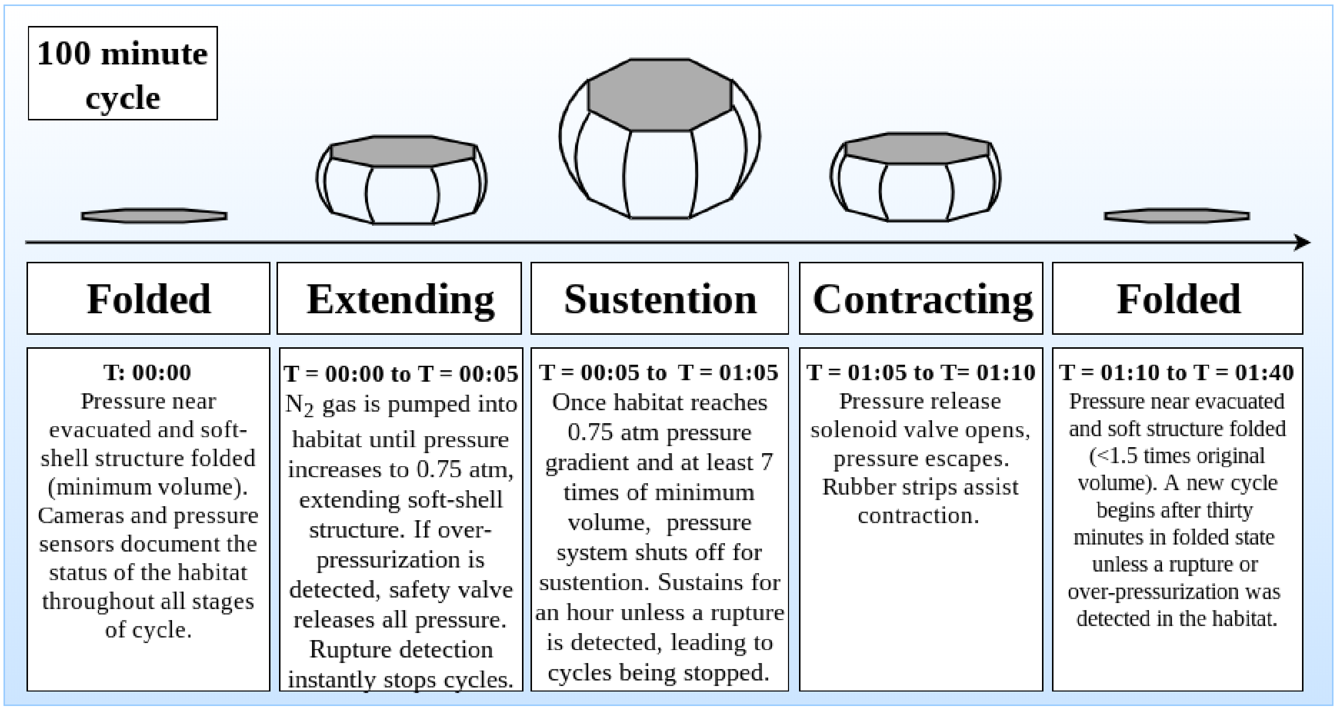


Figure 2: Concept of Operations Diagram

1.6 Mission Success Criteria

In order to achieve mission success, Miura II must complete successful expansion-contraction cycles defined by the following criteria:

1. Extend the soft-shell structure to at least seven times of its initial compressed volume at least three times during flight.
2. Sustain the soft-shell structure at at least seven times of its initial compressed volume at least three times during flight.
3. Contract the soft-shell structure from five times or higher to 1.5 times or lower of its initial compressed volume at least three times during flight.
4. Sustain a pressure between 0.75 atm $\pm$ 0.05 atm inside the habitat at least three times during flight.
5. Sustain a temperature between 20 $\pm 5°$C inside the habitat at least three times during flight.

1.7 Modifications to Original Proposal

1.7.1 Habitat

In order to ensure that the material used in the soft shell structure is minimally compromised by retraction a new material was selected. The new material that is in use is a Ripstop nylon with a urethane coating to reduce porosity. Ripstop was chosen as the new material for its ability to be purchased with coatings already applied and for its folding properties. When Ripstop is folded it does not retain the creases in the material.This property also allows Ripstop to naturally create a different folding pattern every time it is stuffed into a smaller volume.

1.7.2 Testing

Changes to Current Tests

In order to ensure that the pressurization system and the habitat are adequately tested to meet the safety requirements of HASP and the NASA Office of Safety and Mission Assurance, multiple new tests were added and modifications were made to current testing procedures. Now, all pressurization testing will generate a pressure gradient between the inside of the habitat and the outside of 1.00 ± 0.05 atm. This is a minimum of 19% above the flight pressure gradient of 0.75 ± 0.05 atm. All tests will also include a Failure Modes Effect Analysis in order to gain a better understanding of what the effects of the rapid de-pressurization are. In conjunction with a Failure Modes Effect Analysis, a Finite Element Analysis will be performed with each test.

New Tests

To test the effects of re-usability on the habitat 2 new tests will be added. The first of tests to be added will measure the pressure inside of the habitat at rupture after 0, 20, and 100 expansions and contraction cycles. During these cycles the habitat will be pressurized to a pressure gradient of 1.00 ± 0.05 atm as stated in the prior section. After the pre-determined number of pressurization cycles occurs at the over pressurization pressure gradient, the habitat will be pressurized until it ruptures. The other test will have the same pressurization cycles and pressurization pressure gradient as the aforementioned test. However, instead of testing each habitat to the pressure gradient at rupture, the material that each habitat is comprised of will be removed from the base plates. Once the material is removed the base plates it will be tested in a machine that determines a materials tensile strength. This test will provide information on how the tensile strength and elongation of the material different when the number of pressurization cycles is increased from 0 to 20 and then to 100.

The final test that will be added is a Pressure Vessel Destructive Test. This test will test the effectiveness of the Aluminum cage surrounding the entire payload as well as the solid Aluminum housing around the pressure canisters. In order to test the integrity of these structures a Finite Element Analysis of each housing will be performed and both the habitat and gas canister will be purposefully ruptured to observe the effects.

2 Mission Requirements

Type	Description
Mission Statement	Miura II shall repeatedly expand, sustain, and contract a thermally-insulated, pressurized, soft-shell structure on the High Altitude Student Platform while monitoring and documenting the deployment process, internal pressure and temperature, and the material performance in order to evaluate the viability of a reusable, collapsible, soft-shell structure in a near-space environment.
Primary Objective	Repeatedly expand, sustain, and contract a soft-shell structure in a near space environment.
Primary Objective	Pressurize and thermally-insulate the foldable soft-shell structure in a near-space environment.
Primary Objective	Qualitatively monitor and record the expansion-contraction cycle of the soft-shell structure.
Primary Objective	Capture high-quality visual data to analyze the soft-shell structures pressurized expansion process, the retention of the extended state, and the contraction back to the original folded state.

Level 0	Requirements	Rationale	Derived
0.1	Miura II shall expand, sustain, and contract multiple times.	Mission Statement	0
0.2	The payload shall visually document the expansion of the soft-shell structure.	Data for downlink and post-flight analysis.	0
0.3	The pressure within the soft shell structure shall remain within 0.75 ± 0.05 atm while fully expanded.	Mission Statement	0
0.4	The soft shell structure shall be thermally insulated.	Mission Statement	0
0.5	The payload shall quantitatively document the environmental conditions to which the soft-shell structure is exposed.	Data for downlink and post-flight analysis	0
0.6	The payload shall comply with all requirements set forth by the HASP Call for Payloads 2018.	Must be met for flight in September	0
0.7	The payload shall comply with all safety requirements set forth by HASP and the NASA Office of Safety and Mission Assurance.	Safety	0

Level 1	Requirements	Rationale	Derived
0.1.1	The soft-shell structure shall complete each cycle every 100 minutes with a 5 minute allowance during float.	Make sure no mechanical errors hinder the extension of the structure.	0.1
0.1.2	The soft shell structure shall return to its original compact state after each cycle.	Make sure no mechanical errors hinder the extension of the structure.	0.1
0.2.1	The payload shall collect clear visual data.	Visually analyze the folding structure.	0.2
0.2.2	The payload shall gather data to measure the height of the soft shell structure throughout each expansion-contraction cycle.	Monitor the position of the soft shell structure during flight.	0.2
0.4.1	The internal temperature of the system shall remain within a temperature range of 20 $\pm 5°$C once fully pressurized.	Analyze the thermal insulation of the soft shell structure.	0.4
0.5.1	The payload shall sample environmental data once every second.	To analyze the environmental factors of flight for downlink and post-flight analysis.	0.5
0.6.1	The payload shall not exceed the physical constraints of a large payload space.	HASP 2018 Requirements	0.6
0.6.2	The payload shall be built to withstand the entire duration of a High Altitude Student Payload flight.	HASP 2018 Requirements	0.6
0.6.3	The payload shall interface with HASP power and telemetry connectors.	HASP 2018 Requirements	0.6
0.7.1	The soft-shelled structure shall be designed to withstand over-pressurization at 119% of flight pressure.	Prevent burst of pressure vessel	0.7
0.7.2	The payload shall be capable of containing fragments in the case of a pressure failure.	Maintain safety in case of reservoir burst	0.7

3 Design

3.1 Functional Block Diagram

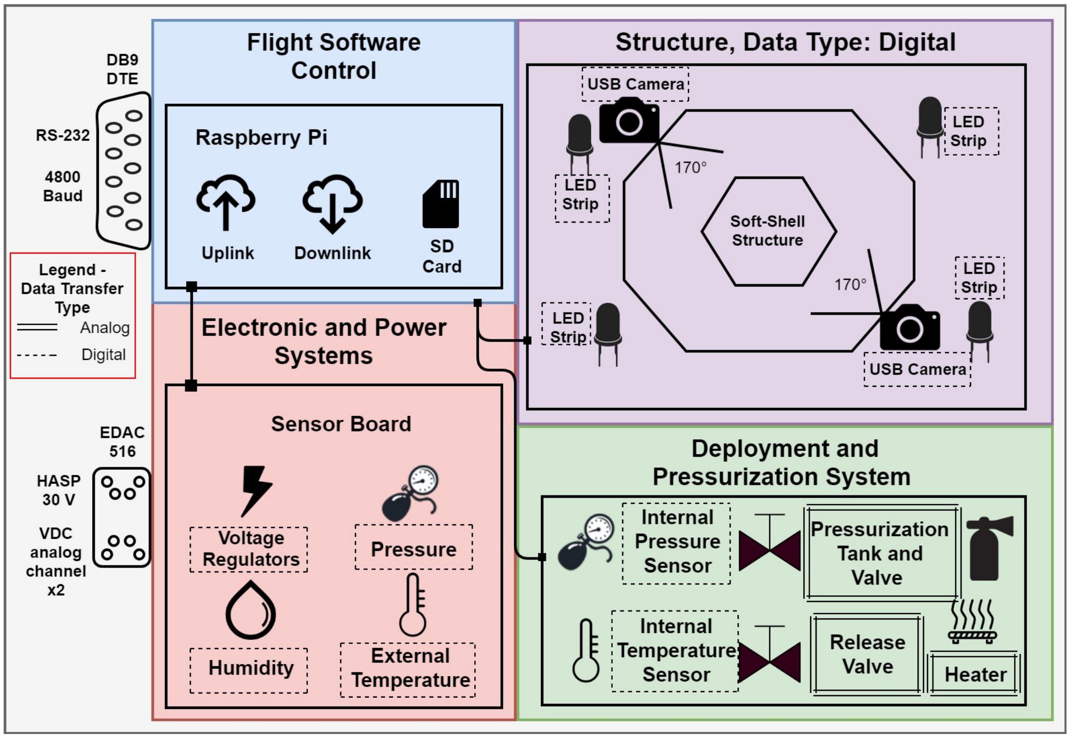


Figure 3: Functional Block Diagram

3.2 Payload and Payload Monitoring

3.2.1 Environmental Data

Table 1 below shows what environmental data is going to be collected, how it will be collected, and what its purpose will be

Table 1: Environmental Data collection and use

Data To Be Collected	**How it will be collected**	**What it will be used for**
Pictures of the soft-shell structure	ELP 8 Megapixel Webcam Camera Sony IMX179 *Saved to SD card*	Visually analyze the functionality of the soft- shell structure for the duration of flight.
Pressure inside the soft-shell structure	MS5803-14BA SparkFun Pressure Sensor Breakout *Downlinked, saved to SD card*	Quantitatively track the pressure inside the structure during inflation and retraction.
Temperature inside the soft-shell structure	MAX31820 One-Wire Ambient Temperature Sensor *Downlinked, saved to SD card*	Quantitatively monitor the temperature inside the pressurized structure for the duration for flight.

3.2.2 Science Data

Below in Table 2 the Science data that will be collect can be seen.

Table 2: Science Data collection and use

Data To Be Collected	How it will be collected	What it will be used for
HD pictures of the soft-shell structure	ELP 8 Megapixel HD Webcam Camera Sony IMX179 Saved to SD card	Visually analyze the functionality of the soft- shell structure for the duration of flight.
Pressure inside the soft-shell structure	MS5803-14BA SparkFun Pressure Sensor Breakout Downlinked, saved to SD card	Quantitatively track the pressure inside the structure during inflation and retraction.
Temperature inside the soft-shell structure	MAX31820 One-Wire Ambient Temperature Sensor Downlinked, saved to SD card	Quantitatively monitor the temperature inside the pressurized structure for the duration for flight.

3.2.3 Camera Choices and Location

Miura II uses two 8 mega-pixel USB cameras to document the expansion and contraction of the structure. The cameras will be positioned in opposing corners of the camera boom structure to provide adequate coverage of the expanding soft- shell structure. The color images taken during flight will be of HD quality. After flight each image will be referenced with images taken during ground testing for reference to determine the extent of the expansion during flight.

3.2.4 Habitat

The expandable habitat will be flexible in order to be reusable. It will have multiple thermal insulation and pressurization layers for habitability. The sheet will attach to the circumference of circular base-plates on both ends.The top face of the habitat will be allowed to move freely; the bottom face will remain fixed to the support structure. The vessel will be made of Ripstop (urethane-coated nylon) that will expand into a sphere. To ensure that the Ripstop will not contract into the pressurization chamber, three metal rings will be attached to the vessel at equal intervals. One ring will be attached to the equator of the sphere, another will be positioned halfway between the base plate and the equator, and the last will be connected halfway between the equator and the top plate. The vessel will collapse into a disk with the same diameter as the largest ring. This design does not require the material to be sharply creased, reducing the the number of weak points in the vessel. Pressurization of the interior will provide the force necessary to expand the structure. Gum rubber strips and pressure evacuation will collapse the structure.

3.2.4.1 Materials

Urethane coated nylon, Ripstop, will be used for the pressurized layer of the Miura II habitat. It is commonly used in yacht sails, parachutes, and camping hammocks because of its strength and durability. NASA uses Ripstop in EVA suits as one of the pressurized bladder layers protecting the astronauts[5].

The fibers of Ripstop are woven into a diamond or box pattern which is both tear and abrasion resistant. In the event of a tear, the weave pattern resists the tear from spreading, thus protecting the habitat from a rapid depressurization. The coating process of the nylon applies polyether urethane to one side of the fabric and it is scraped off with a blade resulting in very thin layer of coating[6]. The coating reduces porosity within the fabric allowing for it to hold constant pressure in the vacuum of space.

Ripstop has a density of 1.14 $\frac{g}{cm^3}$ and a thickness of 76.2 microns. This allows for a large surface area and a decreased payload weight. Ripstop has a break strength of 344.738 kPa, which is over four times greater than the pressure inside the habitat. In a study by Georgia Institute of Technology, Ripstop was studied at three temperatures: 50.6°C, 22.2°C, and -20.6°C. It became less permeable in colder temperatures because the fibers contracted in the cold[7]. In the temperatures of near space, the rate of diffusion through the material will decrease. This is advantageous for pressurization.

A concern of using a soft shell fabric is that it will form permanent creases during repetitive expansion cycles. Overtime, creases reduce the strength of the material and can cause a failure in the pressurized vessel. Ripstop

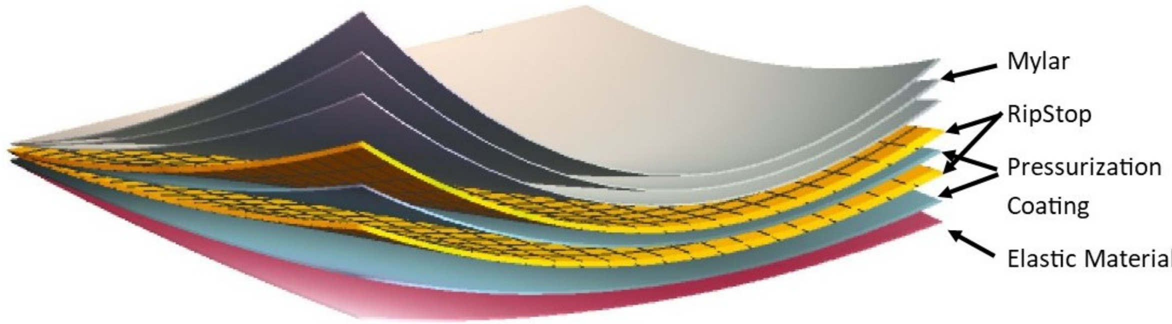


Figure 4: Payload Material Composition

crumples randomly and does not fold along the same lines with each cycle. This will ensure the habitat can withstand the stress of the pressurization over repeated cycles of extension and compression.

3.2.5 Pressure System

The Miura II experiment includes three main structures: the central expandable structure, the pressurization system, and the support structure. The central structure will expand through pressurization.

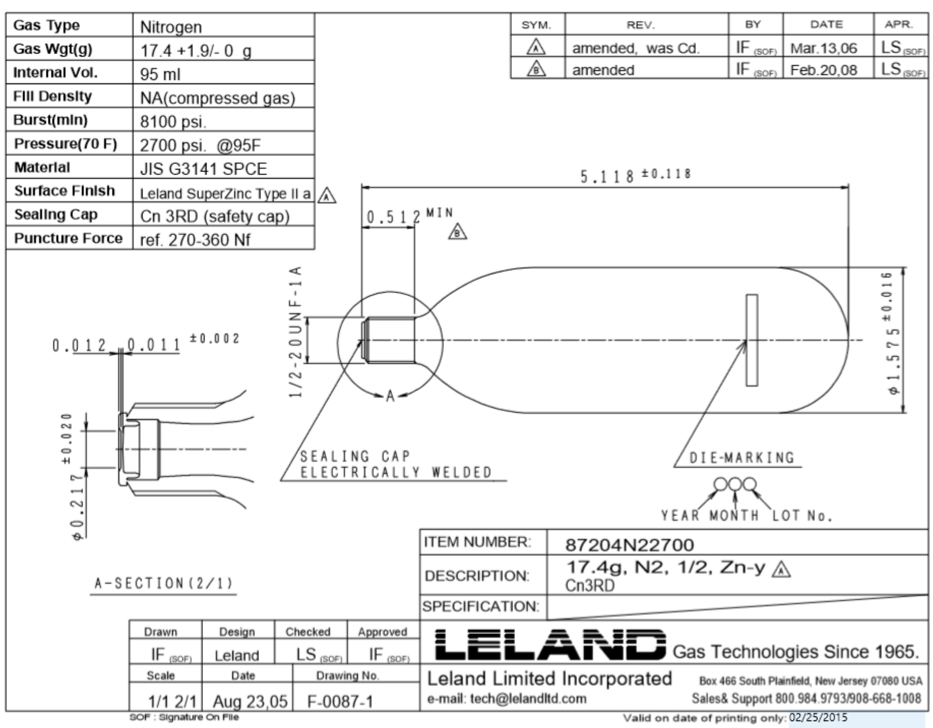


Figure 5: Nitrogen Canister Specifications

The pressurization system includes two compressed nitrogen tanks, solenoid valves, pressure regulators, pressure sensors, and pneumatic tubing. The nitrogen cartridges, shown in Figure 5, will be purchased from Leland Gas Technologies. The safety information detailing how the canister is expected to function under flight conditions is shown in Section 8, Special Requests. There will be four solenoid valves present in the pressurization system. Two of the solenoid valves will control the release of gas from each of the cartridges. The amount of gas released at one time is dependent on the pressure of the payload. As the pressure inside the payload increases, the rate of gas flowing from the nitrogen canisters will decrease, allowing a smooth, controlled expansion. After flowing from the cartridges into the main tubing, the pressure is monitored by a pressure sensor. The ideal pressure in the first stage of the pressure system, located before the first pressure regulator, is 10 atm. The first regulator will vent any additional pressure beyond 10 atm, ensuring the proper pressure is achieved throughout the system. Although 10 atm seems quite high, considering the payload is only pressurized to a 0.75 atm pressure gradient, the drastic change in volume between the tubing and the volume of the actual payload will reduce the effective pressure acting inside the payload dramatically. Once the ideal 10 atm is achieved, the third solenoid will open, allowing the contained gas to be controllably released into the payload. Gas will be released until the pressure difference between the external and internal pressure is 0.75 atm. After the difference is achieved, the solenoid will close, inhibiting the release of nitrogen until the next cycle. The figure below shows a functional block diagram of the pressure system, displaying how the payload is both pressurized and depressurized.

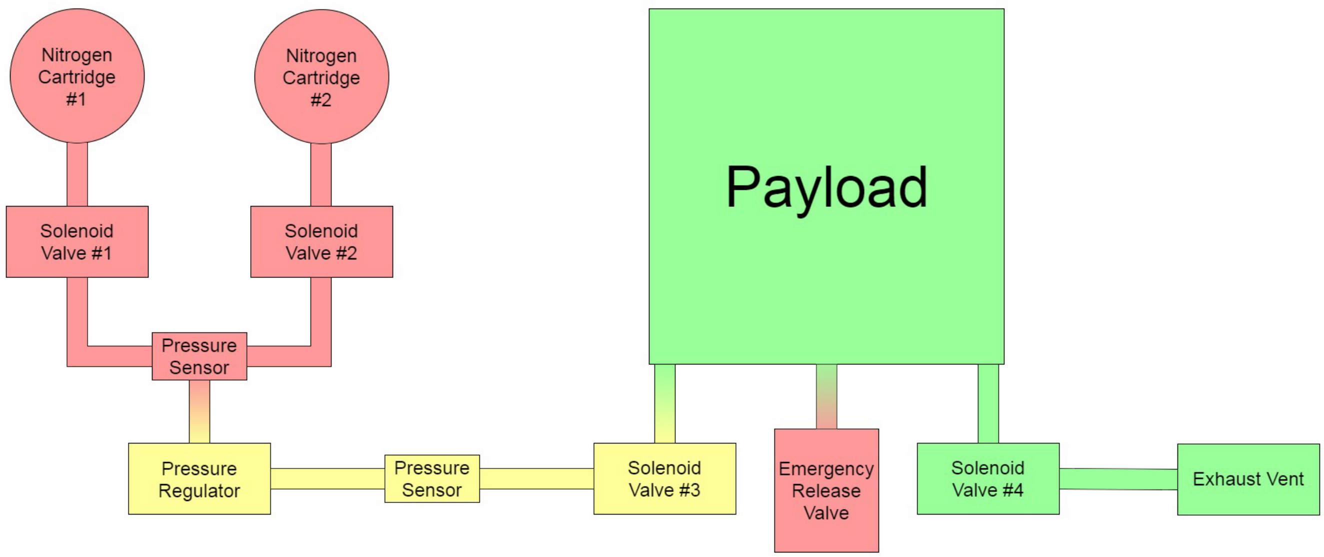


Figure 6: The pressure system will consist of two nitrogen canisters, four solenoid valves, one pressure regulator, two pressure sensors, and pneumatic tubing. One additional pressure sensor, located inside the payload, is not shown in this figure.

The de-pressurization system includes pneumatic tubing and an additional solenoid to regulate the flow of nitrogen out of the habitat. This is seen on the right of the figure, labeled solenoid valve #4 and exhaust vent. This solenoid activates after the payload has been pressurized for one hour, where the nitrogen gas is then vented away from both the payload and the HASP platform at a controlled rate. The rubber layer of the expandable structure will assist the structure in retracting.

Figure 6 includes a variety of safety features to ensure that no components becomes over-pressurized during flight. Sections of the pressure system pressurized to higher than 10 atm are shown in red, between 1 atm and 10 atm in yellow, and below 1 atm in green. The amount of gas exiting the nitrogen canisters is completely controlled by the solenoid valves. These valves can be closed at any time, controlling the pressure of the overall system and the payload. The pressure at any critical point in the system is measured by a pressure sensor. These pressure sensors will relay information to the Raspberry Pi. If the pressure in any critical section rises above a predetermined point, all solenoid valves will close, preventing additional gas from entering the system. All release mechanisms, including the pressure regulator, the emergency release valve, and the exhaust vent will open, venting the system to a stable pressure. As previously mentioned, the pressure regulator will be set to vent after reaching any pressure past 10 atm. The emergency release valve can be opened by sending a command at any point during the pressurization cycle.

3.2.6 Thermal Regulation System

The outermost layer of Miura II will be three sheets of Mylar 1400 gauge insulation film to maintain the internal temperature and protect the internal components of the payload from the extreme temperatures of near-space. This will be used to mimic a space habitat which could maintain a reasonable temperature for human habitation. Each sheet will have a thermal conductivity of 0.155 $\frac{W}{m \cdot K}$ and a thickness of 356 microns. The Mylar layer will act as a passive thermal regulation system without interfering with the collapsing process. The pressurized chamber will also contain a 10 kOhm resistive heater attached to the baseplate of the pressure vessel to maintain an internal temperature of 20° Celsius. This will mimic livable temperatures for human beings and meet requirement 0.4.1 of the mission requirements. The resistive heater will be active throughout the pressurization and depressurization phases of flight.

3.3 Structures

3.3.1 Hard Structures

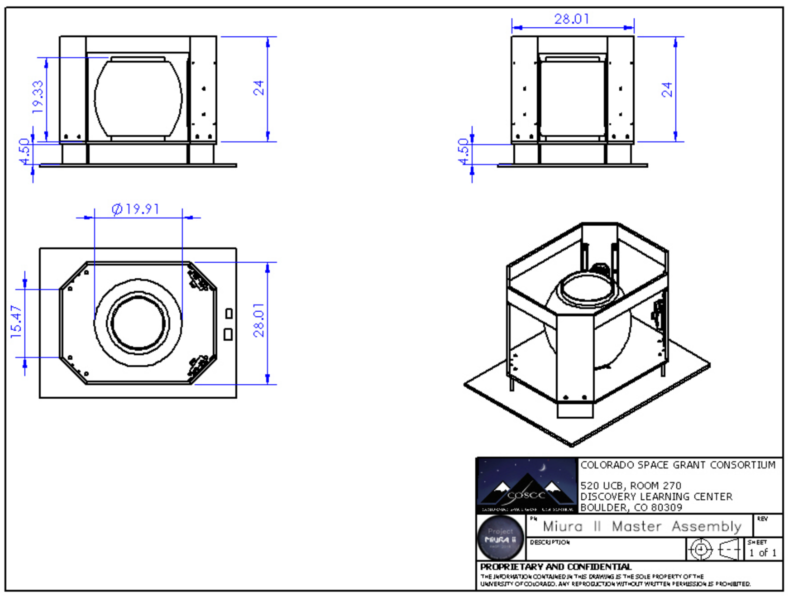


Figure 7: Dimensioned Master Assembly without Aluminum Cage

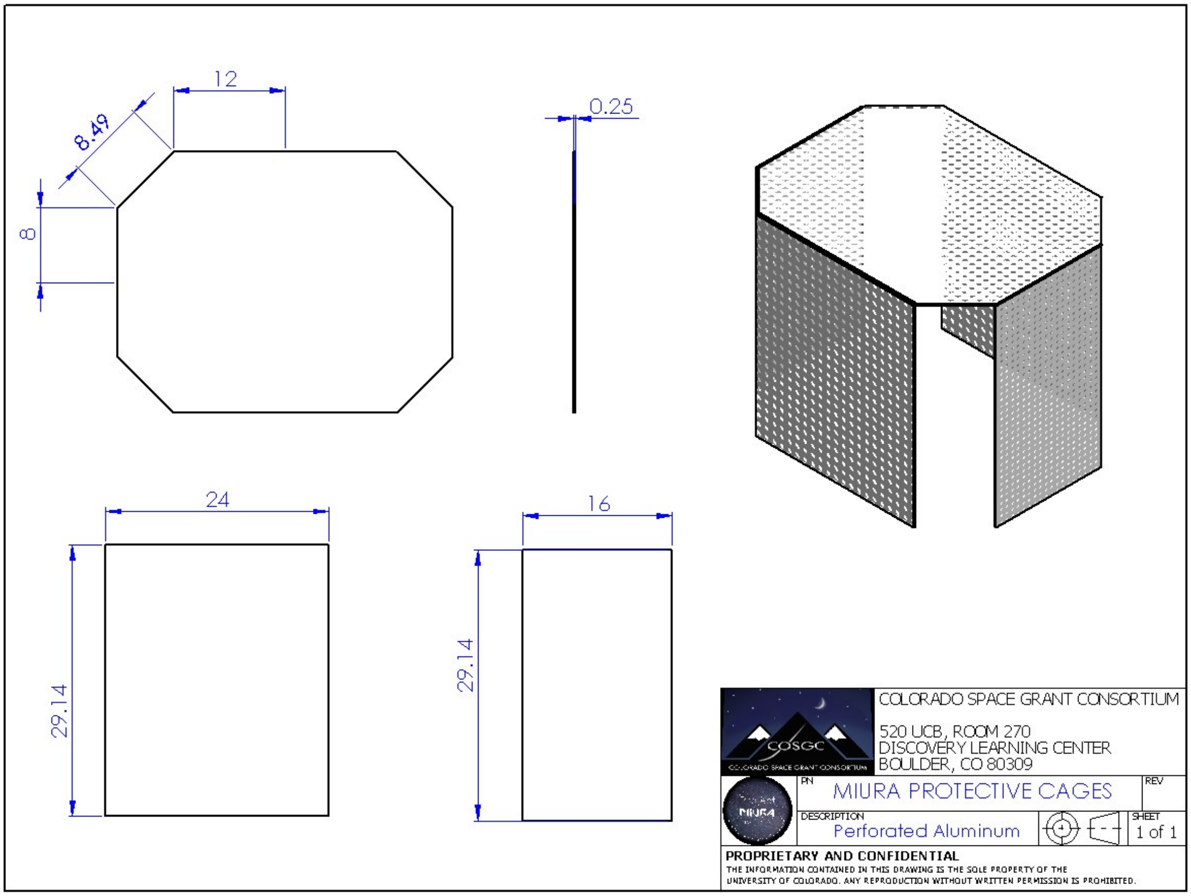


Figure 8: Dimensioned Aluminum Cage

The base housing consists of eight side plates, one baseplate, and one top plate. The Miura II team will manufacture seven of these custom plates, while using the mounting plate supplied by HASP. The manufactured plates will be made of 6061-T6 aluminum, and will serve as a thermal dissipation system for any EPS system components. The base housing will contain the main EPS power board, the Raspberry Pi, and the motor system. In addition, it will act as a ground for any EPS components. A thin layer of polyethylene terephthalate will cover the outside of the box to protect any internal components.

The camera mount consists of a 3D printed ABS base with a standard camera connector. Due to the necessity of multiple camera viewing angles, an arch-like structure will encompass the entirety of the payload. The ABS mount will be connected directly to this structure.

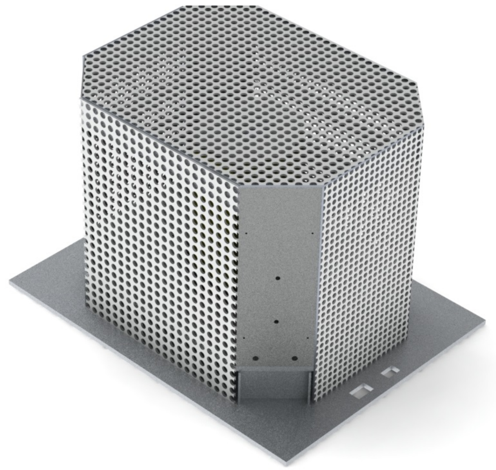


Figure 9: Base housing with aluminum cage

Miura II will be flying a pressure vessel, so there will be extra precautions taken to ensure the safety of other payloads on the HASP platform and the platform itself. The outside of the main base housing will be a perforated aluminum cage that encases the entire payload, and the gas canisters will be contained in a solid aluminum case. Testing shall be done to verify that the cage will contain any unplanned rapid depressurization that might happen during flight.

3.3.2 Structural Integration

The Miura payload will be integrated with the HASP structure using the provided baseplate and four bolts. The bottom plate of the payload contains four holes, allowing a bolt to pass through the base of the structure, and four additional holes drilled into the guide plate provided. The structure will be measured against the provided guide plate to ensure proper structure and hole alignment as well as DB9 and EDAC placement.

3.3.3 Power System Thermal Regulation

Thermal systems will be implemented to ensure no mission failures due to low or high component temperatures. The electrical housing compartment will be insulated by a multi-layer insulation blanket, previously flown on the first Project Miura flight. This insulation serves to help maintain adequate operational temperatures for the electrical components. All electronic components will be directly connected with the 6061-T6 aluminum wall structure to allow for proper heat dissipation. The primary heat sink for all EPS components will be the aluminum payload walls.

The two USB cameras will be exposed directly to harsh temperatures at maximum altitude. The 3D printed casings have proven on the first iteration of Project Miura to be sufficient in keeping the cameras within operating temperature. These precautions will ensure that all components remain within operating temperatures for the full duration of flight.

3.4 Flight Software

The Flight Software (FSW) system aboard Miura II is responsible for communications with the HASP platform, running the mission, and collecting data during flight. The FSW system utilizes one Raspberry Pi 3, which will be running two threads, one for the pressurization cycle and one for sensors, uplink, and downlink. These threads allow for parallel processes, providing multitasking capability as well ease of organization and increased efficiency.

Table 3: All of the tasks of the Flight Software subsystem can be organized into 5 general categories. To ensure that the code body will be organized and extensible, each of these categories will be given a separate concurrently running thread.

Camera Control (CAMC)	Pressure and Temperature Control (PTC)	Sensor (SENS)	Uplink (UPLK)	Downlink (DWNL)
• Take pictures of the structure every second. • Save images to SD card.	• Pressurize soft-shell structure • Heat soft-shell structure • Depressurize soft-shell structure • Pass Internal and External Pressure to Downlink • Detect Full Pressurization • Detect Full Depressurization	• Temperature Sensors (x8) • Humidity Sensor (x1) • Pressure Sensors (x5) • Save data to SD card. • Pass data to Downlink	• Monitor Serial Bus. • Parse Commands. • Pass Commands.	• Writes messages to log files. • Writes data to downlink bus.

3.4.1 Main Thread

Camera Control Function (CAMC)

Camera Control Thread takes color images with a predetermined resolution through the USB Cameras every second and stores the images in an SD card.

Sensors Function (SENS)

The Sensors function manages the reading and recording of all sensors on the payload. It includes eight temperature sensors and a humidity sensor. As a secondary objective, every sensor will assist with data and failure analysis. The primary objectives of each sensor are listed below, as well as each system's unique information that will be sent to the Downlink function.

- **Temperature Sensor**
  Seven temperature sensors will be placed on key components of the payload and outside to record ambient temperature. Two temperature sensors will be placed next to the solenoid valves while two other temperature sensors will be placed on the USB cameras. The Raspberry Pi has its own temperature sensor. Two more sensors will be placed on the baseplate, one will be on the buck converter, and another will be placed inside the expandable structure. A reading of each of these temperature sensors will be taken once a second before being passed to the Downlink function to be recorded and sent to the ground. This data will be monitored to prevent overheating of mission critical components.
- **Humidity Sensor**
  One humidity sensor, located inside the base, will assist with data analysis and troubleshooting. This allows the team to determine whether humidity was the cause of an error. It takes a reading every second and passes this reading to the Downlink function to be recorded and sent to the ground.

- **Pressure Sensor**
  Five pressure sensors shall be on the platform. Four of them are placed within the critical points of the payload, and the last one is an external pressure sensor. These five sensors shall be used to analyze the stability of the payload at any given time. These sensors read every second and passes to the Downlink function to be sent to the ground station.

3.4.2 Pressure and Temperature Control Thread (PTC)

The Pressurization and Temperature Control Thread is responsible for the deployment, heating, and contraction of the soft-shell structure. Once the payload is ready for flight and has been powered on, the thread will monitor the internal and external pressure readings. When the pressurization command is received, or 5 hours have passed since launch, one solenoid valve will be opened, allowing the gas to flow in and pressurize the soft-shell structure. When the internal pressure reaches a difference of 1 ± 0.1 atm, compared to the outside sensor, the solenoid valve allowing the gas to flow in will be closed. During pressurization, if the pressure inside the soft-shell structure does not increase for 10 seconds, or if while inflating the pressure fails to increase for at least 10 seconds, then an error message will be sent to the Downlink Queue. If this error is produced, the cycle will stop and the depressurization cycle will be run. Once the structure has reached its collapsed state, another cycle will be run. If the error occurs three times, the structure will depressurize and remain in that state for the rest of the flight.

Upon successful pressurization, the heater will heat the inside of the structure to 15° Celsius. The structure will remain in this pressurized and heated state until the depressurization command is received. Upon receiving the depressurization command, the second solenoid valve will open, allowing the gas to escape from the soft-shell structure until the internal pressure equalizes with the external pressure within a certain experimentally determined tolerance. The escape valve will remain in the open position while the natural gum rubber strips compress the soft-shell structure to its folded state. At this point, the escape valve will close, returning the structure to its initial state. While the mission is operating, it will be monitored through the pressure sensors.

3.4.3 Downlink Function (DNLK)

The Downlink function manages all information that needs to be sent to the ground over the serial bus, as well as all messages to be logged. Whenever a different function has another piece of information to be logged or downlinked, it adds it to a queue which the Downlink function regularly reads off. Each function has its own separate log kept by the Downlink thread for ease of analysis and debugging. A data packet will be sent to the ground station every 10 seconds.

3.4.4 Uplink Function (UPLK)

The Uplink function acts as the counterpart to the Downlink thread; all messages sent up from the ground pass through the Uplink for handling. The thread constantly monitors the serial bus, and appends the command to its target threads command queue for handling in the thread.

3.4.5 Code Functional Block Diagram

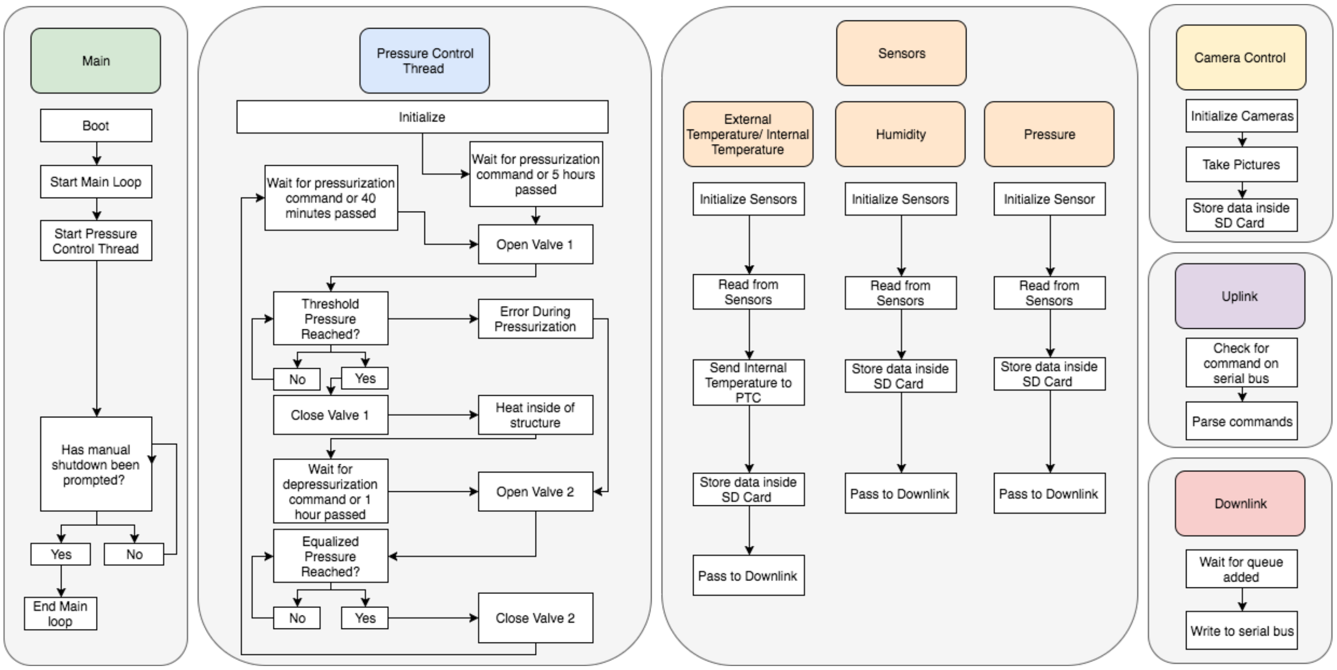


Figure 10: Code FBD

3.4.6 Uplink Commands

The following uplink commands will provide the team with basic troubleshooting capabilities, as well as allow the team to manually downlink data as needed.

Table 4: All uplink commands with 2 byte hex and description

Payload Command	Two Byte Command	Description
Ping Pi	0xAA 0x01	Pings payload to test communication
Pressurize	0xBA 0x00	Pressurize main structure
Depressurize	0xBA 0x01	Depressurize main structure
Query Pressurize	0xBA 0x02	Returns ON if currently pressurizing. Else return OFF.
Query Depressurize	0xBA 0x03	Returns ON if currently depressurizing. Else return OFF.
Safe Mode OFF	0xBB 0x00	Does nothing if safe mode not previously activated. If safe mode previously activated, essentially resets payload to initial state.
Safe Mode ON	0xBB 0x01	Halts motor and sets all relevant flags to false.
Query Safe Mode	0xBB 0x02	Returns ON if safemode is set. Else return OFF.
Reboot Pi	0xDA 0x01	Reboots Pi

3.4.7 Preliminary Data Packet

As previously mentioned, Miura II will downlink data packets every 1 - 10 seconds, depending on which sensor the data is coming from. Each data packet will have the following general format:

`Institution Name, Project Name, Sensor Name and Number of Sensors Working, Hash Value, Time, Sensor Values`

Consider the following example:

`CU M2 HU1 <adler32 checksum> <POSIX timestamp> <sensor data>`

Read from left to right, this data packet identifies the packet as coming from the University of Colorado as part of Project Miura II, and containing one successful read from the humidity sensor. The checksum allows the team to verify that the data hasnt been corrupted. Finally, <sensor data> in this example is the current humidity as measured by the humidity sensor on Miura II.

3.4.8 Anticipated Downlink Rate

The anticipated average downlink rate of Miura II is 1000 bits per second, based on the average downlink rate of Miura I. Every ten seconds, data from the seven temperature sensors, two pressure sensors, and one humidity sensor shall be downlinked.

3.4.9 Discrete Commands and Analog Downlink

Miura II will not use discrete commands nor analog downlinks. These capabilities are not necessary for the successful execution of this mission.

3.5 Electrical Power System

Muira II shall receive 30VDC from the HASP platform, which will require the use of two buck converters to convert the provided 30VDC to 5VDC and 12VDC. The 5VDC will be used to power the USB Cameras and will have a power protection system that will not require an external monitoring system. The 12VDC will be used to power the two solenoid valves.

The Power budget for Miura II is in Table 5 and includes each component's voltage, current, and power of each major device. The total maximum power will be 10.05 W, accounting for all budgeted components operating at maximum power. The HASP platform provides 2.5A at 30VDC for a maximum of 75 W, exceeding what Miura II will require.

The Raspberry Pi will power the Environmental sensors and monitor their outputs. The Raspberry Pi will communicate through the I2C protocol, storing the data on the SD Card. The LED strip will be located at the top of the structure facing Miura II and will be powered through the 5VDC buck converter.

Each buck converter provides 5VDC, but each subsystem will receive its necessary voltage through voltage regulators. The USB cameras will be powered by the USB Multiplexer, and each camera will store its data in the SD card as well. Thermal dissipation of all components with high thermal energy generation will use the 6061-T6 aluminum baseplate of the payload as a heat-sink as to maintain stable operating temperatures of the EPS system. Based on the Miura I tests, no heater is necessary. However, cold tests shall still be conducted in order to ensure that all components function while under those conditions. If there is an issue, heaters will be strategically placed to heat the components and overcome the problem. The electrical components are accounted for in Table 6 and it includes their part numbers and quantity. Also included is the power flow diagram in Figure 11, and the planned electrical schematic in Figure 13.

Table 5: All electrical components on the payload.
*Environmental Sensors consists of 8 temperature sensors, 2 pressure sensors, 1 humidity sensor

Components	Voltage (VDC)	Current (A)	Power (W)
Environmental Sensors*	3.30	0.025	0.0825
USB Camera	5.00	0.15	0.75
LED Strip	5.00	0.08	0.72
STC Solenoid Valves	12.0	0.25	3.00
Raspberry Pi	5.00	1.10	5.50
Total			10.05 ± 2W

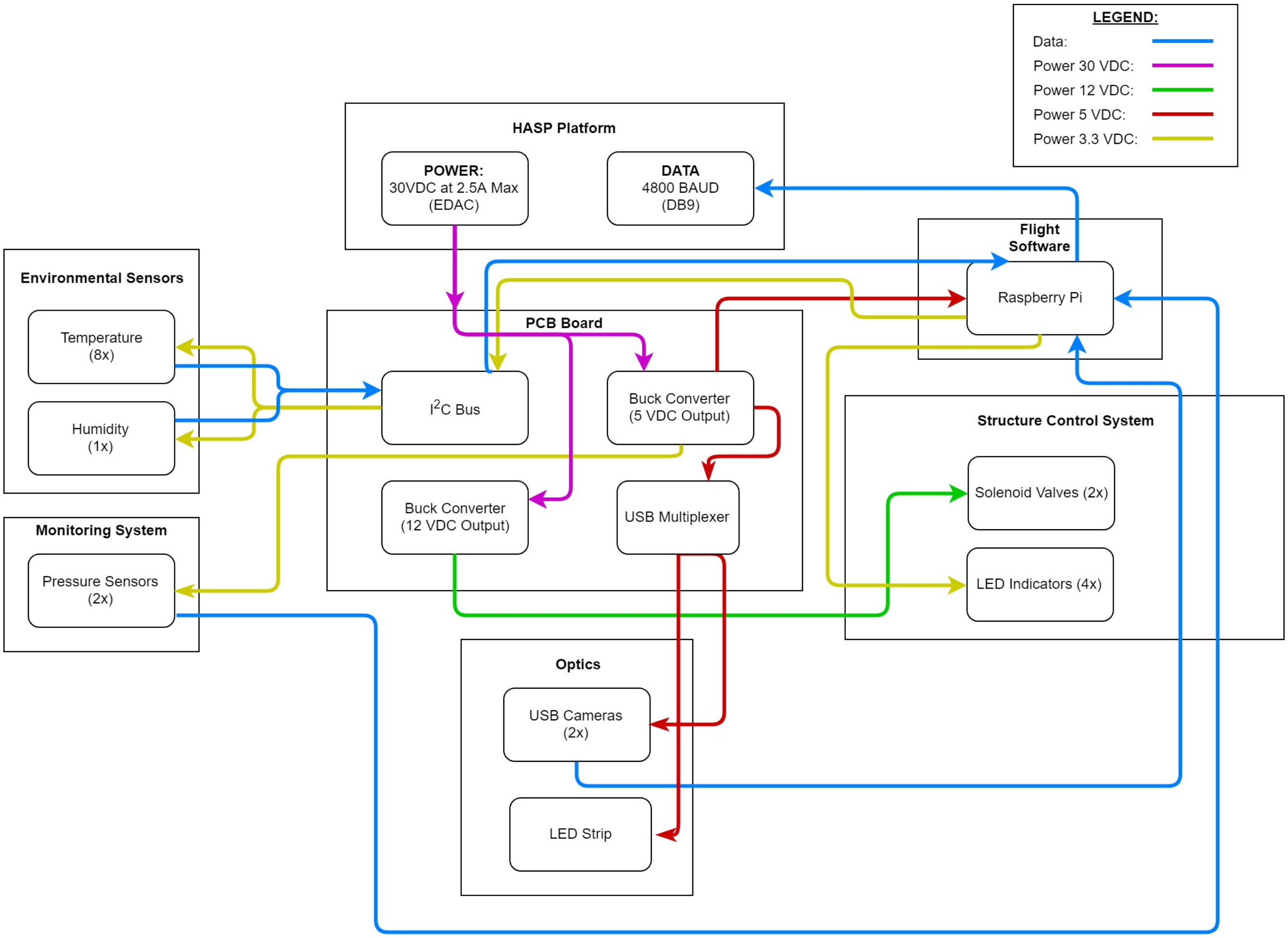


Figure 11: Electrical Power Systems

Table 6: Tally of electrical components and part numbers.

Part Number	Component	Count
B00XL7JSXE	Buck Converters	2
MAX4999	USB Multiplexer	1
MS563702BA03-50	Pressure Sensors	2
HIH6130	Humidity Sensor	1
MAX31820	Temperature Sensors	8
ELP-USB800W0Z6-L21	USB Cameras	2
2P025-1/8	STC Solenoid Valves	2
516-090-000-401	EDAC Connector	1
Raspberry Pi 3	Raspberry Pi	1
RS-232	DB9 Connector	1

Figure 12 shows the EDAC and DB9 connectors that will be used for flight. The EDAC will connect directly to the buck converter on the PCB, because the necessary voltage for all devices is 5VDC and under (not 30VDC). From the buck converter, the chosen wires from figure 17 will split out to connect to the rest of the devices. The pins that will be used from the EDAC are A, B, C, and D for 30V of power (connected to the buck converter), and W, T, U, and X for power ground. The DB9 pins that shall be used are pins 2 (received data), 3 (transmitted data), and 5 (signal ground).

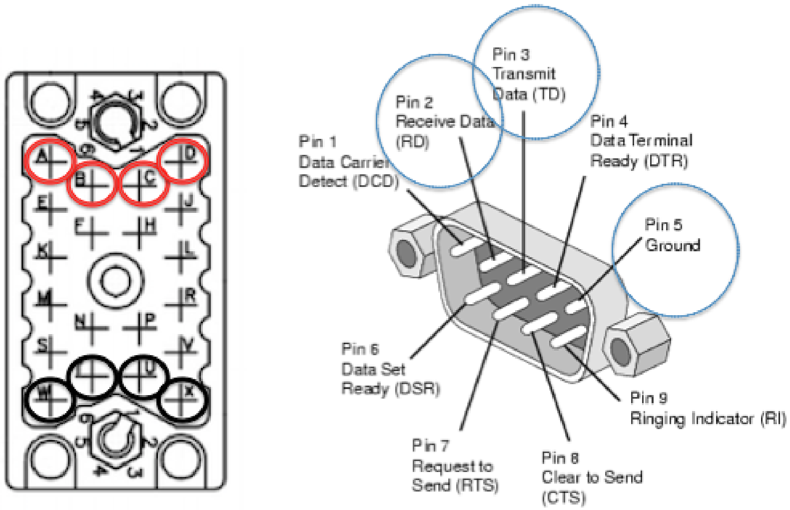


Figure 12: EDAC and DB9 Layout

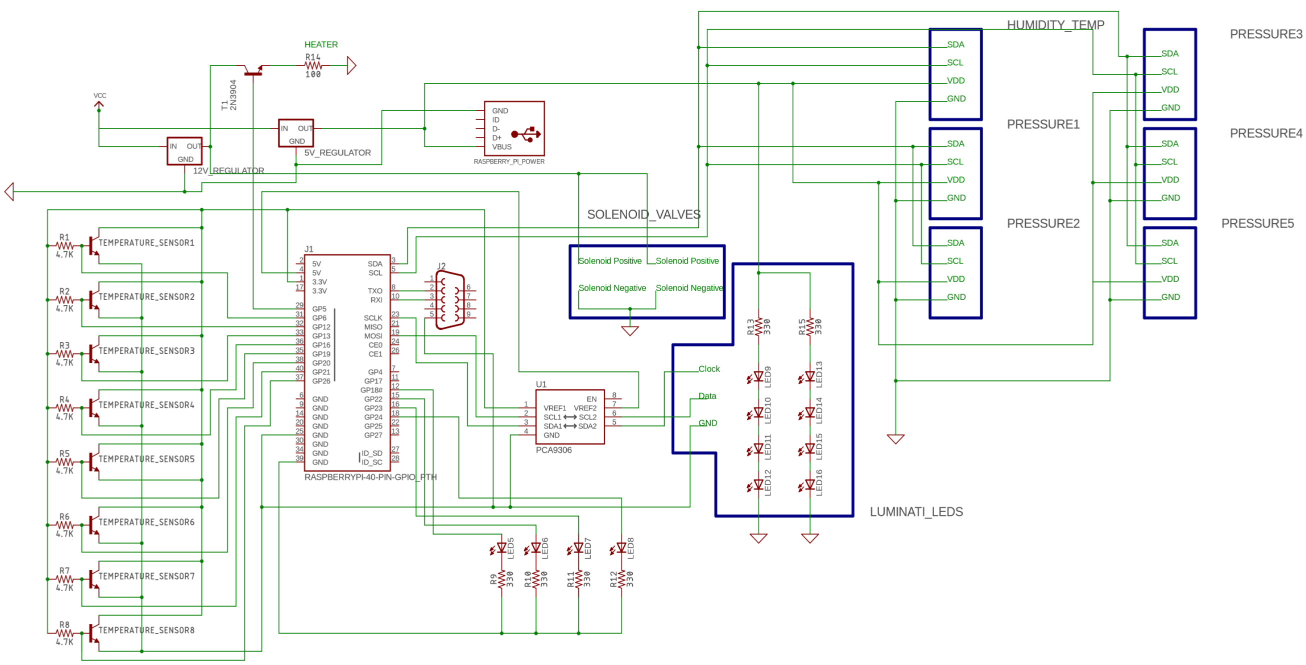


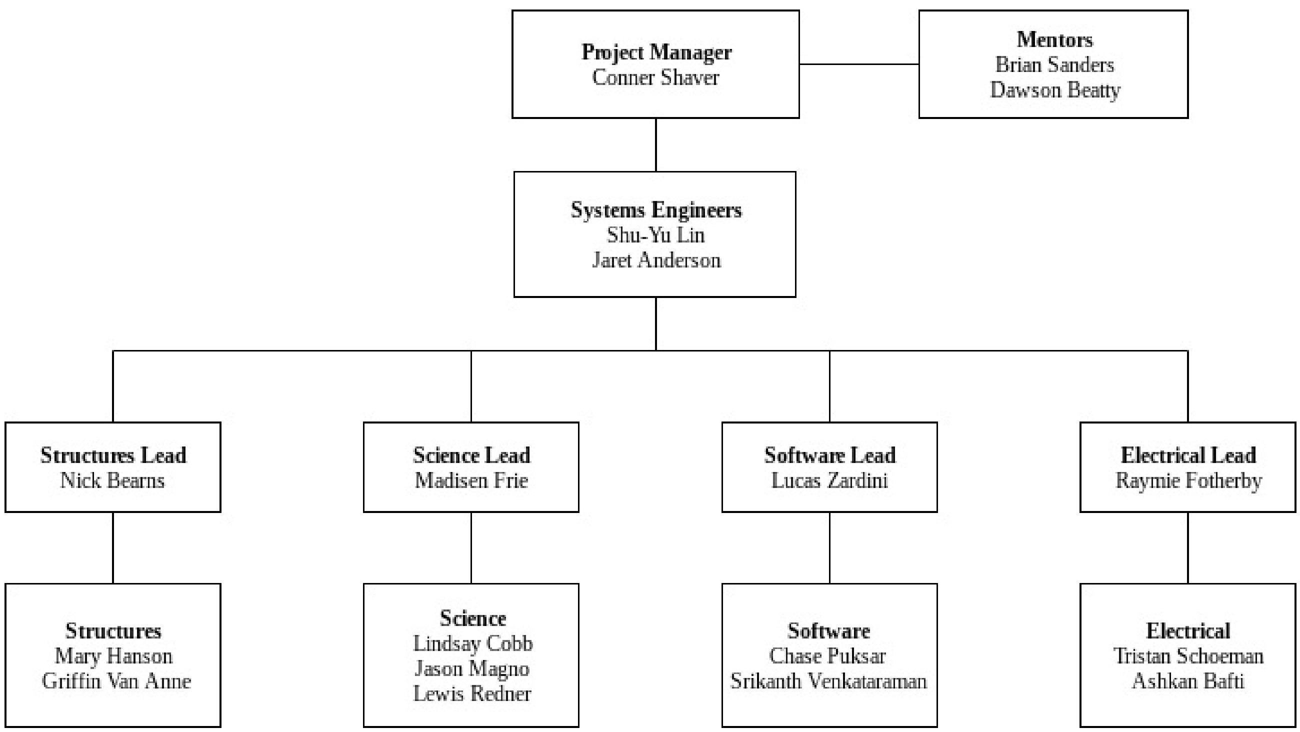
Figure 13: EPS Schematic

3.6 Power Budget Uncertainties

The listed power, wattage, and amps are likely to fluctuate once the building process begins. Since the environmental sensors (humidity, acceleration, temperature, and pressure sensors) generate a small output, they will not account for very much fluctuation. The total wattage of the environmental sensors are expected to be significantly less than 1 W, (0.1 W), and the total amps were also approximately 20mA. The tolerance section for the system shows that the wattage can range from 8.52 W to 11.58 W (tolerance of 1.53 W). These tolerances should not be a problem but the team will keep track of them during production. The future budget could change subtly due to additions or removals of components however will not surpass the limit 30VDC and 2.5A.

4 Management

4.1 Team Roles and Organization



Project Manager

The Project Manager (PM) will be responsible for obtaining project funding and maintaining the financial affairs of the team. The PM will keep track of high-level schedules, including the deadlines set forth by HASP and self-imposed deadlines. He or she will also hold weekly full team meetings lasting about an hour (described in detail later). The PM shall also hold weekly executive meetings with the teams Space Grant mentors.

The PM will be responsible for all communications with HASP, including creating monthly status reports and attending the monthly teleconference.

Systems Engineers

The systems engineers will be responsible for creating and verifying requirements, and coordinating interfaces between subteams. They will also manage system-level budgets and the Concept of Operations. Systems engineers will look for potential risks or requirement conflicts, as well as challenge the teams ideas.

Team Leads

Each of the team leads will be responsible for their own subteam, including setting high-level goals and deadlines. The team leads will work with the PM and the systems engineers to create semester expectations, then break those down into smaller tasks for their team members. Regular team working hours are expected, which will be scheduled and run by the team leader.

After each weekly full team meeting, each team lead must submit a status report discussing priorities for the week to be completed by the next meeting. These tasks shall be concrete and verifiable.

Team leads will be expected to look out for system-level risks, and raise concerns to the PM and systems engineers. While not required, team leads are encouraged to prepare a list of questions for full team discussion at weekly meetings.

All Team Members

All team members will be held accountable for their own decisions. Team members must keep documentation for parts, procedures, contacts, and key decisions. Anything not recorded in writing does not exist.

Mentors

The teams Space Grant mentors will attend weekly executive meetings with the PM to check on action items and upcoming deadlines. The mentors shall also attend all design reviews.

4.2 Meeting Formats

Weekly Full Team Meeting

During each weekly full team meeting, the PM will update the team with upcoming deadlines and the high-level schedule for the next few months. The team leads will then go over subteam updates, including successes and accomplishments, current work, help needed, system-wide decisions, and the status of action items reported last week. The meeting shall end with priorities for each subteam to focus on over the next week.

Subteam Working Hours

Subteam working hours will be 2-3 hours per week during the semester, and all team members are expected to attend. Team leads will run these meetings and focus the team on meeting semester goals.

Weekly Executive Meeting

Weekly executive meetings with the PM and Space Grant mentors will be led by the PM, who shall send the agenda the night before the meeting with appropriate links and attachments. The PM will get advice and discuss upcoming deadlines and action items. The mentors will challenge the PM to justify decisions.

4.3 Schedule Tracking

All major deadlines, team meetings, and working hours shall be stored in an online calendar and shared with the full team.

Table 7: Project Schedule

Milestone	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Submit Proposal	X												
Hire Team			X										
Submit Proposal Revisions			X										
Submit UROP Grant Request			X										
CoDR			X										
Finalize Design				X									
PDR				X									
Finish Machining Plan				X									
CDR					X								
Fabricate Pressure system					X								
Create Expandable Structure					X								
Materials Testing					X								
Soft-Shell Testing					X								
Preliminary PSIP Due					X								
Finish PCB Board					X								
Finish Machining						X							
Assemble Hard Structure						X							
Ballistics Testing						X							
Integrate all Systems						X							
PSIP Due							X						
Systems Testing							X	X					
FLOP Due								X					
Integration in Palestine									X				
Flight										X			
Data Analysis										X	X	X	
Final Science Report Due													X

4.4 Action Item Tracking

All team leads shall submit weekly action items the evening after the full team meeting. These action items should be concrete with distinct success criteria, and should be completed before the next full team meeting.

The Project Manager shall keep a spreadsheet of all submitted action items, and mark them as completed or not at each full team meeting.

5 Mass

5.1 Mass Budget

The current mass limit for any HASP large payload is 20 kg. In its current form, the Miura II payload has a projected mass of 15 kg. This is based off of a 1.5 kg habitat with thermal and pressure layers included, an 8 kg payload structure (including 3 kg of aluminum caging), 1.5 kg of pressure tubing, a 1 kg solenoid system, a 1 kg electronics system, and 2 kg of pressure vessels.

5.2 Mass Uncertainties

Table 7 shows the mass budget and uncertainty in each component on Miura II. As Miura II is still in the preliminary planning stage, these numbers are overestimates and will be calculated more accurately when a refined design has been reached.

Table 8: Mass budget

Component	Mass (kg)	Quantity	Combined Mass (kg)
Baseplate	1.60	1	1.60
Wall Structure	0.80	1	0.80
Top Plate	1.40	1	1.40
Camera Mounting Surface	0.40	2	0.80
Long Band	0.20	2	0.40
Short Band	0.10	2	0.20
Insulation	0.09	2	0.17
Camera Mounts	0.25	1	0.25
Misc. Structures Hardware	0.60	-	0.60
Integration Plates	0.10	1	1.00
Payload Top Plate	0.05	1	0.05
Payload Shield	0.30	1	0.30
Payload	0.02	1	0.02
Aluminum Caging Small	0.65	2	1.30
Aluminum Caging Large	0.85	2	1.70
Pressure Tubing	1.50	1	1.50
Pressure Vessels	1.00	2	2.00
Solenoid Valves	0.40	2	0.80
EPS Components	0.10	1	0.10
Total	-	-	**15.0 ± 3.00**

6 Testing

Since Miura II has a central focus on the pressurization of the habitat, in all tests that involved the habitat it will be pressurized. In order to assure that Miura II can successfully pressurize an independent pressure test will occur prior to all other testing to ensure that Miura II will be able to pressurize under all simulated environments. In order to ensure the safety of the HASP platform, all tests are over-pressurized to a 1.00 ± 0.05 atm pressure gradient, which is a minimum of 19% over-pressurization of the 0.75± 0.05 atm flight pressure.

6.1 Soft-Shell Testing

6.1.1 Pressure Test

To ensure the soft-shell structure will successfully expand in conjunction with the pressurization system, pressure tests will be conducted first to ensure that pressurization will not hinder the mechanism in any other tests. In addition, the pressurization test is vital to familiarize the team with the pressurization system to avoid mechanical errors during flight. The soft-shell system and deployment mechanism will be connected to the pressurization system. In order for the pressurization test to be considered successful, Miura II must complete successive extension-contraction cycles defined by the following criteria:

1. Expansion of the soft-shell structure to at least 7 times of its minimum volume and at least a 1.00 ± 0.05 atm pressure gradient
2. Sustention of the soft-shell structure at 7 times or higher of its minimum volume and a 1.00 ± 0.05 atm difference for 60 minutes.
3. Full contraction of the soft-shell structure to 1.5 times or lower of its minimum volume and a pressure difference of 0.1 atm or lower
4. Completion of the expansion-contraction cycle without tearing or a leak of the soft-shell structure
5. Completion of the expansion-contraction cycle without cracking, warping, or otherwise altering of the material
6. Any change in rigidity of the material due to pressurization shall not hinder the expansion, sustention, and contraction of the soft-shell structure
7. The mechanical system must not experience additional mechanical resistance due to the pressurization system

6.1.2 Cold Test

To mimic the low atmospheric temperatures to which the soft structure will be subjected during its flight, a cold test will be conducted. The average temperature at 37 km is around -30 °C and the coldest temperature for the entire flight could reach down to -60 °C at the tropopause. The soft structure and deployment mechanism will be sealed in a large cooler with 2 kg of dry ice. The system will be left in the cooler for 5 hours and allowed to complete 10 cycles of extension and retraction. Dry ice is capable of reaching a surface temperature of -80 °C so this temperature will be more than sufficient for the test. In addition, the Cold Test will test for the capabilities of the thermal insulation of the payload. In order for the test to be deemed successful, Miura II must complete successive extension-contraction cycles defined by the following criteria:

1. Expansion of the soft-shell structure to at least 7 times of its minimum volume and at least a 1.0 ± 0.1 atm pressure gradient
2. Sustention of the soft-shell structure at 7 times or higher of its minimum volume and a 1.0 ± 0.1 atm difference
3. Full contraction of the soft-shell structure to 1.5 times or lower of its minimum volume and a pressure difference of 0.1 atm or lower
4. Completion of the expansion-contraction cycle without tearing of the soft-shell structure
5. Completion of the expansion-contraction cycle without cracking, warping, or otherwise altering of the material
6. Any change in rigidity of the material due to low temperature shall not hinder the expansion, sustention, and contraction of the soft-shell structure
7. The mechanical system must not experience additional mechanical resistance due to the low temperatures

6.1.3 Condensation Test

To ensure the soft-shell structure will successfully expand in the case that condensation causes ice to form on the material during flight, a condensation test will be performed. The soft structure and deployment mechanism will be sprayed with water from a squirt bottle, and again be placed inside a large cooler with 2 kg of dry ice and for 5 hours to complete 10 cycles of extension and retraction. In order for the test to be deemed successful, Miura II must complete successive extension-contraction cycles defined by the following criteria:

1. Expansion of the soft-shell structure to at least 7 times of its minimum volume and at least a 1.0 ± 0.1 atm pressure gradient
2. Sustention of the soft-shell structure at 7 times or higher of its minimum volume and a 1.0 ± 0.1 atm difference
3. Full contraction of the soft-shell structure to 1.5 times or lower of its minimum volume and a pressure difference of 0.1 atm or lower
4. Completion of the expansion-contraction cycle without tearing of the soft-shell structure
5. Completion of the expansion-contraction cycle without cracking, warping, or otherwise permanently altering of the material
6. Any change in rigidity of the material due to the freezing of condensation must not hinder the expansion, sustention, and contraction of the soft-shell structure
7. The mechanical system must not experience additional mechanical resistance due to the freezing of condensation

6.1.4 Bell Jar Vacuum Chamber Test

To ensure the soft-shell structure will operate properly in a zero pressure environment, the system will be subjected to a pressure test in the Space Grant Bell Jar Vacuum chamber. The purpose of this test is to ensure the structural integrity of the system and proper behavior of the material under pressurization in a vacuum. The soft-shell structure and pressurization system will be subjected to zero pressure for 5 hours and allowed 10 cycles of extension and retraction. In order for the test to be deemed successful, Miura II must complete successive extension-contraction cycles defined by the following criteria:

1. Expansion of the soft-shell structure to at least 7 times of its minimum volume and at least a 1.0 ± 0.1 atm pressure gradient
2. Sustention of the soft-shell structure at 7 times or higher of its minimum volume and a 1.0 ± 0.1 atm difference
3. Full contraction of the soft-shell structure to 1.5 times or lower of its minimum volume and a pressure difference of 0.1 atm or lower
4. Completion of the expansion-contraction cycle without tearing of the soft-shell structure
5. Completion of the expansion-contraction cycle without cracking, warping, or otherwise altering of the material
6. The mechanical system must not hinder the expansion, sustention, and contraction of the soft-shell structure when operating in a vacuum

6.2 Pressure System Components Testing

All tests in this section will also be tested to a pressure gradient of at least 1.5 atm, or double the flight pressure gradient of 0.75 atm. All components in the pressure system have a predetermined maximum pressure as determined by the manufacturer. As these components are often created and tested around sea-level, additional testing is required to ensure operation in a near space environment is successful. This testing is necessary as a near-space environment will expose the components to different thermal distribution, The structures team will repeatedly pressure these components to ensure that the selected components can handle flight operation requirements. The components in question are the solenoid valves, the pressure regulators, and all pneumatic tubing.

6.2.1 Individual Component Testing

Each pressure system component must be tested individually to ensure that each part can handle flight operations. The solenoid valves, pressure regulators and pneumatic tubing will each be tested 50 times. In order to determine the component pressure testing a success, the following criteria must be met:

1. Each component must withstand at least a 1.5 atm pressure gradient
2. Each component must not experience any pressure leaks

6.2.2 Full Pressure System Testing

The complete pressure system will be tested upon completion of the Individual Component Testing. The full system will be tested 50 times. To determine the system test a success, the following criteria must be met:

1. The system must withstand at least a 1.5 atm pressure gradient
2. The system must not experience any pressure leaks

6.3 Material Testing

A two part material test will be conducted on the payload to measure the extreme operating conditions until rupture. First, the habitat will be increasingly pressurized until rupture. This tests the durability of the material and the maximum achievable pressure within the vessel. Second, the same material type will be tested to failure with an increasing tensile load. This will be done using an Instron machine connected to sheets of the soft shell material which will allow for the stress and strain to be measured at the moment the material fails. This tensile stress will define the limits of the material. This two part test will be repeated on a vessel after 20 and 100 pressurization cycles. In order for the test to be deemed successful, it must fulfill the following criteria:

1. Structure must stay intact up to a 1.5 atm pressure gradient(twice the maximum proposed pressure of the system)
2. Material must demonstrate a tensile strength of 0.15 MPa (about the equivalent of a 1.5 atm of pressure gradient)
3. The material must pass criteria 1 and 2 after 20 pressurization cycles

4. The material must pass criteria 1 and 2 after 100 pressurization cycles
5. A Failure Mode Effect Analysis must be conducted after each testing iteration
6. A FEA will be conducted for each number or pressurization cycles.

6.4 Systems Testing

6.4.1 Day in the Life Test

To ensure the payload's subsystems all function independently as well as function as a whole system, the payload will be tested extensively for 24 hours to simulate the longest duration of a flight on the High Altitude Student Platform. The continuous running of the payload will test the consistency and reliability of the system and each of its subsystems. The test will also demonstrate the compatibility of each of the subsystems with each other. In order for the test to be deemed successful, Miura II must fulfill each of the following criteria during the test:

1. Expansion of the soft-shell structure to at least 7 times of its minimum volume and at least a 1.0 ± 0.1 atm pressure gradient
2. Sustention of the soft-shell structure at 7 times or higher of its minimum volume and a 1.0 ± 0.1 atm difference
3. Full contraction of the soft-shell structure to 1.5 times or lower of its minimum volume and a pressure difference of 0.1 atm or lower.
4. Completion of the expansion-contraction cycle without inversion of the folds
5. Completion of the expansion-contraction cycle without tearing of the soft-shell structure
6. Completion of the expansion-contraction cycle without cracking, warping, or otherwise altering the material
7. The mechanical system shall not hinder the expansion, sustention, and contraction of the soft-shell structure
8. All components receive the correct voltage and remain powered for the entire duration of the test
9. Camera batteries shall last the entire duration of the test
10. SD cards in cameras shall be able to store the video for the entire duration of the flight
11. The cameras shall capture each extension, sustention, and contraction of the soft-shell structure
12. All sensors store accurate data to the SD cards
13. The code shall execute as designed
14. The payload downlinks data accurately through the downlink thread
15. Commands are sent and executed properly through the uplink thread

7 Integration and Launch Procedures

7.1 Integration

For integration with the HASP platform, team leads, systems engineers, and the project manager shall ensure proper the integration procedure is followed. A comprehensive checklist shall be used to confirm a successful integration of the Miura II payload. The systems engineers shall test all communication processes and equipment throughout integration to assure proper function. The following is the integration plan Miura II will follow at the Columbia Scientific Balloon Facility in Palestine, TX. In order to make sure that the pressure canister remains in tack and arrives at the facility safely the canister will be shipped via a ground shipping company with all of the proper paperwork and safety precautions.

1. Arrive with payload assembled but pressurization system disconnected
2. Ship the pressurization system to Integration and Testing location via ground shipping
3. Confirm that all components are intact after transportation
4. Test payload to ensure proper functionality
   (a) Connect pressure reservoir
   (b) Power on and let run through start-up

   (c) Confirm that the pressurization cycle is functional
   (d) Confirm that downlink is functional
   (e) Check SD cards for successful video capture

5. Deliver payload to HASP directors
   (a) Mass the payload to confirm it is under the mass requirement
   (b) Attach payload to test stand and power on
   (c) Ensure payload is powered on and is downlinking data
   (d) Deliver payload to be integrated to the platform
   (e) Ensure payload powers on and downlinks data from the platform

6. Run thermal vacuum tests
   (a) Cycles the pressurization cycles three times
   (b) Confirm that all downlinked data is seen in data logs
   (c) Analyze test data to verify payload is functioning as expected
   (d) Uplink relevant commands to payload to verify all systems are working as intended
   (e) Confirm that all downlinked data is seen in data logs

7.2 Launch Procedures

Miura II will send at least four team members to New Mexico with the payload. All members who wish to be present for launch will go. Referring to the experiences of the Miura I team and the HELIOS teams, the Miura II team has concluded that it is not necessary to stay in New Mexico for the entire duration of flight, as a monitoring system from Colorado has proved adequate, but members who wish to remain present may stay. To prevent accidents during shipping from derailing the mission, the Miura II team will send representatives to ensure that the structure arrives without any damage and to complete the integration and test the deployment process.

The following table is an approximation of the launch procedure of the Miura II team constructed from information in the CFP as well as the Miura I and Helios V proposals. The leftmost column is an estimate for when the task would be carried out. The rows associated with each time slot are flight events and system directives. The Project Manager will be responsible for ensuring that all of the flight procedures will be properly followed and completed. The team leads of each subsystem shall be responsible for ensuring that their respective subsystems successfully undergo integration onto the HASP. During the flight the software lead will be responsible for controlling all discrete commands to the Miura II payload on the HASP.

Time	Task	Instructions	Indication of Completion
Upon Arrival	Ensure all parts of structure have arrived without damage.	Inspect for damage or irregularities in the hard and soft-shell structures.	Visual inspection confirming all components are in place and without cracks, dents, tears, or other damage.
Upon Arrival	Ensure that proper connections are made between all components.	Check for leaks in pressure seals and ensure all moving components are connected to the microprocessor.	Visual confirmation that wires are secure and proper connections are in place.
Upon Arrival	Ensure all cameras are ready for flight.	Confirm that cameras are securely attached to structure and connected to proper power supply.	Micro SD cards confirmed to gather data from cameras and have been securely inserted back into cameras.
Upon Arrival	Uplink and sensor check.	Power on structure, run uplink commands, confirm accurate sensor functionality.	Acknowledgement given by mock ground control.
Upon Arrival	System check	Send command to pressurize soft-shell structure.	Visual confirmation of pressurization, soft-shell must stay pressurized with no leaks.
Following Integration	Ensure successful integration.	Structurally and electrically attach payload to platform, confirm power on and downlinking.	Physical check of payload security and visual confirmation of powering on when instructed.
T = 0 hours	Launch payload is powered on.	Ensure data downlink is active.	Confirm data being received by ground control.
T = 1 hours	Verify command uplink.	Send ping to payload.	Ensure acknowledgement is in downlinked data.
T = 2 hours	Begin observation.	Verify tracking and data downlink is behaving correctly. If not, send commands or toggle power on the payload to compensate.	Ensure that data is being received.
T = 2 hours	Expansion cycles start.	Uplink command to begin cycles.	Cycle data verified to be in downlink.
T = 4 hours	Backup cycles start.	Hard-coded cycle start starts expansion cycle if uplink fails.	Cycle data verified to be in downlink.

Table 9: Approximate Launch Procedure

8 Special Request

Since Miura II hinges on the use of a hazard, a pressure vessel, the team is prepared to take rigorous safety precautions to counteract pertinent risks associated with pressurization. Pressurization is an essential mechanic for carrying out the mission. The payload must start in a space-efficient collapsed state, expand to a fully extended state, and collapse back to the original state using a pressurized gas, so without this hazard the method of deployment of the soft-shelled structure would be lost. Additionally, without this method of deployment the interior of the structure would not remain at a habitable pressure while expanded which is another critical objective of the mission.

With HASPs permission to include this hazard on the payload, the team shall take the following precautions to ensure that the payload does not become a danger:

1. A safety valve or similar mechanism will be installed in the soft-shelled structure and pressurization mechanisms to prevent over-pressurization in the N_2 canister or soft-shell structure.

2. A mesh cage or similar structure will be installed around the soft-shelled structure to catch any shrapnel in the case of a rupture.

3. A sturdy aluminum structure will surround the N_2 canister to contain any debris.

4. All pressurization components will be securely attached to the structure to ensure that components are not ejected from the payload in case of a rupture.

In order to assure that the N_2 canister that Miura II will employ can withstand the temperatures and pressures at 36 kilometers a datasheet, [3], has been provided that details information on the strength of the canisters. The third reference is also to a website that sells the canisters that Miura II will use to pressurize the payload. Overall the canisters that Miura II will use can withstand 7,680 psi before bursting while containing an internal pressure of only 3,000 psi[2][3]. These numbers are at sea level, 14.7 psi, which means that at an altitude of 36 kilometers with an atmospheric pressure of 509.14 Pa [4], or 0.07384 psi, there will exist a pressure gradient of an extra 15 psi in the tank which will not be present on the ground. This added pressure of 15 psi is not nearly enough to make the canister rupture. The temperature difference the canisters are rated to is a maximum temperature of $120°F$. Since the temperature at float is roughly $-5°F$ the operating temperature for the canisters are not in question either [3]. The information provided in the References section coupled with an aluminum mesh surrounding the payload and solid aluminum housing around the canisters are adequate protection to prevent damage in a depressurization event.

9 Conclusion

To aid the development and research of expandable structures, the Miura II project will test a pressurized folding system to allow for a small module to be deployed and contracted repeatedly. In order to prove the habitability of the collapsible structure, Miura II will use a controlled pressurization system to extend and contract a thermally insulated, soft-shell structure in the harsh environment of near-space. Miura II will monitor the soft-shell structure to provide data to characterize its expansion and contraction as well as the internal conditions pertaining to habitability. A successful demonstration of the ability to refold a structure after deployment will contribute to advances in compact, reusable, habitable space modules. As it contains a hazard, Miura II will put a strong emphasis on safety. If selected to be part of HASP, Miura II will occupy a large payload spot and will meet all the requirements set by "HASP Call for Payloads 2018."

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