L’Space Team 27 Spring 2019 Level 1 Preliminary Design Review

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I) Summary of PDR Report

1.1 Team Summary

1.1.1 College and University Names.

Team Member	University	Degree
Michael McGrath	Texas A&M University	Aerospace Engineering
Kelly Graham	University of Houston	Biomedical Engineering
Jessica Allen	Lonestar Community College	Atmospheric Sciences
Catherine Schnelle	Fort Hays State University	Computer Science
Mahir Pirmohammad	Texas A&M University	Aerospace Engineering
Anikait Sharma	Texas A&M University	Aerospace Engineering
Sanija Maredia	Lonestar Community College	Structural Engineering

1.1.2 Team Member Locations.

Team Member	Location
Michael McGrath	College Station, Texas
Kelly Graham	Houston, Texas
Jessica Allen	Houston, Texas
Catherine Schnelle	Austin, Texas
Mahir Pirmohammad	College Station, Texas

Anikait Sharma	College Station, Texas
Sanija Maredia	Webster, Texas

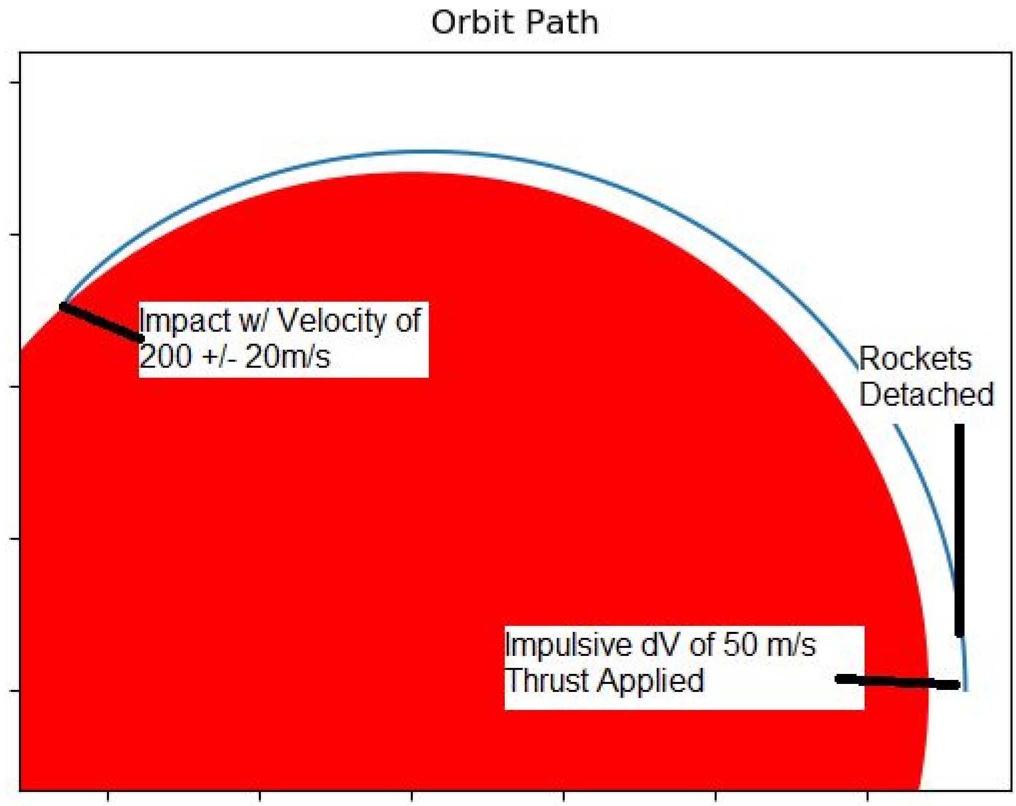
1.1.3 List of relevant expertise on team.

Team Member	Expertise
Michael McGrath	*Relevant coursework includes orbital mechanics, propulsion and controls. I also have experience with orbit simulation from my time spent with my universities cubesat club.*
Kelly Graham	*Relevant coursework includes Matlab, Circuits I, Organic Chemistry lecture & laboratory, Physics I & II, Engineering Mathematics. Experience with Microsoft Office, design & assembly of high powered rockets for IREC's Spaceport America Cup.*
Jessica Allen	*Relevant coursework includes research and data analysis, Excel, Powerpoint, Calculus I & II, Chemistry I & II, and Physics I*
Catherine Schnelle	*Relevant coursework includes computer science, software engineering, and discrete mathematics. Experience with arduino and microcontroller assembly, and C#, C++, Python, JAVA, and MASM programming languages.*
Mahir Pirmohammad	*Relevant coursework includes physics I,Calculus I &II. Experience with Python, C++, JAVA, and SolidWorks (3D Modeling).*
Anikait Sharma	*Relevant coursework includes Calculus I/II physics, engr, csce121. Experience with Python, C++, JAVA, UE4, node.*
Sanija Maredia	*Relevant coursework includes Microsoft Word, Powerpoint, Google Drive, Researching and Analyzing, Communication, Time management, Organization, Detail orientation.*

1.2 Descent Summary

1.2.1 Description of Entry, Descent, and Landing Sequence.

The probe will detach from the orbiter at a parking orbit at an altitude of 250km. The payload will be spun along its axis of symmetry for axial stability and then a pair of rockets will slow down the craft and alter the orbit path into the atmosphere and deorbit due to atmospheric drag. The probe will enter the Mars atmosphere with a flight path angle of 3°. The craft will have no active controls after its initial deorbit burn and the rockets and propellant will detach in the atmosphere and leave the lander, along with it's aeroshell, to passively orient itself and impact the Martian surface at speeds between 200 +/- 20m/s. Upon impact, the aeroshell will provide a minimal cushion for the penetrator's aftbody, shatter, and be penetrated by the forebody which will dive up to .5m into the Martian soil.



1.3 Lander and Payload Summary

1.3.1 Description of Each Mission Element.

Our payload consists of three major components: an aeroshell, aftbody, and forebody. The aeroshell weighs 2.4kg and is a conical structure with the widest diameter of the cone being 0.36m and having a length of 0.365m. The aeroshell will store and protect the payload from the heat of entry as well as slow the craft down.

The aftbody is the section of the payload that will remain on the surface. It’s total dimensions are 0.037m tall by 0.15m wide. The aftbody will house 8 Lithium-Thionyl Chloride batteries giving the craft a total of 4.8 amp-hours of power and weighing a total of 0.320kg. The aftbody will have on its top exterior 6 X-band impact resistant patch antennas weighing a total of 0.05kg for communication with an exterior telecommunication probe. The aftbody will connect to the forebody via a durable communication cable (~0.02kg).

The forebody is a bullet-shaped penetrator that will dig itself around 0.5m into the martian soil. It has a total mass of 0.9kg and is 0.15m long with a diameter of 0.04m at the base. The forebody holds the impact accelerometer which will record data for the deceleration of the craft in the moments of impact in order to characterize the soil as well as approximate the depth of the forebody. It weighs less than a gram and has dimensions of 2.8 x 4.1 x 6.9mm. The forebody also holds the drill and spectroscopy system developed for the Deep Space 2 mission which will allow the probe to obtain a sample of martian soil and verify the presence of water within the sample. The entire subsystem weighs 0.064k, containing a cylinder 2.5cm long and 0.4cm wide.

II) Evolution of Project

2.1.1 Changes made to Descent and Lander Criteria.

Over the course of the semester we made few changes to the EDL of the project. The main decision made was that our landing would be ballistic and not a traditional soft landing. Once this decision was made most of the changes were pertaining to geometry of the aeroshell to maximize stability as well as adjust to the higher impact velocity. The other significant change we made was adding in a deorbit plan to our probe, given that we will be separating from the orbiter and thus need to not only release from the orbiter but also make adjust its velocity to enter the Martian atmosphere.

2.1.2 Changes made to Payload Criteria.

The main criteria changes we made were reductions in the scope of our data acquisition. The mission started with a larger goal to map the depth of the ice and obtain a more accurate chemical breakdown of the water itself utilizing mass spectrometry. However, we decided that since the Mars Reconnaissance Orbiter had accurately mapped the ice depth of the martian surface to an accuracy of ±15m that this was unnecessary. We were also unable to find any studies showing a small enough mass spectrometer to fit within our mass budget so we had to abandon the mass spectrometer for a smaller gas spectrometer that would still provide us with information about the chemical composition of the ice.

2.1.3 Changes made to Mission Experiment Implementation Plan.

Many changes were made to the implementation plan after the initial design phase to add in safety measures and redundancy. One example was the addition of the potential to transmit data to the orbiter instead of the transmission probe if necessary. Another idea we had later on in the process was to have the probe be powered off during the cruise and have it's battery levels be monitored and potentially recharged by the orbiter if necessary.

III) Science Value

3.1.1 Science Payload Objectives.

The probe will carry out 2 specific scientific missions. The water detection assembly is responsible for collecting and sealing an ice sample, and a laser spectrometer will test for the presence of water vapor by heating the sample to determine the presence of ice water within the targeted crater. The second scientific mission will utilize the mini one axis impact accelerometer in order to measure deceleration during impact and measure the depth of impact. These two systems to retrieve scientific data will be used to determine if ice water is present under the 1 meter solid surface of the crater and the depth of impact will help determine the success of impact in order to predict data analysis accuracy.

3.1.2 Payload Success Criteria.

In order for the mission to be successful the payload must satisfy the following requirements:

- Be able to withstand the ballistic landing forces without any critical equipment failures.
- Obtain rapid deceleration data from the impact landing .
- Obtain a soil sample from a depth of .5m beneath the Martian surface and place the sample in the testing chamber.
- Confirm whether, and if so how much, water is present within the obtained soil sample using laser spectroscopy and thermal analysis.
- Relay all data to the telecommunication probe located within the 50km sphere of communication.

3.1.3 Site Analysis Evaluation and Discussion.

188.187 E, 46.625 N

The Arcadia Planitia Region

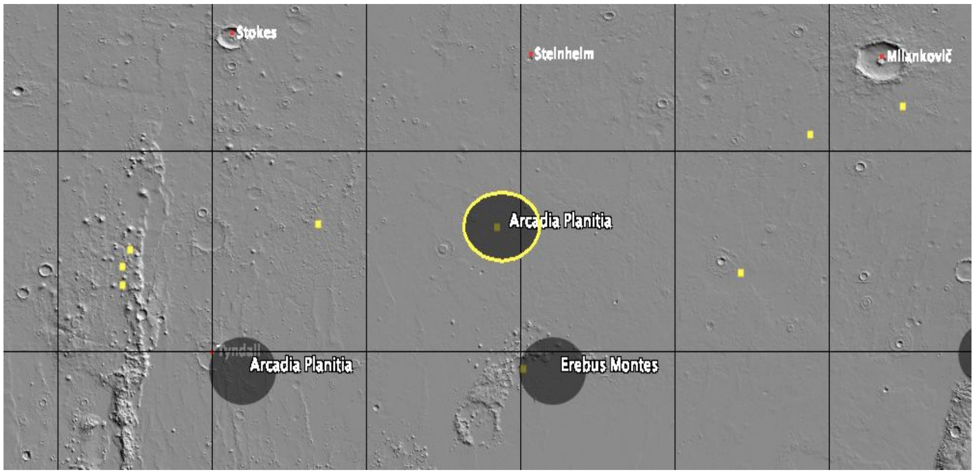


Figure 2. JMARs Screenshot of Arcadia Planitia, the Chosen Landing Site

This region of Mars is a smooth plain with fresh lava flows which contains low areas with grooves and sub-parallel ridges that indicate movement of near surface materials similar to features on Earth where slow moving materials are moved by the freezing and thawing of water. This area contains expanded craters which are large impact sites and gullies which are narrow channels carved by what may have been liquid water in this distant Martian past. In this location of the Arcadia Planitia, the yellow squares in the first image represent icy craters which are promising areas to drill for ice in a region that is mostly flat with 2 other nearby exploration zones. These craters expose excess ice which is mostly free of dust. This region also mostly contains subsurface ice that is within 1 meter below the surface that would allow for drilling. This JMARS site analysis was conducted utilizing the icy craters and human exploration zone filters to locate an area that met both requirements for a landing zone.Upon impact into the crater’s surface, the payload’s onboard scientific payload will deploy. This payload consists of a water detection assembly that is made up of a sample collection system that contains a sealable cup with small 1 cm in depth sample collection electric drill, once the sample falls into the chamber which is then sealed, it is heated in 10 degrees Celsius increments and the turn-able diode laser assembly (TDL) tests the sample at each increment by emitting light directed at the sample. If water vapor is present, it will absorb some of the light. This payload is controlled by an onboard microcontroller, the data collected is stored on a microprocessor by which the data is transmitted to the Mars Orbiter and then to the DSN via UHF antenna. The probe will include a mini one axis impact accelerometer which will measure deceleration during impact, and the depth of impact.

3.1.4 Test and Measurement, Variables and Controls.

In order to test the probe's equipped payload on Earth in order to ensure operational success on Mars, certain variables and controls must be implemented in test planning. We plan to test how these instruments in their insulated packaging can withstand certain Mars conditions, for example, an average Mars surface temperature of -46 degrees Celsius. The science payload must be able to withstand the shock of impacting the Martian surface and still be able to initiate and conduct the sample collection and testing experimentation and store and send raw data to the Martian orbiter. The science payload must be able to withstand extreme heat during entry into the Mars atmosphere and also be able to still perform under increased temperatures during impact and reduced temperatures after impact due to the cooler Martian atmosphere.

With these environmental variables to consider, controls must be in place that mimic the impact the Martian environment will have on the science payload while testing the device on Earth.

3.1.5 Relevancy of Data Collected.

In order to ensure mission success we are using instruments that can independently withstand the Martian atmosphere and shock impact after entry by a larger margin than is needed. This does not include the shock absorbency of the shell of the probe itself.

The 8 Lithium-Thionyl Chloride Batteries that will provide power to the science payload can withstand <60,000 Gs of shock and temperatures as low as -80 degrees Celsius. The instrument microcontroller is capable of surviving high shock <30,000Gs and temperatures as low as -120 degrees Celsius, this is due to its High Density

Interconnect (HDI) high shock packaging. The motor and drill assembly that makes up our Sample Collection System can withstand <30,000 Gs high shock and low temperatures down to -120 degrees Celsius. The microprocessor responsible for data storage and transmission and computing raw data resulting from the results of the Tunable Diode Laser Assembly (TDL) in our Sample Collection System testing, which can withstand up to <30,000Gs of high shock and temperatures as low as -120 degrees Celsius. The Mini One Axis Impact Accelerometer which is responsible to measuring deceleration during impact and depth of impact has a withstanding temperature range of -73 degrees Celsius and up to 177 degrees Celsius without including shock resistant packaging for electronics. In order to test for accuracy; repeatable experimentation to capture temperature range tolerance and high shock survival must be conducted in order to ensure the accuracy of these readings from instrumentation technical specs.

3.1.6 Preliminary Experiment Process Procedures.

Repeatable testing on each instrument by placing them in labs that mimic the concerning elements of the mission and Martian environment is instrumental in accurately predicting mission success. Using lab environment techniques for testing shock resistance such as Drop Tower and Pneumatic Shock Machines, we can get an overall accurate and average prediction of high shock survival to match with the technical specs of each instrument. Using Cryogenic Evaluation we will test the operational functions of each instrument and assembly to ensure that these match that of the technical specs and can withstand the low temperatures on Mars.

Instrumentation calibration will be conducted so that the science payload can withstand the Martian environment and impact; by testing the accuracy of ranges that these instruments can withstand the high shock impact, and extreme temperature ranges that they would encounter on Mars by a higher degree of variance than is needed; testing these conditions on Earth using devices that replicate those conditions is also key in testing for accuracy of these proposed ranges in order to eliminate these potential points of failure. These instruments will be contained and assembled in shock resistant electronics packaging and also be contained within the shock absorbent shell of the probe with a protective heat shield. Integrating these systems within the protective environment of the forbody and aftbody will provide a safer range to ensure the instruments contained within the science payload can function properly after impact on Mars.

3.1.7 Integration Steps and Procedures.

The engineering, instrumentation, and site analysis teams have maintained constant communication throughout the design phase. With an environment open to questions and comments, both teams were able to gain valuable input and requests from each other.

The engineering team specifically was able to solve the needs of the science team to access the subsurface ice by utilizing a ballistic landing and removing the need for a drill. The engineering team was also able to

The instrumentation and science team was in turn able to search out and construct scientific instrumentation that would be able to withstand the forces of such a landing. They were also able to find patch antennas as opposed to the traditional pole antennas. The patch antennas are much easier to construct a payload around as their form is much more functional.

The site analysis team was also able to choose a site that was large enough to contain our entire landing ellipse of 120 by 180km allowing for the entry descent and landing to happen passively without any controls for accuracy.

IV) Descent and Lander Criteria

4.1. Selection, Design, and Verification of Descent and Lander Mechanism

4.1.1 Mission Statement, Requirements, and Mission Success Criteria

Mission Statement:

Our mission will analyze the subsurface ice within the Arcadia Planitia region of Mars using a laser spectroscopy system and soil characterization techniques to evaluate its potential viability as a future landing site for manned missions.

Mission Requirements:

The probe must weigh less than 5 kilograms and fit inside a 0.5 meter cube for cruise. It must be released from orbit of 250km above the surface. The probe and orbiter must not contaminate the Martian samples and environment with any biological agents or species from Earth. The instruments aboard must function at the level that completes their intended purpose for their specific role in data collection. The probe mission cost must be equal to or less than the budget set by NASA. The data collected must match the scientific requirements of the mission.

Mission Success Criteria:

For this mission to be successful, the probe must send back data for one martian day regarding atmospheric density, pressure, and temperature in descent, must impact landing zone at expected velocity, and must deploy scientific payload to perform spectroscopy testing on glacial body. It also must obtain the chemical composition of the ice sheet in Arcadia planitia via the ice sample collected from the probe and send this data back.

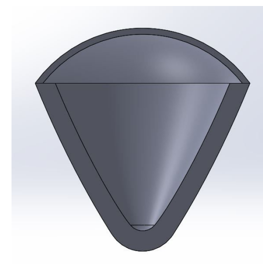
4.1.2 Major Milestone Schedule

- 01/2019 Project Initiation
- 03/2019 Select landing site on Mars
- 03/2019 Finalize Scientific instrumentation for Payload
- 04/2019 Finalize design for Scientific Instrumentation model
- 04/2019 PDR Materials Due
- 09/2019 Manufacturing for Payload begins
- 10/2019 SRR conducted

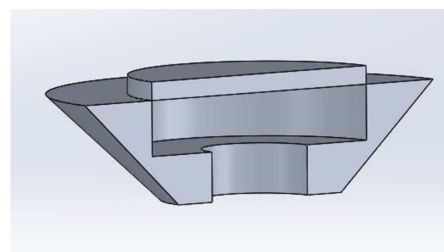
- 09/2020 Payload manufacturing finalized
- 10/2020 CDR conducted
- 04/2021 Earth Test 1 completed
- 12/2021 TRR conducted
- 05/2022 Final Earth Test completed
- 10/2022 Launch date: Cape Canaveral

4.1.3 Systems

Aeroshell (.365 m tall with the diameter of .36m) - A shock absorbent shell that enables the spacecraft to “crash land” into the mars landscape without damaging the inner payload components.



Aftbody (.037 m tall with a diameter of .15 on top and .07 on the bottom) - A casing that holds the experiment components, microprocessor, forebody, and antenna.It also houses the batteries and electronic systems of the payload. Once it has landed this will stay at the surface relaying data from the forebody.



Forebody (.1456 m tall with a diameter of .04m) - A penetrating rod that is shaped to probe the surface of mars using the momentum from the landing of the spacecraft to a depth of .4 to .6 meters. It contains a drill that will collect a sample of ice and a tunable diode laser system to analyze the sample.

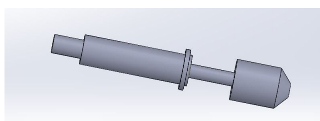
4.1.4 Subsystems.

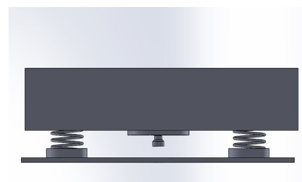
Electronics and Experimental Subsystems to Accomplish the Mission:

Drill (0.02570576 m tall and 0.00381 m wide) - An assembly of parts for a drill that is located in the forebody that will take a sample of the Martian ice under the surface.
Tunable diode laser system - A system that will burn the sample using a laser to analyze the water vapor produced from the ice sample.
UHF Antenna - Able to send the data retrieved back to earth.

Deorbit subsystem:

Spring - An attachment of the orbiter that will give a spin to the payload for stability as it descends through the Martian Atmosphere.
Thrusters - Two thrusters attached to the aeroshell that will enable the probe to deorbit.





4.1.5 *Performance Characteristics for Systems and the Evaluation and Verification metrics.*

The performance characteristics of the EDL system are its ability to safely and accurately place the payload safely at the landing zone with the correct impact velocity and entry angle. The ability of the system to complete these tasks will be evaluated through preliminary testing and computer simulations.

4.1.6 *Verification Plan and Status.*

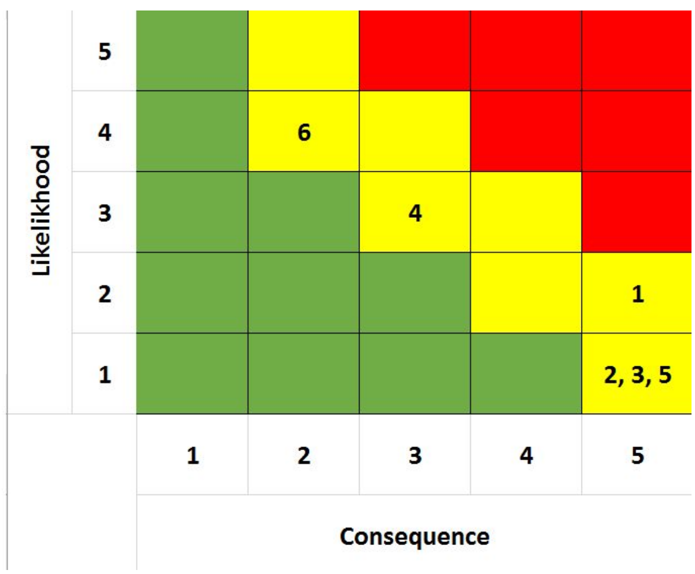
In order to evaluate these characteristics we have and will continue to use computer simulations of the entry. Currently we have produced results for one model of the density and drag of our system. In the future, we hope to run a Monte Carlo simulation with variable density, drag, and initial velocity models. This will allow us to see how our craft performs in a wide variety of different scenarios. Earth drop tests will help validate our simulation results.

The structural properties of the aeroshell will be tested using hypersonic wind tunnel testing as well as air gun impact testing. The wind tunnel tests will evaluate how well the aeroshell handles the immense thermal energy created from the atmospheric drag. The impact tests will verify that the shell shatters upon impact with the martian surface even under the worst possible case of minimum of impact velocity and soft landing site soil.

The directional stability of the craft during entry will be analyzed by using wind tunnel measurements with the aid of computer models.

4.1.7 *Risks and Risk Reductions.*

1.) Deorbit fails due to directional instability
2.) Ballistic impact destroys essential hardware
3.) Data transmission failure due to failure to land within range of the transmission probe
4.) Surface harder than predicted, causing more impact force than predicted
5.) Payload fails to power on after cruise
6.) Testing costs go over budget due to more testing required than predicted



Ultimately, the risks for our project are manageable through adequate testing However, this carries the risk of running over budget. The decision would be to go over budget and considerably increase our confidence in the payload’s ability to handle the strict environment than to skimp on testing and send up a probe with high chance of catastrophic failure.

4.1.8 *Impacts on Project Progression.*

The most complex component will be the aeroshell which will need to satisfy multiple criteria of not only withstanding the heat generated by entry but also shattering upon impact. If the original material chosen is unable to handle these requirements then we would run into budget and time issues.

Besides the aeroshell, the main components that pose risks or delays are the scientific instruments on board the payload that must prove to be durable enough to withstand the impact forces.

4.1.9 *Manufacturing, Verification, Integration, and Operations.*

The manufacturing and verification of our penetrator will be incredibly important as the ballistic landing will impart unusually high stresses on the electronics onboard the system. The manufacturing and verification will be split up into two different groups for the aeroshell and the payload.

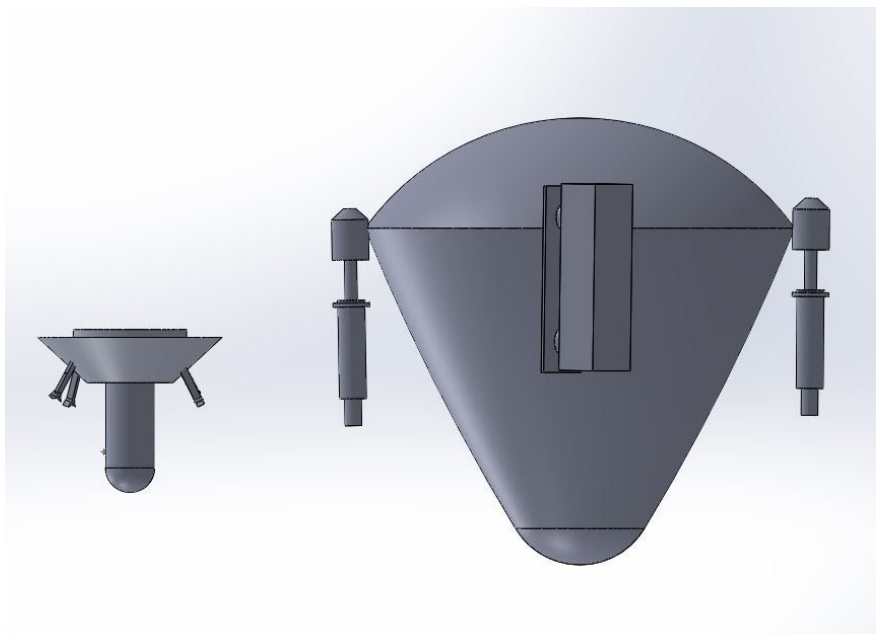
The aeroshell will likely be a manufactured ceramic with the desired factors being low fracture toughness, making the material more brittle and prone to being destroyed upon landing. The aeroshell will also need to have an ablative material layered onto it which will shed the heat away off of the craft. Both of these criteria must be thoroughly tested through impact testing and wind tunnel testing respectively. In order to minimize the amount of time and money spent on manufacturing and testing, the materials performance will also be analyzed via finite element thermal and structural programs.

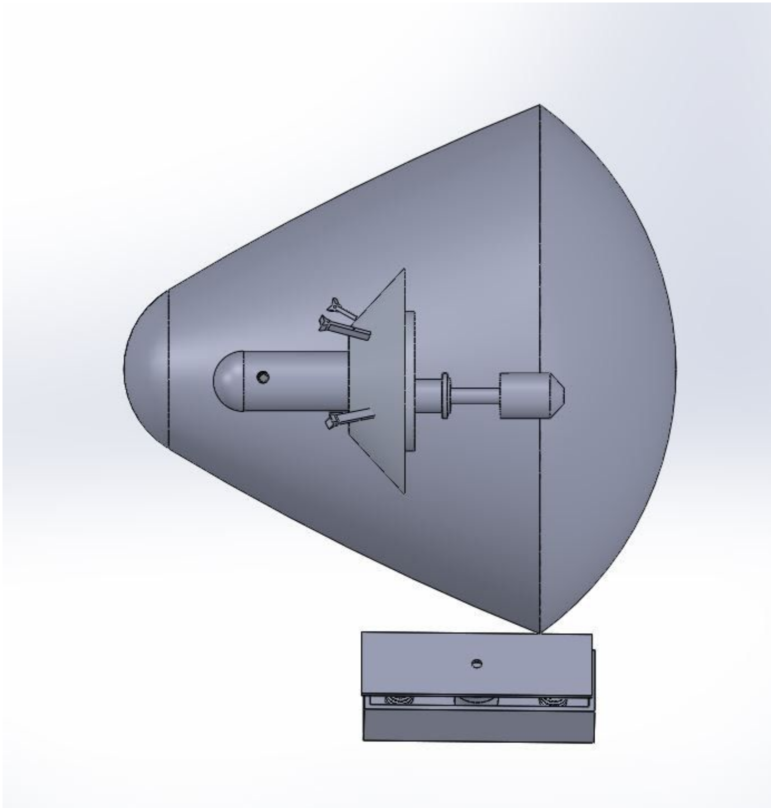
The payload’s forebody and after body will both be machined from carbon steel which was chosen for its high yield strength. Their goal is to withstand the interface collision with the surface of mars. Their structural properties can be measured using standard tensile tests and forego impact testing to save money. Once these tests have been completed, then they can undergo impact testing with the instrumentation placed inside in order to analyze how well the system works.

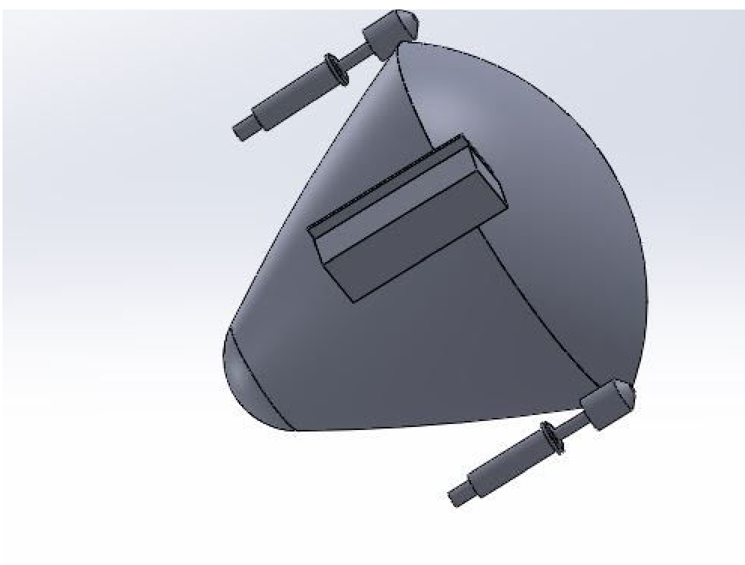
4.1.10 *Confidence and Maturity of Design.*

Our design takes a simplistic idea of using no moving parts to be able to land on mars. Using a direct ‘crash landing’ method we are essentially using the spacecrafts momentum to drive our probe into the ground rather than a drill to do it. We have an aeroshell that will take the original impact and break but the payload inside will be secure due to the inner shell that shall house all the electronic and experiment components. Also, there are legs that will help orient the inner shell upright as the forebody goes into the martian soil and ice.

4.1.11 *CAD of Entire Assembly.*







In these CAD models, the internal parts are displayed outside but parallel to where it would be positioned inside the outer Aeroshell. Their is an exterior model of the spring mechanism that will be attached to the orbiter and spin the probe once released from the orbiter. Along with this there are thrusters enabling the spacecraft to decelerate from orbit to the Martian landscape we have chosen.

4.2 Mission Performance Predictions

4.2.1 Mission Performance Criteria

Mission Performance Predictions:

- Give the probe an angular velocity of 15 rpm and detach from the orbiter at 36.15 N, 55.98 E 250km above the Mars surface.
- Apply a delta V of 45 m/s impulsively over a 20 second burn utilizing two 1N monopropellant thrusters.
- The propulsion system detaches from the payload after burn.
- The craft will passively orient itself in mars atmosphere.
- Utilize atmospheric drag to slow the penetrator down to speeds between 200 +/- 20 m/s upon impact with martian surface.
- Aeroshell shatters upon impact.
- Forebody plunges >0.4m into the Mars soil.

4.2.3 Entry Descent and Landing Simulations

Orbit Simulation:

An orbit simulation was created that simulated the entry of the probe into Mars's atmosphere under the presence of gravitational and atmospheric drag forces. The accelerations for both were modeled using the following vector equations -

$$a_g = \frac{\mu_{mars}}{r^2}\overline{r} \qquad\qquad a_{drag} = \frac{\rho V^2 C_D}{2m}$$

The coefficient of drag, C_D, for the probe and the density model of Mars are the two factors of uncertainty. The density model used in our calculations was the model given by NASA[1] which approximates the density as a piecewise function with an

[1] "Mars Atmospheric Model." *NASA*, NASA, www.grc.nasa.gov/www/k-12/airplane/atmosmrm.html.

interface of 7km. The coefficient of drag was taken to be 1.4 based upon our selected aeroshell geometry and prior data from craft like it[2].

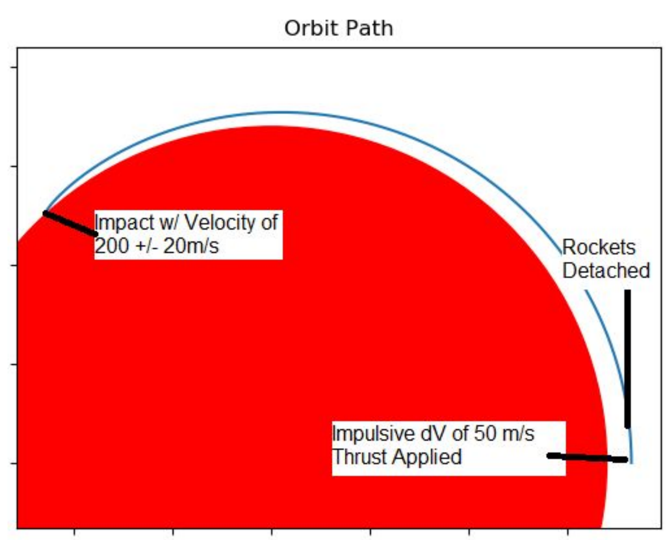
The initial conditions for the craft were it was in a circular orbit with no perturbations 250km above the Mars surface, giving it an absolute speed of 3,430 m/s. The craft will be given an impulsive thrust of 50 m/s (found through simulation) which will lower the craft into the atmosphere and begin braking the craft due to atmospheric drag all the way until the craft impacts the martian surface at 200 ± 20 m/s. Plots of simulated orbit trajectory and velocity, position, and acceleration profiles are given below.

The fuel necessary for the deorbit was calculated using the Tsiolkovsky rocket equation and was found to be ~2% of our initial mass of 4kg or .08kg of fuel. The values of the specific thrust impulse were taken from the data sheet of the selected thrusters[3].

$$\Delta v = I_{sp} g_0 \, ln(\frac{m_0}{m_f})$$

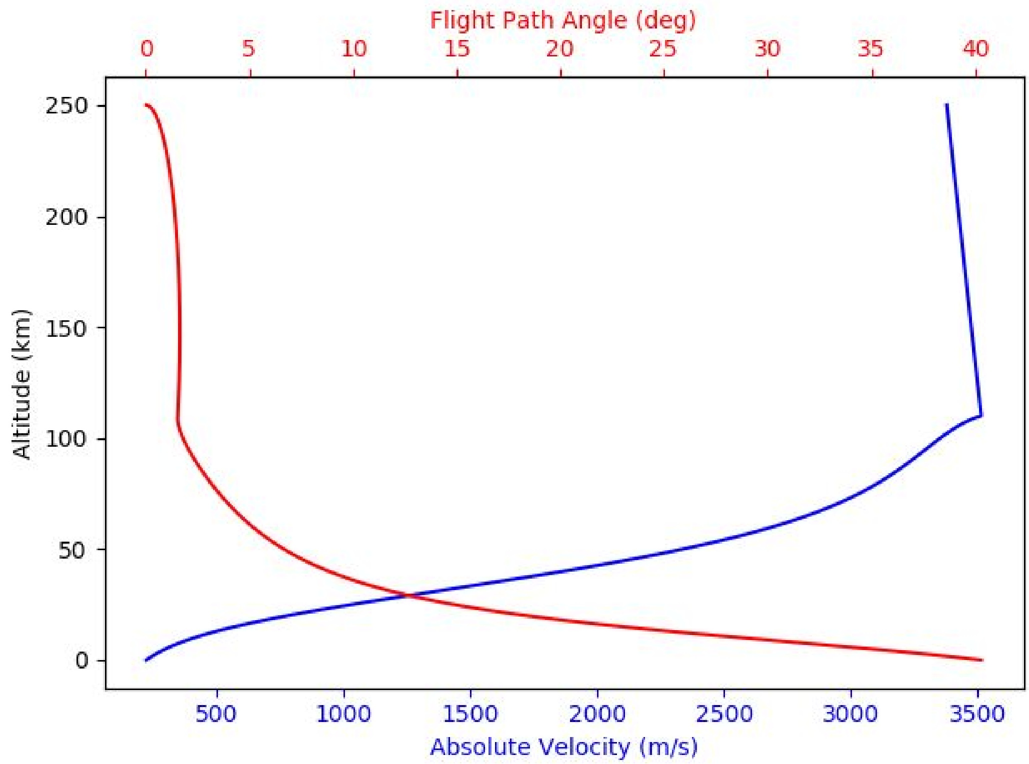
$$m_f = \frac{m_0}{e^{\frac{\Delta v}{I_{sp} g_0}}} = 6.858 \, kg$$

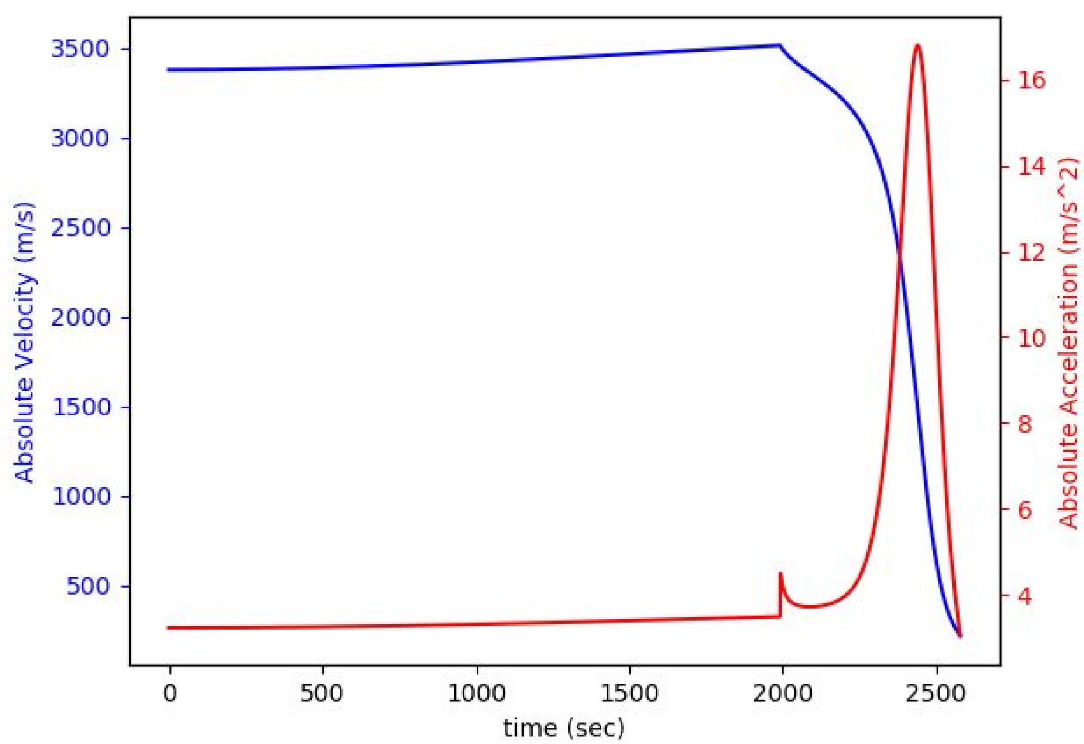
$$Fuel\ Consumed = m_0 - m_f = .142 \, kg$$



[2] Skeen, Michael Anthony, "Conceptual Modeling and Analysis of Drag-Augmented Supersonic Retropropulsion for Application in Mars Entry, Descent, and Landing Vehicles" (2013). Aerospace Engineering Sciences Graduate Theses & Dissertations. 65. https://scholar.colorado.edu/asen_gradetds/65

[3] "1N Monopropellant Thruster Key Technical Characteristics." *Space Propulsion*, www.space-propulsion.com/brochures/hydrazine-thrusters/hydrazine-thrusters.pdf.


Flight Path Angle (deg)
0
5
10
15
20
25
30
35
40
250
200
150
100
50
0
Altitude (km)
500
1000
1500
2000
2500
3000
3500
Absolute Velocity (m/s)


3500
3000
2500
2000
1500
1000
500
Absolute Velocity (m/s)
16
14
12
10
8
6
4
Absolute Acceleration (m/s^2)
0
500
1000
1500
2000
2500
time (sec)

4.2.4 Simulated CP and CG Relationship and Locations.

These are the masses of the three different systems the aeroshell (1st), the innershell (2nd) and the forebody (3rd). When put together the center of gravity would be closer to the lower half of the aeroshell due to the position of the innershell and forebody closer to the nose of the aeroshell. Also this will allow the spacecraft to passively orient itself as it descends into the martian atmosphere and upon landing.

Mass properties of Outer assembly
Configuration: Default
Coordinate system: -- default --

Mass = 1.03 kilograms

Total weld mass = 0.00 kilograms

Volume = 0.01 cubic meters

Surface area = 0.63 square meters

Center of mass: (meters)
X = 0.03
Y = -0.01
Z = 0.02

Mass properties of inner shell
Configuration: Default
Coordinate system: -- default --

Density = 2700.00 kilograms per cubic meter

Mass = 0.69 kilograms

Volume = 0.00 cubic meters

Surface area = 0.06 square meters

Center of mass: (meters)
X = 0.00
Y = 0.00
Z = 0.01

Mass properties of Assem2
Configuration: Default
Coordinate system: -- default --

Mass = 0.56 kilograms

Volume = 0.00 cubic meters

Surface area = 0.03 square meters

Center of mass: (meters)
X = 0.02
Y = 0.06
Z = 0.08

4.3 Payload Integration

4.3.1 Integration of Mars Orbiter and Probe Payload.

The payload will remain attached to the side of the orbiter for the duration of launch, cruise, and all the way up until the orbiter has reached a parking orbit of 250km above the mars surface with an inclination of 90°.

The probes battery life will be monitored through a power connection to the main orbiter to assure that the batteries hold power along the cruise and are recharged if they fall below 80% of their initial power-capacity. This electric feed will also monitor the probe to confirm that the electronics on board are powered off and if powered on for any reason before the release mechanism is broken the orbiter will perform an emergency ejection by releasing the latch early.

Once the probe has reached its parking 250km orbit with 90° inclination and crosses the point of 36.15 N, 55.98 E the payload will begin it's release procedure. The payload will first be spun up to 15rpm along it's symmetrical axis for stability using a motor on the orbiter. Once the payload has reached this velocity, the probe will be detached using the mechanism shown below. The payload will then slowly distance itself from the orbiter due to the impulse of the release mechanism and begin it's deorbit burn once a suitable separation distance has been maintained.

In order to not interfere with the main payload, no electronics on our payload will be powered on until the release system has been activated. This will prevent the thrusters from activating preemptively and harming the orbiter.

4.4 Earth Testing Operation Procedures

4.4.1 System for Earth Analog Testing of Scientific Components

The wind tunnel will be the primary testing system used for examining earth analog component of the probe. The testing will be done at the Sandia National Laboratories Hypersonic Wind tunnel in Albuquerque, New Mexico. The wind tunnel provides data following - diagnostic tests - to help recognize any possible complications that occur based of off certain scenarios. Using the data, engineers can improve the area of the probe that is lacking in confidence. By modifying the flow conditions, engineers can determine which possible stipulations can be hazardous for the probe. The hypersonic wind tunnel simulates speed and flow conditions that are seen in space for an aircraft.

Additionally, Air gun testing will be used to ensure the stability of the penetrator on the payload. It will tested at Eglin Air Force Base in Fort Walton Beach, Florida.

4.4.2 Final Assembly for Earth Testing.

The initial testing will begin following the completion of the first stage of development. Using the completed prototype, the probe will be taken to the hypersonic wind tunnel in New Mexico. The probe will be placed in the tunnel and the diagnostics test will be done on the probe. The data produced will provide valuable information on how to improve the structure of the stage 1 craft. Additionally, it provides feedback on which stipulations the probe does not succeed in. The engineers will use the data provided to finish fix the unsteady portion of the probe. Following the second round of development, the probe will be taken back to the wind tunnel for a final round of testing. If the diagnostics test comes out positive, the probe’s structure is ready to go, however if it is not sound, then final repairs should be done to make the probe structurally sound.

4.5 Safety and Environment for Protocols for Earth-based Testing of a Component from Science Experiment

4.5.1 Safety Officer

The Safety Officer for this team is Michael McGrath and he will be the on-site person at the Earth Testing site.

4.5.2 Preliminary Analysis of Failure Modes of the Proposed Design

The main failure mode implemented in our design is the emergency ejection if the probe is powered on preemptively for any reason. This will prevent the probe from damaging the primary mission of the orbiter from its thrusters.

Other failure modes proposed are emergency battery transmission in which our data acquisition and transmission rates are drastically lowered if the batteries are being drained or start of much lower than their nominal rates. This assures that the mission success criteria will still be met under unexpected circumstances

4.5.3 Listing of Personnel Hazards

In order for a wind tunnel to return valid data, the tests must be conducted to make sure the mach number and Reynolds numbers are within the similarity boundaries. For the results to be within the acceptable range, the value depends on the gas and velocity density in the tunnel. For hypersonic wind tunnel, the values for the velocity and gas density are extreme. Due to this, the primary dangers of using the wind tunnel is the presence of an individual inside the tunnel while it is running. All personels must be located in the control room to avoid the dangers presented from running operations.

4.5.4 Environmental Concerns

The Arcadia Planitia region of Mars, comprised of Amazonian-age volcanic terrain which is mostly flat, produces “Wake Clouds” made up of water and ice that act as a gravity wave that forms as air is forced upwards near topographic regions with higher altitudes. These could be of some concern when landing the impact device inside the crater; however, as the dust is pulled upwards and over the crater from this effect, this is a low risk and should not impact the payload deployment negatively. Deep impact craters in the Arcadia Planitia region provide an opportunistic landing site with low atmospheric pressure (about 600 pascals, compared to Earth’s 101,000 pascals) on the Martian surface. This falls below water’s triple point, causing water ice to sublime into vapor inside deep impact craters the atmospheric pressure increases thus there is more likelihood of not only exposed water and ice, but also liquid water. Since dust is pulled upwards over these topological structures and usually falls in the southern regions, the icy crater should be mostly free of dust providing an optimum testing environment for payload deployment.

V) Payload Criteria

5.1 Selection, Design, and Verification of Payload Experiment

5.1.1 Design Review at System Level

The payload will be composed of the drill and spectroscopy system located within the forebody, the axis impact accelerometer, and the patch antenna telecommunication system.

The drill and spectroscopy system’s purpose is to obtain a sample of the soil around the submerged forebody and test for water within the sample. The sample will be brought to sublimation by heat generated from an electric coil surrounding the sample storage container. If water is present within the sample, then the temperature sensors onboard will be able to detect the anomaly and confirm the presence of water within the system. This system was chosen at is has already been developed for the similar mission Deep Space 2, and would not require research and development.

The axis impact accelerometer will give back valuable information about the hardness of the soil which we land in. Using acceleration data from the fraction of a second it takes for the craft to come to a halt within the martian soil, we will be able to derive how deep our forebody has penetrated. With this data it is also possible to estimate the geological composition of the landing site by comparing the depth achieved with results found from testing of different ice, rock, and dust compositions here on Earth. This system was chosen due to it providing valuable information about the Arcadia Planitia region for little power and mass cost.

The X-band patch antenna telecommunication system purpose is to interface with the main telecommunication probe which will land within 50km of the craft. The patch antennas were chosen as they are better able to handle the hard impact landing and their form is more desirable than the typical pole antenna.

5.1.2 Payload Subsystems.

There are no subsystems. Refer to 5.1.1 for system analysis.

5.1.3 Performance Characteristics for the System.

The payload will be evaluated by its ability to adequately handle the impact landing, accurately record it's science objectives, and transmit the information to the transmission probe. The payload ability to express these characteristics will be assessed via preliminary impact and functionality testing.

5.1.4 Verification Plan and Its Status.

The drill and laser spectroscopy system will be tested using a variety of different soil compositions that the payload might encounter. It's necessary that the drill is able to extract a sample from a potential glacier or pure rock. From there the laser spectroscopy system will be tested to confirm that the sample is heated thoroughly to the proper temperature and that the temperature profile and laser data are able to accurately detect the presence of water within the sample.

The impact accelerometer will undergo air gun impact testing to verify that the instrument begins recording data upon impact and records enough data to extrapolate the position of the craft. It is also necessary that the accelerometer stops recording data once the craft comes to a halt and gives the data to the telecom system.

The telecommunication system will be tested with various configurations of the separation distance between the payload and the transmission probe, entry angles of the craft, elevation differences between the probes, and material interferences between the two craft. The craft will also be tested to see how well it could communicate with the orbiter directly in a worst case scenario where the transmission probe would not function properly.

5.1.5 Preliminary Integration Plan.

Integration of System with Orbiter

In order to assure that the relationship between the payload and the orbiter functions properly from launch until release, the probe will go through stress, power, and functional testing.

The stress testing will confirm that the release mechanism designed will hold through the forces encountered during launch and experience no considerable deformations that would result in a release failure.

The electric system will be tested by assuring that the power relationship between the payload and the orbiter is working nominally, such that the payload’s battery power is monitored and refilled if and only if necessary. The system will also test the failure modes such that the probe is powered on for any reason and must be ejected to prevent damage to the orbiter from the thrusters of the probe.

The release system will be tested to affirm that the system operates properly and that the impulse given by the mechanism will be sufficient to provide a large enough separation distance before the rockets are engaged.

Integration of Payload with Aeroshell

The aeroshell and payload have a few design considerations that went into their integration. Firstly, the aeroshell will protect the payload from the heat of entry and shatter upon impact, allowing the payload to go through the debris. As stated their will be preliminary testing to confirm that the aeroshell can perform this function.

The payload will sit in the front end of the aeroshell to shift the center of gravity of the craft forward and create directional stability. This has been analyzed from computer models, but can further be validated from wind tunnel testing.

5.1.6 Accuracy & Precision of Instrumentation

The impact accelerometer used has a sensitivity for measurements of 20%, but the larger the temperature variation of the environment away from 0 degrees celsius, the more widely varied the sensitivity is. It can function unimpaired in the temperature range of Mars, however, with its operating range from -100 degrees F to 350 degrees F. Additionally, the accelerometer needs to only collect data once, so it does not need to repeat its measurement.

The 8- Lithium-Thionyl Chloride batteries used in the payload are not rechargeable.

The water detection assembly apparatus is not reusable. The collection chamber is sealed after the drill places the sample into it, and there is no mechanism designed to reopen it. The other pieces of this system an be reused, but this will not collect data without a chamber in which to analyze a sample.

5.2 Payload Concept Features and Definition

The concept of this payload is to have a very unique and reliable load carried by the aircraft for the purpose of our mission. The design of this payload is more of a simple design. We decided to keep it minimal, and have a non-traditional approach. This payload is equipped for almost anything it encounters. For example, it is built for a direct crash landing. Our goal when approaching Mars is to have enough momentum from the spacecraft to allow the probe to crash into the ground, and create a deep hole, instead of our drill doing all the work. The probe is built for a hard impact, and still ensures that the payload is safe within. During flight time, we decided that the payload will have no electronics powered on until crash landing has finished. This is to prevent the thrusters from activating, or having anything else activating so the orbiter is not harmed.

One thing that is significant about the payload after landing is that it has small legs that will shoot out, and stand up in order to get itself in an upright position. After the payload is in upright position, it is designed to automatically turn sensors on and start collecting data. As a team, we have decided to have our payload reach a velocity of 15rpm along its symmetrical axis. After reaching the intended speed, the probe detaches, and the payload carefully retreats away from the orbiter. Some creative factors we have incorporated on our payload are our sensors. The payload has 3D sensory for the water ice, and temperature sensors to collect data for what temperature the water ice is.

A unique attribute we thought would be good for our payload was to include a drill that will take a sample from the side of the forebody which will reduce contaminants from the surface on the ice sample. This is a highly sophisticated drill that probes 1 cm in depth to collect about 1 gram of ice samples. On the drill there is a laser spectroscopy device, called a “tunable diode laser” that will directly emit light into the sample. Furthermore, this laser is designed to sense that is vapor is present; it will absorb some of the light. Thus, affirming there is water ice in the depth of the surface. Lastly, the way our payload is collecting and saving the data is through the microprocessor. What happens, is the data will be transmitted to the Orbiter, and sent to the DSN through the UHF antenna.

VI) Activity Plan

6.1 Status of Activities and Schedule

6.1.1 Budget Plan

L'SPACE Budget	2019	2020	2021	2022	2023	2024	
Year	Yr 1 Total	Yr 2 Total	Yr 3 Total	Yr 4 Total	Yr 5 Total	Yr 6 Total	Cumulative Total
PERSONNEL							
Engineer (Pirmohammed, Sharma, McGrath)	$240,000	$247,200	$254,616	$0	$0	$0	
Scientist (Allen, Graham, Schnelle, Maredia)	$320,000	$329,600	$339,488	$349,672	$360,164	$0	
Total Salaries	$560,000	$576,800	$594,104	$349,672	$360,164	$0	$2,440,740
Engineer	$66,984	$68,994	$71,063	$0	$0	$0	
Scientist	$89,312	$91,991	$94,751	$97,593	$100,522	$0	
Total ERE	$156,296	$160,985	$165,814	$97,593	$100,522	$0	$681,211
TOTAL PERSONNEL	$716,296	$898,770	$925,733	$544,859	$561,208	$0	$3,646,865
OTHER DIRECT COSTS	$0						
Total Materials and Supplies	$173	$173	$173	$173	$173	$0	$865
Publications	$0	$0	$0	$0	$0	$0	$0
Total Travel	$0	$0	$0	$10,948	$0	$0	$10,948
Total Services	$0	$0	$0	$0	$0	$0	$0
Total Equipment	$470,527	$0	$2,180,000	$0	$0	$0	$2,650,527
Total Subcontracts (if you have contractors)	$0	$0	$0	$0	$0	$0	$0
Total Participant Support (Interns)	$0	$0	$0	$0	$0	$0	$0
Tuition Remission (not applicable)	$0	$0	$0	$0	$0	$0	$0
Total Direct Costs	$1,186,995	$898,943	$3,105,906	$555,980	$561,381	$0	$6,309,204
Total MTDC	$716,469	$898,943	$925,906	$555,980	$561,381	$0	$3,658,678
Total Subcontract F&A	$0	$0	$0	$0	$0	$0	$0
College or University F&A	$71,647	$89,894	$92,591	$55,598	$56,138	$0	$365,868
Total F&A	$71,647	$89,894	$92,591	$55,598	$56,138	$0	$365,868
Total Project Cost	$1,258,642	$988,837	$3,198,496	$611,578	$617,519	$0	$6,675,072
FED FLOW THROUGH (JPL, ARC, etc.)	$0	$0	$0	$0	$0	$0	$0
Total Project Cost	$1,258,642	$988,837	$3,198,496	$611,578	$617,519	$0	$6,675,072

Travel Budget:

Travel Detail: College Station, TX (CLL) - Coco Beach, FL (MCO)						
Duration (5 days; n-4 nights)	Day 1	Day 2	Day 3	Day 4	Day 5	Totals
Air-fare (roundtrip)+$30 check in luggage each	1,821	0	0	0	0	1,821
Per diem - Hotel ($128 per night x 4 nights)	384	384	384	384	0	1,536
Per diem - Food = $71 (day 1 and 5 @ 75%)	159	213	213	213	159	957
x 5 days (n-4 nights)						
Car rental (compact) @$46/day+Taxes						
x 5 days (weekly rate+ taxes)	0	0	0	0	247	247
Airport Parking, tolls, gas for rental vehicle ($35), mileage to the airport @ $.58/mi	0	0	0	0	70	70
Total	2,364	597	597	597	476	4,631

Travel Detail: Houston, TX (IAH) - Coco Beach, FL (MCO)						
Duration (5 days; n-4 nights)	Day 1	Day 2	Day 3	Day 4	Day 5	Totals
Air-fare (roundtrip)+$30 check in luggage each	956	0	0	0	0	956
Per diem - Hotel ($128 per night x 4 nights)	256	256	256	256	0	1,024
Per diem - Food = $71 (day 1 and 5 @ 75%)	106	142	142	142	106	638
x 5 days (n-4 nights)						
Car rental (compact) @$46/day+Taxes						
x 5 days (weekly rate+ taxes)	0	0	0	0	250	250
Airport Parking, tolls, gas for rental vehicle ($35), mileage to the airport @ $.58/mi	0	0	0	0	62	62
Total	1,318	398	398	398	418	2,930

Travel Detail: Houston, TX (HOU) - Coco Beach, FL (MCO)		Day 1	Day 2	Day 3	Day 4	Day 5	Totals
Duration (5 days; n-4 nights)							
Air-fare (roundtrip)+$30 check in luggage each		478	0	0	0	0	478
Per diem - Hotel ($128 per night x 4 nights)		128	128	128	128	0	512
Per diem - Food = $71 (day 1 and 5 @ 75%)		53	71	71	71	53	319
x 5 days (n-4 nights)							
Car rental (compact) @$46/day+Taxes							
x 5 days (weekly rate+ taxes)		0	0	0	0	0	0
Airport Parking, tolls, gas for rental vehicle ($35), mileage to the airport @ $.58/mi		0	0	0	0	82	82
Total		659	199	199	199	135	1,391

Travel Detail: Austin TX (AUS) - Coco Beach, FL (MCO)		Day 1	Day 2	Day 3	Day 4	Day 5	Totals
Duration (5 days; n-4 nights)							
Air-fare (roundtrip)+$30 check in luggage each		662	0	0	0	0	662
Per diem - Hotel ($128 per night x 4 nights)		128	128	128	128	0	512
Per diem - Food = $71 (day 1 and 5 @ 75%)		53	71	71	71	53	319
x 5 days (n-4 nights)							
Car rental (compact) @$46/day+Taxes							
x 5 days (weekly rate+ taxes)		0	0	0	0	427	427
Airport Parking, tolls, gas for rental vehicle ($35), mileage to the airport @ $.58/mi		0	0	0	0	75	75
Total		843	199	199	199	555	1,995
TOTAL TRAVEL	10,948						

Budget Narrative

Project Overview

Team 27 for L'SPACE Academy 1 designed a small mission concept that characterized ice found on our Human Landing Site. With our instruments and 3D design, we were able to create a payload that would verify if any ice deposits exist at the cite chosen. Our team was allotted a total of $20M for a 50cm cube payload up to 5 kg in mass. The mission spanned a total of five years starting January 2019 to the launch date on October 15th, 2022. All mission costs, including science and engineer personnel time on the project, instrumentation, travel, and other costs were also accounted for in the budget template above. The Travel bank at the end of the Narrative will include images of booked flights, rooms, and car rentals for the team.

Salary

A salary of $80,000 with a fringe rate (benefit) of 28% was used to calculate the salaries of each science and engineer personnel. With three engineers, the total salary cost for the first year was $240,000. Engineers were kept on the payroll until year three in order to counter any discrepancies in the payload and earth testing. Four scientists had a total salary of $320,000 for the first year. They were kept on the payroll for the whole 5 years to gather any data and analyze that data. Each year, a Facilities and Administrative cost of 10% is applied.

Equipment

Out of the $20M allotted, about $470,000 were used towards instrumentation for the payload. All instruments and equipment that was needed either for the payload or just office use was allotted for. The payload consisted of instruments such as two Thrusters, a Mini one axis impact accelerometer, eight Lithium-Thionyl Chloride, one UHF Antenna (400 MHz), a Sample collection system, an Instrument microcontroller, a Tunable diode laser assembly (TDL), a Microprocessor, and a Heat shield. Each instrument made up the mass constraint of up to 5Kg and the size constraint of up to a 50cm Cube. For the remaining office equipment, the total was about $173.00. It mostly consisted of items such as notepads for the team to write on, pens and pencils, first aid kits for any emergencies, and fire extinguishers for any hazards during manufacturing.

The first part of testing was done in April of 2021. The total cost for Wind tunnel testing facility was around$120,000 and the total cost for Air Gun Impact testing facility was around $60,000. However, the manufacturing of materials for the testing was estimated to be a total of $2,000,000. Testing for the launch was completed on May of 2022 before the launch date of October 15th, 2022.

Instrumentation	Weight	Dimensions	Pricing	Power Req.	Source for close estimates
Thrusters	.5 kg		$40,000	N/A	file:///Users/sanijamaredia/Downloads/ECAPS_Overview_March_2013.pdf
Mini One Axis Impact Accelerometer	0.0016 kg	2.8mm 4.1mm	$675.00	140 pF	http://www.pcb.com/products.aspx?m=352A92

		6.9mm			
8- Lithium-Thionyl Chloride battery	.04kg	D-Size Cells or (4 mm 8 mm)	$134.40	3.6 VDC	
1- UHF Antenna - 400MHz	1.4 kg		$29.95		https://www.arcantenna.com/shop-antenna-frequencies/400-490-mhz-uhf/rhwa450sbm-scanner-antenna-for-handheld-police-fire-nascar-hi-performance-long-range-uhf-450mhz-vhf-150mhz-radioshack-uniden-bearcat-whistler.html
Water-detection assembly (Below: part by part)	Total: .064 kg			Total: 1.5w	
1- Sample Collection System	.05kg	11- 3cm	$8,450		https://simpleunmanned.com/collections/payloads-sensors/products/water-sample-collection-system
1- Instrument microcontroller	.01kg	4.8 -3cm	$2.67		https://www.mouser.com/Cart/
1- Tunable diode laser assembly (TDL)	.001kg	.3 - 3cm	21,100		https://www.mt.com/us/en/home/products/Process-Analytics/gas-analyzer/Tunable-Diode-Laser-TDL/oxygen-sensor-GPro-500.html#documents
1- Microprocessor	.0032 kg	2.2 - 3cm	$134.62	6mW	https://www.mouser.com/ProductDetail/NXP-Semiconductors/LS1048ASE7Q1A?qs=sGAEpiMZZMvu0Nwh4cA1wUll2m7DCiigRKuzWllw2MKHBmYDT1PvZw%3D%3D
Heat shield			$400,000		
Total	$470,526.64				

Other material and supplies	Price
16-Notepads	$16.80
2-First Aid Kit	$70.00
2-Fire Extinguisher	$69.00
Pens	$4.97
Pencils	11.99
Total	$172.76

Testing	Price
Renting Wind Tunnel for Testing	60,000
Renting Air Gun for Impact Testing	120,000
Manufacturing for testing	2,000,000
Total	2,180,000

<u>Travel</u>

The travel for the launch and team meeting will happen in year 4 on October 13th, 2022 to October 17th, 2022. The entire team will travel to Cape Canaveral, Florida to attend the launch. All personnel were booked American Airline tickets in Coach at least 3 weeks in advance.

Travel- Airfare:

· Group 1 was travelling from the Easterwood Airport (CLL) in College Station, Texas to Orlando International Airport (MCO) in Coach. The personnel consist of McGrath, Pirmohammad, and Sharma.

- Flight departure from CLL: 6:15am
- Flight arrival at MCO: 12:45pm

- o Baggage check in cost: $30.00 per person
- o The total airfare cost for Group 1 was $1821.00

· Group 2 was travelling from the George Bush Intercontinental Airport (IAH) in Houston, Texas to Orlando International Airport (MCO) in Coach. The personnel consist of Graham and Allen.

- o Flight departure from IAH: 6:35am
- o Flight arrival at MCO: 12:45pm
- o Baggage check in cost: $30.00 per person
- o The total airfare cost for Group 2 was $896.00

· Group 3 was travelling from the Hobby Airport (HOU) in Webster, Texas to Orlando International Airport (MCO) in Coach, The personnel consist of Maredia.

- o Flight departure from HOU: 5:00am
- o Flight arrive at MCO: 12:45pm
- o Baggage check in cost: $30.00 per person
- o The total airfare cost for Group 3 was $478.00

· Group 4 was traveling from Austin-Bergstrom International Airport (AUS) in Austin, Texas to Orlando International Airport (MCO) in Coach. The personnel consist of Schnelle.

- o Flight departure from AUS: 5:05am
- o Flight arrival at MCO: 10:49am
- o Baggage check in cost: $30.00 per person
- o The total airfare for Group 4 was $632.00

· Each personnel's flight had one stop at the Dallas/Fortworth International airport (DFW). Groups 1-3 boarded the same flight from Dallas and arrived together in Florida.

Travel- Airport Parking:

· Group 1 carpooled and arrived at Easterwood Airport around 5:00am and parked their car at the Easterwood parking lot for $35.00 for the entire week.

· Group 2 carpooled and arrived at the George Bush Intercontinental Airport around 5:15am and park their car at the Ecopark lot for $27.70 plus tax for the week.

· Group 3 drove and arrived at the William P. Hobby Airport around 3:30am and parked her car at the Ecopark lot for $47.10 plus tax for the week.

· Group 4 drove and arrived at the Austin-Bergstrom International Airport around 3:30am and parked her car at the Ecopark lot for $40 for the week.

Travel- Car Rental:

After arrival at the Orlando International Airport, Schnelle arrived first with her friends and family. She got a compact car rental through American Airlines alone to drive her family to the accommodation while the others separated into groups of three (Group 1 and Group 2/3).

- Group 1 consists of three personnel who rented a car together. Their rental total for the Nissan Versa was $246.95, which was about $46 per day. They also received $35.00 for gas during the week.
- Group 2 and 3 joined together and rented their Ford Focus through American Airlines for $250.28, which was about $47 per day. They also received $35.00 for gas during the week.
- Group 4 rented her Ford Focus through American Airlines for $427.09, which was about $67 per day. She will also receive $35.00 for gas during the week.

Travel- Hotel Accommodation:

Each personnel were booked a separate room at the Country Inn Hotel for 4 nights for a total of $3,885.00 and the average nightly rate was about $123.89. They received a lodging per diem of $128 per person for every night booked. Each team member also received per diem rates of $71 per day, but only 75% of the per diem rates on travel days. They received $53.00 on October 13th and October 17th, 2022 and $71 for the days in between for their meals. On October 17th, 2022 the team checked out of their accommodations and returned their car rentals around 12:00 or 12:30pm in order to board their flights at 1:35pm to take them to their respectful locations.

Future proceedings:

The year 2023 will be the last year of the project. In this year the scientists will be on payroll to overlook the progression of the payload towards the mission goal and the end of year five will mark the mission deadline, hopefully showing results that were hypothesized.

6.1.2 Schedule – L'SPACE Academy 1:

Conduct Background Research about Mars Environment/Current Mission Technologies			2/20/19	2/27/19
Conduct preliminary research on landing sites with water present on/less than one meter below surface near equator	Jessica, Kelly, Catherine	100%	2/10/19	2/22/19
Conduct intro research on Mars lander mission power requirements and delivery methods	Mihael, Kelly	100%	2/10/19	2/23/19
Conduct intro research on current descent technology available for rover/lander missions	Michael, Anikait	100%	2/10/19	2/23/19
Brainstorm Lander Designs			2/10/19	3/3/19
Choose three potential descent technologies/options and organize into trade study	Michael, Anikait	100%	2/21/19	2/25/19
Choose three potential lander technologies/options and organize into trade study	Michael, Anikait,	100%	2/21/19	2/25/19
Use trade studies in congruence to pick compatible descent/lander technologies	Michael, Anikait, Mahir	100%	2/25/19	2/27/19
Use landing site and chosen technologies to brainstorm integration	Michael, Anikait, Mahir	100%	2/27/19	3/3/19
Use landing site to brainstorm Scientific Payload instrumentation	Cat, Jessica	100%	2/27/19	3/3/19
Science Deliverables			2/10/19	3/10/19
Use JMARS to pick 3 potential landing sites	Jessica, Kelly, Catherine	100%	2/23/19	2/24/19
Create costs-benefits list of each proposed landing site	Jessica, Catherine, Kelly	100%	2/24/19	2/27/19
Select a Candidate Landing Site from chosen three	Jessica, Kelly, Catherine,, Mahir	100%	2/27/19	3/2/19

Compile environmental factors of landing site list for rover/descent consideration	Mahir, Catherine	100%	2/27/19	3/5/19
Use brainstorm notes to create rough outline of scientific instrumentation	Jessica, Catherine	100%	2/27/19	3/2/19
Finalize Scientific Instrument for Payload	Jessica, Catherine, Mahir	100%	3/2/19	3/10/19
Budget			2/10/19	3/30/19
Create and continually update materials list for subteams	Sanija	100%	2/10/19	3/30/19
Research and compile personnel budgeting requirements	Sanija	100%	2/10/19	3/10/19
Create budget spreadsheet for all project expenditures	Sanija	100%	2/10/19	3/30/19
Engineering Deliverables			2/23/19	3/30/19
Model the flight path and characterize the heating/pressure on craft during descent	Michael, Anikait	100%	2/23/19	3/4/19
Begin rudimentary heat shield design for system limitations (50 cm)	Mahir	100%	3/2/19	3/6/19
Finalize choices of power requirements/delivery and batteries	Mahir, Sanija	100%	2/24/19	3/2/19
Create layout of electrical system including chosen specifications of power requirements/delivery and batteries	Mahir, Sanija	100%	3/2/19	3/17/19
Design CAD Model for Delivering System	Mahir, Sanija	100%	3/8/19	3/24/19
Design CAD Model for Lander system	Mahir, Sanija	100%	3/12/19	3/24/19
Cad Scientific instrumentation model	Mahir, Sanija	100%	3/24/19	3/28/19
Check integration of CAD models for electrical, landing/descent systems, and scientific instrumentation	Mahir	100%	3/28/19	3/30/19
Preliminary Design Review			3/17/19	4/4/19
Subject I and II (Summary/Evolution of Project)	Michael, Kelly	100%	3/17/19	3/30/19
Subject III (Descent and Lander Criteria)	Anikait, Micahel	100%	3/24/19	3/30/19

Subject IV (Payload Criteria)	Kelly, Cat	100%	3/17/19	3/30/19
Subject V and VI (Activity Plan and Conclusion)	Kelly, Cat, Anikait	100%	4/01/19	4/10/19
Peer Review	All	100%	4/13/19	4/13/19
Preliminary Design Review Document Completed	Kelly, Cat, Anikait	100%	4/15/19	4/15/19
Preliminary Design Review Document Due	All		4/15/19	4/15/19
Weekly Meetings - Subteam Updates			1/28/19	4/4/19
Week 1 Meeting - Introduction	All	100%	1/28/19	1/28/19
Week 1.1 Meeting - Org Chart Planning	All	100%	2/1/19	2/1/19
Week 2 Meeting - Finalizing Team Structure	All	100%	2/5/19	2/5/19
Week 3 Meeting - Assign Tasks to Subteams	All	100%	2/12/19	2/12/19
Week 4 Meeting - Detail goals and milestones for each subteam	All	100%	2/19/19	2/19/19
Week 5 Meeting - Review Site Analysis progress	All	100%	2/24/19	2/24/19
Week 6 - Update as needed	All	100%	3/3/19	3/3/19
Week 7 - Update as needed	All	100%	3/10/19	3/10/19
Week 8 - Update as needed	All	100%	3/17/19	3/17/19
Week 9 - Update as needed	All	100%	3/24/19	3/24/19
Week 10 - Perform peer review	All	100%	3/31/19	3/31/19
Week 112 - Review edits & Finalize PDR	All	100%	4/15/19	4/15/19
Scientific Milestones			2/23/19	3/10/19
Task 1 - Finishing Researching All Data	Jessica, Kelly, Catherine	100%	2/21/19	2/20/19

Task 2 - Select a Candidate Landing Site	Jessica, Kelly, Catherine, Mahir	100%	2/27/19	3/2/19
Task 3 - Finalize Scientific Instrument for Payload	Jessica, Catherine, Mahir	100%	3/2/19	3/10/19
3D Modelling Milestones			3/8/19	3/28/19
Task 1 - Finalize 3d model of the spacecraft	Mahir, Sanija	100%	3/8/19	3/28/19
Task 2 - Finalize 3d model of instrument on or in spacecraft	Mahir, Sanija	100%	3/24/19	3/28/19
Project Management Milestones			2/10/19	4/4/19
Task 1 - Finish budget	Sanija	100%	2/10/19	3/30/19
Task 2 - Finish rough draft of PDR	Kelly, Cat, Anikait	100%	3/17/19	3/30/19
Task 3 - Finish finalized PDR	Kelly, Cat, Anikait	100%	3/17/19	4/4/19
Entry/Descent Milestones			2/25/19	3/30/19
Task 1 - Descent System Finalized	Michael, Anikait, Mahir, Mahir, Sanija	100%	2/25/19	3/24/19
Task 2 - Aerodynamic forces and heating characterized	Michael, Anikait	100%	2/23/19	3/4/19
Task 3 - Flight Path Model finalized	Michael, Anikait	100%	2/23/19	3/4/19
Electrical Engineering			2/10/19	3/30/19
Task 1 - Finish all system specifications	Mahir, Sanija	100%	2/10/19	3/17/19
Task 2 - Finish CAD of electrical system	Mahir, Sanija	100%	3/8/19	3/24/19

6.1.3 Mission Education and Public Outreach Summary

Our mission education and public outreach will utilize both social media and community interaction through a public event that will include informational and exciting activities to help the audience understand the goals of this mission. Social media accounts through Instagram, Facebook, or even Twitter will allow us to reach a broader audience of different ages by providing visuals from the mission and payload. Uploading various images of the payload and the steps taken towards our deadline will further public interest in our mission and make them feel included throughout our process.

Social media will be an important platform to promote our public outreach where everyone would be invited to meet with our team and see our development of the project in person. They would not only be able to ask questions about the making of payload, but also visualize a remake of how the payload landed on the surface of Mars through our VR goggles. This activity will spark more interest in people of all ages and allow them to share our celebration of its successful completion. Both social media and our public event are a way to include our community in our goal. This not only opens doors for more conversation with others, but also motivates the younger generation to work towards a goal that may go farther than Mars.

VII) Conclusion

7.0 Summary of Mission

7.1.1 Progress on Mission Formulation and Design up to CDR.

The mission has been reviewed by the team leading L'SPACE, and design oversights or otherwise incorrect assumptions were improved upon. An area looked into is the reusability of the scientific instruments, as nearly all are not reusable and this can limit results or even scrap a mission if the first round of testing is inconclusive. Design improvements may include having three chambers to ensure multiple trials and therefore more precise results, or an extra instrument whose purpose is that of a waste receptacle. This could also call for the addition of payload subsystems. Improving upon the depth of design will be the focus leading up to the CDR, as the mission goal remains the same.

7.1.2 Testing Results and Mission Success Outlook.

An inexpensive way to test the results of the design from Academy one and Academy two would be a very thorough trade study of every subsystem and component. Constructing a working model is a highly impractical goal given the limited time, knowledge, and resources of undergraduates. Once this trade study is completed, the mission designs can be fully compared to give an accurate result to what improvements benefited the mission goals as a whole and where our design improved significantly. Overall, our design could be successful if a careful review is done of its components.