RESOW

REcurring Slope lineae OvervieWer

Preliminary Design Review

Inaugural L'SPACE Level 1, Team 5

To the Reader

This document serves as the preliminary design review imposed on L'SPACE Team 5 at the NASA L'SPACE Academy Level 1 during the Fall of 2018 for the development and operation of [name of mission]. It serves as the official paper of the [name of mission] mission and contains the evolution of the project, descent and lander criteria, payload criteria, plan of action, any changes made throughout the project process as well as the current mission standing.

This is a student project, and should not be treated as an actual mission. The reason behind this review is to gain InSight [shameless plug] on mission development and requirements to actual NASA missions. This academy was developed by NASA employees and lead by Sheri Boonstra, Dan Garcia et al. This paper was created by the first group of students in this new program.

Document Revision History

Revision	Date	Sections Changed
1	30 Nov 2018	Baseline
2	Date	1. *will not be revised until Spring 2019

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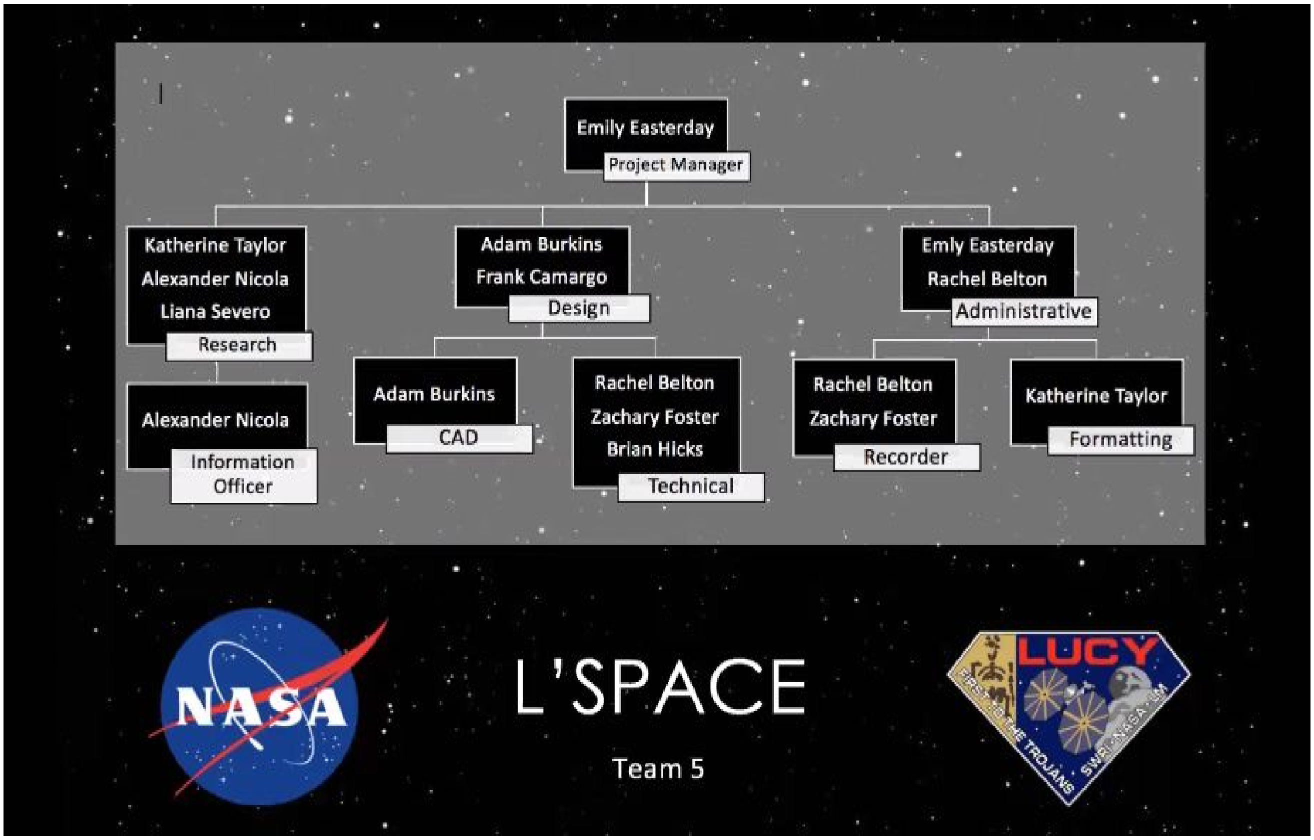
1.0 Summary of PDR Report

1.1 Team Summary



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1.2 Descent and Lander Summary

1.2.1 Earth Prototype

Our design process started with the constraint of only having mechanical functions. As such,we knew we must harness the force of gravity as our work mechanism. To accomplish this we plan to deploy a parachute from the top of the Cubesat and utilize the tension forces created by the decelerating effects of the parachute to a string attached to each landing leg.

The landing legs are mounted on axles and the upward pulling force of the parachute translates into rotational force on the landing legs, deploying them outside the vehicle. This method of combining the two systems into one process saved on weight and simplified the overall design by using the excess work from the parachute to deploy the landing mechanism.

1.2.2 Mars Prototype

Our design process for the Mars lander was to use proven methods from previous NASA missions as our basic mechanics. These included the PICA-X carbon fiber heat shield and the nylon, kevlar and Technora blended material for the construction of the descent vehicle.

1.3 Payload Summary

Argus 1000 Infrared Spectrometer - Space Grade Version + Kit
RAD6000 single onboard computer by IBM
Thermal Control System
Lithium Ion Batteries

1.4 Scientific Objective

To determine or rule out possible compositions of the seasonal flows called Recurring Slope Lineae (RSL) on the surface of Mars.

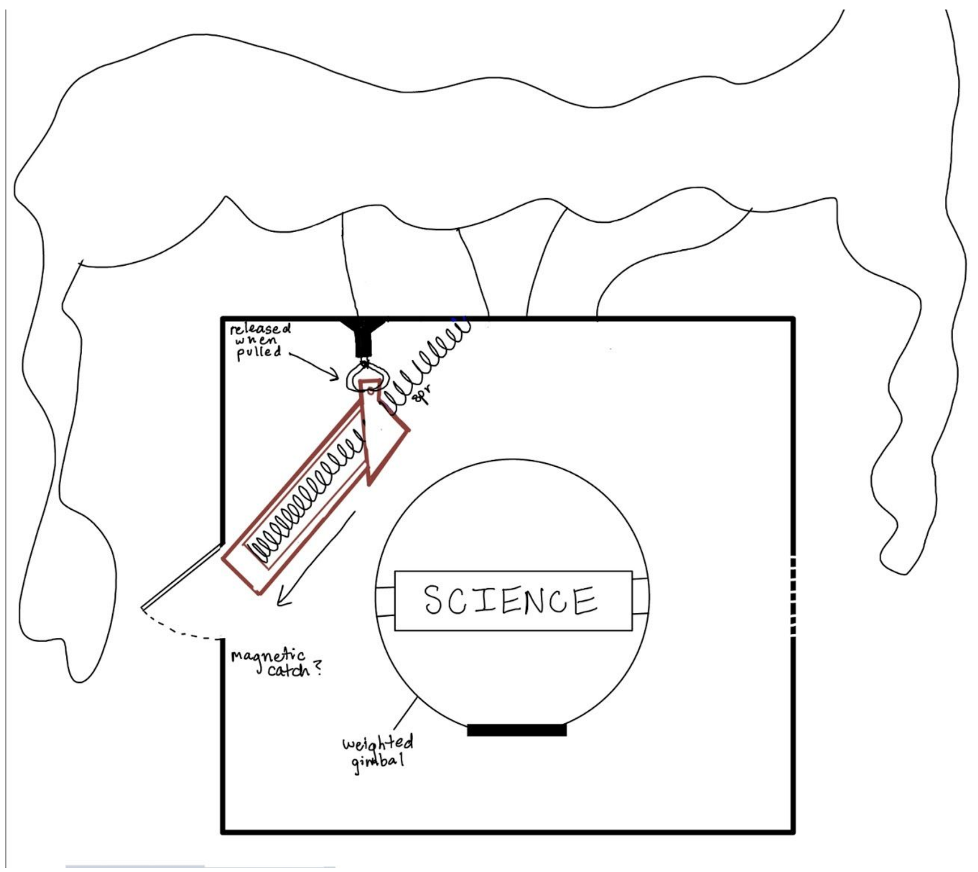
2.0 Change Log

2.1 Descent and Lander Changes

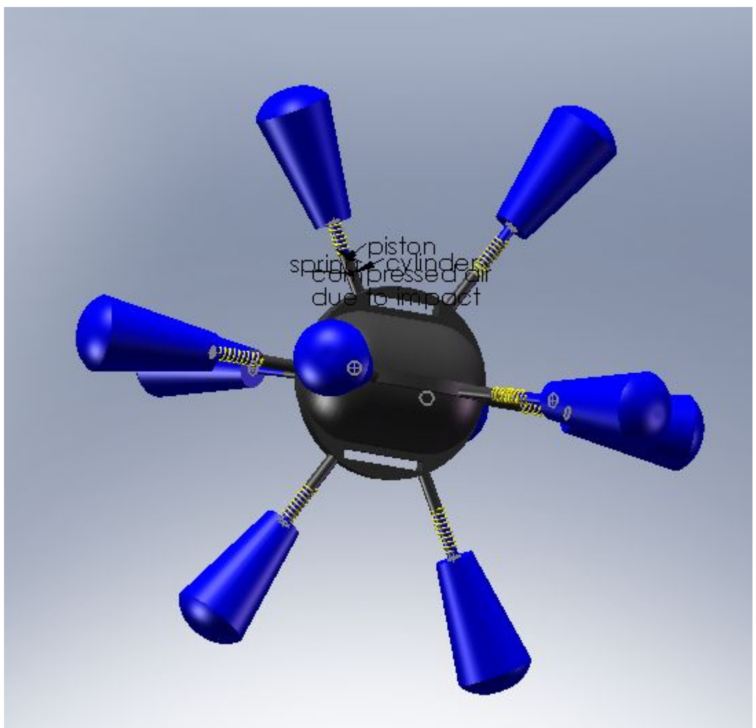
2.1.1 Original Concept

Our original design consisted of a four spring landing mechanism which was deployed by the forces of the parachute through a string attachment and a release plate. The parachute was deployed by the weight of the body pulling away from the lid of the cube and releasing the parachute from the open top.

We also considered a compressed air canister being released through the force of the parachute that would inflate a balloon at each corner to create the landing mechanism. We abandoned this idea because we did not think that the tension of the parachute would be great enough to release the compressed air.



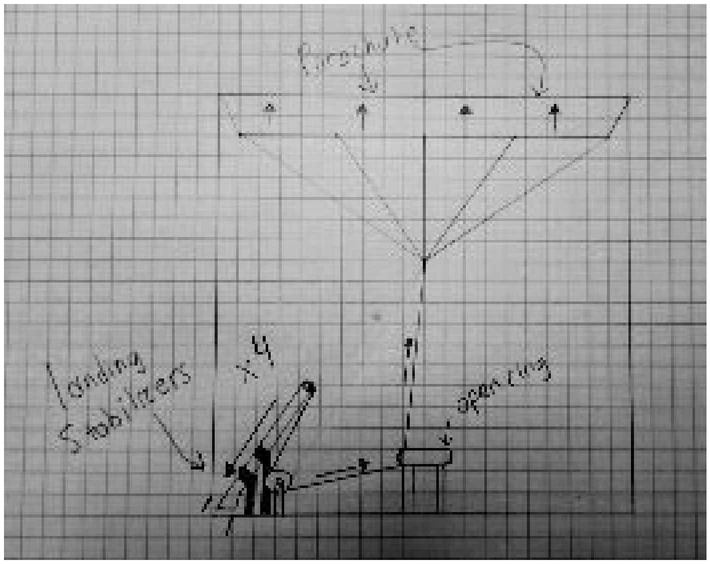
The dark blue mechanism part in the above right GIF would initially be rested in a downwards position where the clasp is closed. The parachute is attached to this blue part and once deployed would pull up on the mechanism and release the clasp, resulting in the spring mechanism to be released and the righting-leg to be deployed out the side.
The scientific package would primarily rest in a weighted gimbal so that the instrumentation would be oriented upright no matter how the vehicle might land. Shock absorbers that would propel from all sides (see the figure below) were considered so that the vehicle could land in whichever orientation without the need for a self-righting mechanism. A gimbal creates complications, however, due to the need to wire the instrumentation to heaters attached to the inside of the descent vehicle walls. A design that would require a gimbal was too complicated a design process for the little manpower and time we had to allocate towards this project and was thus dropped.



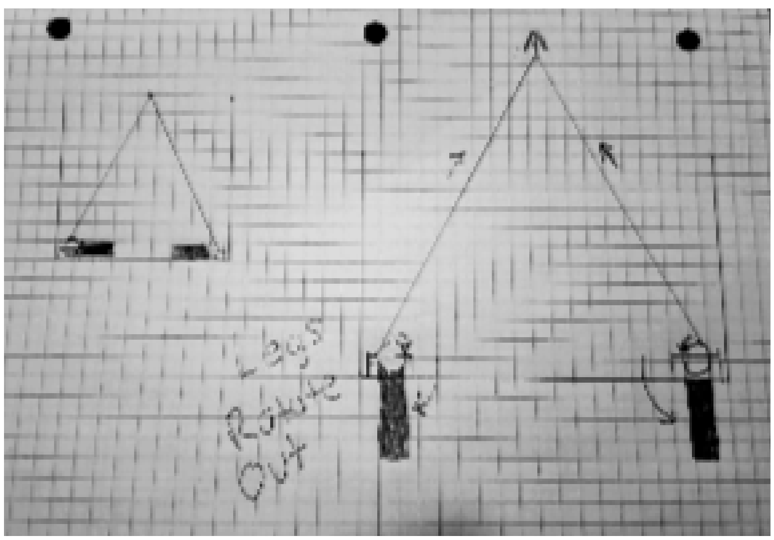
Source: https://grabcad.com/library/sock-absorbing-dashpot-and-spring-1

2.1.2 Second Design

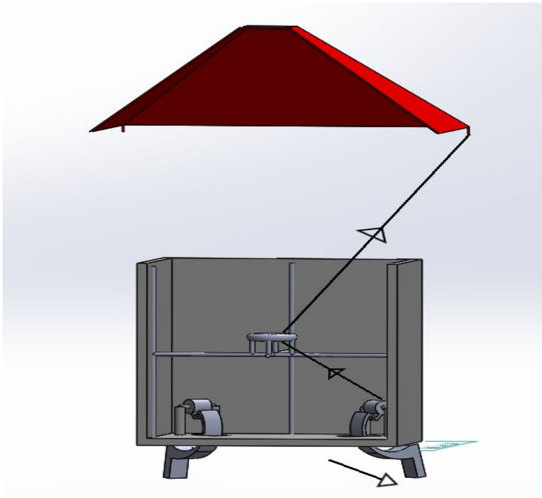
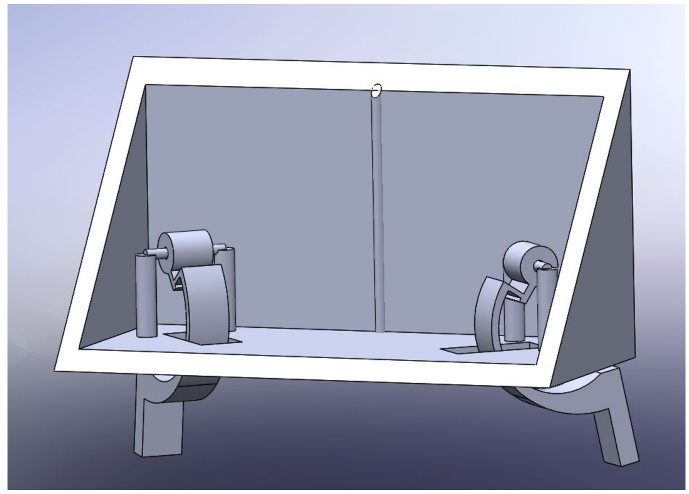
We moved away from the spring landing mechanism due to its complexity and chance of rebounding off the ground upon landing, which could endanger mission safety. We then moved to a leg that slid out of the bottom through a pulley and a slide track system driven by the pulling of the string by the parachute. This design proved too intricate to be reliable or cost effective inside of our twenty dollar budget.



We decided to design a leg that would rotate out from the bottom of the cube using the force of the parachute. The base of the legs will be the outside casing of the Cubesat and will be deployed through a swing arm that attaches the leg base to a mounted axle inside that is rotated through the rising of the parachute string.



We further enhanced this design by deploying the legs outward at a one hundred and thirty degree angle from its original position. We also incorporated a central ring for organizational help with the strings inside and to assist in centralizing the pulling force of the parachute and distributing it evenly to each leg.

2.2 Science Package Changes

2.2.1 Scientific Objective/Instrumentation

1. We first contemplated tardigrade re-animation kits, but bringing anything biological to Mars is against NASA's Policy Directive against biological contamination [(NPD) 8020.7G] so this scientific objective was dropped.
2. We explored the possibility of looking for life where magnetic fields still exist on the surface, as this may be one of the last areas life could have survived if it ever was ever present on Mars. Magnetometers were researched but found to be impractical as the magnetic field of Mars has been mapped out with accuracy.
3. Detecting localized surface emissivity and surface thermal inertia were researched but were found to be impractical for relevant research due to technology already being sufficient in existing Mars orbiters.
4. We looked into ramen spectroscopy to search for biosignatures. Not having a chemistry student on our team made this instrument hard for us as we did not understand its uses well. We could not find any molecule we could say was definitely a detectable biosignature because of this.
5. Any radar-based instrumentation was found to be not viable due to the scope and requirements of the project being too small for anything of relevant enough power.
6. We were going to use a gas chromatograph to look for possible gases expelled by possible life, but no gas chromatograph would fit the payload restrictions within a reasonable budget.
7. Catalytic and infrared gas detectors were researched but found to be impractical for numerous reasons. Catalytic Detectors are easily contaminated and would need shielding and a heavily controlled environment in order to meet scientific requirements.

A Catalytic detector would only be able to test for a single gas, reducing the versatility that the project may be able to have if other instruments were used instead. Infrared gas detectors require a large amount of the required gas to be tested in order to work, and was deemed not viable due to the uncertainty of such concentrations in any possible landing sites.

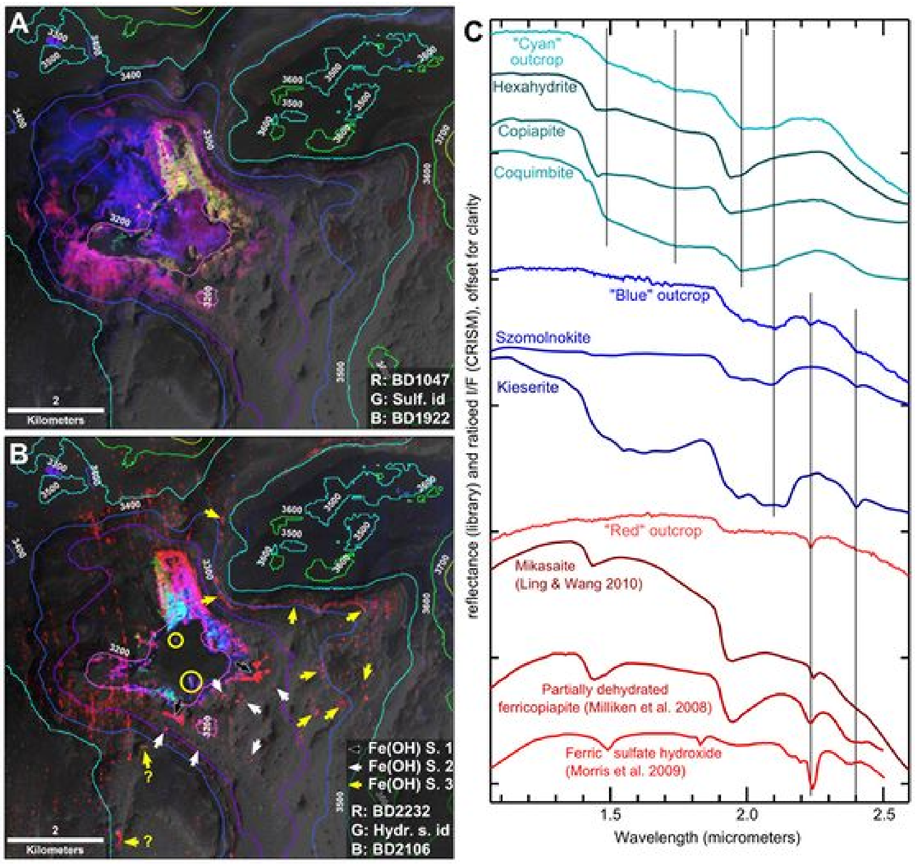
8. We looked into a polarimeter. When there is life, one enantiomer would be favored over the other, whereas a 50/50 racemic mixture would suggest the absence of life. We could not find an instrument to fit the physical boundaries of our payload carrier, so this scientific objective was dropped.
9. Methane detection was a primary scientific objective in our research. Halites are thought to play a possible role in methane sequestration on Mars; carbonaceous material could trap Methane in halite deposits but released via aqueous alteration, aeolian abrasion, heating, or impact shock. This scientific objective was scrapped upon consultation with the L'SPACE mentors. Methane detection was too impractical for the technology and scope of the project requirements given.
10. Our current scientific objective is to look for signs of water and organics in recurring slope lineae (RSL). We believe that a laser infrared spectrometer is the instrument that can answer our scientific objective.

2.2.2 Landing Site

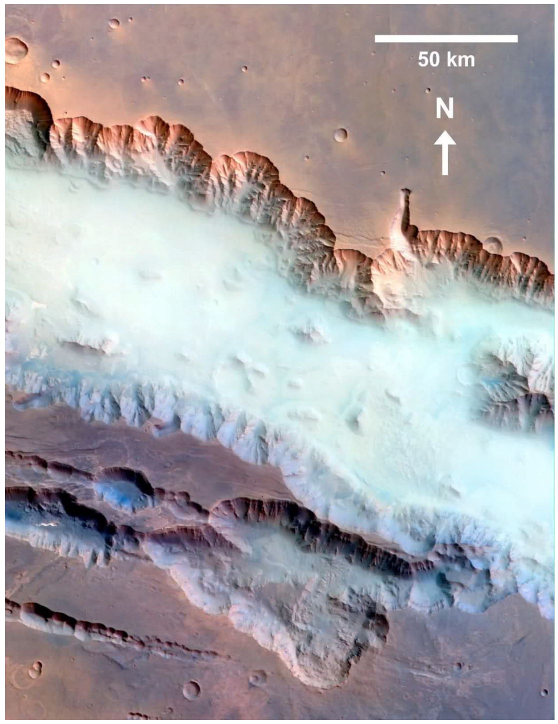
1. Starting this project, we weren't completely sure what we were trying to do, so we initially started with the Newton crater due to its high amount of pyroxene and possible lava tubes, we first decided against it because of the low magnetic field in the area and the draw to more diverse landing site options.
2. Next, we looked to Horowitz to be our landing spot, it had more information available, and seemed to be in an easier spot to land, after some more research, though, we decided that since it was such a recently created crater it probably wouldn't have a lot of the materials we were looking for since they were likely blown out on impact.
3. Next we focused on Noctis Labyrinthus because we thought it to be likely that we find microbes there that might be useful to us. It had a spot with a moderate magnetosphere which was of interest to us and our initial scientific objective of finding a place where the Martian magnetosphere was still strong in order to determine if there were any differences in soil or other compositions. "A depression in Noctis Labyrinthus has some of the greatest mineralogical diversity yet observed on Mars" [*Weitz et al.*, 2011] and would provide an interesting place to inspect with instrumentation. The area was close to the equator and had hot spots from landslides occurring over time on the slopes. The area shows many signs of having a large amount of pre-existing volcanic

or geothermal activity. There are many depressions and other areas which are characteristic of water having been present.

4. We also considered Arabia Terra, Elysium Planum, and Arcadia-Memnonia as they were seen to contain some of the highest methane concentrations detected on Mars. These landing sites were discarded once we changed our scientific objective from detecting methane to determining the composition of Recurring Slope Lineae.



Source: **https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2011JE004028**



Fog from noctis was an interesting characteristic that went into consideration when determining our scientific objective and instrumentation.

5. After much deliberation, we finally decided to focus on Recurring Slope Lineae on Mars which made us look back to Newton. Newton might be the only evidence of flowing water on mars, and seems to have evidence that it might still be active.

3.0 Descent and Lander Criteria

3.1 Selection, Design, and Verification of Mechanical Descent and Lander Mechanism

3.1.1 Mission Statement

To form a cohesive team, where all opinions and ideas are valued, while advancing the scientific body of knowledge through successful design, testing, and deployment on Mars.

3.1.2 Requirements

Non-Functional Requirements

#	Requirement	Description	Additional Details
1	Mission Statement	A written declaration of the project's purpose and focus.	
2	Requirements	A description of all things needed or wanted to create a successful mission.	Include Functional and Non-Functional Requirements.
3	Mission Success Criteria	The complete fulfilment of all objectivest, without any unplanned loss of property.	
4	Major Milestone Schedule	A schedule of all of the significant and major project-related milestones.	Milestones include Project Initiation, Design, Manufacturing, Verification, Operations, and Major Reviews.
5	Verification Plan	Independent procedures used for checking that the system meets requirements and specifications and that it fulfills its intended purpose.	Describe the status of the verification plan.
6	Performance Characteristics	A description of the performance characteristics for the system / subsystems.	Includes the evaluation and verification metrics.
7	System Level Design Review	A review of the design at a system level that goes through each system's functional requirements.	Includes sketches or CAD of options, selection rationale, selected concept and characteristics.
8	Risk Plan	Definitions of the risks and the plans for reducing the risks for each system that	Take all factors that might affect the project including risks associated with testing,

		demonstrate an understanding of all components needed to complete the project and how risks/delays impact the project.	acquisition and/or delivery of parts, adequate personnel, holiday schedules, budget costs, etc.
9	Demonstrate Planning	Demonstrate planning of Manufacturing, Verification, Integration, and Operations.	Include Component Testing, Functional Testing, or Static Testing.
10	Change Log	An account of project changes.	
11	CAD Drawing	A detailed 2D or 3D illustration displaying the components of the project.	
12	Mission Performance Predictions	Flight profile simulations, altitude predictions with simulated descent and lander data, component weights, different descent profiles depending on Earth and Mars local weather conditions, stability margin, simulated Center of Pressure/Center of Gravity relationship and locations.	State mission performance criteria.
13	Integration Plan	Combining subsystems to become a whole system that works cohesively	
14	Dummy Payload Final Assembly Outline	Drawing of the overall lander and payload with scientific instruments	
16	Payload Preliminary	Outline of integration	

	Integration Plan	plan	
17	Payload Analysis	An analysis of the payload's instrumentation, repeatability of measurement, and recovery system.	
18	Science Value Analysis	Science payload objectives, success criteria, and preliminary experiment process procedures.	Describe the experimental logic, approach, method of investigation, test and measurement, variable and controls, relevance of expected data, and accuracy/error analysis.
19	Budget Plan	List of materials and respective prices that fits given budget	
20	Timeline	Order of operations with due dates	
21	Outreach Summary		

Functional Requirements

- Lander Volume
  - 30cm x 30cm x 30cm cube.
  - Carried inside of a slightly larger box.
  - Mission instruments must fit inside of volume restriction.
- Mass of Lander
  - 500g Maximum
- Science package needs to land safely and upright or be self-righting upon landing once dropped from a height of 9 meters.
- Electronics to transmit data results from science payload to a Mars orbiter using UHF frequencies.
- Mission must comply with Level IVc planetary protection requirements (contamination [insert documents and MSDS here]

3.1.3 Mission Success Criteria

The Mission will be considered successful if it meets the following criteria:

- Lander volume is a 30cm x 30cm x 30cm cube.
- Mass of lander is 500g maximum
- Science package lands safely and upright or be self-righting upon landing after a 9m drop.
- Scientific Instrumentation successfully completes objectives with precision.
- Scientific Data is transmitted to Mars Orbiter

3.1.4 Systems Review

Descent Vehicle

Materials

Earth Prototype

1. Cardboard
2. Duct Tape
3. 3D Printed Plastic
4. Fishing Line
5. Plastic Sheet

Mars Prototype

Casing:
1. 5052-H32 Sheet Aluminum
2. 6061-T6 Aluminum

Heat Shield:
1. PICA-X
2. Aluminum Alloy

Parachute:
1. Nylon
2. Kevlar
3. Technora

Descent-Vehicle Selection Rationale

Earth Prototype

The constraints of the twenty dollar budget and the five hundred gram weight limit the usage of hi-tech materials. The materials chosen in the Earth prototype are selected for their lightweight but strong characteristics but mainly for their cost effectiveness. The body will consist of cardboard reinforced with duct tape. The internal frame-work will consist of 3D printed plastics. The parachute will be made from a thin plastic sheet.

Mars Prototype

We selected proven mechanisms from previous NASA missions for the Mars prototype. We chose their standard parachute design for our deceleration. We chose the cost effective PICA-X carbon fiber material for our heatshield.

Parachute

Earth Prototype

The material design for the Earth prototype is to be as light as possible while still performing nominally. Most likely during testing phases we will narrow it down to some form of plastic sheeting. The forces applied upon it will be small with the mass of only five hundred grams and the force of gravity acting upon it, so the material does not need to be very strong.

Mars Prototype

Our selection of the parachute for the mars lander is the standard parachute deployed by NASA on similar Mars missions. The parachute material is a blend of Kevlar, Nylon, and a material named Technora, an aramid fiber which is a class of synthetic fibers that are specially designed to be strong and heat resistant. This material is sufficient in handling the stress loads applied when deployed at supersonic speeds.

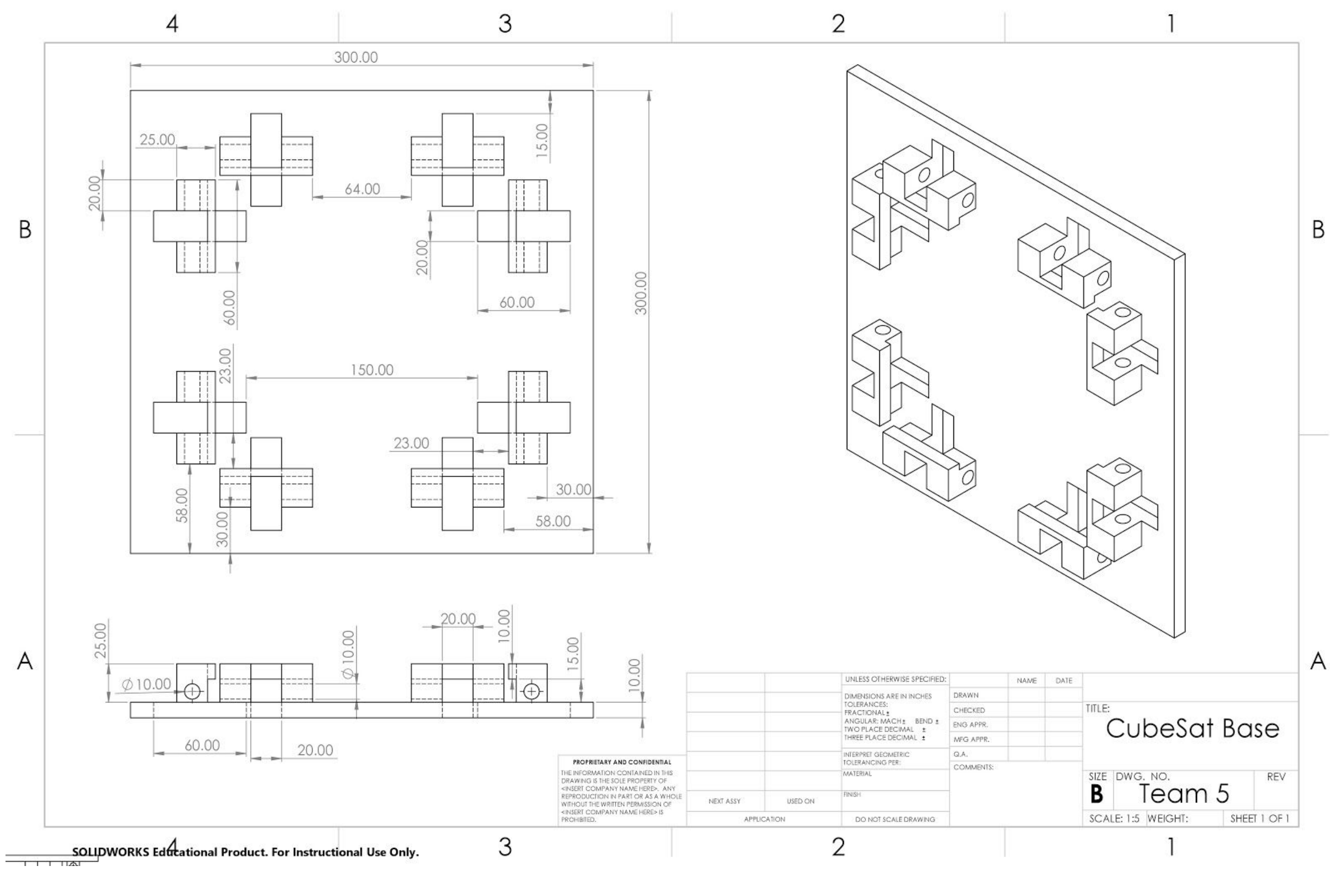
Parachute Selection Rationale

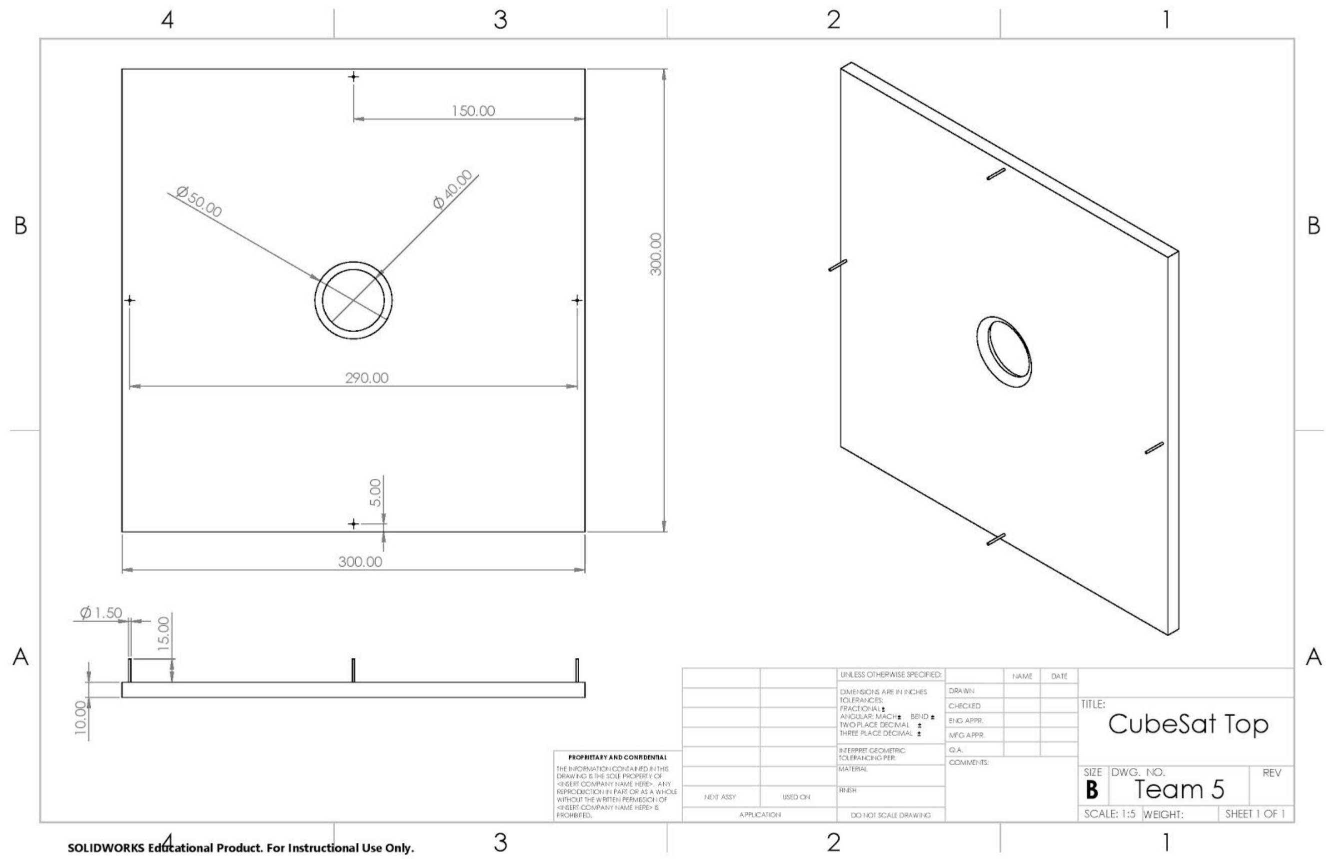
The core idea behind the design is to maximize the surface area of the base of the parachute. To do that we developed a design that would fold down into the cube much like a bat folding its wings in when sleeping. The V pattern increases surface area by maximizing the number and size of the surface planes present inside the cube.

Landing Mechanism

Landing Mechanism Selection Rationale

Constraints on design require that the landing mechanism be only deployed via mechanical means. The parachute will be dragged upward and provide the force necessary to deploy the landing mechanism via a simple hinge. The simplicity of the hinge reduces the probability of risk in deployment success as it requires little friction or force to work effectively. Having the legs be part of the descent vehicle casing will increase the space available inside. Spring flaps resting on the unopened hinges will snap over the holes where the landing legs used to be once deployed.

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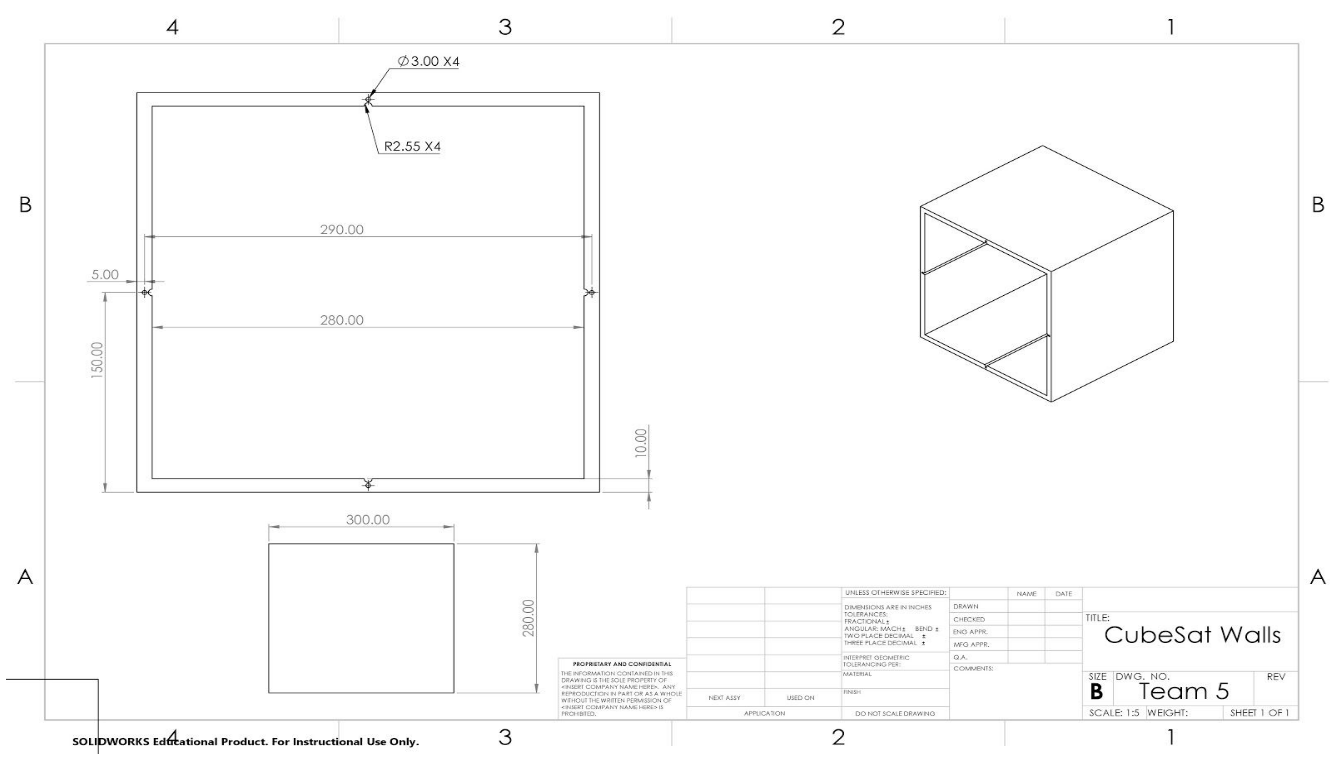
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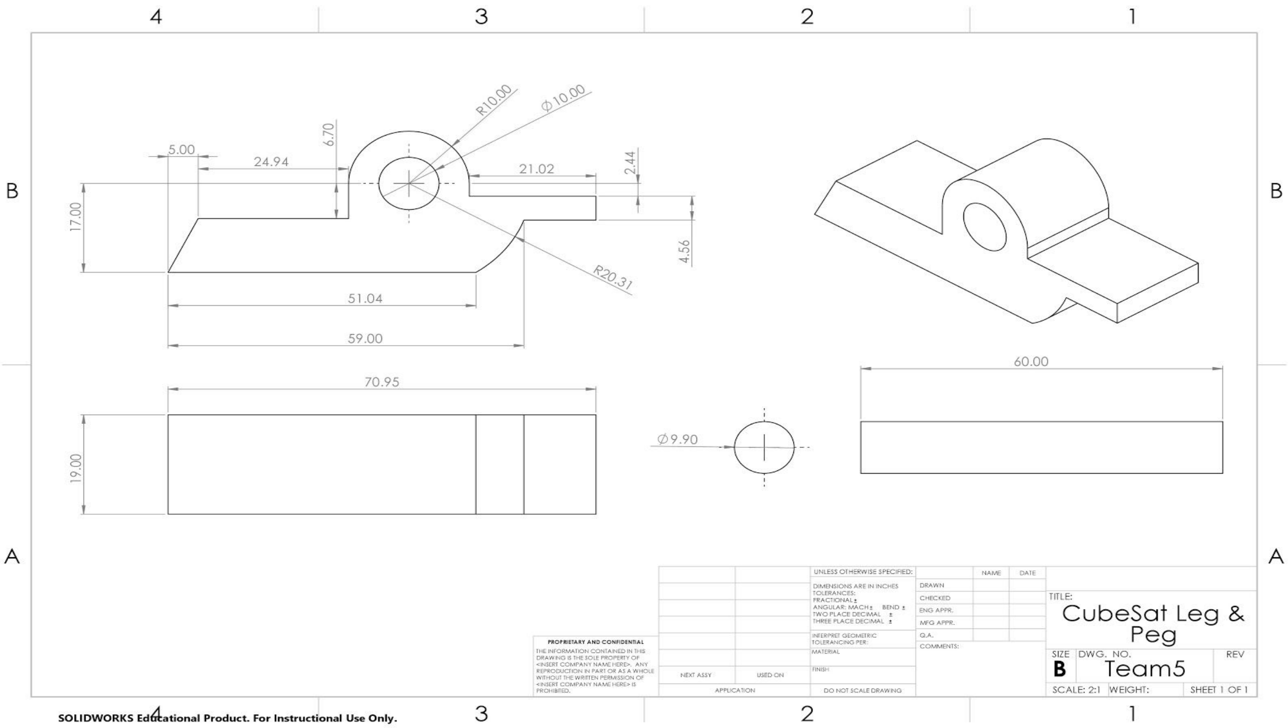
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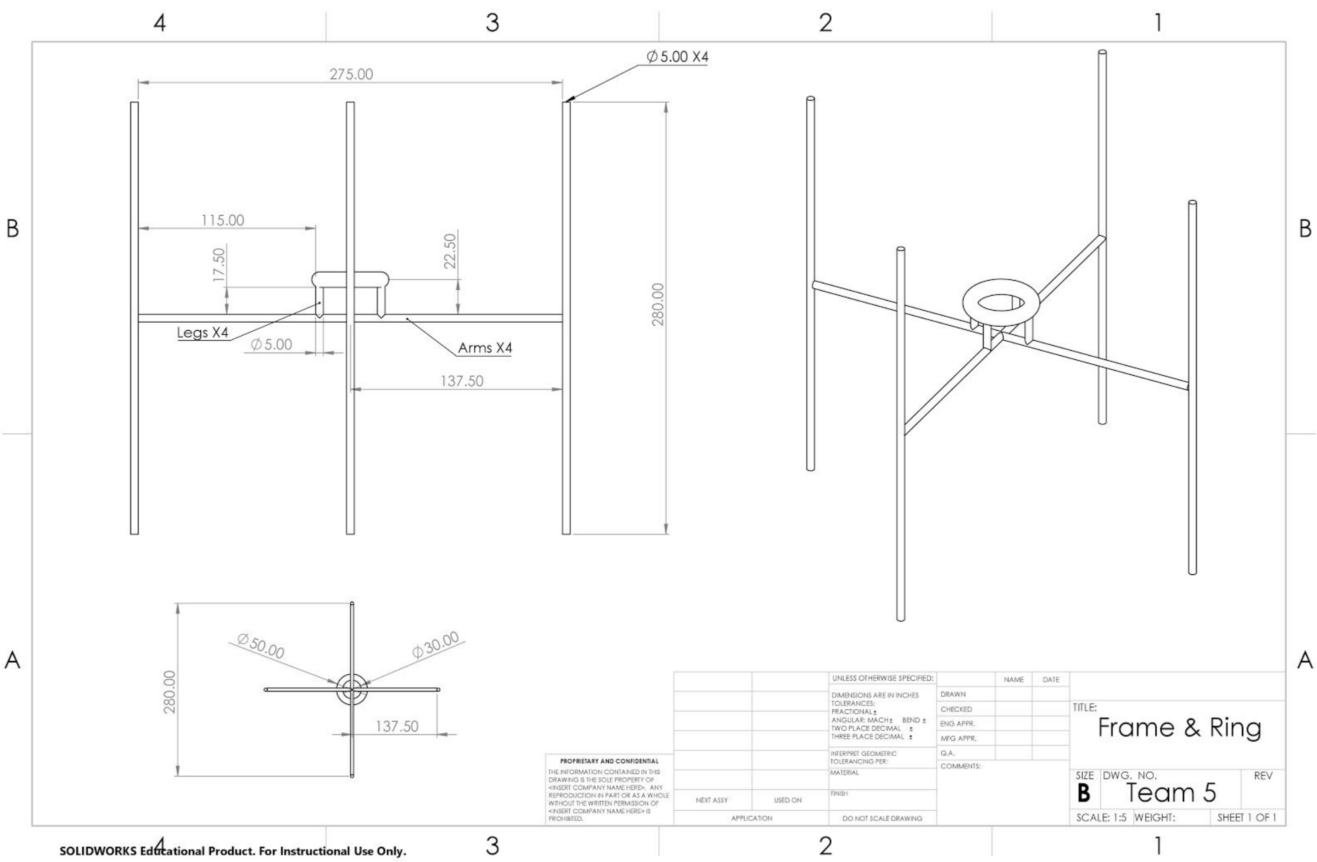
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3.1.5 Risks

Risk Plot

Heat Map of Likelihood (x-axis) vs. Impact (y-axis)

a. qq. b. r. d. s. jjj. 4k. 5k. n.	bbb. rr. c. rrr. e. ss. ee. g. ggg. 3k.	bb. sss! eee. gg.
aaa. m. Fff. oo. ii. ppp. j. jj. kk. ll.	aa. ff. i. mm. mmm. o. q.	f. k.
h. hh. l. ooo.	p. pp.	

All items below were assigned a value for impact and one for likelihood (I,L) and these were multiplied to yield a value for the heat map above.

Project Management

Schedule Planning:
a. 3,1 = 3 - Schedule not created/defined
aa. 2,2 = 4 - Schedule not met

aaa. 2,1 = 2 - Rescheduling not met
Resource Planning:
b. 3,1 = 3 - Not working according to strengths (knowledge & tasks)
bb. 3,3 = 9 - Not addressing weaknesses (reassign/redistribute/help as needed)
bbb. 3,2 = 6 - There's no "i" in team
Project Disciplines (Admin, Mechanical, Physics, CAD, Technical, Safety) :
c. ALL are 3,2 = 6?
d. Cost Estimation: $20 (3,1 = 3)

Organizational

Schedules:
e. 3,2 = 6 - Group meetings
ee. 3,2 = 6 - Team/task meetings
eee. 3,3 = 9 - Deadlines
Unrealistic Objectives:
f. 2,3 = 6 - Too much assigned to one person
ff. 2,2 = 4 - Too much due on the same day
fff. 2,1 = 2 - Overbudget?
Management/Communication:
g. 3,2 = 6 - Lack of communication
gg. 3,3 = 9 - Absence of team members
ggg. 3,2 = 6 - Unclear & undefined objectives

Technical

Technical Changes:
h. 1,1 = 1 - changes in instrumentation (maybe one breaks or something forces a change in s.q.)
hh. 1,1 = 1 - change in scientific question
Complexity:
i. 2,2 = 4 - An overly complicated design = difficult to replicate if the original designs were lost
ii. 2,1 = 2 - A complicated design could be an expensive investment (especially if it fails)
Quality:
j. 2,1 = 2 - Insufficient yields form the landing site
jj. 2,1 = 2 - Defective materials not revealed as such in testing
jjj. 3,1 = 3 - Defective instrumentation not revealed as such in testing
Performance:
k. 2,3 = 6 - Landing Mechanism fails to deploy
kk. 2,1 = 2 - Instrumentation fails to work as intended
3k. 3,2 = 6 - Transmission to satellite fails to send

4k. 3,1 = 3 - Satellite uplink fails
5k. 3,1 = 3 - Payload landing site varies from intended location
Budget:
l. 1,1 = 1 - Materials increase in price
ll. 2,1 = 2 - Replacements for broken/faulty/stolen/lost parts
Mass/Size Requirements:
m. 2,1 = 2 - Instrumentation larger/heavier than intended
mm. 2,2 = 4 - Materials larger/heavier than intended
mmm. 2,2 = 4 - Backup instrumentation/materials running size/weight overcapacity

External

Laws and Regulations:
n. 3,1 = 3 - International Contamination Regulations
Manufacturing and Procurement:
o. 2,2 = 4 - Pieces not delivered on time
oo. 2,1 = 2 - Pieces no longer in production
ooo. 1,1 = 1 - Pieces only purchasable in bulk
Labor Issues:
p. 1,2 = 2 - Build/research time longer than anticipated
pp. 1,2 = 2 - Laborer(s) injured/sick/out for family issues/etc
ppp. 2,1 = 2 - Laborer(s) dead
Weather:
q. 2,2 = 4 - Inclement weather conditions during landing
qq. 3,1 = 3 - Extended/severe inclement weather during mission duration
Gondola/Delivery Issues:
r. 3,1 = 3 - Gondola breaks
rr. 3,2 = 6 - Failure to deploy from Gondola
rrr. 3,2 = 6 - incomplete deployment?
Catastrophes:
s. 3,1 = 3 - Uplink Satellite breaks down/is destroyed
ss. 3,2 = 6 - Lander lands too quickly; breaks
sss. 10,10 = 100 - Cthulhu returns and enslaves us all!!!!!!!!!!!!!!!!!!!

Risk Mitigation Plan

UNFINISHED - NO WORK DONE

Conclusion

The first two categories were initially assigned by one team member, while the second two risk categories were assigned according to a second team member. It is interesting to note the different ways that items can be categorized, and how integral each team member feels each item is to the overall project. Some could be overly cautious, some could have too little caution. That is why discussion and agreement from a diverse set of voices is important. It is equally important to revisit this heat map and the issues it covers; adjusting and removing as appropriate.

3.1.6 Manufacturing Plan

CNC machining tools are available at Asheville-Buncombe Technical Community College and University of Central Florida. Aluminum sheeting will be purchased and cut into the required forms in one of these workshops. Assembly will follow MSDS guidelines and under the guidelines of more experienced instructors. 3D Printing is available as a manufacturing alternative for any materials that may be integrated during the Earth Testing Phase.

Hazards

CNC Machinery Safe Operation Considerations

- Have appropriate training.
- Supervise the machine at all times while it is running.
- Ensure proper maintenance schedule and test functionality prior to each task.
- Don’t use broken or sub-par tools (they should be sharp and in good working order).
- Watch for screws while routing.
- Come to work focused and able to handle the task.

http://www.multicam.com/6-unbreakable-safety-rules-for-cnc-machinery-safety/

This document also has a handy safety check sheet that could be used by our team:
http://www.wsps.ca/WSPS/media/Site/Resources/SmallBusiness/sb_330_DDK_01_IGDO_Safety_Chk_CNC_Mchn_Sfty.pdf?ext=.pdf

Aluminum MSDS Summary

Based on the cited sample document, eyes, skin, and lungs must be protected when cutting aluminum sheets. Protective eyewear, protective clothing, footwear, and gloves, and a particulate mask should be worn at all times when handling and cutting the sheets. This will protect the users from dust, small metal particles, and any fumes.
https://www.rdcaa.com/wp-content/uploads/2014/12/MSDS-Aluminum.pdf

3.1.7 Verification Plan

UNFINISHED - NO WORK DONE

3.2 Mission Performance Predictions

UNFINISHED - NO WORK DONE

3.3 Earth-Testing Operations

3.3.1 Balloon Selection

UNFINISHED - NO WORK DONE

3.3.2 Hazards

Airspace

- The traditional definition of airspace is 1200 ft above the surface, and we would not be launching any type of controllable craft, nor does it contain any propelling fuel, so from what we researched, NAR regulations would not apply.
- Safety considerations will still be followed, as outlined below.

General

- Weather: do not attempt drop test in the rain or other inclimate weather conditions.
- Protection: all participants should wear protective eyewear, helmet, closed footwear.
- Height: since the project will be dropped from a height of 9 meters, participants would take care and use good judgement to prevent falls of participants and objects other than the mock-up that is being Earth tested.
- Ground: ground level considerations should ensure appropriate communication between participants and perhaps a sectioned off drop area that takes into account wind and other factors to prevent injury to both participants and passers by. OSHA would be another helpful resource. This site also mentions how to prevent additional (unintentional) falling objects and also states that, “In the U.S. in 2016, there were 225 fatalities caused by a falling object.” https://neverletgo.com/dropped-object-prevention/
- Should any injury occur, seek immediate help and/or treatment if necessary.

3.4 Safety and Environment

3.4.1 Failure Modes

Issues with battery, issues with thermal control systems, issues with line of site, landing upright/facing towards sample.

3.4.2 Hazards

- High winds at landing site; dust storms may affect visibility between laser spectrometer and samples to be tested.
- Difficult terrain; landing on a level surface.

3.4.3 Environmental Concerns

This mission falls under a Category IV protection level as per NASA's Planetary Protection Policy.This category includes the following requirements for the mission to proceed:

- General Heavy Documentation
- Bioassays (a measurement of the concentration of a substance by its effect on living cells or tissues on)
- Analysis of the probability of contamination
- Various implementing procedures including, but not limited to:
  - Trajectory biasing
  - Use of Clean Rooms during assembly and testing (minimum Class 100,000)
  - Complete sterilization of the entire spacecraft

https://planetaryprotection.nasa.gov/requirements
https://en.wikipedia.org/wiki/Interplanetary_contamination

4.0 Payload Criteria

4.1 Selection, Design, and Verification of Payload Experiment

4.1.1 System Level Design

Selection

Argus 1000 Infrared Spectrometer - Space Grade Version + Kit

Specifications and Performance

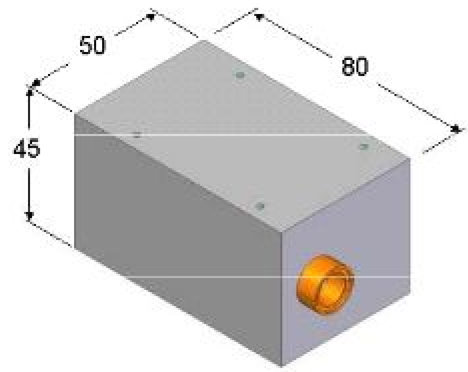


Figure 4.1.1 Source:
www.thothx.com/manuals/Argus%20Owner%27s%20Manual,%20Thoth%20Technology,%20Oct%2010,%20rel%201_03.pdf

Spectral Range	1000 nm to 1700 nm
Power	400 mW
Dimensions	45 mm x 50 mm x 80 mm
Weight (Earth)	< 230 g
Survival Temperature	-25°C to + 50°C
Operating Temperature	-20°C to +40°C
Interface	RS232
Material	InGaAs
Aperture	15 mm
Field of View	0.15°
Grating	300 g/mm
Microprocessor	10-bit ADC with co-adding feature to enhance precision to 13-bit

Input Voltage	3.6 - 4.2 V
Current	250mA - 1500mA (350mA typical)

Gas	Absorption Strength
Oxygen (O_2)	1.25µm (10^{-24} mol.cm^{-2})
Carbon Dioxide (CO_2)	1.57µm (10^{-23} mol.cm^{-2}) 1.61µm (10^{-22} mol.cm^{-2}) 2.05µm (10^{-21} mol.cm^{-2})
Water (H_2O)	900nm (10^{-21} mol.cm^{-2}) 1.20µm (10^{-21} mol.cm^{-2}) 1.40µm (10^{-19} mol.cm^{-2})
Carbon Monoxide (CO)	1.63µm (10^{-22} mol.cm^{-2})
Methane (CH_4)	1.67µm (10^{-20} mol.cm^{-2}) 2.25µm (10^{-20} mol.cm^{-2})
Hydrogen Fluoride (HF)	1.265µm (10^{-19} mol.cm^{-2})

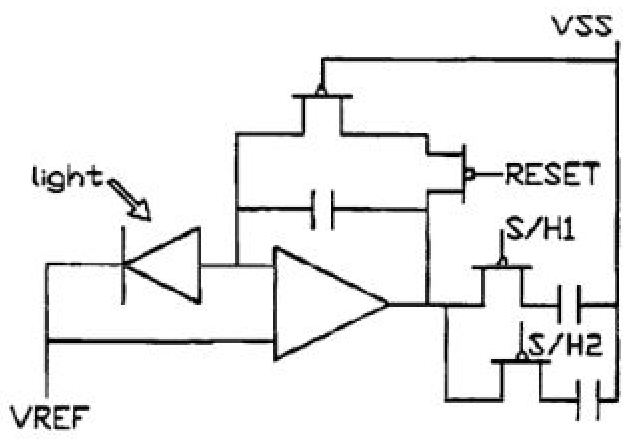


Figure 4.1.2 Source:
http://www.thothx.com/manuals/Argus%20Owner%27s%20Manual,%20Thoth%20Technology,%20Oct%2010,%20rel%201_03.pdf

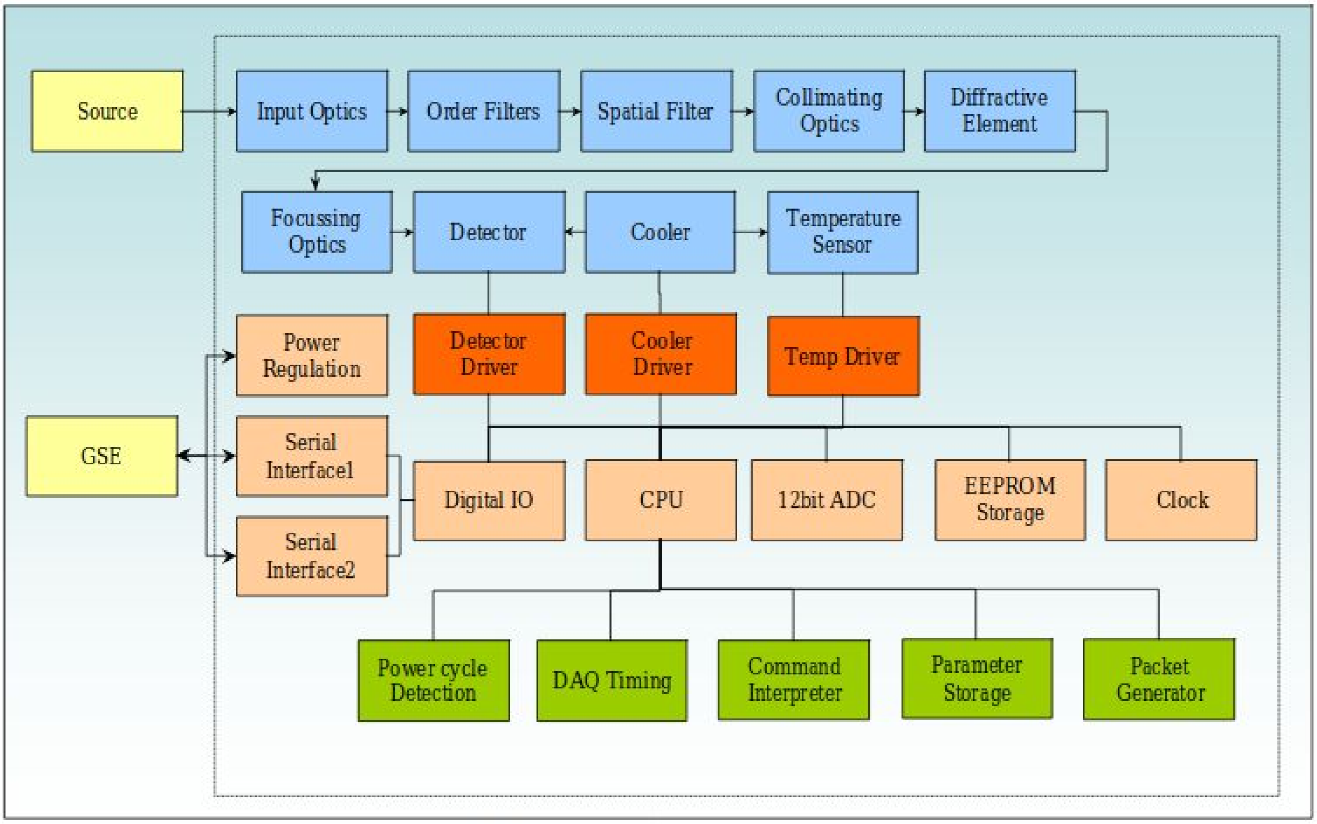


Figure 4.1.3 Source:
www.thothx.com/manuals/Argus%20Owner%27s%20Manual,%20Thoth%20Technology,%20Oct%2010,%20rel%201_03.pdf

Single Board Computer

We have chosen to use the RAD6000 single onboard computer by IBM due to its radiation hardened design, and proven track record in previous NASA missions. The computer will run a real-time operating system to ensure that incoming data is processed quickly, with minimal buffer delays.

Technical Specifications:

- 33 MHz single core CPU
- 8KB of L1 cache
- 128 MB of RAM

Thermal Control System

In order to maintain a safe temperature inside the spacecraft, there must be an autonomous method to dissipate and create heat within the chassis. This is done with the Thermal Control System. The design of this system encompases the following componenets:

- Radiator
- Electric Heater
- ROM Device
- 2 JK Flip Flops
- Temperature Sensor

The ROM device and the two JK Flip flops are then used to read the incoming signal from the sensor, and output the correct response. In Figure 1, an Algorithmic State Machine (ASM) shows how the system works. Figure 2 shows the corresponding next state table, and Figure 3 shows the controller hardware design and address range in hexadecimal/binary.

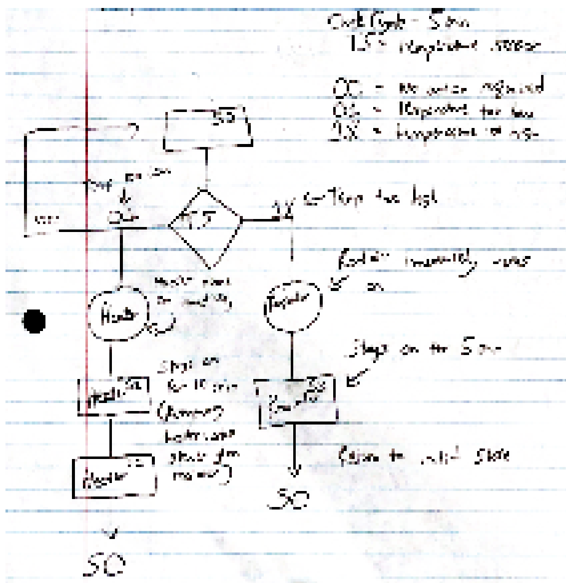


Figure 4.1.4

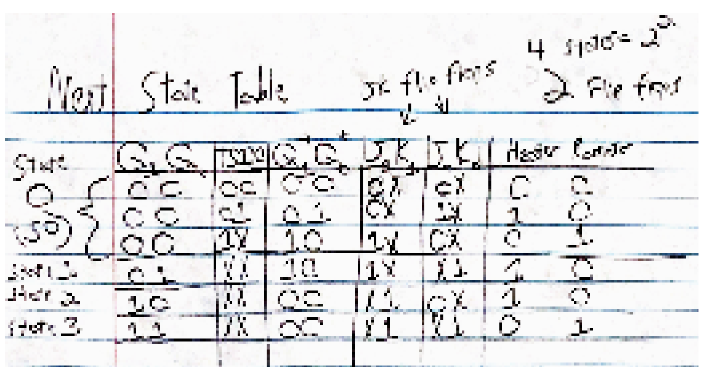


Figure 4.1.5

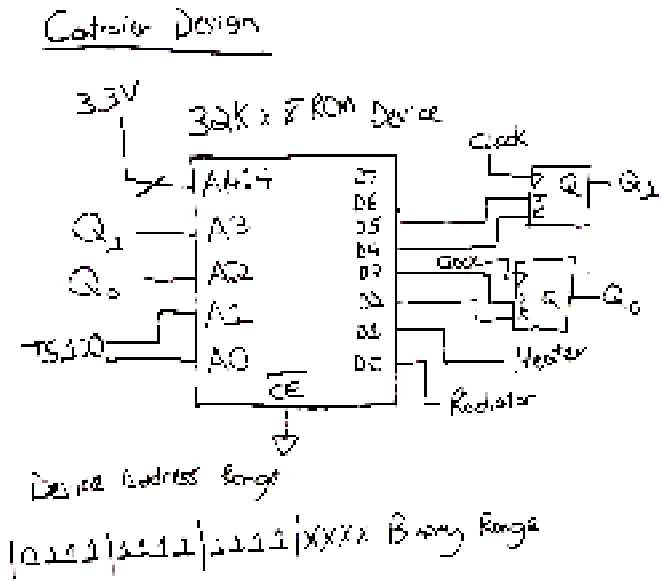


Figure 4.1.6

As shown in Figure 4.1.4, in state 0 the temperature sensor has 3 opcode options to choose from. During 00, the temperature is in a sufficient range, and therefore does not need to be heated or cooled by the hardware. It then loops back to the initial state and checks again until a change is detected. When the temperature is too low, the temperature sensor goes into 01. An asynchronous output then immediately turns the heater on, before moving into State 1. Because the clock cycle is 5 minutes long and the heater takes longer to operate than the radiator, 2 states are used to achieve 10 minutes of operation before returning back to state 0. When the sensor goes into state 1X the temperature is too hot. This then immediately activates the radiator in an asynchronous output, but only leaves it on for 5 minutes before looping back to state 0 and checking again.

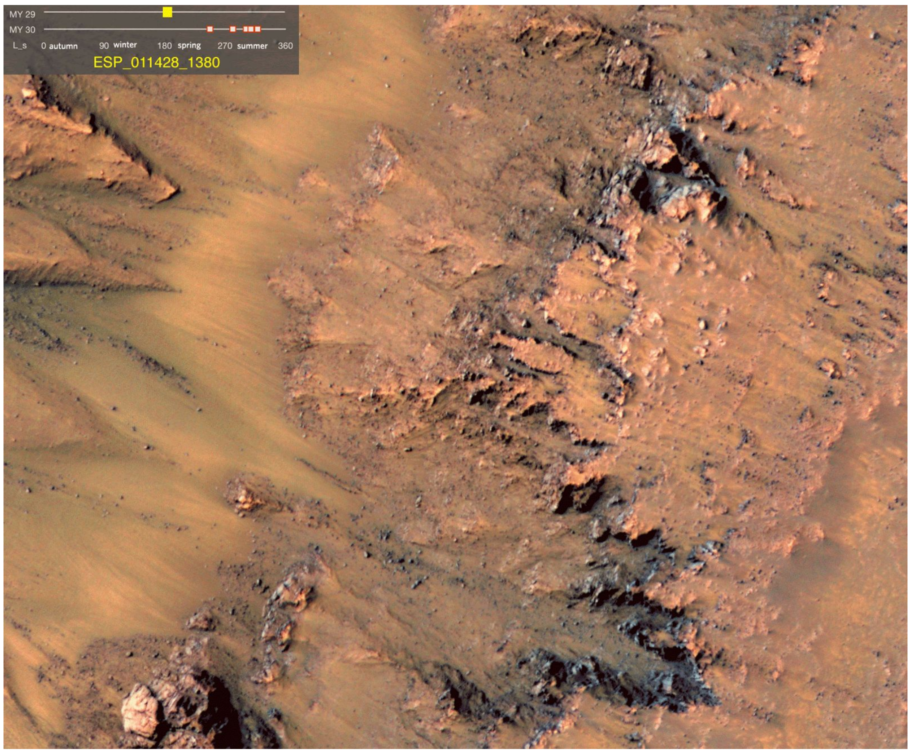
4.2 Payload Concept Features and Definition

Argus 1000 is a miniature infrared spectrometer with integrated optics for remote sensing applications, including environment monitoring and process control. The device uses an InGaAs detector array of approximately 100 illuminated elements that is actively cooled. (“Argus 1000 Infrared,” 2018)

4.3 Science Value

4.3.1 Science Payload Objectives

A laser mass-spectrometer will be used to test soil samples at Newton Crater where a phenomenon currently known as Recurring Slope Lineae (RSL) exists. It is not currently known what the composition of RSL is.



4.3.2 Payload Success Criteria

4.3.3 Experimental Logic, Approach, and Method of Investigation

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4.3.4 Landing Site

Newton Crater

- Pyroxene heavy, possible site of lava tubes
- Low elevation with multiple useful craters

- Site with clear Recurring Slope Lineae, likely evident of liquid water in the past (and possibly present)
- Imagery and useful information already available

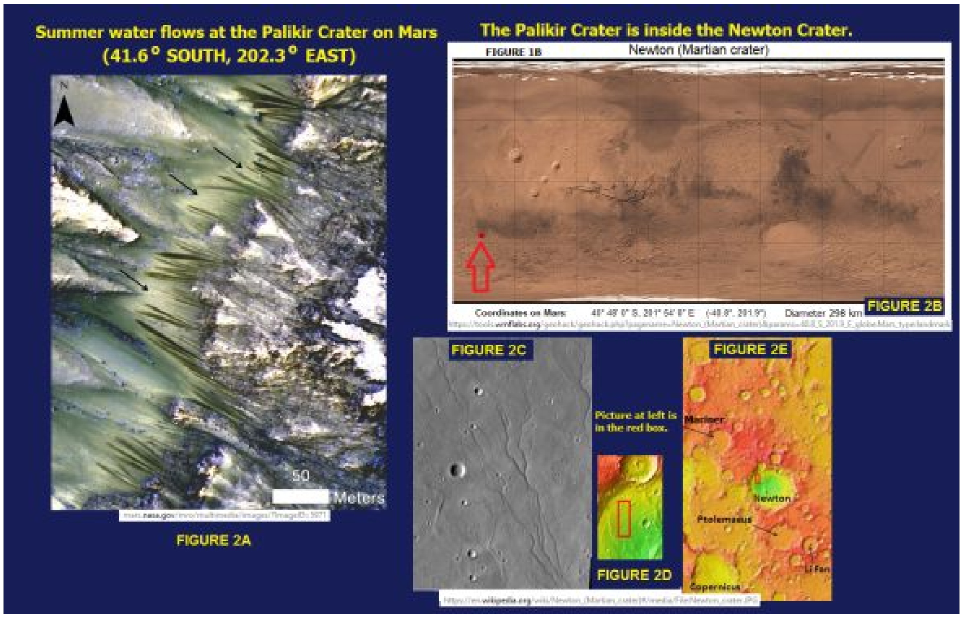

Figure 4.3.4 Source :http://davidaroffman.com/photo2_13.html

5.0 Activity Plan

5.1 Budget Plan

5.1.2 Earth Testing

5.1.3 Mars-Ready Design

5.2 Timeline

5.3 Outreach Summary

Our outreach plan consists of hosting water bottle rocket competitions at high schools in Orlando, Florida and Asheville, North Carolina. We'll be using NASA's ready-made water bottle rocket outreach and activity plan in an effort to make it as relevant to the L'SPACE project as possible. Students will learn about the engineering design process in a team setting, the physics involved in aerospace missions through trial and error with bottle rocket ascent/descent, and about the different mechanisms and physics behind them with inertia-based parachute designs.

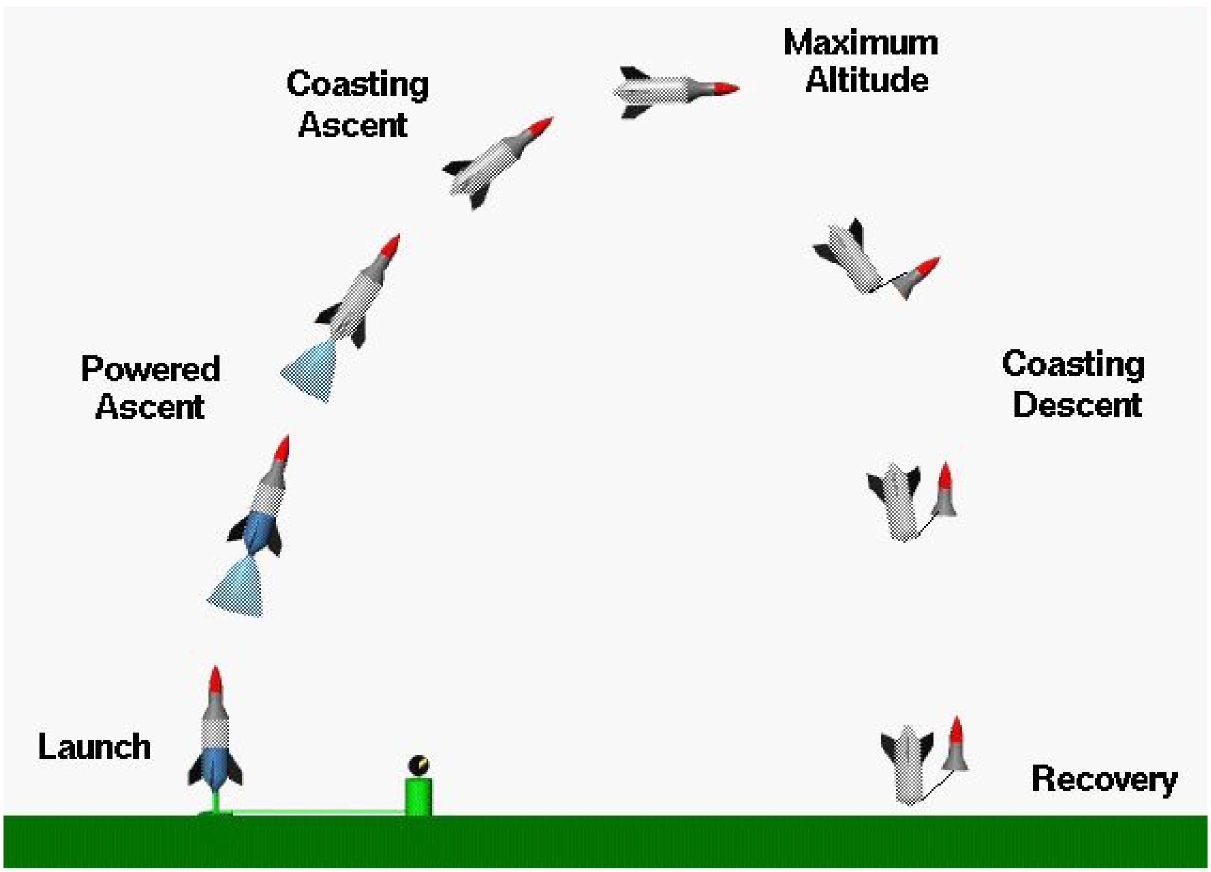

Figure 5.3.1 Source: https://www.grc.nasa.gov/www/k-12/rocket/rktbflght.html

The L'SPACE program will also be heavily advertised in Asheville-Buncombe Technical Community College, University of Florida, and University of Central Florida. An outreach plan includes posting materials such as fliers around the school in appropriate areas. Testimonies will be given from classroom to classroom.

Asheville-Buncombe Technical Community College has approved a press plan and will be contacting two major radio companies that own 14 stations and the ABC television affiliate in the metro area of Asheville, NC and Western North Carolina. They have also agreed to advertise the project and outreach process on their social media platforms including Facebook, Twitter, Instagram, and YouTube. Additionally, the team will be utilizing LinkedIn to promote L'SPACE and to log the progression of outreach as it is being executed.

Several activities are being discussed regarding outreach to the community that are to be hosted by the Asheville Museum of Science throughout the spring. A meeting is planned for next month to further finalize details. The audience for these activities are primarily K-9 and would primarily focus on physics and engineering.

6.0 Conclusion

Our team had (pay)loads of great ideas, but we were unable to coalesce them together into a final project in the time allotted. This was due to several factors:

1) We were unable to complete this preliminary design review due to roadblocks. The main issue we faced was finding instrumentation within physical limits to complete the scientific objective. Because we could not find an instrument to answer the scientific objective, the objective would change, which in turn changed our landing sight, continually delayed the engineering team, and we ended up stuck in the Project Initiation Phase.

   In future projects, it would be helpful if teams were given a short outline of how to proceed.
   For example:
   a) ask them to confirm a type of instrument they would like to use that fits the project parameters in terms of size and weight,
   b) then, ask them to devise a scientific objective that fits the instrument,
   c) then, ask them to choose an appropriate and attainable landing site
   d) then, project design can proceed from there

   Ultimately, we are undergraduates who have never worked on a project such as this before, and things beyond school played a role, so a little more direction at the start of the project would be very helpful in getting us to manage our time more wisely.

2) Several team members were unavailable due to illness during large portions of the project. In an ideal work setting, their work could be covered by other team members

and/or they could be temporarily replaced as needed. Often, only 5-6 members of our team were active in the chats and were producing their weekly assignments. This was not a manageable way to function for the semester.

These were all great learning opportunities, and, although our report is of a lesser quality than most of us would normally be proud of, we all still learned a great deal, both from the scientific and managerial realms.

We were all able to learn new skills and be a part of areas we were unfamiliar with or even uncomfortable committing to initially. For example:

Rose - designated project manager of a team with larger scope and responsibilities than had ever previously dealt with. Had to explore different communication mediums and frequencies in order to create a cohesive team experience.
Rachel - took on lots of research and managerial roles
Katherine - took on risk management and researching outside of her area of expertise
Zach - took on risk management and researching outside of his area of expertise
Adam - took on CAD design of the Earth Lander Prototype with minimal CAD experience
Alexander - took on researching different instruments and landing sites
Frank - designed thermal control system

We are also comforted by the fact that this is a *preliminary* design review, and that those of us moving forward to the second semester will be able to adjust this plan, or add on to other plans as needed.

As scientists, failure is important, and it teaches us a lot. Because of L'SPACE Academy, we are going to move forward to being better team members and team leaders in our futures.