2016 – 2017

NASA Student Launch

Proposal

1000 W. Foothill Blvd. Glendora, CA 91741

Aegis

Fragile Material Protection

September 30, 2016

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Commonly Used Acronyms

AED ....Automated External Defibrillator
APCP....Ammonium Perchlorate Composite Propellant
ATF....Bureau of Alcohol, Tobacco, Firearms and Explosives
BLS ....Basic Life Support
BMP .... Barometric Pressure
CAD .... Computer-Aided Design
CATO .... Catastrophic Takeoff
Cd ....Coefficient of Drag
CPR .... Cardiopulmonary Resuscitation
CNC ....Computer Numerically Controlled
EMF .... Electromotive Force
FAA .... Federal Aviation Administration
FAR ....The Friends of Amateur Rocketry
GUSD....Glendora Unified School District
HTC....Honors Transfer Council of California
IMU .... Inertial Measurement Unit
MDARS ....Mojave Desert Advanced Rocketry Society
MSDS....Material Safety Data Sheet
NAR .... National Association of Rocketry
PPE.... Personal Protective Equipment
PS ....Physical Science
NFPA....National Fire Protection Association
RAC....Risk Assessment Code
ROC ....Rocketry Organization of California
RSO....Range Safety Officer
STEM....Science, Technology, Engineering, and Mathematics
TRA....Tripoli Rocketry Association
UV....Ultraviolet

General Information

1. School Information
Citrus College
1000 W. Foothill Blvd
Glendora, CA 91741

More information about Citrus College can be found in Appendix A.

2. Adult Educators

Dr. Lucia Riderer
- Team Advisor
- Physics Faculty

lriderer@citruscollege.edu
(626) 914-8763

Rick Maschek
- Team Mentor
- Director, Sugar Shot to Space

rickmaschek@rocketmail.com
(760) 953-0011

3. Safety Officer
Janet
alonsojanet21@gmail.com
(626) 608-8584

4. Team Leader
Yvonne
y.villapudua@gmail.com
(909) 244-2662

5. Team Members and Proposed Duties

Table 1 gives the title and proposed duties of the members of the Rocket Owls team.

Table 1: Team Member Proposed Duties		
Team Member	**Title**	**Proposed Duties**
Isabella	Outreach Officer	• Educational engagement • Rocket design and construction
Janet	Safety Officer	• Implementation of safety plan • CNC programmer
Jimmy	Payload Specialist	• Website maintenance • Payload analysis
Lillian	Payload Specialist	• Rocket design and construction • Payload analysis
Yvonne	Team Leader	• Communication and coordination • Rocket design and construction

Figure 1: Team Organization Chart

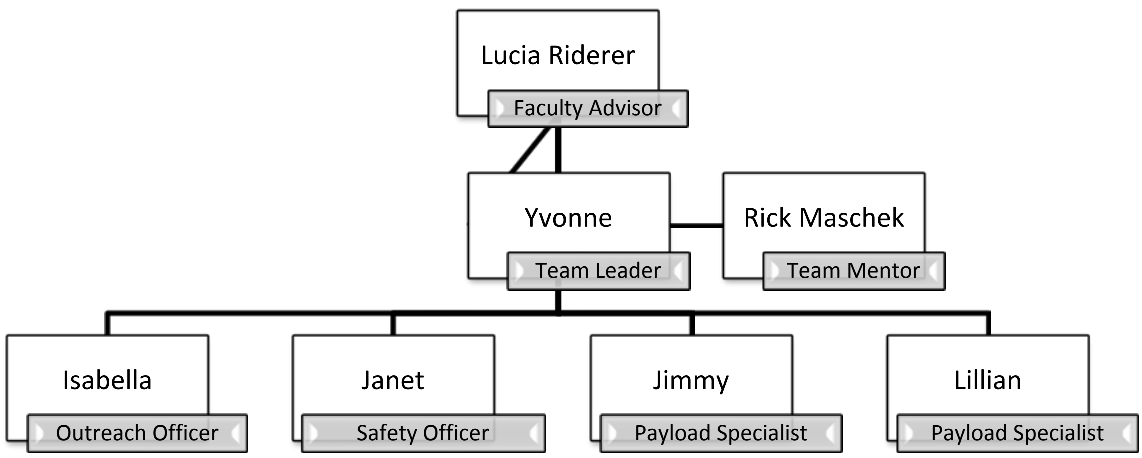


Figure 1 outlines the Rocket Owls team organization chart

5. NAR/TRA Sections

For launch assistance, mentoring, and review, the Rocket Owls will associate with the Rocketry Organization of California (ROC) (NAR Section #538, Tripoli Prefecture #48) and the Mojave Desert Advanced Rocket Society (MDARS) (Tripoli Prefecture #37).

Facilities/Equipment

1. Facilities and Equipment Resources

Wind Tunnel

The Citrus College Rocket Owls have access to a subsonic wind tunnel at the California Polytechnic State University, Pomona's (Cal Poly Pomona) School of Aeronautical Engineering. The wind tunnel is located in the Supersonic Wind Tunnel Laboratory in Building 13 with ancillary equipment located in a separate utility room. It is approximately 53' x 22' in overall size, with a test section of 28' x 40'. It has the ability to perform airfoil testing, data acquisition, and simulate speeds up to 190 mph.

Cal Poly Pomona Supersonic Wind Tunnel Laboratory
Location: Building 13 Room 1229
Staff Contact: Dr. Don Edberg
Availability: by appointment

Citrus College Machine Shop

The team has access to an on-campus supervised student engine shop. The shop has one lathe that can facilitate any material, a Bridgeport vertical mill, and several other pieces of heavy-machinery equipment.

Citrus College Machine Shop
Location: TE Room 121
Staff Contact: Professor Dennis Korn
Availability: 8:00am-10:00pm Monday-Thursday

Citrus College CNC Machine

The team has access to a newly installed CNC machine located in Citrus College's Physics laboratory room, PS 125. The team will use the CNC machine to cut wood and other project-related materials in a well-defined way.

Citrus College CNC Machine
Location: PS Room 125
Staff Contact: Dr. Lucia Riderer
Availability: 8:00am – 8:00pm Monday – Friday

Jet Propulsion Laboratory 3D Printers

The team will have access to the 3D printers located at NASA Jet Propulsion Laboratory (JPL) Library, the HUB Space. Available resources include Tinkerine DittoPRO and MakerBot Replicator II. JPL Library staff will be present when the equipment is being used by the team to ensure that safety rules are followed and the equipment is operated properly.

The HUB at the Beacon Information Commons
Location: JPL Building 111
Staff Contact: Marlon Hernandez
Availability: 8:00am – 4:00pm Monday – Friday
5:00pm – 7:00am Monday – Friday (After hours)

Citrus College Conference Room and Computer Lab

The college's Physical Science (PS) building conference room, equipped with computers, is an area dedicated to science and engineering projects. This room is available during school days, 7:00 am to 10:00 pm. The computers' hardware and software include:

• Eight Dell OptiPlex i5-3570 CPU (3.40 GHz Processor and 4.00 GB RAM)

• One Dell OptiPlex 760 Intel Core 2 Duo (2.93GHz Processor and 3.25 GB RAM)

• Microsoft Office 2010

• RockSim Pro 2 (with EngEdit Pro 2)

• VideoPoint Physics Fundamentals

The team also has access to three Dell 3000 series laptops with Intel i3 CPU processors. RockSim Pro 9 has been downloaded onto these laptops.

The Career Technology (CT) Computer Lab is available to the team for the use of Autodesk AutoCAD 2013.

Teleconferencing Equipment

Teleconferencing will be held in the PS building conference room at Citrus College. The team has all of the equipment needed to perform video teleconferencing with the NASA Student Launch Project Office:

• Broadband internet connection

• Dell OptiPlex 760 computer (Windows XP)

• Panasonic PT-FW300 projector

• Logitech Webcam Pro 900 USB camera

• ShoreTel 230 speakerphone

Required documentation and project updates will be uploaded to the team's website managed by Jimmy. Website maintenance will be performed on the college's computer lab and on students' personal computers by the team members.

Contact information for connectivity issues
Dr. Eric Rabitoy
erabitoy@citruscollege.edu

Friends of Amateur Rocketry Site

The Friends of Amateur Rocketry (FAR) site is a ten-acre static test and launch facility in the Mojave Desert; it is located under the R2508 controlled air space umbrella of Edwards Air Force Base, at the edge of a military supersonic corridor. The Federal Aviation Administration (FAA) waiver of the FAR site allows launching of rockets up to 9,208 lbf-s total impulse. Launch peak altitudes are permitted to 18,000 ft. from Monday through Friday, and 50,000 ft. on Saturday and Sunday [1].

The FAR site has pyrotechnic operators licensed by Office of the State Fire Marshal and the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) to help manufacture, store, set up, test, and launch rockets in a safe manner. The facility has a blockhouse, viewing bunkers, explosive magazines, firefighting equipment, propellant storage, static test stands, and launch rails. Other accommodations include: an assembly building, workshops, storage, sun shade, weather station, internet, electrical power, street lights (for night operations), non-potable water, restrooms, and campground.

The FAR site is also equipped with heavy equipment such as: all-terrain-forklifts, skip loaders, and boom cranes to help with loading, unloading, and setup. Additionally, the facility has a lathe, a mill, a drill press, a chop saw, a grinder, and a welding machine, for modification purposes. In order to ensure the safety of the people participating in events organized at the FAR location, the site offers first aid kits, an automatic defibrillator, oxygen tanks, and a helipad for emergency evacuations.

Friends of Amateur Rocketry Site Location: Mojave Desert
Contact: http://friendsofamateurrocketry.org/
Availability: 1st and 3rd Saturdays of every month

Safety

1. Safety Plan

The Citrus College Rocket Owls value and heavily emphasize safety. The safety plan detailed in this section was created to ensure that all participants in activities performed and facilitated by the Rocket Owls team are safe at all times.

The Citrus College Rocket Owls safety officer, Janet, will ensure that the safety plan is followed and up to date. She will make sure that the team members, as well as the children participating in the outreach events, are safe during all activities conducted or facilitated by the Rocket Owls as part of the NASA Student Launch. The safety officer's responsibilities are:

- Certify that the safety plan corresponds with federal, state, and local laws.
- Update the team members of any safety concerns from the previous week.
- Inform the team members of expected safety concerns for the upcoming week at the team's weekly meeting.
- Ask team members to express their safety concerns during the weekly meetings.
- Train the team on proper use of Personal Protective Equipment (PPE).
- Ensure that all team members understand and sign the team safety contract (see Appendix D).
- Be aware of all hazardous chemicals and machinery accessed by team members and ascertain that all safety precautions are followed before and after usage.
- Conduct safety briefings before the usage of any new equipment and/or materials.
- Read and keep a Material Safety Data Sheet (MSDS) for each hazardous chemical used, and safeguard that information in a safety binder, along with safety checklists and protocols.
- Ensure that the safety binder is available to all team members at all times.
- Identify safety violations and eliminate the hazard appropriately.
- Have detailed knowledge of the TRA code for High-Powered Rocketry.
- Inform the team advisor, mentor, and members if the safety plan is violated by a team member.

MSDS information can be found in Appendix B and safety protocols in Appendix C

A hazard is a potential threat to life, health, property or environment. Assessment of a hazard is made by combining the severity of the consequence with the likelihood of occurrence in a matrix. Hazard analysis is the first step to assessing preliminary risk levels with the goal of controlling and/or eliminating the risk. Table 2 shows the risk matrix used to analyze the severity and probability of a hazard for the entire duration of the NAS

Table 2 : Risk Matrix				
Probability	**Severity**			
	1 Catastrophic	2 Critical	3 Marginal	4 Negligible
A-Frequent	1A	2A	3A	4A
B-Frequent	1B	2B	3B	4B
C-Occasional	1C	2C	3C	4C
D-Remote	1D	2D	3D	4D
E-Improbable	1E	2E	3E	4E

The severity of a hazard ranges on a scale from negligible to catastrophic. The definitions of the words chosen to describe severity are provided in the following table.

Table 3: Severity Definitions		
Severity	**Values**	**Definition**
Catastrophic	1	Permanent injury or loss of life; loss of facilities, systems, or associated hardware; irreversible or severe environmental damages that violate laws and regulations
Critical	2	Severe injury; Major damages to facilities, system or associated hardware; reversible damages that causes a violation of law or regulations
Marginal	3	Moderate injury; moderate damages to facilities, equipment, or systems; moderate environmental damages that can be repaired, but don't cause a violation of a law or regulation
Negligible	4	Minor injury that can be treated immediately only requiring first aid treatment; negligible environmental damages that do not violate laws or regulation

Table 4 classifies risk into categories that represent their likelihood. Each hazard is assigned a probability of occurrence ranging from improbable (1) to frequent (5).

Table 4: Likelihood of Occurrence Definitions	
Description	**Definitions**
A-Frequent	High likelihood to occur immediately or expected to be experienced continuously
B- Probably	Expected to occur frequently within time
C- Occasional	Expected to occur occasionally within time
D-Remote	Unlikely to occur frequently
E- Improbable	Very unlikely to occur

Table 5 demonstrates the facility hazards present in the construction of the rocket that pose sufficient risk to require mitigation procedures.

Table 5: Facility Hazard Analysis and Mitigation				
Facility	**Hazard**	**Pre-RAC**	**Mitigation**	**Post-RAC**
Citrus College Computer Lab	Lost or corrupted data Damaged facilities	**4E**	The lab will not be used for the physical aspects of the project. Drinks or food will not be allowed in the computer lab.	**4E**
Launch Sites 1. Rocketry Organization of California (ROC) 2. Friends of Amateur Rocketry (FAR) 3. Mojave Desert Advanced Rocketry Society (MDARS)	Bodily harm	**2D**	NAR High Powered Rocket Safety Code will be followed at every launch. Before launches, a certified team member will use a team created checklist to assure the rocket is safe to launch. The Range Safety Officer (RSO) will determine if the rocket is safe to launch and the team will agree with their assessment.	**2E**
Cal Poly Pomona Wind Tunnel	Physical injury or damage to the rocket	**4D**	Trained personnel will operate the wind tunnel. All activities will be supervised by Cal Poly personnel.	**4E**

Citrus College Machine Shop	Physical injury, skin or eye irritation	2D	Gloves, mask, goggles, and closed toe shoes will be worn. Team members will be trained before usage of the machine in the shop.	2E

MSDS is used to understand the potential hazards of the materials mentioned in Table 6 below. In addition, the preliminary risk levels are also provided in Table 6.

Table 6: Material Hazards Analysis and Mitigations

Materials	Hazard	Pre-RAC	Mitigation	Post-RAC
Wood	Splinters and cuts	**4B**	Gloves and protective masks will be worn at all times when handling the material.	**4C**
Fiberglass	Skin and eye irritation; hazardous fume inhalation	**4D**	Gloves, masks, goggles, and lab coats will be worn at all times when handling the material. Any skin that comes in contact with the material will be washed immediately under running cold water for at least 15 minutes.	**4E**
Acetone	Lung, eye, or throat irritation; highly flammable	**2C**	Acetone will only be used in designated ventilated areas and away from potential sources of ignition.	**3D**
Epoxy	Skin, eyes, and respiratory irritation; rashes and allergic reactions	**4C**	Appropriate safety gloves and masks will be worn when working with the material.	**4D**

Black Powder	Burns, severe physical injury, and property damage	**1E**	Black powder will be handled solely by the team mentor.	**2E**
Solder	Burns, respiratory irritation	**2B**	Appropriate goggles, masks and protective clothing will be worn. Soldering equipment will be used only in well-ventilated areas.	**3C**
Paint	Respiratory irritation	**3C**	Protective masks will be worn. Painting will be done in well-ventilated areas.	**4C**
Batteries	Chemical burns, skin irritation	**3C**	Batteries will be stored in a cool and dry place and kept away from heat sources. Batteries will also be disconnected when not in use.	**3D**
Super glue	Eye and skin irritation	**3B**	Gloves, masks, and eye protection will be worn when handling the material.	**3D**

Table 7 below lists the equipment required in the construction of the launch vehicle that poses sufficient risk to require mitigation.

Table 7 : Equipment Hazards Analysis and Mitigation				
Equipment	**Hazards**	**Pre-RAC**	**Mitigation**	**Post-RAC**
Power tools	Physical injury	**3B**	Team members will be properly trained before usage of all the power tools before using them independently. Power tools will be used only in appropriate lab facilities.	**3D**
Machinery	Bodily harm	**1D**	Team members will abide by all the safety rules that correspond to the machinery being used. Team members will not be allowed to work alone and/or under fatigue.	**3E**
Rocket motor	Bodily harm, burns, property damages	**2D**	Team members certified by the Tripoli Rocketry Association will handle the motor. All personnel will be at the minimum required distance from the motor being tested and before ignition.	**3E**

Table 8 demonstrates descriptions of hazards that may occur during the arrangement and launch of the rocket.

Table 8: Launch Vehicle Hazard Analysis and Mitigation			
Hazards	**Pre-RAC**	**Mitigation**	**Post-RAC**
No deployment, unwarranted or delayed deployment	**1D**	Redundant altimeters and black powder charges will be used to secure deployment. A safety checklist will be made to confirm that the proper electronics are installed and activated.	**2E**
Unstable flight	**1D**	Rocket simulation software will be used to stimulate the center of pressure before launch.	**2E**
Injury during ground or launch testing	2C	Team members will be at a required distance from the launch vehicle when conducting ground or launch testing.	2D
Failure to recover rocket	**1D**	Rocket simulation software will be used to ensure rocket stability. Rocket must pass launch safety inspection. A GPS system will be used.	**1E**
Catastrophic takeoff (CATO)	**1C**	Only certified motors will use. The mentor will oversee the installation of the motor.	**3E**

The safety guidelines listed below will be followed to ensure the safety of the participating students at the team's outreach events:

- Mechanical operations such as drilling and/or hammering will be done beforehand by the members
- Minors will be under the direct supervision of adults to ensure the child safety
- Potentially hazardous materials and equipment will be locked at all times to prevent access
- Written permission of the parent or guardian will be obtained before publication of photograph of the minors

- Proper authorities will be notified should a minor share information that could pose a threat to other or themselves

Table 9 lists potential hazards during the construction of the payload and their corresponding mitigations.

Table 9: Payload Hazards and Mitigation			
Hazard	**Pre-RAC**	**Mitigation**	**Post-RAC**
Cuts and/or burns	**2D**	Protective clothing will be worn while constructing the payload.	**3E**
Skin and eye irritation	**3B**	Gloves, masks, and goggles will be worn while constructing the payload.	**3D**
Fume and/or particle inhalation	**3C**	Protective masks will be worn while constructing the payload.	**4C**

Table 10 lists the hazards that may occur during the outreach events hosted by the team and ways to respond to those potential hazards.

Table 10: Outreach Hazard Analysis and Mitigation			
Material	**Hazard**	**Mitigation**	**Treatment**
Razors	Cuts	Minors will not be allowed access to razors. Only team members will use the razors and only when it is appropriate.	Rinse and disinfect the cut, then cover the area with a sterile bandage.
Super glue	Skin and/or eye damage	Minors will not work on their project unsupervised. Appropriate measures will be made to ensure the minors are using super glue in a proper way.	Rinse the affected area with warm, soapy water to remove all the substance on the skin. Seek immediate medical attention for eye exposure.
Hot glue	Burns	Minors will not work on their projects unsupervised. Minors will not be allowed access to hot glue guns.	Rinse the affected areas with cool water and cover the burn with a sterile, dry, bandage.
Rocket motors	Burns, fires, and/or destruction of property	Certified team members will supervise assembly of rocket motors and rocket launches.	Rinse affected area under cool running water and cover the burn with a sterile bandage. In case of a minor fire, use a fire extinguisher to subdue the flame.

Wood	Splinters and cuts	Minors will use balsa wood when constructing their projects to prevent harmful splinters.	Remove the splinter with tweezers and soak the affected area with soap and water.
Paint	Respiratory irritation	Minors will not be allowed access to the paint. Only team members will handle the paint.	Immediate medical attention will be sought.
Small bits	Choking	Minors will not work on their project unsupervised.	Performance of CPR by certified personnel will be done and immediate medical attention will be sought.

Table 11 list the hazards and the mitigations related to the environment and the dangers those hazards could cause to the team members as well as the success of the launch.

Table 11 : Environment Hazard Analysis and Mitigation

Hazards	**Pre-RAC**	**Mitigation**	**Post-RAC**
Unstable weather conditions	**3B**	Confirm launch to be on a day with favorable conditions (no rain, extreme heat or wind).	**4B**
Sunburn	**4B**	Apply sunscreen constantly when working in the sun.	**4C**
Heat stroke and dehydration	**2D**	Work will be done under a shade area if possible. Appropriate clothing will be worn. Team members will drink plenty of water.	**3E**

Wild animal encounters (snakes and spiders)	**1D**	Team members will be aware of their surrounding at all times when in an environment inhabited by poisonous animals. Appropriate apparel will be worn, such as close-toed shoes and long pants.	**1E**
Air space (aircraft overhead)	**2C**	Check the skies for any helicopters, planes, drones, and other aircraft. Wait until the air space above is clear, if aircraft is present.	**3E**

There are multiple risks to the success of the completion of this project. One of the risks the team must consider is one or more member(s) leaving before the competition has been completed. This is unlikely to occur given the extensive interviews conducted by the team advisor before member selection. In the event of this incident, his or her responsibilities will be distributed among the remaining team members. Weekly meetings will be conducted to keep all team members up to date on all aspects of the project so that taking over a lost team member's responsibility will not be overwhelming. The launch vehicle will be tested earlier than the required date to allow multiple test launches and time to repair the vehicle, in the event of unforeseen natural occurrence such as bad weather, fires, and earthquakes, along with construction malfunctions.

1.1 NAR/TRA Procedures

All team members are responsible for acknowledging and following the NAR High Power Rocketry Safety Code. Rick, the Rocket Owls team mentor has many years of experience in handling and constructing rockets and will inform the team members of any hazards and risk involved. The safety officer will work with the team mentor to enforce the required safety procedures. The mentor's responsibilities are as follows:

- Ensure compliance with the NAR High Power Rocketry Safety Code
- Assist in purchasing, transporting and handling of motors

- Oversee handling of hazardous material and operations
- Ensure the recovery system are installed properly
- Handling and wiring all ejection charge igniters
- Accompany the team to Huntsville, Alabama

Table 12 introduces a description of the team's compliances with the NAR Safety Code.

Table 12: NAR/TRA Safety Code and Compliance		
	NAR Code	**Compliance**
1	**Certification**: I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.	Only team members with the appropriate level of certification and the team mentor, Rick, who has a Level 2 TRA certification, will be allowed to handle rocket motors.
2	**Materials**: I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.	All team members are responsible for using appropriate material on the rocket.
3	**Motors**: I will use only certified, commercially-made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, or heat sources within 25 feet of these motors.	Only rocket motors certified by TRA/NAR will be purchased and be handled by TRA certificated members of the team. Rocket motors will be stored in appropriate locations.
4	**Ignition System**: I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated	The team leader and safety officer are responsible for ensuring that the integration at the launch site is

	prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the “off” position when released. The function of onboard energetics and firing circuits will be inhibited except when my rocket is in the launching position.	performed following the TRA safety code.
5	**Misfires**: If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket in question.	The Range Safety Officer (RSO) will have final say over all misfires that may occur at the launch site. The team members will follow all final ruling of the RSO.
6	**Launch Safety**: I will use a 5-second countdown before launch. I will ensure that a means is available to warn participants and spectators in the event of a problem. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table. When arming onboard energetics and firing circuits I will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable. When conducting a simultaneous launch of more than one high power rocket, I will observe the additional requirements of NFPA 1127.	The rocket will be presented to the RSO, who will determine if the rocket is safe to launch.
7	**Launcher**: I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and	All launches will occur in at the launch site(s) listed in Table 5 and under

	that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour, I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor's exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5, clearing that area of all combustible material if the rocket motor being launched uses titanium sponge in the propellant. 51	appropriate launch conditions Launches at sites not listed in the proposal will not be allowed. The RSO will determine if the rocket is safe to launch.
8	**Size**: My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.	The team leader will be responsible to ensure the rocket follows these constraints.
9	**Flight Safety**: I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.	The RSO will have final say regarding the rocket being allowed to be launched.

10	**Launch Site**: I will launch my rocket outdoors, in an open area where trees, power lines, occupied buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater, or 1000 feet for rockets with a combined total impulse of less than 160 N-sec, a total liftoff weight of less than 1500 grams, and a maximum expected altitude of less than 610 meters (2000 feet).	All launches will occur at the launch site(s) listed in Table 5, Launches at other launch sites beside those listed in the proposal will not be allowed. The RSO will determine if the rocket is safe to launch.
11	**Launcher Location**: My launcher will be 1500 feet from any occupied building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.	All launches will occur at the launch site(s) listed in Table 5, Launches at other launch sites beside those listed in the proposal will not be allowed. The RSO will determine if the rocket is safe to launch.
12	**Recovery System**: I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.	The team leader and safety officer will ensure that the recovery system adhere to all of these requirements.
13	**Recovery Safety**: I will not attempt to recover my rocket from power lines, tall trees, or other dangerous locations, or fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.	The safety officer will ensure that the team members follow this requirement.

Table 13 shows the minimum distance required to ensure the safety of participants and spectators during a rocket launch.

Table 13 : Minimum Distance for Launch Safety				
Installed Total Impulse (Newton-Seconds)	**Equivalent High Power Motor Type**	**Minimum Diameter of Cleared Area (ft.)**	**Minimum Personnel Distance (ft.)**	**Minimum Personnel Distance (Complex Rocket) (ft.)**
0 — 320.00	H or Smaller	50	100	200
320.01 — 640.00	I	50	100	200
640.01 — 1,280.00	J	50	100	200
1,280.01 — 2,560.00	K	75	200	300
2,560.01 — 5,120.00	L	100	300	500
5,120.01 — 10,240.00	M	125	500	1000
10,240.01 — 20,480.00	N	125	1000	1500
20,480.01 — 40,960.0	O	125	1500	2000

1.2 Hazard Recognition and Pre-Launch Briefing

Before any construction, test, and launches the team will have a safety meeting. At this meeting the safety officer will brief all team members of safety regulations. The briefing will consist of an MSDS safety overview, as well as a review of safety protocols described in the safety manual. Team members will also be briefed on the purpose of using new materials and/or equipment. If safety risks are observed at any time, the team members will take the required steps to mitigate the risks. In addition, the safety officer will be informed so that he can proceed to resolving the situation and educating the parties responsible for the incident, in order to prevent the same situation from happening again. Moreover, all team members are expected to keep up to date with the regulations as changes and revision are made to protocols and regulation within the safety manual. The team safety manual covers the following topics:

- Lab Safety
- Material Safety Procedures
- Safety Protocols for Equipment Operation
- MSDS information
- Launch Safety Procedure
- PPE Regulations

All MSDS forms for the proposal and the safety manual will be kept in binders located in the lab space where the rocket construction is being performed. Team members will refer to the binders before the handling of any hazardous material or chemicals. Furthermore, to avoid accidents, each team member must agree to and follow the rules outlined in Appendix #? and the regulations and protocols outlined in the safety manual.

Pre-launch Briefing

Before any launches the team will have a pre-launch briefing. The briefing will consist of an overview of the safety procedures and rules associated with the launch site. In order to ensure the proper assembly and engagement of all project components, the team will create a protocol checklist. The checklist will include the necessary steps needed to prepare the rocket for launch. Several of the TRA certified team members will inspect the rocket and check off the list before presenting the rocket to the RSO. Team members will be reminded that all RSO rules are final and anyone displaying inappropriate behavior will not be allowed to launch the rocket and/or leave the launch site.

1.3 Caution Statements

The Rocket Owls will include caution statements for all plans, procedures, and other working documents. The safety Officer will ensure that these documents are available during the construction of the launch vehicle to reduce potential risk. Potential hazards during the construction process will be identified. Team members are expected to read, understand, follow, and enforce precautions stated in the MSDS report for every material used during construction. The Safety Officer will refer to the appropriate MSDS for specific safety guidelines and will remind all team members of proper usage of any machinery and/or chemicals prior to their use. Team members will not be allowed to work under fatigue or by themselves. Team members will remain focused on the task at hand and will be aware of their surroundings at all times. Prior to construction, the safety officer will demonstrate the proper use of PPE. Team members will dress appropriately for the lab space, including removal of loose clothing and jewelry, tying back long hair, putting on necessary gloves, and wearing appropriate eye protective glasses, and respiratory masks. Team members will act appropriate in the lab space, including cleaning the work space of any obstacles, turning off machinery when finished, properly storing chemicals and cleaning the work place when finished.

1.4 Rocketry Laws and Regulations

The Rocket Owls will perform test launches leading up to the NASA Student Launch competition at one of the following sites: Rocketry Organization of California (ROC), Friends of Amateur Rocketry Inc. (FAR), or Mojave Desert Advanced Rocket Society (MDARS). The aforementioned facilities work with the FAA to meet the following guidelines listed in the Federal Aviation Regulations 14 CRR, Subchapter F, Part 101, Subpart C:

No person may operate an unmanned rocket:

- In a manner that creates a collision hazard with other aircraft
- In controlled airspace
- At an altitude where the horizontal visibility is less than five miles
- Into clouds
- Within five miles of the boundary of any airport
- Within 1.500 feet of any person or property that is not associated with the operations

- Between sunset and sunrise (Sec.6(c). Department of Transportation Act (49 U.S.C. 1655(c)) [2].

Any time an unmanned rocket is launched, the person operating it is required to contact the nearest FAA ATC facility 24-28 hours prior to the beginning of the operation to give them critical information. The facilities utilized by the team will provide the following information to the FAA ATC facility in compliance with this act:

- The name and address of the person designated as the event launch coordinator
- The estimated number of rockets operated
- The largest size rocket planned to be launched
- A maximum altitude which none of the rockets can surpass
- The location, date, time, and duration of the operation
- Any other pertinent information requested by the ATC facility [3].

The team mentor, Rick, will handle the low-explosives used by the team. Rick will closely follow the Code of Federal Regulation 27 Part 55: Commerce in Explosive as summarized below:

- Unless exempted by law, federal permits are needed to transport, ship, cause to be transported, or receive explosive material. Permit must keep complete and accurate records of the acquisitions and dispositions of explosive material
- Obtaining a Federal license or permit does not permit any one from violating any state or local ordinance
- No person shall store any explosive material in any matter that violates applicable regulations

The Rocket Owls understand the importance of fire prevention and will do the following in accordance with the NFPA 1127"Code for High Power Rocket Motors":

- Material that are explosive and flammable will not be stored in a detached garage or outside
- Explosive material will be stored in a noncombustible container
- All storage of explosive will be with accordance with federal, state, and local laws.
- Igniters will not be stored with explosives.

Title 19, California Code of Regulations, Chapter 6, Article 3, §981.5(b)(6) defines the Pyrotechnic Operator -- Rockets Third Class license, which is relevant for the launching of high-power rockets in California. The California State Fire Marshall has established regulations that identify at least one pyrotechnic operator license at each launch event. This license permits the licensee to handle, supervise, and discharge rockets which produce an audible or visual effect in connection with group entertainment

1.5 Rocket Motor Usage Plan

Motors will be purchased, stored, transported, and handled by the team mentor, Rick, who is a Level 2 certified member by the TRA. Energetic devices, including e-matches and black powder will also be handled by Rick. Only rocket motors certified by TRA/NAR will be purchased from online stores. Motors will not be purchased from on-site vendors.

Storage

Motors will stay disassembled and be kept in the original packaging until launch day. If stored in secondary container, the container will be clearly labeled (including the NFA diamond). Ammonium Perchlorate composite motors will be stored in a cool, dry place away from sources of heat, flame or sparks. Igniters will be stored separately from the motor.

Transport

The main ingredient in a high-power rocketry motor is solid Ammonium Perchlorate Composite Propellant (APCP). As of January 2010, APCP is no longer included in the list of explosive material in the U.S. Bureau of Alcohol, Tobacco, Firearm and Explosive (ATFE). The motor will not require a permit or licenses to be transported to the launch sites. Therefore, the team will transfer the motor in the original packaging via an air conditioned vehicle. At the launch site, the motor will be kept in a shaded area. The motor used for the NASA Student Launch will be shipped to the launch site. See section 1.4, for details in the handling and storage of other energetics.

Use of Rocket Motor

Only TRA/NAR certified members will handle the rocket motor. Before using a rocket motor, simulation of the flight using that specific motor will be done.

1.6 Safety Contract

The Rocket Owls consent to and will adhere to the relevant regulations to high-power rocketry and project team safety as stated in the Student Launch Handbook, distributed by NASA. The rules listed below are included in the safety contract.

1.6.1 Range safety inspections of each rocket before it is flown: each team shall comply with the determination of the safety inspection or may be removed from the program.

1.6.2 The RSO has final say on all rocket safety issues. Therefore, the RSO has the right to deny the launch of any rocket for safety reasons.

1.6.3 Any team that does not comply with the safety requirement will not be allowed to launch their rocket.

All members of the Rocket Owls are required to sign the contract in order to engage in any construction or participate in launches. The safety contract can be found in Appendix D.

Technical Design

1. Rocket and Payload Experiment

a. Vehicle Specification

Table 14 provides the general vehicle dimensions and illustrates the way the specifications of the launch vehicle are altered based on the motor utilized.

Table 14: General Vehicle Dimensions

Aspect	Without Motor	With M1500G Motor*	With L2200G Motor*
Length (in.)	128.00	128.00	128.00
Diameter (in.)	6.08	6.08	6.08
Length/Diameter Ratio	21.05	21.05	21.05
Mass (lbs)	35.79	46.58	46.26
C.P. (in from top)	101.60	101.60	101.60
C.G. (in. from top)	79.80	87.93	87.75
Stability (caliber)	3.63	2.28	2.31
Average Thrust (N)	-	1449.23	2126.72

*See Section d below for additional motor information.

Figure 2 illustrates the full scale rocket as designed by the team utilizing RockSim Pro 9.

Figure 2: Proposed Rocket

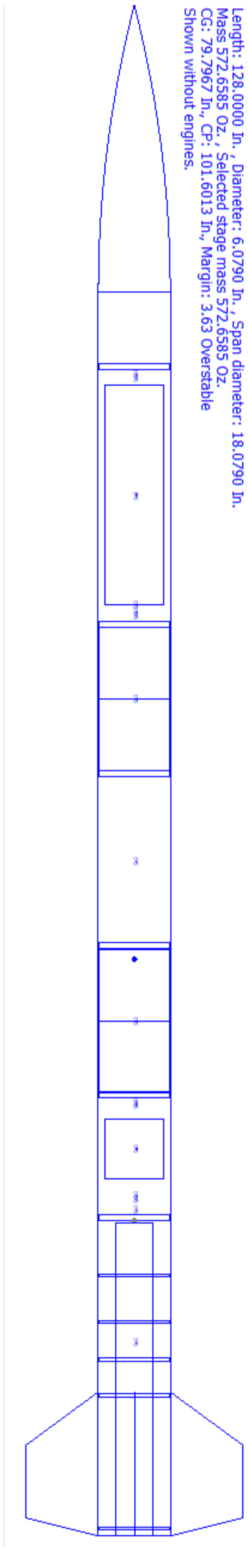


Figure 2 displays the launch vehicle proposed by the team.

Table 15 lists the main rocket components, the materials that will be used in their construction, and their corresponding manufacturing methods.

Table 15 : Rocket Materials and Construction Methods			
Main Vehicle Components	**Material**	**Justification**	**Construction Method**
Nose cone	Fiberglass filament wound	Strong and durable	Commercially available
Airframe	Blue tube 2.0	Rigid, stronger than phenolic tubing	Cut with miter saw, sand by hand, fiberglass, bond with epoxy
Bulkheads	5-ply plywood, ½”	Strong, easy to cut, sand and bond	CNC cut
Centering rings	10-ply aircraft plywood, ¼”	Strong, easy to cut, sand and bond	CNC cut
Fins	10-ply aircraft plywood, ¼”	Strong, stiff, resists flutter	CNC cut
Parachutes	Ripstop nylon	Light-weight, tear resistant	Commercially available
Shock cords	1” Tubular nylon	High-breaking strength	Commercially available

b. Projected Altitude and Calculation

The outlined projected altitude is 5280 ft. AGL. Given the information found in Tables 14 and 15 and Figure 2, RockSim Pro 9 predicts an altitude of 5263.19 ft. with a M1500G motor. However, if the actual mass of the rocket ends up lower than predicted, a L2200G motor will be utilized. Over estimating the amount of epoxy to be used during construction and/or the mass of hardware pieces that vary among manufacturers could yield a lower mass for the launch vehicle than predicted. The M1500G motor provides a higher total impulse in comparison to the L2200G, making it more efficient for a rocket with higher mass to reach the projected altitude.

c. Parachute System Design

Table 16 describes the recovery system for the drogue and main parachutes, how and when they will deploy along with their corresponding launch vehicle descent rate.

Table 16: Recovery System				
Altitude (AGL in ft.)	**Means of deployment**	**Parachute**	**Cd**	**Descent rate (ft/s)**
5263 (Apogee)	Black powder	24" drogue	1.5	81.54
800	Black powder	144" main	2.2	11.17

All flight recovery events will be initiated by a redundant Missile Works RRC2+ altimeter system. At apogee, a black powder charge will separate the booster section of the rocket from the avionics bay and deploy the drogue parachute. The rocket will fall at a rate of 81.54 ft/s as two tethered sections. At 800 ft, a second black powder charge will separate the forward section of the avionics bay from the forward airframe and eject the main parachute. The rocket will descend at a rate of 11.17 ft/s as three tethered sections. Redundant black powder charges with a 1s delay will be used for both parachute deployments to ensure deployment. The proposed rocket will land with a kinetic energy of 69.38 ft-$lb_{f,}$ as calculated using the descent rate of the rocket (11.17 ft/s) and the mass of the rocket without the motor (35.79 lbs). In the event of a mass decrease due to less use of epoxy or varying masses of hardware, the descent rate of the rocket will be adjusted as necessary to ensure that all components land with less than 75 ft-lb_f of kinetic energy.

d. Motor Brand and Designation

Specifications for K650RR Animal Works and K780R Aerotech motors [4] are summarized in Table 17 below, noting the higher average thrust in the Aerotech L2200G motor, but higher burn time of the Animal Works M1500G motor.

Table 17: Motor Specifications		
Manufacturer	Aerotech	Aerotech
Model	M1500G	L2200G
Diameter (mm)	75	75
Length (in.)	26.18	26.18
Launch weight (lbs.)	10.79	10.47
Empty weight (lbs.)	4.99	4.92
Total impulse (Ns)	5217.24	5104.14
Average thrust (N)	1449.23	2126.72
Maximum thrust (N)	1716.51	3101.77
Burn time (s)	3.60	2.40

The Aerotech M1500G will be utilized if the mass of the rocket stays as predicted or increases lightly. Figure 3 below shows the thrust curve for this motor.

Figure 3: Aerotech M1500G Thrust Curve

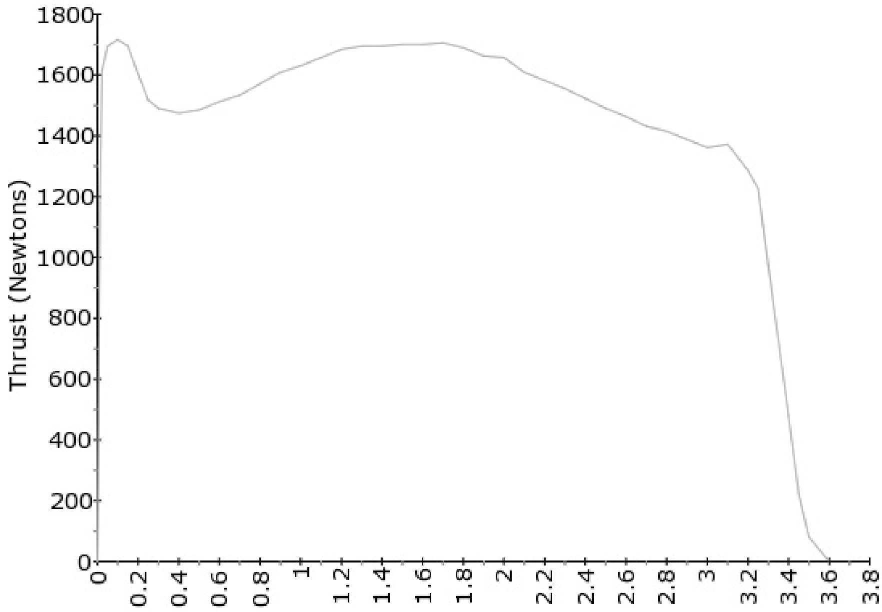


Figure 3 shows the thrust curve for the Aerotech M1500G. The thrust of this motor rapidly increases during the first 0.1s of flight. The motor then rapidly decreases thrust for approximately 0.2s then increases again until it reaches its maximum at approximately 1.6s and then slowly decreases until burn out at approximately 3.6s.

If the predicted mass of the launch vehicle decreases significantly, the Aerotech L2200G would be a more efficient motor. Figure 4 shows the thrust curve for this motor.

Figure 4: Aerotech L2299G Thrust Curve

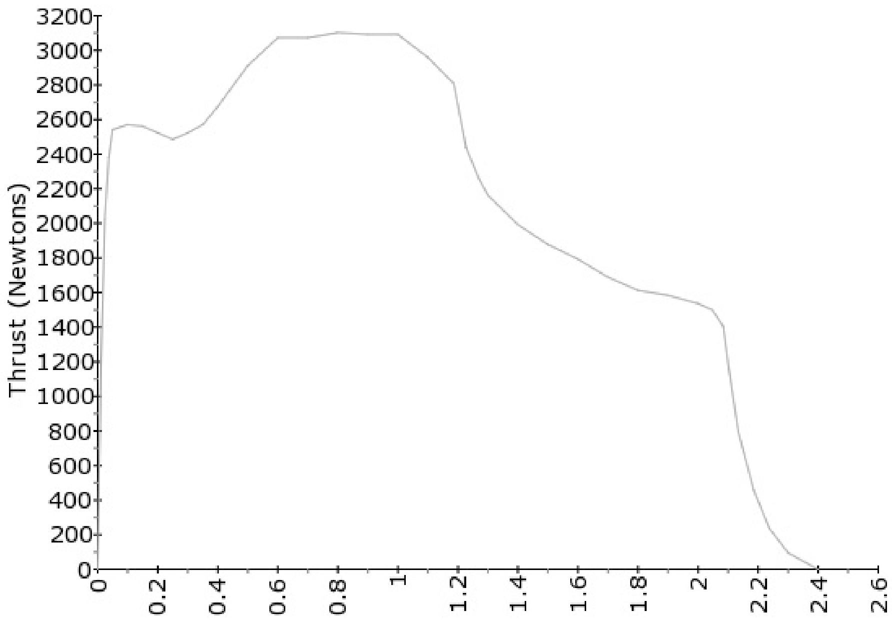


Figure 4 shows the thrust curve for the Aerotech L2200G. The thrust of this motor increases rapidly within the first 0.1s of flight and slightly dips for approximately 0.2s then increases until its maximum at approximately 0.6s and slowly decreases until it fully burns out at approximately 2.4s.

e. Payload Specification

The team will design and construct a container able to protect one or more objects of any size, shape and material. The container described in this section of the proposal was designed by the team under the assumption that those objects are solid samples collected on the surface of Mars and brought back to Earth. The modifications made to the proposed container in order to be able to protect liquid samples under the same assumption are described at the end of this section.

Main Dimensions

The team needs a material that is easy to use, affordable, and has a high impact strength. Therefore, the container will be made from polycarbonate knowing that

“One of the biggest advantages of polycarbonate is its impact strength” [5]. Polycarbonate is also affordable and easy to handle. The container will consist of a cylinder of 12” in height, with a 5” outer diameter and a 4.75” inner diameter. The container will have an interior chamber with a 4.25” otter diameter and a 4” inner diameter. These dimensions were selected to maximize workspace while making the container easy to transport.

Outer Shell

The outside of the container will have a layer of a 9% borated flexi-panel cemented on to it with plastic epoxy that has adhesive full strength of 3450 psi [6]. These two layers will then be lined with a 2mm coat of Line-X that will increase the tensile strength up to 6,600 psi and tear strength up to 780 lbs/in [7]. Refer to section 3.2 for a more detailed description of the impact capabilities of the outer shell.

Inner Chamber

The inside chamber of the container will have a manual rail system that will be used to secure, isolate and maneuver the objects up and down inside the inner chamber. There will be two silicon plates per section in order to allow a single object or multiple objects to be secure and restrict their ability to come into contact with each other or the container as shown in figure 8. The inner chamber will also be lined with aerogel to keep the temperature constant. According to NASA “Aerogels provide very effective insulation, because they are extremely porous and the pores are in the nanometer range. The nano pores aren't visible to the human eye. The existence of these pores makes the aerogel so adept at insulating.” [8] Further detail on temperature change will be explained later in the proposal.

Table 18 contains all the individual parts that will be used in the construction of the container shown in Figure 5.

Table 18: Container Materials		
Materials	**Specifications**	**Function**
Polycarbonate	Cylinder: 12” in height with a 5” outer diameter, 4.75” inner diameter and an inner chamber 4.25” outer diameter and 4” inner diameter	Increases impact resistance
Borated flexi-panel	Sheet: 0.275” in thickness, 6.5” in width, and 11.8” in length	Shields against radiation
Aerogel insulator	Sheet: 0.19685” in thickness, 6.5” in width, and 11.8” in length	Insulates against changes in temperature
Silicone disks	Disks: 3.75” in diameter and 0.25” in thickness	Hold solid samples in place while inside the container
Pressure sensitive overlaminate	Film Thickness**:** 0.197”	Increase durability of the silicon disks
Compression springs	0.5” in length and 0.25” in diameter	Add shock resistance in between the silicone disks
Threaded metal rods	Everbilt zinc threaded rods 0.25” in diameter	Enable the silicon disks to move up and down inside the container
Nuts	UNC x 0.25" F and 0.09375” in height	Secure the laminated silicon plates together

Flat washer	0.025”in thickness, inner diameter 0.281”,and outer diameter 0.625”	Increase the seal of the nuts and the silicon disks
Lock washer	410 SS and 0.25" in diameter	Secure the seal between the nuts and silicon disks
Threaded adaptor	5.5” in diameter	Allows a cap to be sealed onto the top of the container
Threaded cap	5.5” in diameter	Seals the container

Figures 5 – 10 introduce the proposed payload and its components from different views and with various levels of detail.

Figure 5: Proposed Container (Isometric View)

Figure 5 shows an isometric view of the assembled container.

Figure 6: Inner Rack (Isometric Exploded View)

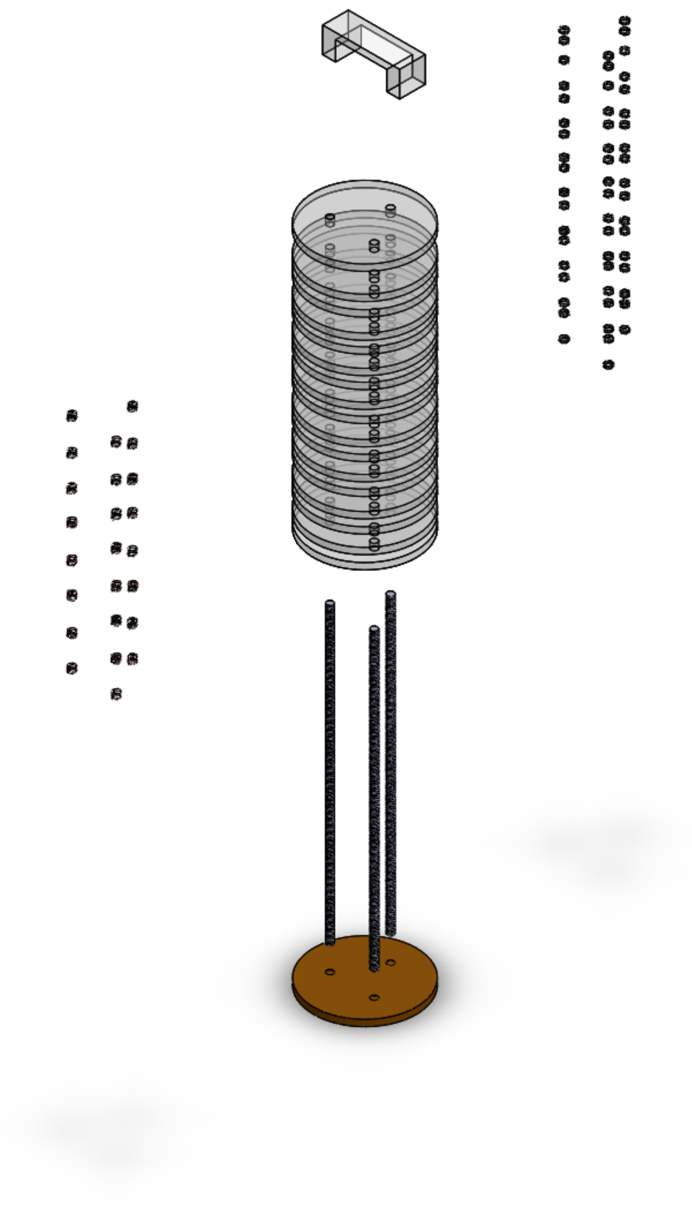


Figure 6 shows the inner rack in an isometric exploded view.

Figure 7: Inner Rack

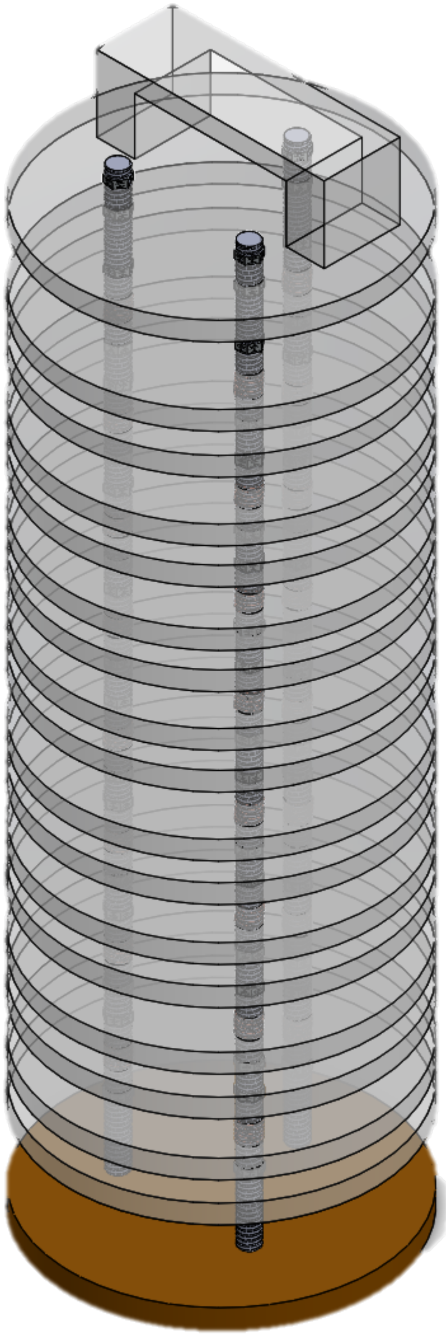


Figure 7 displays the container's inner rack proposed by the team.

Figure 8: Inner Rack (Cross Section View)

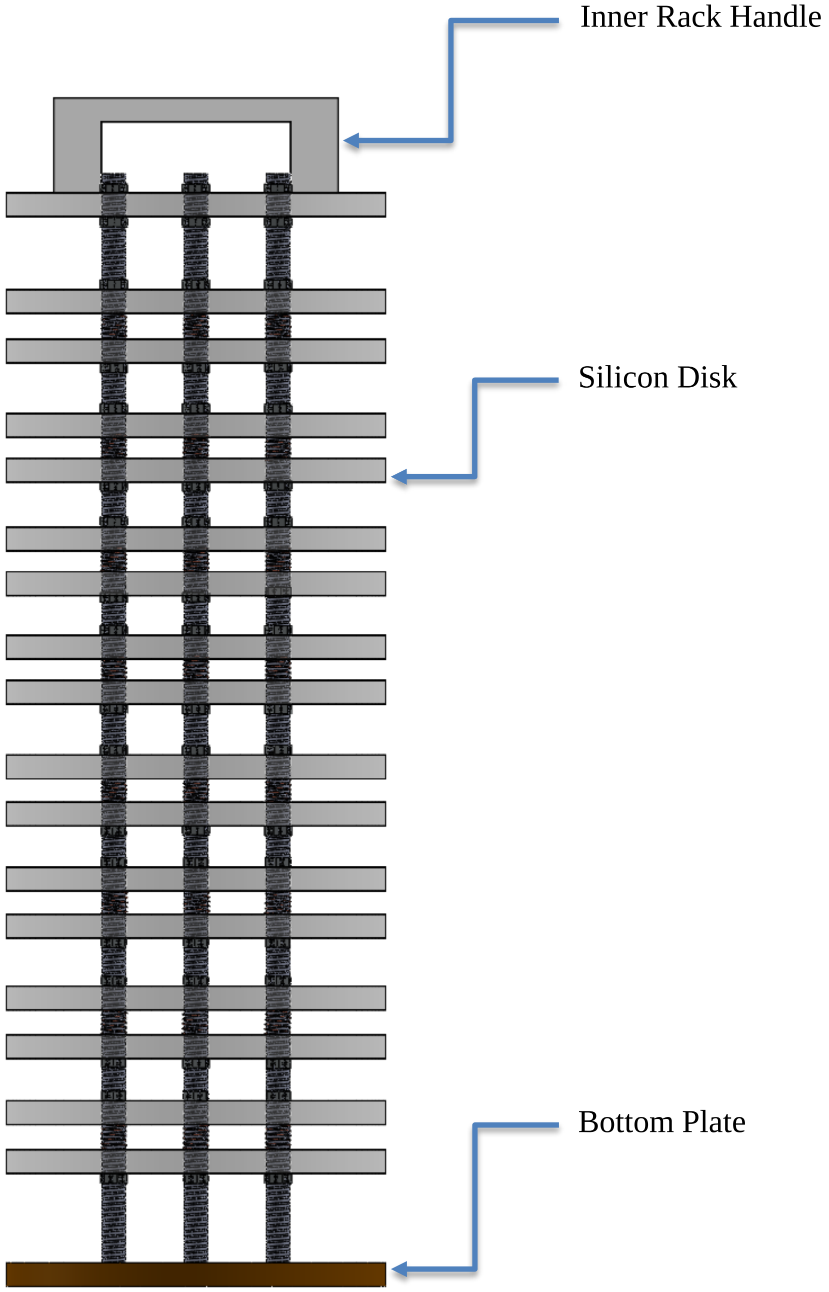


Figure 8 shows the inner rack of the container with the handle, bottom plate, and a silicon disk labeled.

Figure 9: Inner Rack Subsections (Close Up View)

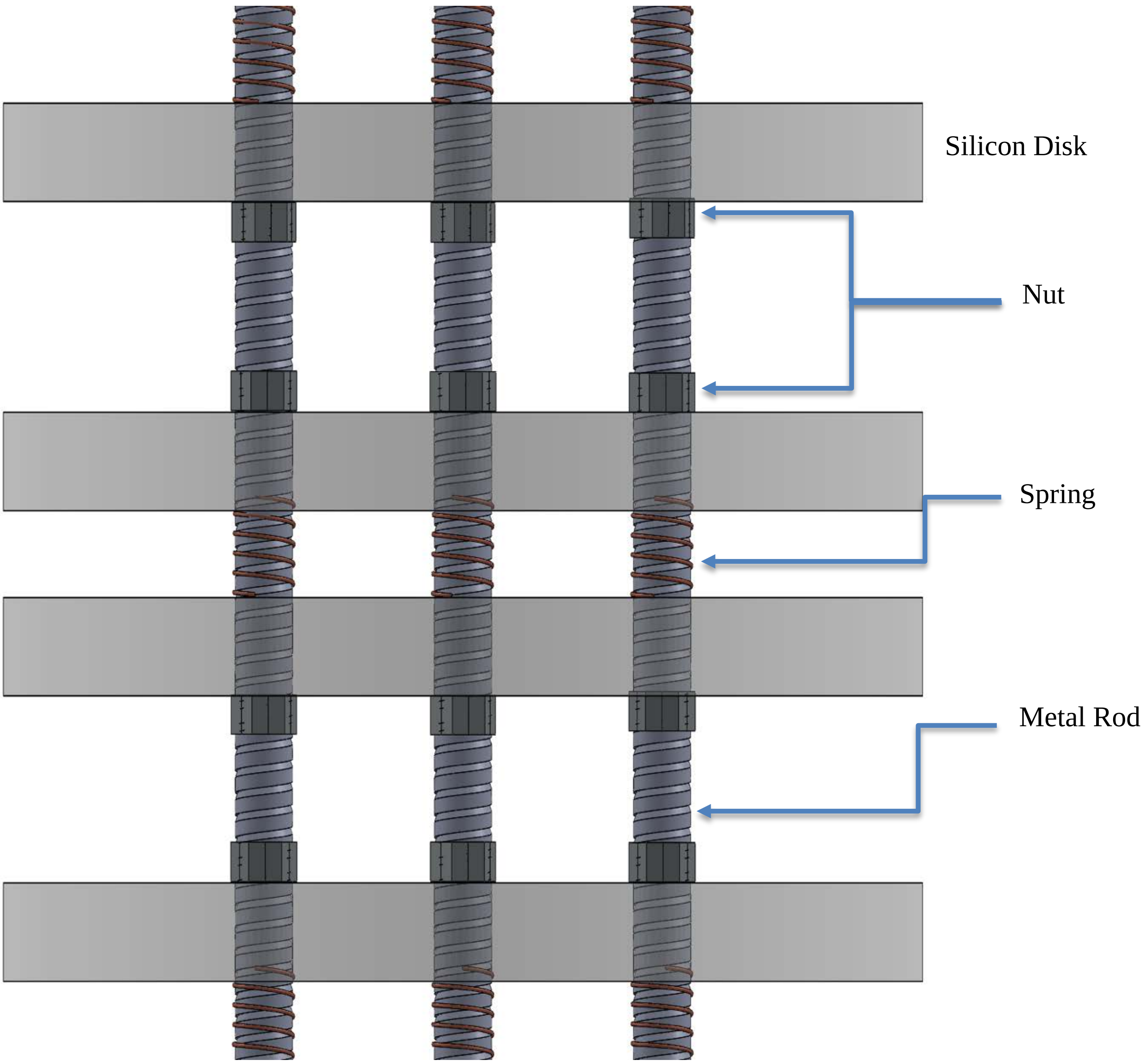


Figure 9 shows a close up view of the subsections within the inner rack of the container with major components labeled.

Figure 10: Proposed Container (Exploded View)

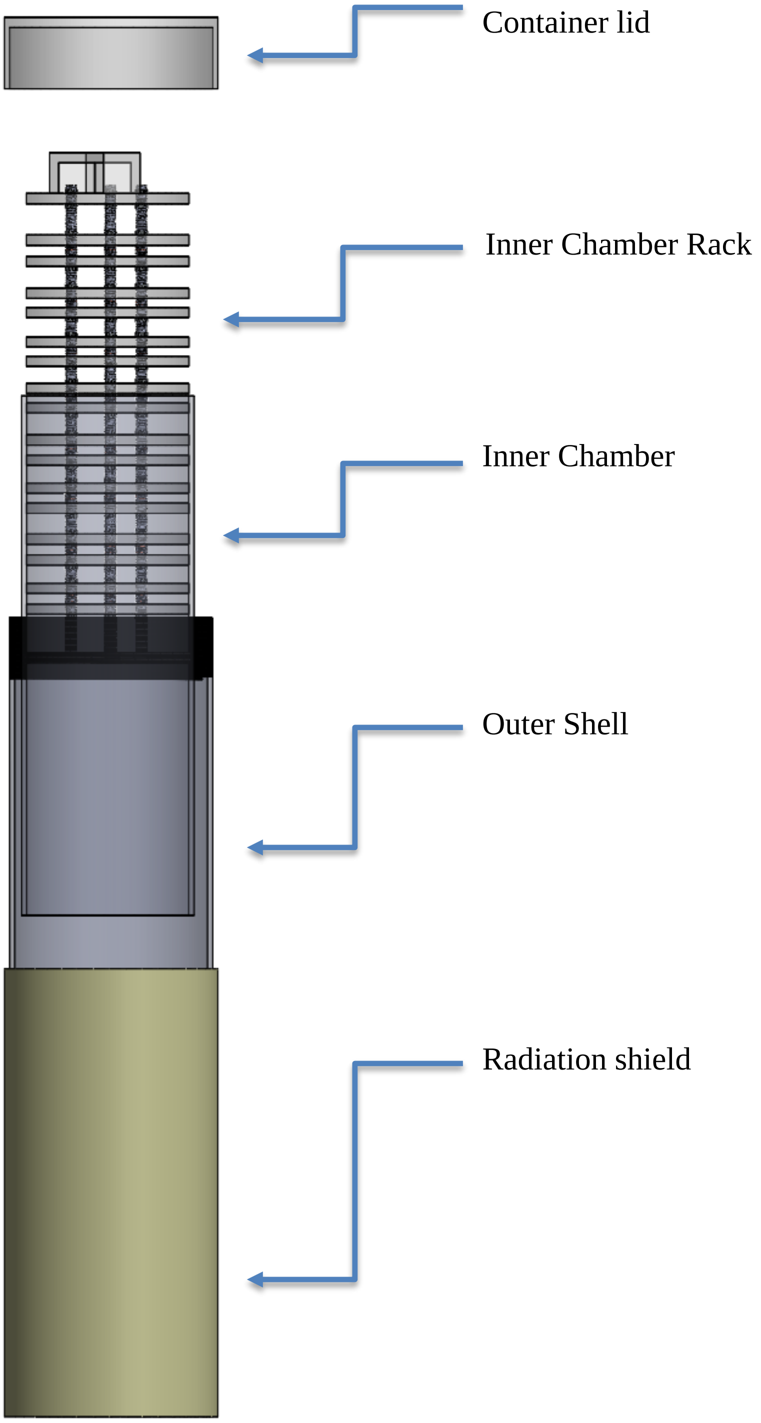


Figure 10 shows an exploded view of the complete container with all major parts labeled.

Container Considerations

The container has been designed to house and protect samples obtained from Mars and brought back to Earth. In order for the container to successfully protect the samples there are several concerns the team had to address. A sample from Mars will have to withstand any impact or shock that occurs during the flight and landing of the rocket. If the object is fragile, impact may cause damage to it. The sample must also be protected from the temperature change it will endure during the trip to Earth. Mars is significantly colder than Earth and this difference in temperature could cause issues such as phase changes in molecular bonds or chemical structures being altered because of the increase in heat. Mars also has a vastly different atmospheric pressure. As the sample travels to Earth the pressure will increase and if it is not properly protected the change in pressure could crush the sample. In the possible scenario that the sample combusts or a material near the sample container catches fire the container itself needs to be flame resistant. A fire in space can survive on less oxygen and burn for longer periods of time, so the container must be effective at protecting the sample from fire [9]. Samples from Mars may also need to be kept separate from each other to prevent cross contamination. Objects of the same material can be cross contaminated by each other which could potentially alter the results of any observations or experiments done with the material. To further prevent contamination and leakage the container must be hermitically sealed. Radiation is also a danger in space that the sample should be protected from. This is especially important in the case of obtaining an organic sample. Radiation may cause changes to its chemical composition or alter it molecularly, compromising the validity of any experiments on the sample.

Impact

Samples from space exploration may be sensitive to impact hence the container designed to safeguard those samples must be able to withstand a great amount of force. The total tensile strength of polycarbonate, borated flexi-panel, and Line-X will give the outer shell a combined tensile strength of about 10,000 psi. This level of strength will allow the container to withstand a significant amount of impact on Earth Considering that gravity on Mars is 0.375 % of Earth’s gravity, the proposed container will be able to absorb a range of different impact strength on Mars due to handling errors (i.e. dropping the container) as well as general sources of impact. The inner compartment of the proposed cylindrical container will house the samples. It will be made with clear polycarbonate and is 6.5” in height, with a 4.0” outer diameter and a 3.75” inner diameter. Polycarbonate is an impact resistant material with a tensile strength of 8702.26 -10500.73 psi [10].The strength of the polycarbonate is a result of the covalent bonds in its molecular structure. In addition, the aromatic rings that compose this material also make it heat resistant and transparent. The container’s inner compartment is secured to the main cylinder using Loctite Epoxy Plastic Bonder which was chosen because of its bonding properties. This plastic bonder works well with polycarbonate and several different plastics and rubber-like materials. Its compression shear strength on polycarbonate is 1713 psi, which will provide additional strength to hold the two materials together.

Shock

Samples from Mars may be sensitive to shock as well as impact Highly fragile materials and some reactive chemicals can be damaged or cause damage if they experience shock or vibrations. To account for this there is a rack in the inner cylinder made from three identical 6.5” Everbilt zinc threaded rods. The rods are 0.25” in diameter and are epoxied to a nylon disk at their ends. At the top of the rack is an additional-0.25” rod that serves as a handle. The rods run through eight silicone disks, each 3.75” in diameter and 0.25” in thickness. These disks are laminated with 0.197” PS Over laminate for additional strength. Additionally, three springs of 0.5” length and 0.825” diameter run through the threaded rods and lie between each pair of disks. These disks hold the samples securely in place and prevent any motion inside the cylinder. To insert the samples into the container, the rack is pulled out of the inner cylinder and the samples are placed in between the silicone disks. The disks are then pressed together, compressing the spring, and are held in place with aluminum nuts which are located on each side of the pair of silicone disks. The rack is inserted back into the container and the lid is then sealed. This design will allow the collected samples to move slightly, while still being held securely. As a result most of the shock felt on the objects housed in the container will be absorbed.

Temperature Change

Keeping the temperature of the collected samples constant is crucial to have accurate data when examining the samples on Earth, because the team must consider that "Increasing the temperature increases reaction rates because of the disproportionately large increase in the number of high energy collisions. It is only these collisions (possessing at least the activation energy for the reaction) which result in a reaction."[11] To avoid unwanted reactions the inside of the proposed container will be lined with a layer of aerogel insulation in order to increase the container's capability to maintain a constant temperature. Aerogel has a very low thermal conductivity of 0.016-0.03 (W/mK) at 298.15K Furthermore, when considering the total mass of the container "aerogel has the lowest density of any know solid [at 0.31-12.49 lb-ft^3]." [12]

Flammability

On Earth, small fires possess a teardrop shape caused by buoyant flow of cool air displacing the hot air within a flame, allowing the flame to obtain necessary oxygen to burn. However, in circumstances of low gravity buoyancy does not occur, allowing a flame to spread in different directions, potentially yielding a dome-like shape [13]. Though fire prevention is ideal during material retrieval, ideal situations cannot be assumed. Figure 5 displays the proposed container sealed with threaded caps that restrict the oxygen supply to a potential flame developed within the container. This way, if a fire were to develop within the container, it would burn until the oxygen supply within was depleted. Limited oxygen supply in combination with the self-extinguishing properties of polycarbonate [14], the material that will be used for fabrication of the proposed container, ensure a small and contained fire, should a combustion occur.

Isolation

Isolation of the collected samples from possible collisions with the surroundings or with each other inside the container's inner chamber is another significant criterion to be considered in order to accomplish the goal of the proposed container, as indicated in section e of this document. To ensure an effective isolation, the interior chamber of the proposed container will house a custom-built, adjustable threaded rail system comprised of 16 silicon disks able to move freely up and down the rails and separate the container into compartments, as needed. Each compartment will be enclosed by two silicon plates that will in-close the object restricting its movement and ability to come in contact with other elements of the surrounding environment, including other samples or parts of the container. The two silicon plates will be held down by a combination of washers and nuts tighten on the rails. In addition, there will be three springs in between each set of two silicon plates that will increase the flexibility of the silicone disks allowing them to encompass the sample(s) in a more effective manner, refer to Figure 9 for more details.

Contamination

Contamination is a serious concern when samples are retrieved and transported from one location to another In order to avoid cross contamination of the samples, should more than one be retrieved, the seal between any two silicon plates on the rail system housed by the inner chamber of the proposed container will be extremely tight as a result of using a combination of nuts, flat washers and lock washers. Additionally, the lid used to hermetically seal the container t will provide protection of the samples from any contaminants that may be in the surrounding area. The proposed container must remain hermetically sealed until it has been placed into a controlled environment on Earth for data analysis.

Radiation

There are two types of radiation in space, ionizing radiation and non-ionizing radiation. Ionizing radiation is caused by magnetic fields and cosmic rays, among other things. “Space radiation consist mostly of ionizing radiation”, this includes gamma rays, protons, and neutrons [15]. To protect the collected sample from radiation a 6.75”x 11.25”x 0.275” 9% borated flexi panel is adhered to the outside of the proposed container using Loctite Epoxy Plastic Bonder as shown in Figure 10. This material is lightweight and self-extinguishing; and will protect the sample from a possible external fire along with shielding the rest of the rocket if the sample were to combust. It is commonly used for radiation shielding in fusion test facilities and in high energy accelerators. The material has a high hydrogen and boron density which attenuates the radiation field. It also contains a hydrogenous additive which reduces the speed of the neutrons, contributing to the reduction of the radiation field. The flexi-panel’s gamma resistance level is

Pressure

Mars has an atmosphere composed of 95% carbon dioxide, 3% nitrogen, and 1.6% argon. The atmospheric pressure in Mars is approximately 100 times thinner than that on Earth [17]. As the proposed container returns to Earth from Mars, it will experience an increase in pressure, from 0.11 psi to 14.70 psi, on its external walls [18]. Using the van der Waals equation for non-ideal behaving gases, and the fact that the atmosphere on Mars is mainly composed of carbon dioxide, the pressure inside the container while in Mars can be estimated [18]. On average, Mars reaches a low temperature of 120.15K[17], using this value in the van der Waals equation the pressure inside the container is expected to be 6.47 psi if the object were obtained during the lowest temperature in Mars. The average high temperature on Mars, 293.15K[17], was also used in the equation as a separate scenario in the case that the extraction occurred during Mars' warmer weather, this resulted in a pressure value of 15.87 psi inside the proposed contained. The pressure inside the proposed would increase as the rocket descends to Earth until the pressure value is around 14.69 psi. Opening the container on Mars to insert the unknown object(s) will equalize the container's internal pressure with the atmospheric pressure of Mars. As the container descends it will experience an increase in pressure on the walls of the proposed container. Polycarbonate has a tensile strength of 10,500 psi and a compressive strength of 1,150 psi [19]. Loctite Epoxy Plastic Bonder has a bond strength of 3,450 psi [20] and will be used to hold the components of the proposed container together. The 0.25" thick polycarbonate walls of the proposed container will be capable of withstanding the pressure that is exerted on it, due to its tensile strength, and help reduce the change in pressure that the sample experiences. Since the tensile strength of the polycarbonate and bonding agent are higher than the pressure force that is expected to occur within the proposed container, the container is expected to be durable enough to withstand the pressure change that will occur during the return flight.

Liquid containment

In order to accommodate safe storage of liquid sample(s) the proposed container will have a section on the outer rim of the inner chamber completely separated from the rest of the chamber, as shown in Figure 10 able to hold the sample. Because leakage should occur when the liquid undergoes active fluid motion, a nitrile rubber gasket installed in the lid will be used to prevent any liquid from escaping. Nitrile rubber has ideal engineering properties and is a general-purpose sealing lip material [21]. A nitrile rubber gasket will hermitically close the proposed container by providing a tight enclosure between the cap and the container's rim. Additionally, the flexibility feature of the nitrile rubber gasket will also provide a tight filling of irregular gap between the cap and the lip of the proposed container.

In order to maintain the state of the liquid sample(s), the inner chamber of the proposed container must preserve its pressure and temperature. The pressure will be controlled by not allowing any air (gas) in or out. This will be achieved with the seal of the lid. The temperature of the liquid sample inside the container will be controlled by the aerogel insulator lining inside the liquid compartment.

f. Vehicle, Recovery System, and Payload Design Requirements

The Citrus College Rocket Owls have carefully assessed all requirements as specified by the NASA Student Launch Handbook and have verified that the proposed launch vehicle and payload meet those requirements.

Table 19 provides the specific requirements and pertaining resolutions for the launch vehicle.

Table 19: Launch Vehicle Requirements

Requirement	Resolution
1.1. The vehicle shall deliver the science or engineering payload to an apogee altitude of 5,280 feet above ground level (AGL).	RockSim Pro 9 simulations and test flights will determine the appropriate motor to reach the target altitude.
1.2. The vehicle shall carry one commercially available, barometric altimeter for recording the official altitude used in determining the altitude award winner.	The official altitude will be recorded by one of the Missile Works RRC2+ altimeters.
1.2.1. The official scoring altimeter shall report the official competition altitude via a series of beeps to be checked after the competition flight.	The Missile Works RRC2+ altimeters report the AGL altitude via a series of beeps, each corresponding to a specific number.

1.2.2. Teams may have additional altimeters to control vehicle electronics and payload experiment(s).	Only a redundant altimeter will be utilized for recovery.
1.2.3.. At the Launch Readiness Review, a NASA official will mark the altimeter that will be used for the official scoring.	NASA officials will have the official altimeter available at the launch readiness review to be marked.
1.2.4. At the launch field, a NASA official will obtain the altitude by listening to the audible beeps reported by the official competition, marked altimeter.	The Missile Works RRC2+ altimeters relay the maximum altitude via audible beeps.
1.2.5. At the launch field, to aid in the determination of the vehicle’s apogee, all audible electronics, except for the official altitude determining altimeter shall be capable of being turned off.	The official scoring altimeter will remain on at all times. All other audible electronics, if any, may be turned off.
1.2.6. The following circumstances will warrant a score of zero for the altitude portion of the competition.	See below
1.2.6.1. The official, marked altimeter is damaged and/or does not report an altitude via a series of beeps after the team’s competition flight.	The Missile Works RRC2+ will be housed securely inside the avionics bay to prevent damage.
1.2.6.2. The team does not report to the NASA official designated to record the altitude with their official, marked altimeter on the day of the launch.	The team will report to the NASA official after their launch and recovery.
1.2.6.3. The altimeter reports an apogee altitude over 5,600 feet AGL.	RockSim Pro 9 simulations along with test launches will be conducted to ensure that the altitude does not surpass 5,600 feet AGL and that the desired altitude is reached.

1.2.6.4. The rocket is not flown at the competition launch site.	The team will pay utmost attention when following all specified requirements in constructing and testing the rocket so that the launch vehicle is cleared to launch during the competition.
1.3. All recovery electronics shall be powered by commercially available batteries.	Commercially available 9V batteries shall power all recovery electronics.
1.4. The launch vehicle shall be designed to be recoverable and reusable.	Current RockSim Pro 9 simulations predict that all rocket components will be recovered within close range from the launch pad. All launch vehicle components are designed to be reusable.
1.5. The launch vehicle shall have a maximum of four (4) independent sections.	The launch vehicle has two (2) independent sections.
1.6. The launch vehicle shall be limited to a single stage.	The launch vehicle only has one stage.
1.7. The launch vehicle shall be capable of being prepared for flight at the launch site within 4 hours, from the time the Federal Aviation Administration flight waiver opens.	A compiled checklist will be utilized to ensure that flight preparation is efficient, thorough, and completed in less than two (2) hours. These operations will be practiced during test launches.
1.8. The launch vehicle shall be capable of remaining in the launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any critical on-board component.	All onboard electronics can remain in launch-ready configuration for several hours due to their low power drawing properties.
1.9. The launch vehicle shall be capable of being launched by a standard 12-volt firing system.	The launch vehicle will use a commercial, APCP motor that will ignite with a 12- volt direct current.

1.10. The launch vehicle shall require no external circuitry or special ground support equipment to initiate launch (other than what is provided by Range Services).	The launch vehicle will not use external circuitry or special ground support to initiate launch.
1.11. The launch vehicle shall use commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR).	The team will utilize a certified L2200G or M1500G motor from Aerotech
1.11.1. Final motor choices must be made by the Critical Design Review (CDR).	The final motor choice will be stated in the CDR.
1.11.2. Any motor changes after CDR must be approved by the NASA Range Safety Officer (RSO) and will only be approved if the change is for the sole purpose of increasing the safety margin.	The team will only make a motor change request if it increases the safety margin significantly.
1.11. Pressure vessels on the vehicle shall be approved by the RSO and shall meet the following criteria:	Pressure vessels will not be used.
1.12.1. The minimum factor of safety (Burst of Ultimate Pressure versus Max Expected Operating Pressure) shall be 4:1 with supporting design documentation included in all milestone reviews.	Pressure vessels will not be used.
1.12.2. The low-cycle fatigue life shall be a minimum of 4:1.	Pressure vessels will not be used.
1.12.3. Each pressure vehicle shall include a pressure relief valve that sees the full pressure of the tank.	Pressure vessels will not be used.

1.12.4. Full pedigree of the tank shall be described, including the application for which the tank was designed, and the history of the tank, including number of pressure cycles put on the tank, by whom, and when.	Pressure vessels will not be used.
1.13. The total impulse provided by a Middle and/or High School launch vehicle shall not exceed 5,120 Newton-seconds (L-class).	The launch vehicle is part of a College team.
1.14. The launch vehicle shall have a minimum static stability margin of 2.0 at the point of rail exit.	The launch vehicle will have a 2.28 stability margin with the Aerotech M1500G at the point of rail exit.
1.15. The launch vehicle shall accelerate to a minimum velocity of 52 fps at rail exit.	The launch vehicle will accelerate to a velocity of 71.7 fps at rail exit.
1.16. All teams shall successfully launch and recover a subscale model of their full-scale rocket prior to CDR.	The team will launch and recover a 2/3-scale model of the full-scale rocket prior to CDR.
1.16.1. The subscale model should resemble and perform as similarly as possible to the full-scale model, however, the full-scale shall not be used as the subscale model.	
1.16.2. The subscale model shall carry an altimeter capable of reporting the model’s apogee altitude.	The subscale model will have a redundant commercially available altimeter system.
1.17. All teams shall successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown at FRR must be the same rocket to be flown on the launch day.	The team will launch and recover the full-scale (4.5’’ diameter) rocket successfully prior to FRR in its final flight configuration
1.17.1. The vehicle and recovery system shall function as designed.	The vehicle and recovery systems will be constructed according to the designs.

1.17.2. The payload does not have to be flown during the full-scale test flight. The following requirements still apply:	See below
1.17.2.1. If the payload is not flown, mass simulators shall be used to simulate the payload mass.	A mock payload matching the mass of the true payload will fly with the launch vehicle.
1.17.2.1.1. The mass simulators shall be located in the same approximate location on the rocket as the missing payload mass.	The full-scale rocket will be flown with a mock payload matching the mass and location of the actual payload.
1.17.3. If the payload changes the external surfaces of the rocket (such as with camera housings or external probes) or manages the total energy of the vehicle, those systems shall be active during the full-scale demonstration flight.	The payload experiment will be active throughout the full scale flight
1.17.4. The full-scale motor does not have to be flown during the full-scale test flight. However, it is recommended that the full-scale motor to be used to demonstrate full flight readiness and altitude verification.	The full-scale motor will be flown during the full-scale test flight.
1.17.5. The vehicle shall be flown in its fully ballasted configuration during the full-scale test.	The vehicle will be flown in its fully ballasted configuration during the full-scale test.
1.17.6. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components shall not be modified without the concurrence of the NASA Range Safety Officer.	The launch vehicle will not be modified after the full-scale demonstration flight with the concurrence of the NASA RSO.
1.17.7. Full scale flights must be completed by the start of FRRs (March 6th, 2016).	Full scale flights of the launch vehicle will be completed by the start of FRRs.

1.18. Any structural protuberance on the rocket shall be located aft of the burnout center of gravity.	The launch vehicle will not have structural protuberances.
1.19. Vehicle prohibitions	See below
1.19.1. The launch vehicle shall not use forward canards.	The launch vehicle will not use forward canards.
1.19.2. The launch vehicle shall not use forward firing motors.	Forward firing motors will not be utilized by the launch vehicle.
1.19.3. The launch vehicle shall not utilize motors that expel titanium sponges.	Motors that expel titanium sponges are not utilized by the launch vehicle.
1.19.4. The launch vehicle shall not utilize hybrid motors.	Commercially available solid APCP motors are utilized for the launch vehicle.
1.19.5. The launch vehicle shall not utilize a cluster of motors.	A single motor is used for the launch vehicle.
1.19.6. The launch vehicle shall not utilize friction fitting for motors.	The launch vehicle will use a threaded metallic flange with a fitting threaded cap for motor retention.
1.19.7. The launch vehicle shall not exceed Mach 1 at any point during flight.	The launch vehicle will not exceed Mach 1 at any point during flight.
1.19.8. Vehicle ballast shall not exceed 10% of the total weight of the rocket.	Launch vehicle ballast will not exceed 10% of its total weight.

Table 20 lists the requirements and resolution for the recovery system.

Table 20: Recovery System Requirements

Requirement	Resolution
2.1. The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude.	Missile Works RRC2+ altimeters will eject the drogue parachute at apogee, and the main parachute at 800 ft.

2.2. Each team must perform a successful ground ejection test for both the drogue and main parachutes. This must be done prior to the initial subscale and full scale launches.	Successful ground ejection tests will be conducted prior to all initial subscale and full scale launches.
2.3. At landing, each independent section of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf.	The team will theoretically calculate and utilize test-flight data to calculate the kinetic energy of landing for each rocket section. The combined descent rate of the rocket and untethered payload experiment will be adjusted as necessary to ensure that all components land with less than 75 ft-lbf of kinetic energy.
2.4. The recovery system electrical circuits shall be completely independent of any payload electrical circuits.	Each altimeter will be independent of any payload electrical circuits, including other recovery altimeters.
2.5. The recovery system shall contain redundant, commercially available altimeters. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.	The recovery system will contain redundant Missile Works RRC2+ altimeters to deploy the parachutes.
2.6. Motor ejection is not a permissible form of primary or secondary deployment.	Motor ejection will not be utilized.
2.7. Each altimeter shall be armed by a dedicated arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.	All RRC2+ altimeters will have separate external arming switches accessible when the rocket is in launch position.
2.8. Each altimeter shall have a dedicated power supply.	Each altimeter will have a dedicated 9V power supply.
2.9. Each arming switch shall be capable of being locked in the ON position for launch.	The arming switches will require a key to lock them in the ON position.

2.10. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.	All parachutes compartments will be attached with #2 nylon shear pins.
2.11. An electronic tracking device shall be installed in the launch vehicle and shall transmit the position of the tethered vehicle or any independent section to a ground receiver.	The launch vehicle will have two (2) GPS tracking devices.
2.11.1. Any rocket section, or payload component, which lands untethered to the launch vehicle, shall also carry an active electronic tracking device.	All payload components will be inside of the rocket. All rocket sections will be tethered together.
2.11.2. The electronic tracking device shall be fully functional during the official flight on launch day.	The GPS tracking device will be fully functional at the launch site competition.
2.12. The recovery system electronics shall not be adversely affected by any other on-board electronic devices during flight (from launch until landing).	The recovery system electronics will be independently wired.
2.12.1. The recovery system altimeters shall be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.	The recovery system altimeters will be physically separated from the GPS transmitter by being installed in their own avionics bay.
2.12.2. The recovery system electronics shall be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system electronics.	The recovery system electronics will be shielded from the GPS transmission and from any other onboard devices that may adversely affect their proper operation.

2.12.3. The recovery system electronics shall be shielded from all onboard devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.	Equipment yielding magnetic waves will not be utilized.
2.12.4. The recovery system electronics shall be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.	The recovery system electronics will be secured inside the avionics bay without interference of other electronics.

Table 21 below lists the requirements and resolutions for the experiment.

Table 21: Fragile Material Protection

Requirement	Resolution
3.1.1. Each team shall choose one design experiment option from the following list.	The team has chosen experiment three (3): fragile material protection.
3.1.2. Additional experiments (limit of 1) are encouraged, and may be flown, but they will not contribute to scoring.	The team will not have additional experiments.
3.1.3. If the team chooses to fly additional experiments, they shall provide the appropriated documentation in all design reports so experiments may be review for flight safety.	

3.4.1. Teams shall design a container capable of protecting an object of an unknown material and of unknown size and shape.	The proposed contained will be adjustable to accommodate multiple shapes, sizes, and quantities.
3.4.1.1. There may be multiple of the object, but all copies shall be exact replicas.	
3.4.1.2. The object(s) shall survive throughout the entirety of the flight.	The team will design and construct a container that will protect the unknown object(s) throughout the entire flight.
3.4.1.3. Teams shall be given the object(s) at the team check in table on launch day.	The team will test the protection caliber of the proposed container with other fragile materials.
3.2.1.4. Teams may not add supplemental material to the protection system after receiving the object(s). Once the object(s) have been provided, they must be sealed within their container until after launch.	Supplemental material for protection will not be added after receiving the object. The container will have a threaded cap closure seal that will remain closed until after launch.
3.4.1.5. The provided object can be any size and shape, but will be able to fit inside an imaginary cylinder 3.5” in diameter, and 6” in height.	The proposed contained will be able to accommodate a volume of 57.70 in^3 and withstand a minimum of 4 ounces for the unknown object(s).
3.5.1.6. The object(s) shall have a maximum combined weight of approximately 4 ounces.	

g. Technical Challenges and Solutions

Table 22 describes the technical challenges and solutions for the fragile material protection experiment.

Table 22: Technical Challenges in Fragile Material Experiment and Development

Challenge	Resolution
The object's quantity is unknown.	The proposed contained will have adjustable platforms to accommodate 1-8 object(s) of the same size and shape.
The object's size and shape are unknown.	
The proposed container must remain stable inside the launch vehicle.	The proposed container will be fixed inside the launch vehicle. Filler foam will fill the space between the outside of the container and the inside of the rocket to ensure the stability of the container.
The object(s) sensitivity is unknown.	The proposed container shields the object(s) from temperature and pressure change, collisions, radioactivity, flammability, leakage, and shock.
The object(s) may be in a liquid state.	The proposed container can hold liquids in a separate leak-proof compartment between the outer and inner chamber of the container.
The proposed container must be structurally strong and durable.	The proposed container will be constructed from polycarbonate to ensure durability.

Educational Engagement

The educational engagement activities that the Citrus College Rocket Owls plan to conduct include year-long programs, booth presentations, and weekend workshops targeting students in grades 5-8. In addition, the team will organize and conduct several other Science, Technology, Engineering and Mathematics (STEM) activities designed to increase interest of students from local colleges and school districts in STEM fields

A detailed description of the major educational engagement activities planned by the team is introduced below.

Year-long Programs

Junior Rocket Owls Program

The Rocket Owls are looking forward to mentoring the third generation of Junior Rocket Owls. The Junior Rocket Owls is a year-long program designed to spark and enhance the interest of 5th grade students enrolled in the Glendora Unified School District (GUSD) in STEM fields through multiple rocketry and other STEM- related experiences. The Citrus Rocket Owls will act as mentors to a number of 30 students during the monthly weekend workshops that will take place at Citrus College. The 5th grade GUSD students will work in teams under the facilitative leadership and guidance of the Rocket Owls to design, build and launch simple model rockets, as well as apply physics principles and learn how to use rocket simulation computer software to predict and analyze the performance of their model rockets. Furthermore, the Junior Rocket Owls will present what they have learned in this year-long program at a Symposium that will take place at Citrus College at the end of the academic year. The Junior Rocket Owls Symposium will showcase the professional posters that the 5th graders will design and create to display their methods, results and analysis through the scientific method.

Detailed information about this program can be found on the Junior Rocket Owls website at: http://www.citruscollege.edu/academics/owls/jr/.

It's Rocket Math!

It's Rocket Math! is an outreach program consisting of activities planned and facilitated by the Citrus College Rocket Owls using NASA educational resources [22]. Middle school students enrolled in the 7th grade GUSD GATE program will be provided the opportunity to participate in the program and develop skills in mathematics applications to rocketry, along with hands-on rocketry, science and technology skills. .

The outreach activities include building air rockets, and using sighting tubes, angle measurements, and tangent tables to determine the altitude of the air rockets ; building wind tunnels to test the air rockets; designing and building parachutes of different surface areas, then testing them to analyze the effect of a parachute's surface area on the rocket's time in flight; building and launching model rockets, analyzing their flights and comparing them with the mathematical models created beforehand; and preparing professional posters and presenting them at the end-of-the-program symposium organized at Citrus College.

Booth Presentations

By hosting informational/activity booths at local events, including the Azusa 8th Grade Majors Fair, Claremont-Summer Elementary School Science Fair, and Citrus College Physics Festival, the Rocket Owls will share their passion and knowledge in rocketry and other STEM fields with the community. Booth presentations provide opportunities for local members and students to ask the Rocket Owls questions pertaining to rocketry, NASA and its educational programs, as well as each team member's experience in STEM.

The booths will also provide activities tailored to the participants, along with multiple handouts explaining rocketry principles and STEM topics. Additionally, the Rocket Owls will take advantage of these events to network with the local community, so that the team may be introduced to future educational engagement and fundraising opportunities.

Weekend Workshops

The Rocket Owls plan to organize and facilitate weekend workshops where participants will work in small groups to conduct experiments related to rocketry with the goal of introducing K-8 students enrolled local school districts to new ways of exploring science and mathematics, typically not seen in regular classroom environments.

All workshops will begin with a detailed presentation on the importance of safety procedures when building and launching a rocket, followed by an interactive discussion on basic rocketry principles, and guiding participants in the process of successfully constructing model rockets. During a short break, the Rocket Owls will introduce their goals for the NASA Student Launch Competition, along with the strategies for meeting those goals.

The workshops will end with students launching the rockets that they built. Before launch, the Rocket Owls will ask the participants to predict the behavior of their rocket, followed by an after-launch discussion comparing their hypotheses to the actual rocket's behavior.

Evaluation

The Rocket Owls will use pre- and post-activity surveys to determine the impact of the outreach program on the participants. The posters created and presented by the 5th grade students participating in the Junior Rocket Owls program and 7th grade students participating in the It's Rocket Math! program will indicate the gains of these middle school students in rocketry-related concepts along with any improvement of their communication and technical writing skills.

Project Plan

1. **Project Timeline**

NASA SL Timeline

Figure 11 list all important deadlines and milestones of the project as well as the expected date of completion of each task

Figure 11**:** Main Event Timeline

ID ↑	Task Name	Dura	Start	Finish
1	Rocket and payload	6d	8/15/2016	8/22/2016
2	Designs are finalized	9d	8/23/2016	9/2/2016
3	Proposal rough draft	7d	9/2/2016	9/10/2016
4	Proposal rough draft	6d	9/9/2016	9/16/2016
5	Autocad and rocksim	1d	9/16/2016	9/16/2016
6	Proposal is submitte	2d	9/29/2016	9/30/2016
7	Proposal winners anr	1d	10/12/2016	10/12/2016
8	Rocket and payload	37d	10/13/2016	12/2/2016
9	Sub-scale constructic	17d	10/13/2016	11/4/2016
10	Payload construction	17d	10/13/2016	11/4/2016
11	PDR Q&A	1d	10/14/2016	10/14/2016
12	PDR writing	6d	10/15/2016	10/21/2016
13	Payload prototype te	6d	11/4/2016	11/11/2016
14	PDR draft is due	1d	10/21/2016	10/21/2016
15	PDR draft review	5d	10/24/2016	10/28/2016
16	PDR is submitted	1d	10/31/2016	10/31/2016
17	PDR Teleconferences	13d	11/2/2016	11/18/2016
18	CDR planning	2d	11/19/2016	11/21/2016
19	CDR Q&A	1d	11/30/2016	11/30/2016
20	CDR draft is written	17d	12/1/2016	12/23/2016
21	Construction of full s	1d	12/2/2016	12/2/2016
22	Sub-scale launch at F	1d	12/3/2016	12/3/2016
23	CDR first review	1d	1/2/2017	1/2/2017
24	CDR second review	7d	1/2/2017	1/10/2017
25	CDR is submitted	1d	1/13/2017	1/13/2017
26	CDR Teleconferences	11d	1/17/2017	1/31/2017
27	FRR Q&A	1d	2/8/2017	2/8/2017
28	Full scale launch at L	1d	2/11/2017	2/11/2017
29	FRR is submitted	1d	3/6/2017	3/6/2017
30	FRR Teleconferences	13d	3/8/2017	3/24/2017
31	Travel to Huntsville	2d	4/5/2017	4/6/2017
32	LRR is submitted	1d	4/5/2017	4/5/2017
33	Launch Day	2d	4/8/2017	4/9/2017
34	PLA writing and revie	11d	4/10/2017	4/23/2017
35	PLA is submitted	1d	4/24/2017	4/24/2017

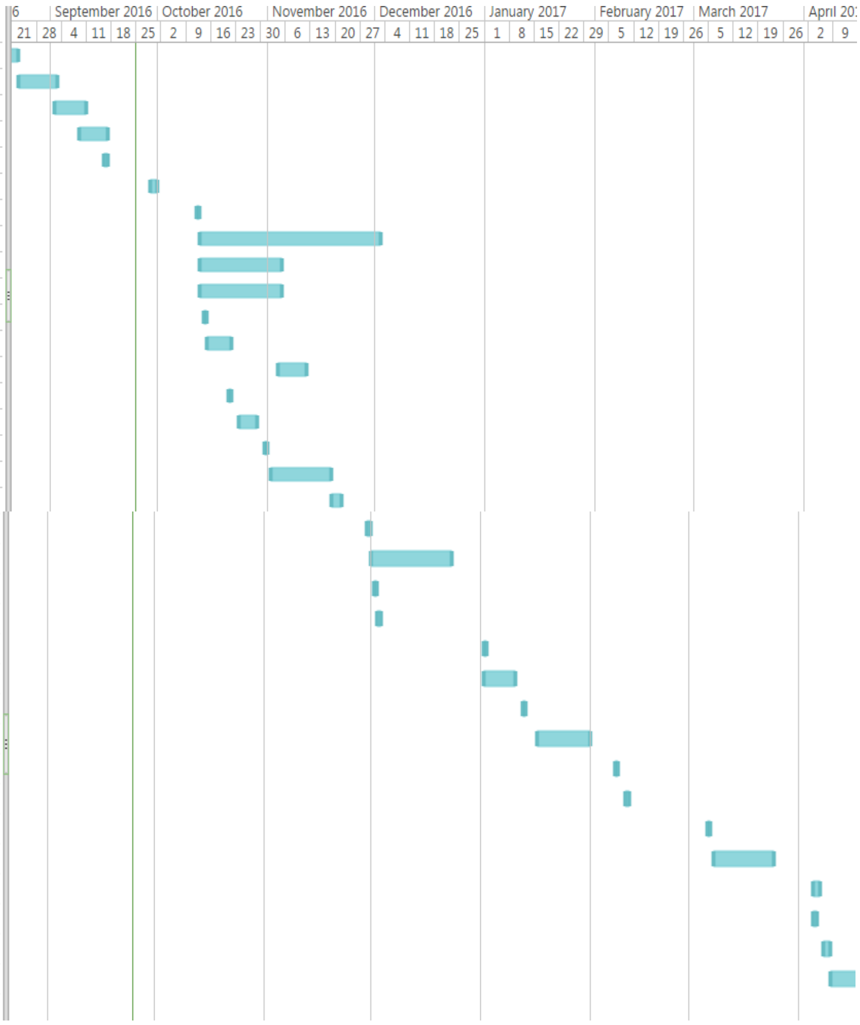


Figure 11 shows the Gantt chart detailing the NASA SL main events and their planned deadlines

The information represented in Figure 11 above is also listed in Table 23 below along with a brief description of the events.

Table 23: NASA SL Timeline		
Task	**Description**	**Due**
Rocket and payload are designed	Team designs rocket and payload	8/22/16
Designs are finalized	Final decisions are made regarding the designs of the rocket and payload	9/9/16
Proposal rough draft is due	Each teammate's section of the proposal is due for review	9/10/16
Rough Draft is reviewed by team	The proposal is edited by the team	9/16/16
AutoCAD and RockSim diagrams are due	All diagrams pertinent to the proposal are due	9/16/16
Proposal is submitted	Proposal is submitted to NASA	9/30/16
Proposal winners are announced	NASA announces proposal winners	10/12/16
PDR Q&A	Team members ask questions pertaining to the PDR	10/14/16
PDR writing begins	Sections of PDR are divided among team members and the team begins writing	10/17/16
Construction begins	Construction of sub-scale rocket and payload begins	10/13/16

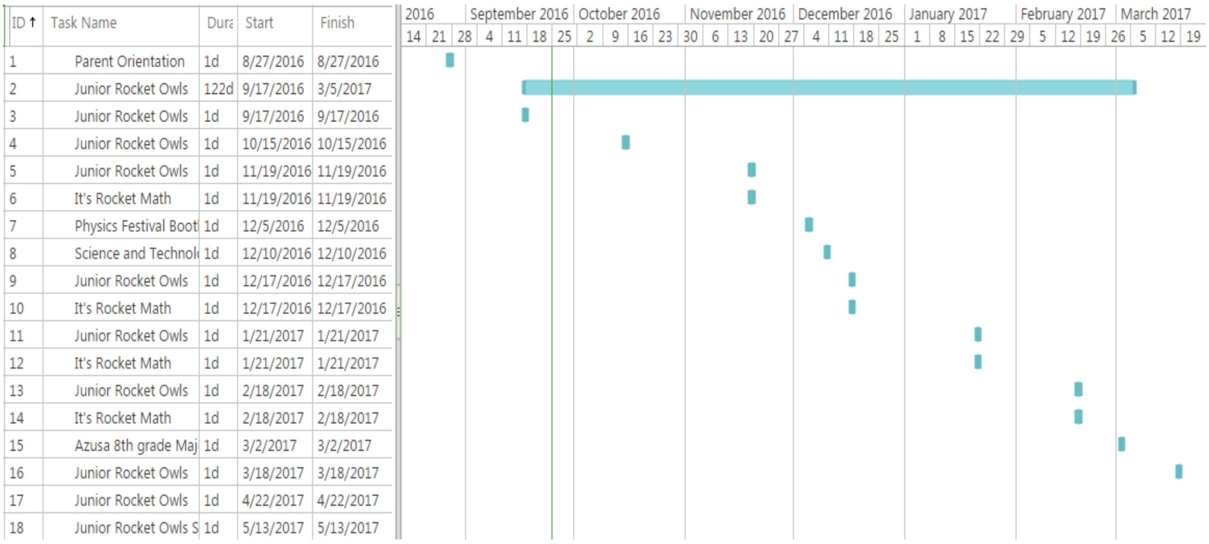
Sub-scale construction is completed	Sub-scale rocket construction is completed	11/4/16
Payload prototype is tested	The containers strength and isolation components are tested	11/4/16
PDR draft is due	Each team member's section of the PDR is due for revisions	10/21/16
PDR draft is edited by team	PDR draft is edited collectively by the team	10/24/16
PDR is submitted	PDR is submitted	10/31/16
PDR Teleconferences are held	NASA holds teleconferences	11/2/16-11/18/16
CDR is planned	Section of the CDR are divided among the team member	11/19/16
Construction of the full scale rocket is completed	Full scale rocket construction is completed	12/2/16
CDR Q&A	Team members ask questions pertaining to CDR	11/30/16
Sub-scale launch at FAR	Sub-scale is launched at FAR and its flight analyzed	12/3/16
CDR draft is due	Each team member's section of the CDR is due for revisions	12/31/16
CDR is edited by team	Team edits CDR	1/2/17
CDR is reviewed by team	CDR is revised	1/9/17
CDR is submitted	CDR is submitted to NASA	1/13/17
CDR Teleconference are held	NASA teleconference are held	1/17/17-1/31/17

FRR Q&A	Team ask questions pertaining to FRR	2/8/17
Full scale launch	Full scale rocket launch at Lucerne	2/11/17
FRR is submitted	FRR is submitted to NASA	3/6/17
FRR teleconferences are held	NASA teleconference are held	3/8/17-3/24/17
The team travels to Huntsville	Team travels to Huntsville	4/5/17
LRR is submitted	LRR is submitted to NASA	4/5/17
NASA SL launch day	Launch day	4/8/17
Team begins writing PLA	PLA sections are divided among the team members and writing begins.	4/10/17
PLA is reviewed by team	Team reviews PLA sections	4/19/17
PLA is submitted	PLA is submitted to NASA	4/24/17

Citrus College Rocket Owls 2016-2017 Outreach Schedule

Figure 12 below gives an overview of all outreach dates.

Figure 12: Outreach Event Timeline



ID ↑	Task Name	Dura	Start	Finish
1	Parent Orientation	1d	8/27/2016	8/27/2016
2	Junior Rocket Owls	122d	9/17/2016	3/5/2017
3	Junior Rocket Owls	1d	9/17/2016	9/17/2016
4	Junior Rocket Owls	1d	10/15/2016	10/15/2016
5	Junior Rocket Owls	1d	11/19/2016	11/19/2016
6	It's Rocket Math	1d	11/19/2016	11/19/2016
7	Physics Festival Boot	1d	12/5/2016	12/5/2016
8	Science and Technol	1d	12/10/2016	12/10/2016
9	Junior Rocket Owls	1d	12/17/2016	12/17/2016
10	It's Rocket Math	1d	12/17/2016	12/17/2016
11	Junior Rocket Owls	1d	1/21/2017	1/21/2017
12	It's Rocket Math	1d	1/21/2017	1/21/2017
13	Junior Rocket Owls	1d	2/18/2017	2/18/2017
14	It's Rocket Math	1d	2/18/2017	2/18/2017
15	Azusa 8th grade Maj	1d	3/2/2017	3/2/2017
16	Junior Rocket Owls	1d	3/18/2017	3/18/2017
17	Junior Rocket Owls	1d	4/22/2017	4/22/2017
18	Junior Rocket Owls S	1d	5/13/2017	5/13/2017

Figure 12 lists all outreach events and their corresponding dates.

Table 24 lists all outreach events hosted by the Rocket Owls over the course of the NASA SL as well as a brief description of those events.

Table 24: Rocket Owls Outreach Schedule		
Event	**Date**	**Description**
Junior Rocket Owls: Parent Orientation	8/27/16	Rocket Owls meet the parents of the new generation of Junior Rocket Owls
Junior Rocket Owls: Outreach Workshop	9/17/16	Junior Rocket Owls are introduced to the program
Junior Rocket Owls: Outreach Workshop	10/ 15/16	Rocket Owls introduce the 5th grade students to basic rocketry concepts
Junior Rocket Owls: Outreach Workshop	11/19/16	Junior Rocket Owls build and launch Estes model rockets

It's Rocket Math	11/19/16	Rocket Owls introduce the 7th grade students to basic rocketry concepts and mathematical relations
Physics Festival Booth	12/5/16	Rocket Owls present their NASA SL project to Citrus College Physics students
Science and Technology Day	12/10/16	Elementary and middle school children from local school districts participate in STEM hands-on activities facilitated by the Rocket Owls
Junior Rocket Owls: Outreach Workshop	12/17/16	Junior Rocket Owls design and create their payloads for the LoadStar rockets
It's Rocket Math	12/17/16	Rocket Owls introduce the 7th grade students to relationship between angles and flight altitude
Junior Rocket Owls: Outreach Workshop	1/21/17	Junior Rocket Owls build the LoadStar rockets
It's Rocket Math	1/21/17	Rocket Owls introduce the 7th grade students to more mathematical relationships related to rocketry
Junior Rocket Owls: Outreach Workshop	2/18/17	Junior Rocket Owls launch the LoadStar rockets
It's Rocket Math	2/18/17	The 7th grade students build and launch Estes rockets
Azusa 8th Grade Majors Fair	3/2/17	Rocket Owls introduce the 8th grade from the Azusa Unified School District to basic physics and rocketry concepts
Junior Rocket Owls: Outreach Workshop	3/18/17	Junior Rocket Owls design and create their professional posters in preparation for the symposium

Junior Rocket Owls: Outreach Workshop	4/22/17	Junior Rocket Owls practice their presentations
Junior Rocket Owls Symposium	5/13/17	The Junior Rocket Owls and It's Rocket Math Symposium takes place at Citrus College

2. Budget

Table 25 lists the materials needed to complete the NASA SL project as well as an estimation of the individual and total costs.

Table 25: Rocket Owls NASA SL Budget

No.	Item	Qty.	Price/unit	Tax (~9%)	Shipping	Total
1	Shear pins	5	$3.10	$0.00	$4.88	$20.38
2	24" Nomex	2	$13.99	$0.00	$5.85	$33.83
3	6" Blue tube coupler	1	$19.95	$1.80	$12.10	$34.93
4	Rail button	2	$4.65	$0.00	$4.88	$9.98
5	Fiberglass resin	1	$42.99	$3.87	$10.96	$58.81
6	Fiberglass hardener	1	$21.99	$1.98	$9.92	$34.78
7	Fiberglass laminating cloth 3 oz. satin weave	3 yrds	$9.96	$8.07	$9.12	$42.51
8	Altimeter	4	$44.95	$0.00	$7.00	$186.80
9	Palm sander	1	$29.99	$2.70	$6.99	$40.31
10	Sandpaper 80 grit	1	$15.38	$1.38	$5.99	$22.75
11	Synthetic grease	1	$5.89	$0.53	$5.99	$12.95

12	Sandpaper 5” 120 grit	1	$14.40	$1.30	$5.99	$21.69
13	Dremel(cordless)	1	$89.99	$8.09	$0.00	$98.08
14	Nitrile gloves (size:M)	1	$8.16	$1.22	$5.48	$14.86
15	Terminal blocks	1	$9.05	$6.03	$0.00	$15.08
16	22-gauge stranded wire pack	1	$19.95	$2.41	$6.83	$29.19
17	Heat shrink tubing	1	$10.99	$0.70	$5.33	$17.02
18	Key switches	4	$4.62	$2.13	$5.14	$25.75
19	6” Blue tube	4	$66.95	$0.00	$104.27	$372.03
20	4” Blue tube	2	$38.95	$0.00	$26.89	$104.79
21	98mm E-bay	2	$42.95	$7.73	$9.13	$103.58
22	6” E-bay	2	$71.95	$12.95	$19.51	$178.12
23	Rocket epoxy (pt)	1	$38.25	$0.00	$11.82	$50.07
24	18” Nomex	2	$10.49	$0.00	$5.09	$26.07
25	6” Ogive 4:1 nose cone	1	$129.00	Included	$12.90	$141.90
26	4” Ogive 4:1 nose cone	1	$65.00	Included	$8.95	$73.95
27	1” Tubular webbing	40	$0.45	$1.62	$5.99	$25.61
28	¼” Aircraft plywood	1	$112.75	$10.15	In store	$122.90
29	Polycarbonate tubing	1	$215.25	$19.37	$12.00	$246.62
30	Silicone sheet	1	$156.55	$12.52	$9.58	$178.65
31	Zinc threaded rails	3	$5.11	$0.46	In store	$16.71

32	Epoxy plastic bonder	2	$4.26	$0.38	In store	$9.28
33	9% Borated flexi-panel	1/2	$75.00	$0.75	$12.00	$92.75
34	Polycarbonate tubing	2	$15.20	$1.37	$10.00	$43.14
35	Tickets to Huntsville	6	$518.00	$46.62	$0.00	$3387.72
36	Hotel expenses	2	$134.00	$12.06	$0.00	$292.12
42	Food expenses	15	$20.00	$0.00	$0.00	$500.00
43	Outreach supplies	12,000.00				
Grand Total for supplies		$18,636.71				

3. Funding Plan

As shown in Table 25, the projected cost of the project is $18,552.71. The funds needed for the successful completion of the project as well as traveling to Huntsville and accommodations in Huntsville for the Rocket Owls team are provided by private and governmental organizations, as shown in Table 26 below.

Table 26: Funding Plan		
Funding Source	**Amount ($)**	**Used for**
GUSD	8,850.00	Supplies for the Junior Rocket Owls
Citrus College Foundation Innovation Grant	1,000.00	Rocket Owls' activities
Race to STEM Federal Grant	$2,000.00	Rocket supplies
California Space Grant Consortium	$2,000.00	Supplies for rocketry projects
Private donations	$3,000.00	Rocket Owls' activities

Mathematical association of America-Tensor Foundation	$6,000.00	Supplies for the It's Rocket Math! program and traveling expenses for the Rocket Owls.
Total	$22,850.00	

4. Plans for Rocket Project Sustainability

In the interest of sustaining the rocketry projects at Citrus College as well as in the community, the Rocket Owls plan to maintain their long standing collaboration with Cal Poly Pomona and JPL, as well as develop new relationships with local 4-year universities and industry, including University of Southern California, California State University at Fullerton, and NASA Armstrong.

In addition, the team will submit abstracts of their research for the annual Student Research Conference for California Community Colleges hosted by the University of California Irvine. Participating in this conference gives the team the opportunity to highlight their research, receive scholarships, have their research published, and gain experience in a professional and academic setting. Moreover, the Citrus College Rocket Owls will take advantage of their participation in this event to disseminate their results of the NASA SL project to over 200 students from other community colleges located in Southern California.

A new Rocketry and Robotics team will be developed at Citrus College during the fall semester of the 2016-2017 academic year. The Rocket Owls will conduct classroom presentations in the college's STEM classes in order to recruit students to be part of this team. The students in the Rocketry and Robotics team will be mentored by the Rocket Owls throughout the year in order to gain rocketry knowledge and skills and with the purpose of becoming the next generation of Rocket Owls at Citrus College that will participate in the 2017-2018 NASA SL.

The Rocket Owls team will also conduct presentations in the community (Glendora Public Library, Glendora Kiwanis Club) and ask local business owners for their support. All sponsors will receive a thank you card with a picture of the team and the rocket as well as email updates on the project's development. The team will also accept donations online using their Facebook page:

(https://www.facebook.com/CitrusCollegeRocketOwls/?ref=aymt_homepage_panel)

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Appendix A: Citrus College Profile

Since 1967, Citrus College has been offering a quality educational experience for the communities of Azusa, Glendora, Duarte, Claremont and Monrovia. It is currently home to over 12,000 students, the majority of whom are considered ethnic minorities, and is dedicated to creating a diverse and welcoming learning environment that supports educational achievement for all of its students.

Citrus College offers many programs that promote community awareness in numerous STEM related fields. Biological and Physical Sciences is the second most common major in the school. There are also numerous extracurricular programs aimed at increasing interest in STEM subjects within the community, such as the SIGMA (Support and Inspire to Gain Motivation and Achievement) peer mentor program; the PAGE (Pre-Algebra, Algebra, Geometry Enrichment) summer K-12 mathematics enrichment program; and the Secrets of Science Summer Camp that provides K-12 students with practical experience in biology, chemistry, astronomy and physics laboratories.

Students at Citrus College are active participants in many STEM-related activities. In past years, students have participated in NASA’s Reduced Gravity Education Flight Program (RGEFP), have launched a near-space sounding balloon, and have also traveled to Huntsville, Alabama and to Salt Lake City, Utah as participants in the 2013, 2014, and 2015 USLI SLP (University Student Launch Initiative Student Launch Projects). In 2015, three teams of students participated in the NASA/CASGC Microcomputer and Robotics Internship.

Appendix B: MSDS Information

Appendix is available as a separate document and includes the complete MSDS information for the following items

- Acetone
- Alkaline Batteries
- Ammonium Perchlorate Composite Motors
- Black Powder
- Epoxy
- Fiberglass
- Isopropyl Alcohol
- Lithium Batteries
- Nitrile Gloves
- Nylon
- Paint
- Plastic
- Solder
- Steel wood
- Sunscreen
- Superglue
- Wire
- Wood Dust/Filler

Appendix C: Protocols

Appendix is available as a separate document and included the protocols that the team developed. The protocols will be continuously be update during the duration of the project and will be kept inside the safety binder which will be located where construction will take place

- Epoxying
- Hot glue gun
- Hand Drill/Drill Press
- Soldering Iron
- Painting
- Table Saw
- CNC machine
- Jigsaw
- Dremel
- Sanders
- Wet/Dry Vacuum
- Wind Tunnel

Appendix D: Safety Contract

Safety Contract

All members of the team understand and agree to the following safety rules and regulation provided by the NASA Student
Launch Proposal documentation:

1.6. Safety Regulations

1.6.1 Range safety inspection of each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program

1.6.2. The RSO has the final say on all rocket safety issues. Therefore, the RSO has the right to deny the launch of any rocket for safety reasons.

1.6.3 Any team that does not comply with the safety requirements will not be allowed to launch their rocket.

All team members will also understand the safety procedures outlined in pervious section pertaining to:

- The risk and mitigation of hazardous materials
- Using power tools
- General Safety

All team members must understand and abide by the following as mention above:

- State and local laws
- FAA rules and regulation
- Fire prevention code

By signing this contract, the team members acknowledge that they have read and understood the information detailed in the safety section. And agree to abide by the aforementioned rules outlined in the safety contract. Team members will not be allowed to work on this project without signing the contract.

Yvonne Villapudua
Name (Printed)
[signature]
Signature
Date: 09/26/16

Isabella Molina
Name (Printed)
Isabella Molina
Signature
Date: 09/26/16

Lillian Chang
Name (Printed)
Lillian Chang
Signature
Date: 09/26/16

Janet Blancas Alonso
Name (Printed)

[signature]
Signature

Date: 09/26/16

Jimmy Lopez
Name (Printed)

[signature]
Signature

Date: 09/26/16

Lucia Riderar
Name (Printed)

[signature]
Signature

Date: 9/26/2016