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NASA Student Launch Proposal

Prepared for NASA by Boy Scout Troop 17 Student Launch Team

Date	Revision	Remarks
Sept 19, 2021	1.0	Initial Proposal

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1 General Information

1.1 Introduction

Boy Scout Troop 17 is very excited to have the opportunity to submit a proposal for the 2021-2022 NASA Student Launch Initiative (SLI). We have previously successfully completed both the 2017-2018 and 2018-2019 SLI programs, and we are looking to build on that success and apply lessons learned to make the 2021-2022 season even more rewarding for our team members and the community we serve with our STEM education program. We have participated in the Team America Rocketry Challenge (TARC) since 2007 and qualified for the National Finals four times, we have large interest in and experience with hobby rocketry, we placed 15th in TARC for the 2020-2021 season, and we are honored to be invited by NASA to submit a proposal for SLI for a third year.

STEM education has long been an important but often under-recognized part of Boy Scouting. Even at the beginning of Boy Scouting in the early 1900's, almost one-third of the original 53 merit badges were STEM-related. The focus on STEM has increased since then, and 90% of merit badges introduced since 2009 have a STEM component. In 2012, BSA National introduced the STEM/Nova program as a focused STEM program. And in 2014, Troop 17 became one of the only Troops in Virginia to offer this program at the Troop level (in most areas, STEM/Nova is only offered at the Council level).

Rocketry fits into the Troop's STEM program in multiple ways:

- It serves as a challenging STEM event that fulfills BSA STEM/Nova requirements to earn the Supernova Medals (the highest awards in STEM/Nova).
- It allows us to offer STEM-related education and outreach within the Boy Scouts, including Scouts in our own Troop as well as Boy Scouts and Cub Scouts in other units. For example, we use the Rocketry program to teach merit badges including Space Exploration, Aviation, Electronics, Computer Programming, and others. We also use it as a way to reach younger youth in Cub Scouting.
- It also gives us an opportunity to promote STEM education and outreach within the community at large, including local schools and other community groups.
- It helps to create hands-on experience and passion for STEM that is very well aligned to the natural interests and talents of our youth.

Student Launch, Troop 17 (SLT17) was formed over the Summer of 2017 and we are now entering our third year of SLI participation. Interest in SLT17 was large in our first two seasons, and has grown even more this year, with several experienced senior team members returning and numerous new younger team members joining. We have been conducting frequent meetings to organize, plan, and get the groundwork in place so we are ready for the RFP. With the skills, experience, and passion of our team members, the full commitment and support of our Troop's adult leadership, and the support of sponsors, we feel that SLT17 is strongly positioned for success in the 2022 NASA Student Launch Initiative.

1.2 Team Contacts

The following is contact information for SLT17 youth and adult leadership. To comply with BSA Youth Protection and Online Safety requirements, youth are referred to in this document (and all other public documents) by first name only and youth contact information is not provided here, but will be provided to NASA directly in a private communication.

Name	Title	Email	Phone
Steve Yates	Troop 17 STEM Chair, SLT17 Adult Educator	steveyates@embarqmail.com	434-825-2850
Bill Brown	Troop 17 Committee Chair, SLT17 Assistant Adult Educator	wfbrown100@gmail.com	609-440-0354
Tim Hoagland	Tripoli/NAR Mentor	timhoagland@gmail.com	937-624-2259
Beau	SLT17 Team Leader		
Eoin	SLT17 Safety Officer		

All deliverables during the period of performance for the program, other than this proposal, will be delivered to NASA and made publicly available via the team's website, which is a sub-page under the existing Troop 17 website: http://www.troop17bsa.org.

Note that both of SLT17's Adult Educators have attended the NASA Advanced Rocketry Workshop, as required by SLI rules. Steve Yates attended the ARW in person in Huntsville during July of 2017, and Bill Brown attended the virtual ARW during July of 2021.

1.3 Team Structure and Members

SLT17 currently consists of 11 team members, one adult educator and one assistant adult educator, and a Tripoli Level 3 mentor. There was a focused recruiting effort over the summer of 2021, including multiple presentations to the Troop about SLI, along with informational meetings and Q&A sessions with prospective members.

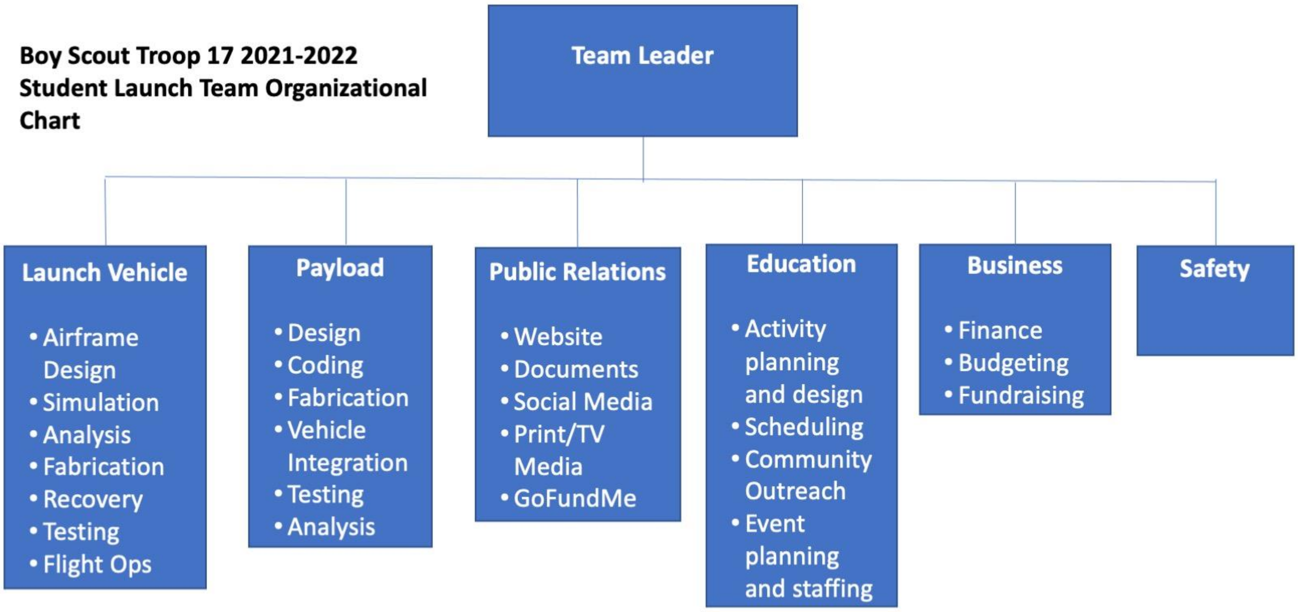
SLT17 is organized into six functional sub-teams: Rocket, Payload, Public Relations, Business, Education, and Safety. There were several key lessons learned from past years related to team structure, leadership, and day-to-day operations. First is that there needs to be a focus on subteams during day-to-day operations, document and report preparation, and regular team meetings. This year, the regular weekly team meetings will be subteam meetings instead of all-team meetings. Second is that due to our young team age (still mostly middle school) that we need a dedicated adult advisor for each subteam. Third is to divide the subteams into "full time" and "part time" categories and have individual SLT17 members play a role on two subteams, one from each category. The reason is that some of the subteams have ongoing full-time duties, such as the Launch Vehicle, Public Relations, and Payload. In past years, members of these full-time subteams tended to stay more engaged and more satisfied with their SLI experience. But members of other part-time subteams such as Business or Creative (the previous name of Public Relations) were less engaged, had a harder time in the program, and were less satisfied with their experience in SLI. Based on this feedback, we feel these changes will help improve the SLI experience for our participants.

Also each subteam has an elected youth leader and also has a designated adult advisor with experience in that area. During our first year, the lack of subteam leaders and adult advisors meant that the subteams did not have clear leadership or subteam-level mentorship, which reduced the effectiveness and increased the workload on the all-team leadership to the point that it created difficulties. By delegating many of the leadership tasks and the step-by-step work planning into the subteams, the subteams are more independent and effective, and can work autonomously and be less dependent and less held up waiting for instructions from senior leadership.

In order to maintain independence and full authority of Safety within SLT17, Safety is a separate functional team reporting directly to the Team Leader. Safety is discussed in more detail later, but we feel that structuring SLT17 so that Safety is an independent function stresses the importance of safety, while giving the Safety Officer the necessary independence and authority to truly create a culture of safety. We are very proud that we experienced no safety issues during our two years of prior SLI participation, and it is critically important to us to repeat that result this year.

The following table and organization chart provide details on team members, their roles, and team structure.

Name	Role	Team
Beau	Team Leader	
Eoin	Safety Officer	
	Team Member	Payload
Cole	Subteam Co-leader	Launch Vehicle
	Team Member	Business
Luke	Subteam Co-leader	Launch Vehicle
Brayden	Team Member	Launch Vehicle
Alex	Subteam Leader	Payload
Brayden	Team Member	Payload
Curtis	Subteam Leader	Public Relations
	Team Member	Education
Bryce	Rocket Art	Public Relations
Shrey	Subteam Leader	Business
	Team Member	Payload
Sean	Subteam Leader	Education
Mac	Team Member	Launch Vehicle



1.4 Tripoli and NAR Assistance

Tripoli Central Virginia #25 has graciously offered its assistance to SLT17. This Tripoli prefecture is located very close to us, and is providing assistance including an expert mentor, design and documentation review, and what is probably the best high-power launch site in Virginia which called Battle Park and is located near Culpeper, VA and typically has an FAA waiver of 15,000 feet AGL. Tripoli #25 is experienced working with SLI teams. Troop 17's TARC team has conducted launches with Tripoli #25 for 14 years. The prefecture also sponsors the "Battle of the Rockets" which is a well-established high school and college-level rocketry challenge that is similar in some ways to SLI.

The Battle Park launch facility is available for our use by special permission from the prefecture's leadership outside of scheduled launches. This is because the Battle Park FAA waiver is in place for the entire launch season and not only just on the weekends of organized launches. Also, many of the prefecture's senior leadership are retired or have flexible employment, and so they are able to open the range, setup equipment, and serve as RSO most days, providing a very flexible mitigation plan in case weather, illness, or lack of preparedness causes us to miss the regularly scheduled weekend public launch dates at Battle Park.

We also will be working with the Northern Virginia Association of Rocketry (NOVAAR), NAR Section 205. NOVAAR is the sponsoring NAR section for the TARC finals, and they offer a wealth of mentoring as well as a backup launch site near Warrenton, VA with a 5,000 foot AGL FAA waiver. The backup site is Great Meadow, where the TARC finals are normally held. Due to the small size and low FAA waiver, the Great Meadow backup site is only suitable for the subscale flight.

1.5 Time Spent on Proposal

Across all team members, SLT17 has spent a total of 74 hours of time on this proposal.

2 Safety

2.1 Introduction

Priority one for SLT17 is safety. Priorities 2 and 3 are also safety. Safety is not something that can be added after the fact.

SLT17 is firmly committed to the fact that safety is the foundation of everything we do, and safety is THE primary mission goal that's even more important than the science or flight objectives. Without safety, there can be no science, so safety is the cornerstone of the team. Also, our sponsoring organization, Boy Scout Troop 17, has a similar safety culture, so this makes safety incredibly important to SLT17.

As previously discussed, we have structured the team to highlight this founding principle.

We are very proud to have completed our prior two years of SLI participation with a highly effective safety program that demonstrated its effectiveness. During both the 2017-2018 and 2018-2019 seasons, there were zero safety incidents, and 100% successful and safe flights, including the high-power demonstrations of our 2017-2018 and 2018-2019 full scale rockets at the TARC Finals in May 2018 and May 2019. But we are not complacent, and it is extremely important for us to repeat this strong safety record in the 2021-2022 season.

2.2 Compliance with Boy Scout Safety Regulations

Since we are a part of a Boy Scouts of America unit, SLT17 is committed to fully complying with all safety regulations and guidelines as set forth by the Boy Scouts of America National Council. These BSA regulations include the following:

- Youth Protection (http://www.scouting.org/Training/YouthProtection.aspx)
- Cyber Protection (http://www.scouting.org/cyberchip.aspx)
- BSA COVID resource page, including COVID mitigation plan, BSA COVID leader training, BSA guidance, and CDC COVID resources: https://www.scouting.org/outdoor-programs/camping-covid-19-resource-center/
- Youth use of power tools (http://www.scouting.org/filestore/healthsafety/pdf/680-028.pdf). This regulation states that youth under the age 14 cannot use power tools at all. Youth between 14 and 18 can only use small handheld sanders, drills, electric screwdrivers, and similar handheld tools. Only adults 18 and older can use power saws.
- Transportation (http://www.scouting.org/scoutsource/HealthandSafety/GSS/gss11.aspx)
- Use of chemicals (http://www.scouting.org/scoutsource/HealthandSafety/GSS/gss06.aspx)
- Adult leader training requirements applicable to SLT17's activities

We feel that the BSA safety guidelines are an advantage to SLT17, as they address many underlying issues of personal safety, online safety, and youth protection in a clear and coherent fashion. This contributes to our culture of safety.

The team's designated Safety Officer will make certain that all rules and regulations are followed at all times by all members of the team. The Safety Officer will brief all team members on the procedures outlined in the

Safety Plan. Also, the NAR/TRA mentor and Safety Officer shall oversee launch operations and handling of energetics. The NAR/TRA mentor will be the official owner of the rocket for insurance purposes, and they will be the purchaser and user of rocket motors and black powder ejection charges for compliance with relevant laws and regulations.

Safety briefings conducted by the Safety Officer will utilize Safety Data Sheets and will come before every activity that requires tools and/or hazardous materials, as well as before all launches. Team members that are late will have to be briefed before they are allowed to begin work on the project. On launch days Flight, Post-Flight checklist and Safety Data Sheets will be handed out and reviewed to ensure the safety of the team members as well the general public. All team members will follow instructions given by NAR/TRA mentor, team leader and/or safety officer. All launches will be conducted in full compliance with all NAR and TRA Safety Code requirements.

The main facility that the team will utilize when fabricating the rocket is the Lightstorm Research high-bay shop in Charlottesville Virginia. All members of the team must follow the BSA Guidelines that state youth under the age of 14 cannot use any power tools. Further, only adults 18 or older can use power saws. We will purchase pre-cut rocket components such as airframe tubes and fins to avoid the need to use saws. Only Scouts 14 and older will be allowed to use permitted small power tools such as drills and power screwdrivers.

2.3 COVID

COVID-19 will remain an important safety requirement during the 2021-2022 SLI year. SLT17 will fully follow all COVID-related restrictions, public health advisories, recommendations, laws, and policies of the Commonwealth of Virginia, the Virginia Department of Health, the CDC, the Boy Scouts of America, the Virginia Headwaters Council of the BSA, Troop 17, and the Dioceses of Richmond (which Troop 17 is part of). Such restrictions may include but are not limited to masking, physical distancing, meeting outdoors whenever possible, quarantine, isolation, and any and all requirements that may arise or change during this program year.

SLT17 is currently planning on attending Flight Week in Huntsville, assuming our proposal is accepted and we deliver all milestones on time and are approved to proceed. However, should the COVID situation materially change or new restrictions emerge, SLT17 may opt to participate remotely.

COVID may have an especially large impact on our STEM educational activities, since those are with youth who may not have an opportunity to be vaccinated, and many schools and youth organizations may have restrictions on in-person activities. We will attempt to conduct our STEM education events outdoors, to minimize the chance of spread.

2.4 Safety Briefings

The Safety Officer will be responsible for briefing the team of any possible risks that could occur throughout the designing/build process, as well as before each launch. During the briefing, the Safety Officer will inform the team of all necessary procedures to avoid risks or hazards. The Safety Officer will regularly brief team members about these risks in order to create a safe environment. The Safety Officer will also be responsible for informing the team of any laws and regulations that may apply set by the NAR/TRA, including NFPA 1122 (code for Model rocketry) and NFPA 1127 (code for high power rocketry).

2.5 NAR/TRA Mentor

Tim Hoagland has graciously agreed to mentor our team and accompany our team to all launches and Launch Week in Huntsville in April 2022. Mr. Hoagland is a certified Level 3 with the TRA and NAR. His duties will include the purchase, storage, transportation and installation of rocket motors and black powder for ejection charges. Mr. Hoagland is already actively engaged, and has helped the team tremendously with this year's proposal, and he is also providing us with a rocket fabrication and meeting facility.

Mr. Hoagland will be advising the team during design and construction, and during the handling of hazardous or restricted materials. He will also brief the team on launch safety and protocol prior to launch.

Mr. Hoagland is also a registered and trained leader in the Boy Scouts of America. He is an Assistant Scoutmaster at Troop 1028 in Charlottesville. While Troop 1028 is not part of SLI this year, his offer to assist us is a tremendous demonstration of Scouting spirit and collaboration that SLT17 is deeply grateful for.

In addition to Mr. Hoagland, Mr. Ben Russell can also serve as SLT17's NAR/TRA mentor should Mr. Hoagland become unavailable.

2.6 Procedures for Team Mentor to Perform

The team mentor shall maintain the proper certification required for the motor impulse used in the launch vehicle. The mentor shall have completed at least two flights in the proper flight class prior to PDR. The TRA certified mentor will purchase, store, and transport rocket motors, black powder, and electric matches in storage magazines approved for use for these materials. The mentor will be the owner of record for the rocket for TRA/NAR insurance purposes. During flight operations, the Safety Officer and mentor will work together to choose a location where the motor will not be damaged and is at least 25 feet away from any heat sources or flammable liquids. The motor shall be transported separately from the rest of the rocket. During transportation the motor will be protected to prevent any damage or accidental ignition. The motor will never be transported with the igniter installed, and the igniter will only be installed at the launch pad when directed by the RSO or their designated official representative.

2.7 Procedures for TRA/NAR Personnel to Perform

The Safety Officer will work in conjunction with TRA/NAR personnel and the mentor to ensure that the team complies with the TRA/NAR High Power Safety Codes. The Safety Officer, mentor, and TRA/NAR personnel shall ensure that before launch all conditions are met for a safe launch. The Range Safety Officer (RSO) shall arm the launch system, and will ensure all members and spectators are not within 200 feet of the rocket. The RSO shall countdown from five before launch; if the vehicle does not launch, the RSO shall disarm the system and wait 60 seconds before investigating. TRA/NAR personnel along with the safety officer shall ensure no one attempts to catch the rocket on return or remove it from a dangerous location such as a power line.

2.8 Handling of Hazardous Materials

Some of the materials to be used will require extreme caution and care. Team members will be reminded of the safety rules based on which portion of the project they are working on by Safety Data Sheets.

The materials include but are not limited to fiberglass, black powder, epoxies and other adhesives, powdered aerogel, and rocket motors. The Safety Officer will be tasked with designing protocols for handling, storing, and disposing of these materials. The Safety Officer will be engaged before the purchase of any materials, to make certain that the existing Safety Plan is adequate to address any new safety issues, to proactively identify and acquire any Personal Protective Equipment (PPE) needed, and to collect and maintain all MSDS's and other safety information.

Also, the Safety Officer will be responsible for briefing all team members on protocols and regulations for the use of all materials. As fiberglass will be a primary hazard all team members that are working with this airframe material will be required to properly use PPE such as safety goggles and dust masks at all times when sanding, cutting, and painting to prevent dust from getting into their eyes or lungs. Since we are using Aerogel in a power form as part of the payload, team members will be required to wear the proper PPE. Also, the proper clothing will be worn, including a long sleeve shirt, jeans and gloves, to prevent injury to the legs or arms from sharp objects.

The Safety Officer shall brief team members on any other hazards associated with materials used in the rocket or the science payload. The Team will follow all of the BSA regulations as well those stated in the "Policy on the Storage, Handling, and Use of Chemical Fuels and Equipment."

2.9 Compliance with the Law

A mandatory team briefing will be done by the Safety Officer along with NAR/TRA mentor reviewing all guidelines and regulations upon proposal acceptance by NASA. BSA regulations will be followed at all times. Other relevant laws and regulations that the Safety Officer will educate all team members on that the team will be required to follows at all times are Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; Amateur Rockets, Code of Federal Regulation 27 Part 55: Commerce in Explosives; and fire prevention, NFPA 1127 "Code for High Power Rocket Motors."

2.10 Safety Regulations Links:

- BSA Safety Guide: http://www.scouting.org/filestore/pdf/34416.pdf
- BSA Age Guidelines For Tools : http://www.scouting.org/filestore/healthsafety/pdf/680-028.pdf
- BSA Policy on the Storage, Handling, and Use of Chemical Fuels and Equipment": http://www.scouting.org/filestore/pdf/680-013WB.pdf
- Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C: https://www.law.cornell.edu/cfr/text/14/part-101
- Amateur Rockets, Code of Federal Regulation 27 Part 55 Commerce in Explosives: https://www.law.cornell.edu/cfr/text/27/555.141
- NFPA 1127 Code for High Power Rocket Motors: http://www.nar.org/safety-information/high-power-rocket-safety-code/
- MSDS for Rocketpoxy: https://www.apogeerockets.com/downloads/MSDS/ROCKETPOXY_MSDS.pdf
- MSDS for Acetone: http://www.sciencelab.com/msds.php?msdsId=9927062

2.11 Team Member Agreement to Comply with Safety Rules

After a mandatory safety briefing, all team members will sign a Safety Agreement to abide by the regulations discussed as well as the following safety regulations:

- 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.
- The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.
- Any team that does not comply with the safety requirements will not be allowed to launch their rocket. The Safety Agreement will also state that any violation of safety protocols can result in dismissal from the Team with no warnings.

Project Risks

Risk	Probability	Effect	Prevention
Team members dropping out	Moderate	Team will have to work hard and pull double rolls	Ensuring all members are able to commit time to the team. Making sure all roles can be filled by someone else if needed by cross training. Make sure prospective team members are aware of the time commitment and expectations up front so they do not drop out due to time conflicts.
Funding shortages	Moderate	Inability to purchase the necessary items to complete the project	We are soliciting funding pledges mainly from corporate donors, and we will also get some funds from the Troop. Should funding be inadequate, we may have to cut back on the amount of people who can go to Huntsville. Camping in Huntsville is always an option because we are Boy Scouts. Also, families can self-fund travel if needed.
Falling behind schedule	Moderate	Inability to complete required tasks, causing time constraints and leading to suboptimal work or missed deadlines	Having enough team members to make sure work gets done, even if some members are short on time due to other commitments. Make sure that all team members have clear instructions and understand assignments and expectations. Start on tasks early, do not wait until the last minute to do design, simulation, flight testing, safety analysis, document writing and other tasks.
Launches cancelled	Moderate	Missing a full or sub-scale test launch	Launches will be at Battle Park in Culpeper VA but if a launch is cancelled we will first attempt to schedule a makeup launch day at Battle Park directly with Tripoli #25 leadership. This could be on any day, pending weather and prefecture leader availability. As a third level backup, we would go to VAST in Monterey VA or Great Meadow in The Plains VA. If necessary, the team will go to other high-power launches throughout NC, MD, DE, or VA.
Motors in limited supply due to demand or production problem	Moderate	Inability to acquire needed motors for qualification or competition flights	Have backup motors from multiple manufacturers identified so that we are not dependent on a sole source motor manufacturer. Purchase enough motors to assure adequate stock even if the motors become unavailable on the open market. Purchase motors as early as

			possible so that leadtime issues are mitigated.

Safety Risks

Risk	Probability	Effect	Prevention
COVID exposure or infection	Moderate	Minor to serious disease including potential hospitalization and spread to other team members and people in the community; Potential disruption of team personnel due to need for quarantine or isolation.	Wear masks at all in-person indoor team activities, maintain at least 6' of physical separation during team activities, assure all personnel are symptom free as a condition of attending team activities, and fully follow all applicable federal, Virginia state, local, BSA, and other applicable COVID laws, regulations, requirements, recommendations, and best practices. Conduct meetings via Zoom whenever possible to minimize contact. If team members are forced to quarantine or isolate, involve them remotely. If critical personnel are unavailable due to illness, the Team Leader will appoint and train a replacement as necessary.
Injury during fabrication	Low	Minor to serious injuries including cuts and burns	Receiving training in the safe use of all equipment, require PPE to be used at all times, follow BSA safety requirements, and make sure a first aid kit is always present during all team functions.
Injury during rocket launch	Low	Minor to serious injury	Following all launch safety procedures, such as staying the proper distance away and inspecting launch guide, motor casing, and other parts beforehand, and following all NAR/TRA safety code requirements. Also follow all BSA safety requirements, and make sure a first aid kit is always present during all team functions. Follow launch checklist to assure that the rocket is prepared for flight correctly and all safety critical items are addressed.
Accidental ignition or detonation of material	Low	Possible burns	Following safety procedures for the handling of flammable or explosive material; ensuring

			everyone is in a safe location in case of detonation on launch pad.
Injury during rocket recovery	Low	Minor burns	Follow all recovery safety procedures. Let motor casing cool down before handling. Disarm recovery avionics before handling rocket in case unfired ejection charges are present.
Motor mount failure	Low	Damage to rocket and potentially observers	Testing the motor mount in simulations, static fire tests, and experimental flights. Inspecting as specified by pre-launch checklist.
LiPO battery fire	Low	Damage to rocket, injury to personnel, ignition of grasses or trees in landing area	Per NASA regulations, all LiPO batteries will be protected from impact with the ground, they will be brightly colored, they will be clearly marked as a fire hazard, and they will be easily distinguished from other rocket components.

3 Facilities and Equipment

SLT17 will have access to necessary workspace and tools required to successfully and safety complete all aspects of the SLI program, from launch vehicle design, payload design, rocket and payload fabrication, ground and flight testing, team meetings, videoconferences with NASA SLI personnel, and post-flight data analysis.

3.1 Lightstorm Research Office and Production Space

SLT17's main facility is Lightstorm Research office and production space in Charlottesville, VA. This facility has a 5000 square foot high-bay laboratory and workshop area that SLT17 can use for all launch vehicle and payload fabrication, assembly, and ground testing activities. In addition, the Lightstom Research facility has a conference room and high-speed broadband that are suitable for design review teleconferences with NASA. Lastly, the Lightstorm facility has meeting rooms that can be used for all-team and individual functional sub-team meetings. Note that SLT17 may hold meetings not requiring in-person attendance via Zoom.

The Lightstorm facility is available outside of regular business hours 7 days a week. It is a locked and access controlled space for security, and this will prevent unauthorized personnel from accessing SLT17 materials and either adversely impacting SLT17 progress or causing safety issues. SLT17 will have a dedicated location within the Lightstorm facility to store the launch vehicle, payload components, and work in process, for safety, security, and continuity. SLT17 will need to clean up any debris after each building session, but the in-process rocket and payload will remain in our dedicated area and will be undisturbed during business hours. This area is only accessible to Lightstorm employees, and they will be instructed not to disturb SLT17 items.
The Lightstorm facility also has the equipment to manufacture and assemble the structural and electrical components of the rocket. The facility offers a full complement of work benches, small hand and power tools,

and support equipment for fabricating in wood, metal, or fiberglass. It also has a fully equipped electronics lab that can be used to fabricate, integrate, and test and debug the science payload hardware and software.

Available equipment includes the following:

- Basic hand tools (e.g., saws, screwdrivers, hammers, etc.)
- Basic power tools (e.g., drills, Dremel, sanders, router, etc.)
- Small power saws (can be used only by adults per BSA regulations)
- Electronics assembly equipment (soldering irons, heat guns, microscopes)
- Electronics test equipment (digital multimeters, oscilloscopes, benchtop power supplies)

As backup sites, SLT17 subteam and all team in-person meetings not requiring fabrication can be held at Troop 17's sponsor's facility, The Church of the Incarnation in Charlottesville, VA, in case the Lightstorm facility is unavailable on critical meeting days. Further, team members also have home workshops that can be used as backup facilities for fabrication should the Lightstorm high bay location be unavailable when we need it.

With our strategy of modifying a commercial off the shelf (COTS) high power rocket kit, we do not anticipate the need for use of power saws (table saws, band saws). The avoidance of need for power tools that youth are prohibited from using under BSA regulations is a major reason we have adopted a strategy of basing the rocket on a COTS kit. Should cutting airframe tubes or other operations requiring the use of prohibited tools become required, SLT17 will attempt to outsource this to a commercial vendor of high power rocketry parts. As a last resort, it is possible an adult affiliated with the team will have to perform those operations, but we will keep it to a minimum and notify NASA in advance in the unlikely event this becomes necessary (because the goal is for the youth team members to do everything).

3.2 Required Supplies

To complete the various elements of the project, the following supplies will be required. All of these supplies are commercially and readily available. Some will be donated directly by sponsors, and the rest will be purchased through the team budget.

- Fiberglass body tubes, sheets, and nose cone for the primary rocket and subscale, available as a kit to allow off-the-shelf purchasing.
- Recovery harnesses and equipment, including main and drogue parachutes.
- Electronic components including altimeters, flight computers, sensors, and microcontrollers such as Arduino.
- Tracking devices
- Batteries for all the electronic systems
- Mid and high-power rocket motors
- Assorted hardware, wiring, adhesives (including JB Quik epoxy, Rocketpoxy, Loctite thread locker, and cyanoacrylate / super glue), and finishing materials such as primer, paint, topcoat, and sanding supplies.

3.3 Technical Tools

The following software and technical tools will be used by the team to facilitate collaboration, technical design/development, communication, and project management.

3.3.1 Google Drive

Google Drive is an online document sharing system that allows easy access to the files needed by the team. The team uses it to organize and compile documents in a central location as well as share important links and information such as meeting notes and agendas.

3.3.2 Arduino IDE or other Payload Computer Development Environment

The Arduino IDE is a free software program that is used to program the Arduino microcontroller. It is currently envisioned that an Arduino will be used to acquire and log data in the science payload, however during the Preliminary Design phase, multiple low-cost computer platforms (Raspberry PI, ESP32, Arduino, and others) will be evaluated and a final selection will be made based on technical, availability, and software support considerations. Whatever computer system is selected for the payload during the Preliminary Design phase, its corresponding free open-source development environment will be used to develop and test software to perform the functions of acquiring and storing vibration data on an SD card.

3.3.3 OpenRocket

OpenRocket is a free, open source rocket design and simulation program that is being used by the team to help design the rocket, analyze static stability margin, and predict rocket flight performance: apogee, velocity upon rail exit, max velocity, speed and therefore kinetic energy during descent, motor selection, ballast sizing, etc. OpenRocket was selected as our main rocket design and simulation software because it is freely available, and all team members who are interested can download and use it without paying any fees.

3.3.4 RockSim

RockSim is a commercial rocket design and simulation program that SLT17 already owns through our participation in TARC. However, we only have one license, and to prevent the expense of purchasing additional licenses, we are not using RockSim as our primary rocket software. Our plan is to use RockSim to validate the simulation results produced by OpenRocket before we fabricate or order rocket kits, parts, or motors.

3.3.5 Slack

SLT17 is using Slack as our primary team collaboration and communications platform through which members can send messages, post files, and pose questions, and brainstorm ideas. Especially in the case of SLT17, our team is spread across multiple different schools, so an efficient and accessible online team collaboration tool is critical to discuss issues and brainstorm and then analyze and implement solutions. Slack has already proved to be invaluable in the proposal phase.

Our Slack account is organized by functional teams, and there is a Slack channel for every team: Safety, Launch Vehicle, Payload, Business, Education, and Public Relations.

Slack also has an extra benefit for us as a BSA unit. Boy Scout youth protection regulations prohibit one-on-one adult-youth contact, and this has been construed to include electronic communications such as email, social media, texting, and other forms. By communicating through Slack channels and prohibiting direct messaging from youth to adults in Slack, all communications will be in the open and thereby comply with these BSA requirements. Plus Slack will retain a complete record of the entire conversation with full context, organized by functional area.

3.3.6 Teleconference Facilities

The Lightstorm Research facilities have video conference equipment available for team use. The facility has a guest Wi-Fi network throughout and 250Mbps broadband service. These facilities will be available to the team for the required reviews with NASA.

4 Preliminary Launch Vehicle Design

Recognizing that SLT17 is composed mainly of middle school students, our approach is to de-risk the rocket design and construction to the greatest extent possible. This allows us to maximize safety and our chances of success. Also, most team members are below 18 years old, so BSA safety regulations prohibit their use of power saws and similar power tools, so it is very difficult for us to cut airframe or payload tubes, fins, nose cones, couplers, and other rocket parts. Therefore, our approach to procuring pre-cut parts is to base our launch vehicle on a commercially-available high-power rocket kit modified with other off-the-shelf components which result in a new design allowing it to carry the science payload and to meet other SLI requirements (like 2.0 calibers of static margin). Basing the launch vehicle on a kit mainly becomes an effective way to procure pre-cut components that mitigate the limitations we would otherwise have on part fabrication. This approach also gives our young team an example of a successful dual deployment high power rocket to start from, and it also helps avoid possible issues with parts availability since many of the parts all come together.

We feel our approach even follows NASA's example of re-using existing technology for new missions, where possible. This approach is followed extensively in SLS, with the re-use of many designs and technologies developed for the Space Shuttle such as the SSMEs and SRBs, adapting them as necessary.

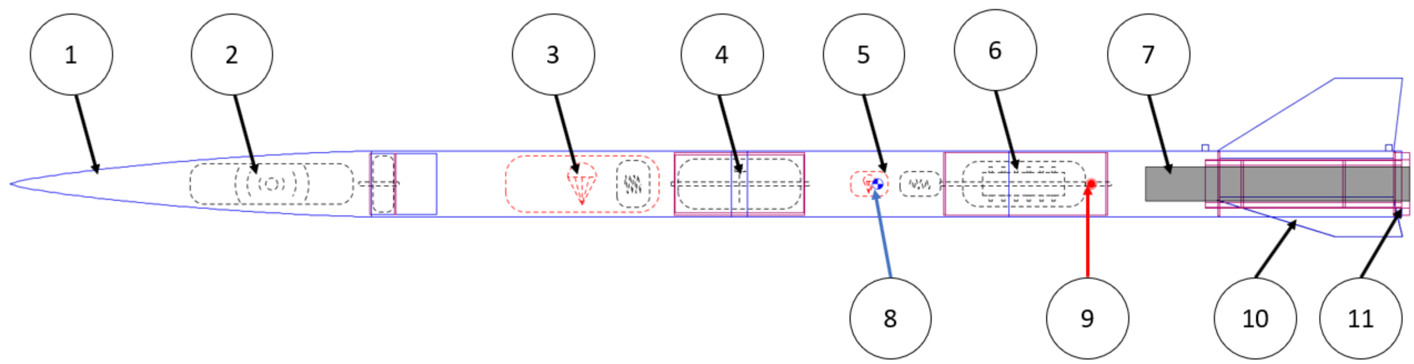
We recognize that basing our design on a modified commercial off-the-shelf (modified COTS) kit does not reduce the need for design simulation, analysis, testing, or safety activities. The modified kit really is a new design that must be analyzed, simulated, tested, and validated just as thoroughly as a totally from-scratch design. We will undertake all these activities just like we had a scratch-designed rocket.

The projected launch vehicle is based on a modified Mad Cow Formula 98 with dual deployment. One advantage of this kit is that Mad Cow offers a second kit that can serve as a subscale version that we can use as our sub-scale rocket: the fiberglass Mad Cow Formula 75. One risk with this approach is that the Formula 75 is no longer being manufactured by Mad Cow. However, SLT17 found stock still at distributors and has already procured these to avoid any impacts to our project. These kits were selected because they meet all of our mission requirements as shown in preliminary OpenRocket simulations and because they can be modified to carry our payload. Specific factors include: they are easy to build, they are strong, the subscale rocket will be a dual deployment design which gives us more experience with building and flight operations relevant to the full scale, the subscale can carry our science payload so we can gather additional data from the subscale flight, and they have already been flight tested (though we are not reducing our levels of testing or analysis this year).

One new requirement in SLI since our last participation is requirement 2.18.5 which states that the subscale rocket may not exceed 75% scale of the full-scale rocket. While the subscale strategy described in the previous paragraph is right at this 75% scale limit, we do still comply with 2.18.5, and we feel strongly that making the subscale a dual-deployment rocket that can fly our science payload gives us more practice with construction and flight operations, helps validate the payload, and helps us increase the safety and reliability of our full-scale flights more than making the subscale a much smaller rocket.

These rockets will be built using the RocketPoxy structural epoxy. All appropriate PPE will be used during the construction of the rockets. These include but are not limited to: protective eyewear, protective outer clothing, vented space, and the use of nitrile gloves. Additionally, dust masks will be used during any sanding. Good ventilation will be used when using solvents (acetone), epoxies, and paints.

We are designing, analyzing, building, and flying entirely new rockets. The full-scale rocket is currently envisioned to be 4 inches in diameter and 85.6 inches in length with 3.25 calibers of static margin as shown below:



Component Number	Description
1	5:1 Von Karman filament wound nosecone
2	Missile Works RTx Navigator for GPS tracking
3	Main Recovery - SkyAngle Classic II 60” chute with 25’ kevlar harness
4	Electronic bay - 2x Missile Works RRC3 flight computers with independent LiPO batteries and redundant black powder charges
5	Apogee Recovery - SkyAngle 12” drouge with 25’ kevlar recovery harness

6	Science experiment data acquisition and logging unit including an Arduino or other embedded computer, three-axis accelerometers, SD card data storage system, LiPO battery
7	Aerotech K805 motor
8	Center of Gravity (CG) - 53” from tip of nose cone
9	Center of Pressure (CP) - 66” from tip of nose cone
10	Fins - 3 G10 fiberglass ⅛” thick
11	Aeropak 54mm motor retrainer

The currently projected motor for the full-scale rocket is the Aerotech 54mm K805. OpenRocket was used to compare multiple motors and from that analysis, we have preliminarily selected the K805. This motor achieves the projected flight performance as detailed in the table below. Our preliminary altitude target would be 4890’ AGL based on this result.

Motor	Velocity at Rail Exit	Apogee	Max. Velocity	Max. Acceleration	Time to Apogee	Flight time	Landing velocity
Aerotech K805	83.6 ft/sec	4889 ft	640 ft/sec	359 ft/sec	17.2 sec	84.8 sec	18.8 ft/sec

The preliminary and backup deployment and altitude recording flight computers are:

- Marsa Systems MARSA33LHD as the primary
- Missile Works RRC3 as the back up

We propose to use two different models and manufacturers of altimeters to control the two fully redundant recovery deployment systems. Redundant deployment systems built with two instances of the same brand and model altimeter would meet the minimal NASA requirements for recovery redundancy, but we feel that using two entirely different brands and models of altimeters adds an entirely new dimension of redundancy that exceeds NASA requirements and increases safety even more. The advantage of this approach is that a pervasive issue in the altimeter design, materials, manufacturing, software, or configuration that could potentially impair both instances of a common altimeter type (and therefore would circumvent the physical redundancy) will be avoided, increasing safety.

Each of the flight computers will have their own power source and black powder charges. For apogee deployment, our preliminary plan is for the MARSA33LHD flight computer to be set to deploy the drogue at apogee and the RRC3 flight computer will be set to deploy the drogue 1 second after apogee. For main deployment, the MARSA33LHD will be set to deploy the main at 700’ and the RRC3 will be set to deploy the main at 500'. The preliminary deployment altitudes and times are subject to change in later design phases, but offsetting the firing of charges eliminates the possibility of structural failure (and possible separation and uncontrolled recovery) of the rocket due to overpressure caused by simultaneous firing of both charges. If the first charge successfully deploys the chute, then the second charge will harmlessly fire out of the already open airframe tube. But if the primary charge fails for any reason, the backup provides critical safety redundancy, to greatly reduce the chances of an unsafe ballistic recovery. Typically, the backup charges are 50% larger than the primary charges, to help overcome any unusual or unexpected friction preventing recovery system deployment.

Note that redundancy is neither required nor provided for the science payload. Since failure of the payload would only impact the science mission but could not result in any safety issues with the rocket flight, it is not deemed necessary to make the payload redundant.

The Missile Works RTx Navigator will be used for tracking. Since all parts of our rocket remain tethered during recovery, only one tracking device is required per the NASA SLI requirements. The RTx provides GPS tracking over the 900 MHz unlicensed radio frequency band, with more than sufficient range in comparison with the SLI flight objectives. It will be placed in the nose cone. Missile Works also assures that the RTx will not interfere with recovery avionics and that shielding of the recovery avionics is not required.

For recovery of the vehicle, the SkyAngle Classic II has been preliminarily selected as our main parachute and the SkyAngle 12" for the drogue. The drogue will be deployed at apogee to control the descent of the rocket in an orderly and safe manner while keeping wind drift within the maximum specified by NASA. The main will be deployed at a lower altitude to achieve a safe recovery. The main and drogue deployment charges will both be ground tested to determine the charge sizes for deployment and to verify successful deployment prior to any flights. We will also analyze the descent and landing kinetic energies to assure they comply with the limits set by NASA.

The major technical challenges and the primary mitigation strategy for each includes the following:

- Motor not available – Obtain sufficient stock early on, select another motor if necessary
- Primary launch site availability – use one of two back ups
- Not enough space in the booster section for the payload – extend the booster section with an avionics bay to hold the payload.
- The size of the main chute doesn't meet the required landing forces – select a larger chute which will pack in the same space.

5 Preliminary Science Payload Design

5.1 Overview

Our proposal for the science payload is to study in-flight vibrations experienced by the rocket. Vibrations are inherent in spaceflight, especially during launch. However, they are a major concern for NASA, since they can cause detrimental effects ranging from minor inconvenience and temporary disruptions all the way up to complete loss of the mission and launch vehicle.

Our approach to the science payload is to use our two years of SLI eligibility to conduct a two-year series of science missions that build on each other. During our previous two years of SLI participation from 2017-2019, we ended up following a similar strategy (admittedly without advance planning) that involved the study of the waste heat generated by the motor in flight in the first year, and using that data to conduct an experiment to harvest the waste thermal energy into electrical energy in the second year.

While we are proposing a sequence of two experiments over our two years of eligibility, SLT17 also understands that acceptance into SLI is not guaranteed in the second year. It most definitely is our plan to participate both years, and we will make every effort possible to do so. However, we also feel it is important to define Year 1 so that its science results will stand on their own and be interesting and relevant to NASA should our Year 2 participation not occur for whatever reason. Our strategy is to make the first year consist of fundamental research into the topic so that these results will be useful on their own. Year 2 will be a project that acts on the results of Year 1.

We propose the following two-year sequence of science missions:

- **Year 1:** The science payload will acquire, record, log, and communicate high-fidelity vibration data from the rocket in all three axes. The payload will consist of high precision three-axis accelerometers, data acquisition and digitization circuits, an embedded computer to collect and store the data, a non-volatile storage medium to store the data as it is generated and store it after the mission until it can be retrieved and analyzed, and a communication capability to download the data to other computers for analysis. Vibration data will be collected by at least one three-axis accelerometer, but we will investigate the feasibility during the Preliminary Design phase of placing multiple three-axis accelerometers at different locations along the length of the rocket to determine how vibrations vary in different locations. The payload will also detect and record major events during the boost phase of the flight (launch, burnout, apogee) and record this along with the vibration data so that the differences in vibrations during these phases can be identified and studied. In summary, the objectives of Year 1 are to collect fundamental data on the nature of vibrations in the rocket: magnitude, frequency, how they vary during the flight phases, what axes the vibrations occur in, and possibly how they vary in different parts of the rocket. This should be useful and relevant science for NASA even as a standalone project, even if for unforeseen reasons we are unable to continue on to Year 2.
- **Year 2:** We will use the data from Year 1 to guide the design of our second science payload in Year 2. We are currently considering two possibilities for the Year 2 payload, either of which require the same vibration data from Year 1.
    - The first possibility is designing and demonstrating an active vibration dampening system. This payload would sense vibrations and then use that to generate an opposing dynamic force in real time by electromagnetic means. With a closed-loop control system, this opposing force would greatly reduce or even eliminate vibrations. This technology could be very useful in the future for protecting delicate payloads, and for helping to improve launch vehicle stability and reliability. The Year 1 data will be critical to understand the magnitude, frequency, direction, and duration of the vibrations so that the damping system can be designed to provide an opposing force of the correct magnitude, direction, and frequency range.
    - The second possibility is designing and demonstrating an energy harvesting system that converts the kinetic energy of vibrations into electrical energy. This is similar to our 2018-2019 payload which converted thermal energy into electricity, in that we would harvest what would otherwise be wasted energy into a useful form. While this would not generate a large amount of electricity, it would be enough to power wireless sensors without the need for any wiring at all for either data communications or power, allowing them to be placed in areas where it is impractical to run

power cabling. This would allow sensors to be placed in distant areas or inhospitable areas (for example, inside or around fuel tanks or engines), where power cabling would carry too much risk of sparking and explosion.

For the remainder of this discussion, we focus on the Year 1 science payload. Year 2 will be defined and proposed in more detail prior to the start of the 2022-2023 SLI program.

5.2 MEMS Accelerometer Overview

A Micro-Electromechanical Systems (MEMS) accelerometer is shown in conceptual form in the previous figure. The device is built on a silicon chip like other electronic components, except for the creation of a moving mass and spring structure from the silicon chip. When subjected to acceleration, the mass and spring deflect, causing the distance between the mass and the fixed outer places to change, resulting in a change in the capacitance between the mass and the two plates. This change in capacitance is proportional to the deflection, which is in turn proportional to the acceleration. The change in capacitance is converted into an analog voltage provided at the output of the accelerometer. So the analog voltage output of the MEMS accelerometer is proportional to the acceleration.

A 3-axis accelerometer is built with three such devices, measuring acceleration in the X, Y, and Z axes.

Our preliminary plan is to use the Analog Devices ADXL345 three-axis MEMS digital accelerometer, which can measure up to +/-16G in each of the three axes. The ADXL345 is readily available on the Adafruit ADXL345 breakout board, which can be connected to the embedded computer using a 5-pin or greater cable. The ADXL345 also offers a data sampling rate of 3.2kHz per axis, which we feel is sufficient for our purposes. One major advantage of the ADXL345 is that it contains an on-board 13-bit A/D converter, giving it a 4 mg (milli-g's, not milligrams) resolution. This also means that the computer board the accelerometer connects to does not need to have an A/D converter on board, plus the signals connecting the accelerometer and the computer are serial digital signals, not analog, so they will be less sensitive to noise. However, the computer board will need to offer an SPI or I2C serial digital interface for the accelerometer.

5.3 Measurement System

To capture vibration data, the payload will include a three-axis digital accelerometer, an embedded computer board, a non-volatile storage medium such as a MicroSD card, and possibly an optional communications interface such as Wi-Fi. As an alternative, it would also be possible to omit the communication interface and instead remove the MicroSD card after each flight and insert it into a laptop for data retrieval and analysis. Final determination on whether to include a communications interface like Wi-Fi will be made during the Preliminary Design phase, based on considerations such as power consumption, software support, usefulness, hardware availability, and other factors.

Our system will acquire real-time data from the three-axis accelerometer. The instantaneous acceleration in each axis is converted into a 13-bit digital number in the digital accelerometer, and the digital values are then transmitted over a high-speed digital serial interface to the computer board, which de-serializes the acceleration data and stores it in the MicroSD card.

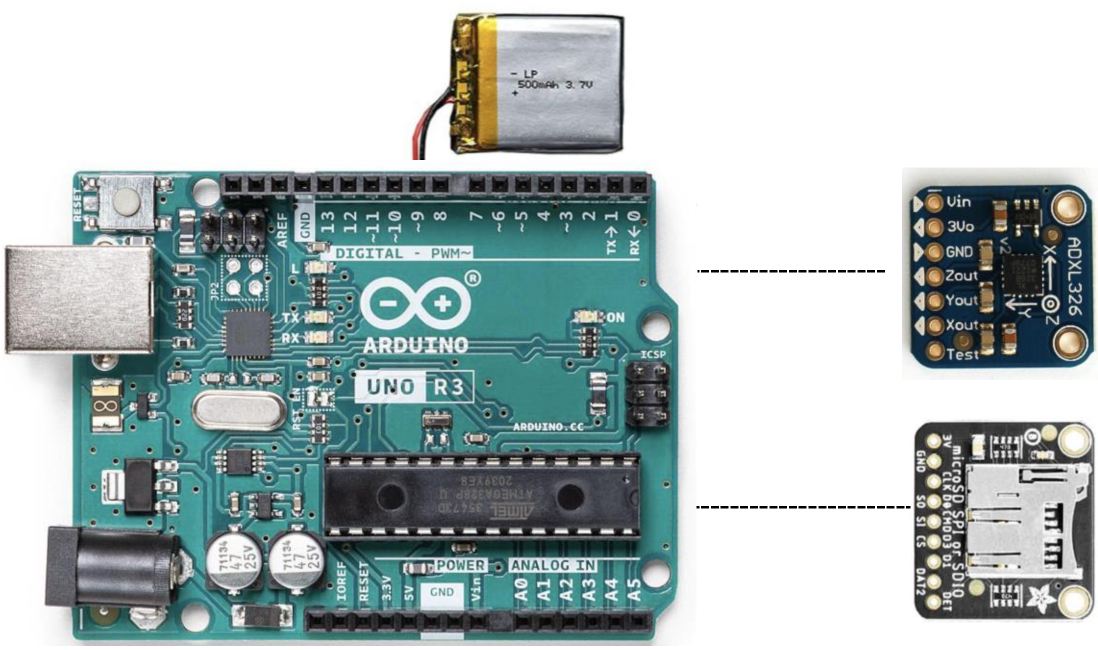
During the Preliminary Design phase, we will investigate placing multiple 3-axis accelerometers at different locations along the rocket, and how to connect these to the payload computer (cable, low-power wireless network, etc.). Our current plan is to have just one sensor, but we would like to explore the possibilities of more sensors during the PDR phase, when we can perform detailed risk/benefit tradeoff analysis and determine if this would be useful and advisable or not.

It is important to also measure when major events occur during the flight so that the acceleration data can be correlated to specific times and phases during the boost phase of the flight (motor ignition, motor burnout, apogee). This way, different vibration characteristics of each phase can be measured and understood. Since the payload already includes a vertical accelerometer, it is straightforward to detect these events with software running on the embedded computer board. These events will all be evident in the vertical acceleration of the rocket, so a separate device is not required to detect them.

Our preliminary plan is to use an Arduino family board as the embedded computer. The precise model of Arduino will be determined during the Preliminary Design phase. In past SLI projects, SLT17 has used an Arduino Uno for the payload computer. This year, however, we are concerned that the Uno will be too performance limited to process and store accelerometer data at a 9.6 ksample per second rate for just one 3-axis accelerometer. There are other Arduino sub-families such as MKR, WiFi, NANO, and GSM that offer far greater capabilities than the Uno, such as 3x-10x the overall performance, on-board Wi-Fi or even cellular data connectivity, Bluetooth Low Energy for creating low-power wireless sensor networks, and many other features. None of these others are as low power consumption as the Uno, however, so that is a major design consideration.

Because of these concerns, during the Preliminary Design phase we will compare multiple different options for the embedded computer that may offer more performance, but likely at the cost of larger power consumption, and in turn larger batteries, more heat generation, and other possible downsides. Based on a thorough review and analysis of all design requirements, risks, benefits, and options, we will select the optimum choice during the PDR phase, and justify that choice with facts and our decision rubric.

A preliminary conceptual diagram of our payload follows.



Parts Needed:

- Three-axis MEMS accelerometer breakout board (Analog Devices AXDL345 +/-16g)
- Arduino Uno computer board or other suitable embedded computer board
- MicroSD breakout board (may not be necessary for other computers with MicroSD on board)
- MicroSD Card for data storage
- Analog input board (not needed for Arduino, since the A/D converter is already included)
- LiPO battery
- External switch to power on/off the experiment
- Sled to hold computer, accelerometer, MicroSD card board, and battery

SLI requirements specify that the payload must be able to run prior to launch for at least two hours. Preliminary sizing can be based on the Arduino Uno. Based on this, a 650 mAhr LiPo battery weighing 59 g will power the payload system for approximately 13 hrs. Even computers consuming up to 6.5x the power of an Arduino Uno could still meet the 2 hour requirement.

The science payload will be housed in a payload bay located in the bottom part (booster) of the rocket. While the payload computer and sensors may be small enough to reside in the avionics bay with the flight computers, we are opting for a separate payload bay to completely isolate the recovery electronics and payload electronics. This is due to safety concerns about possible electromagnetic interference, electrical short circuits, or other malfunctions of the payload adversely impacting the flight safety critical recovery electronics. Therefore, an experiment avionics bay just forward of the motor mount will house the experiment and protect it from ejection gasses while isolating it from the recovery electronics.

6 Educational Engagement

Educational Engagement is very important to SLT17, and we take pride in our past awards in this category. STEM education is something we are very passionate about, and we are actively working on adapting our educational program to have maximum impact especially considering the restrictions and limitations brought on by the COVID pandemic. Not only does STEM education fulfill our deliverables for SLI, but we view it as a major community service activity in line with the service mission of Boy Scouting and the service culture within Troop 17.

Our STEM education focus is on (1) elementary age students (K-5), (2) economically disadvantaged youth, and (3) other Scouting units.

The ongoing COVID pandemic is a major consideration in the STEM education program, since by definition the entire goal is to reach as many youth with hands-on educational events as possible. The rapidly evolving situation may require changes to our education plans throughout the year, but what will not change is our commitment to youth STEM education and our promise to persevere in a safe manner whatever obstacles may emerge. We are planning to make our STEM events primarily outdoors, in keeping with our Scouting background and to maximize COVID safety. This will also reduce the chances that we will have to completely abandon specific events or switch them over to virtual, which would result in significant disruptions and attendance issues.

*6.1 Virginia Discovery Museum Kid*Vention*

Kid*Vention is an annual STEM fair held in Charlottesville for young elementary children in K-4 and their families. The focus is on quality, not just sheer quantity, and this event has been a highlight for us in the past. We are planning on repeating again this year, pending the confirmation from the Virginia Discovery Museum that this event will proceed. The event did not happen in early 2021 but we are hopeful it will proceed in early 2022.

6.2 Scouting Units

Our main strategy for educational engagement is to use resources and contacts within the Boy Scouting organization to reach younger elementary and middle school youth. This is also aligned well with our other BSA STEM/Nova program goals, which include STEM education for younger Scouts in other units locally.

We will conduct STEM educational engagement with other Scouting units in several ways:

- At regional camporee weekends, we will have STEM Education tables that engage many Scouts. For example, at our District's Apple Harvest Camporee we have an activity that uses slingshots to explain and engage Scouts with a hands-on experiment in projectile motion. We also are discussing a similar STEM event at Winter Camp. These events are naturally outdoors, and thereby help to minimize COVID risks. We expect several hundred contacts at each Camporee.
- We will also contact local Cub Scout Packs and schedule an outdoor STEM program that we conduct at a Pack or Den meeting. To generate maximum attendance, we would lead the Cub Scouts in their Adventure in Science elective. This would be a hands-on outdoor activity involving rocketry, such as rocket balloons or water rockets.
- Host a rocketry day for local nearby Scouting units and the public at large, where we conduct an outdoor rocketry program and invite others to take part.
- We will make a STEM educational program part of our annual troop open house.

6.3 Boys and Girls Clubs

The Boys and Girls Clubs are an excellent way to reach economically disadvantaged youth. We held very successful events, and plan on doing it again this year.

6.4 Direct Engagement with Local Schools

A new strategy for STEM education we are pursuing this year is to directly engage with local central Virginia schools to host outdoor STEM events, including schools that are disadvantaged or serve disadvantaged youth. We will start with schools that our team members attend, and broaden from there.

6.5 Collaborative Educational Events with Other Nearby SLI Teams

We collaborated with the Piedmont Student Launch Team in the past and we would look for opportunities to do that again this year. Our idea is that by teaming, we have greater resources to undertake bigger and more impactful activities. While the collaboration is not yet defined in detail, we will look to collaborate with other SLI and USLI teams whenever possible.

7 Project Schedule

7.1 Schedule

The following is SLT17's preliminary schedule that demonstrates the feasibility of our plans and our ability to complete the deliverables on time. The schedule will be finalized during the PDR phase. Note that the subscale and full scale qualification flights will take place by the dates shown below assuming that we have to resort to backup launch sites and dates, so they are worst case dates. Do not interpret this schedule as indicating that our first launch attempt will be on the dates shown.

Task / Milestone	Start	End
Team recruiting, Organization and Setup	16-July-2021	15-September-2021
RFP Released		18-August-2021
Proposal Writing	18-August-2021	20-September-2021
Payload Selection	22-August-2021	12-September-2021
Conceptual Design	29-August-2021	12-September-2021
Technical Proposal Writing	22-August-2021	20-September-2011
Proposal Submission		20-September-2021
Kickoff and PDR Q&A		07-October-2021
Website and Social Media Presence Established; Handle sent to NASA		21-October-2021
Preliminary Design	07-October-2021	25-October-2021
Prepare PDR Documents	18-October-2021	01-November-2021
PDR Report, Presentation, Flysheet Submission		01-November 2021
PDR Video Teleconferences	02-November-2021	23-November-2021
CDR Q&A		30-November-2021
Critical Design	23-November-2021	04-January-2022
Build Subscale	19-November-2021	02-January-2022
Subscale Launch		02-January-2022
Prepare CDR Documents	09-December-2021	03-January-2022

CDR report, Presentation, Flysheet Submission		03-January-2022
Freeze Design of Full Scale		03-January-2022
CDR Video Teleconferences	06-January-2022	26-January-2022
FRR Q&A		27-January-2022
Final Design of Full Scale	27-January-2022	8-February-2022
Full Scale Design Freeze		8-February-2022
Full Scale Rocket Production	25-January-2019	04-March-2022
Vehicle Demonstration Flight and Payload Demonstration Flight (may combine into a single flight pending NASA approval)		05-March-2022
Prepare FRR Documents	18-January-2022	07-March-2022
FRR Report, Presentation, Flysheet Submission		07-March-2022
FRR Video Teleconferences	09-March-2022	28-March-2022
Travel to Huntsville		20-April-2022
Launch Day		23-April-2022
Backup Launch Day		24-April-2022
Prepare PLAR Documents	25-April-2022	09-May-2022
Submit PLAR Documents		09-May-2022

8 Project Budget

8.1 Overview

The total cost for this project is estimated at an upper limit of $13,644. This includes two primary expense categories: rocket-related, and travel.

8.2 Rocket Expense

The rocket-based expenses are based on costs researched by team members online. It includes rocket kits, motors, computers and payload for a full-sized Formula 98 rocket ($1158), and the subscale Formula 75 rocket ($290). We have estimated $100 expenses for a budget safety margin, based on last year’s actual expenses and the fact that we expect fewer contingencies this year. We’ve also estimated an estimated $100 for miscellaneous rocket expenses.

Our budget for rocket expenses is based on the fact that we can re-use the GPS tracker and receiver used in previous years. However, we will need to purchase a new payload computer, payload sensors and other components, and potentially payload batteries, and these expenses are included in our budget. Also, some other items such as the MARSA33LHD primary altimeter, RRC3 backup altimeter, and LiPO batteries for the altimeters used in the past are in excellent shape and can be re-used this year.

8.3 Travel Expense

The largest cost category for SLT17 by far is travel-related expenses. We have included an estimate of $11,996 for travel. This includes the following items:

- Transportation: $5,376 - It is 1,200 miles round trip to Huntsville, AL. from Charlottesville, VA. Based on the number of team members, we estimate seven personal vehicles making the trip at $0.56 per mile (IRS estimates).
- Lodging: $3,200 - We estimate 8 rooms with at 3 or more people in each room, at $100 per night, for four nights in Huntsville.
- Food $3,420 - We estimate a per diem of $30/day for 6 days for 19 people (including team members and accompanying parents).

The plan is to apply funds raised first to rocket and payload and related equipment, and second to travel-related costs. That way, if there is a fundraising shortfall, the science and flight objectives are not impacted and we can compensate by reducing travel expenses.

Note that our transportation and lodging costs are relatively high because our team is composed of minors who require greater levels of adult supervision since they are under 18. This also is required to comply with BSA youth protection rules requiring two-deep leadership at all Scouting events. Our approach is to solve this by asking all team members to travel with at least one parent to accompany them. We will deal with situations where team members must travel without parents to Huntsville as special cases.

Possibilities for covering travel expenses include the following:

- Renting or hiring small buses to transport the team to and from Huntsville, and/or sending the team to Huntsville by train. This may reduce the transportation cost. However, once the team arrives in Huntsville, we would have to rent one or two vans to shuttle the team between the hotel and the NASA launch, making this option less appealing.
- There is also a possibility that parents will absorb and share some or all of travel costs. This will require a team decision to be made closer to the time of the travel and on the basis of how much money has been raised.
- Depending upon fundraising success, Boy Scout Troop 17 may be willing to contribute in some funding to support the trip.
- The total cost per person for food, lodging, and transportation, is $631. This may be more expensive than many will find possible to fund. So the number of Scouts attending may decline, but the ultimate cost per person would remain the same.

8.4 Budget Detail

In total, we will need $13,644 to cover all expenses. So we will need to do a lot of fundraising and hopefully get gracious sponsors.

	No. of units	**Cost / Unit**				
Sources of Funds						

Uses of Funds						**Comments**
Total Uses			**13,354**	**290**	**13,644**	The biggest costs are travel-related
			Full Scale	**Sub Scale**	**Total**	
Rocket			**1,158**	**290**	**1,448**	
Full scale Formula 98	1	250	250		250	
Sub scale Formula 75	1	145		145	145	
Full scale reload - K805	3	115	345		345	
Sub scale reload - I600	2	50		100	100	
Full scale motor hardware - K805	1	179	179		179	
Sub scale motor hardware - I600	1	45		45	45	
Flight Computer - Marsa 33	1	199	199		199	Replace RCC2 with Marsa 33; works for both rockets
New Arduino	1	35	35		35	
Accelerometers and cables	1	50	50		50	
Safety Margin	1	100	100	0	100	Reduced from $500 estimated last year
			0	0	0	
Education			**200**	**0**	**200**	
Website			0	0	0	
Troop 17 website			0	0	0	
Educational Materials	1	200	200	0	200	General costs of material for educational activities
Design		1	0	0	0	
			0	0	0	
Travel			**11,996**	**0**	**11,996**	
Rooms 8 rooms @ $100/nt; 4 nights	32	100	3,200	0	3,200	Assume 8 families make it, for 3 nights (could be 4 nights)
Travel: 600 miles each way x $0.56/mi x 8 vehicles	**9,600**	**0.56**	5,376	0	5,376	19 people could be making the trip; assume 1 car/family, means 8

						cars; we considered a bus, but determined the cost and lack of mobility was a problem; each family covered own travel costs
Food ($30/day x 6 days x 19 people)	114	30	3,720	0	3,720	
			0	0	0	
		Rooms	**Total**	**Adults**	**Youth**	
		1.0	2	1	1	Allen
		1.0	3	1	2	Brown
		1.0	2	1	1	Sanusi
		1.0	3	1	2	Yates
		1.0	2	1	1	Carter
		1.0	2	1	1	Smith
		1.0	2	1	1	Panicker
		1.0	3	1	2	O'Malley
		8.0	19	8	11	

8.5 Fundraising Plan

The SLT17 funding will come from several locations and sources. These include corporate sponsors, private donations, online sources, and fundraisers.

- First, we are contacting sponsors from previous years to see if they are willing to support us again this year.
- The Virginia Space Grant Consortium has indicated they might be willing to donate, and we are contacting them to try and secure their potential sponsorship.
- We are also contacting individuals who contributed in the past to try to obtain their support again this year.
- We may do other fundraisers, time and COVID permitting, such as yard work, car washes, and bake sales.
- Note that the BSA has strict policies and procedures on fundraisers that we must comply with, and fundraisers must be pre-approved by the local council (http://www.scouting.org/filestore/financeimpact/pdf/CFD-Manuals/Policies_and_Procedures.pdf)
- We will contact local stores and businesses to see if they would be willing to give us some percentage of their earnings or to sponsor us. In the past, some fast food restaurants such as Bojangles donated a portion of their sales on certain days to us. We will pursue similar opportunities this year.
- There has also been preliminary interest in donations expressed by some leading aerospace and defense companies, and we are attempting to secure this funding.