University of Notre Dame

2021-2022

Notre Dame Rocketry Team
Safety Handbook

NASA Student Launch 2021

Planetary Landing System and Apogee Control System

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1 Introduction

1.1 Justification and Description

The Notre Dame Rocketry Team (NDRT) Safety Officer's role is to ensure the safety of all team members, students, and members of the public involved with any activities conducted by the team. To accomplish this, the Safety Officer shall encourage a culture of safety in all aspects of the team's mission and operation. The NDRT safety handbook clearly identifies all rules and regulations that the team must follow, and offers a wealth of knowledge for team members to use in their respective roles. The purpose is to create a resource that will create a common baseline of knowledge among all members of the team that will allow for a higher quality of knowledge among all team members. By offering a compiled collection of information and knowledge regarding the Rocket Team's functions, tools, operations, and policies, the handbook will help to create a base level of knowledge that will inform team members to be more effective when fulfilling their role, and to be safe while doing so.

1.2 Version History

Table 1: Safety manual version history

Version	Date Published	Changes Made
1.0	3/4/19	Safety manual published
2.0	3/2/20	Safety manual fully updated
2.1	11/1/20	2021 mission updates
2.2	8/30/20	2022 mission updates

2 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) is equipment worn to protect its user from hazards and injury in the workplace. As per 29 CFR 1910.132, the OSHA General requirements for PPE:

Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the

function of any part of the body through absorption, inhalation or physical contact.

For the purpose of the team, PPE shall be worn and utilized during construction of the rocket, testing, and launch. However, PPE only mitigates hazards; it does not prevent incidents from occurring. That being said, preventing incidents should be left to engineering and administrative controls. The following visuals display icons and their respective meanings.

Icon	Meaning
	Caution
	Warning
	Danger
	Must wear nitrile gloves
	Must wear cut-resistant gloves
	Must wear heat-resistant gloves
	Must wear antistatic gloves
	Must wear safety glasses
	Must wear safety goggles

	Must wear dust mask
	Must wear respirator
	Must wear laboratory coat
	Must wear ear protection

Enforcing PPE in the workshop is important to ensure team safety. As a result, helpful printouts have been made and posted in the workshop to alert team members to PPE required for certain tasks. These printouts can be located in Appendix B.

2.1 Emergency Kits

Due to potential hazards in the workshop, multiple medical kits are kept at the ready. The First Aid kit and Burn kit are located near the entrance of the workshop and clearly labeled. The kits are unobstructed so that they are easily accessible in case of emergency. Figure 1 shows the location of the First Aid and Burn kits.

Figure 1: Location of the First Aid and Burn kits in the front of the workshop

The First Aid kit stores multiple size bandages as well as medical gauze. There is a small pair of scissors in order to cut the gauze or bandages. Multiple packages of antibiotic gel and antiseptic wipes are in the kit in order to disinfect wounds. There are small packages of aspirin to temporarily alleviate pain. The kit also contains medical tape, tweezers, eyewash solution, and eye pads. In case of an emergency there is an Emergency First Aid Guide included with the kit.

The Burn kit contains gauze, instant ice packs, burn gel and multiple sized bandages. The First Aid kit can supplement burn injuries if the materials in the Burn kit are insufficient.

While the kits can temporarily treat wounds, any injuries should be assessed by medical professionals immediately. The University Emergency Number is clearly displayed at the front of the workshop and is in line sight of all locations within the workshop, as shown in Figure 2. In case of emergency call 574-631-5555.

Figure 2: Location of the emergency number sign

2.2 Clothing

All members must adhere to SFL clothing guidelines when entering the workshop which consists of long pants, closed-toe shoes, and a short sleeve shirt. Additionally, long hair must be tied back and all wrist watches or bracelets must be removed. These guidelines are applicable

for any circumstance in all workshops or labs unless specified by a faculty member in their respective facility.

2.3 Gloves

As per 29 CFR 1910.138, the OSHA Hand Protection standard, appropriate hand protection shall be used when one's hands are "exposed to hazards such as those from skin absorption of harmful substances; severe cuts of lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes."

Gloves can be found in the cabinets near the front of the workshop. Each cabinet is labeled for organization. Figure 3 shows the location of the nitrile gloves.

Figure 3: Location of nitrile gloves in workshop

2.3.1 Nitrile Gloves

Nitrile gloves are made of a synthetic rubber and provide protection from most hazardous materials that the team will use, such as binding agents like epoxy. Figure 4 shows an image of nitrile gloves.

Use Nitrile Gloves when:

- Handling hazardous materials
- Applying adhesives

Figure 4: Nitrile Gloves

In accordance to 29 CFR 1910.1030, the following rules and regulations shall be adhered to when using Nitrile Gloves in an injury-related situation. Nitrile gloves shall be used to prevent skin-contact with potentially infectious materials such as blood or mucous membranes. Nitrile gloves shall be replaced when contaminated or when their ability to function as a barrier is compromised. Nitrile gloves shall not be washed or decontaminated for re-use.

2.3.2 Cut Resistant Gloves

Cut-resistant gloves offer protection from any sharp objects that may cause harm to one's hands, such as hand saws or splinters. Figure 5 shows an image of cut-resistant gloves.

Use Cut-resistant Gloves when:

- Using sharp objects
- Handling fibrous materials (i.e. fiberglass)
- Cutting a material that could splinter

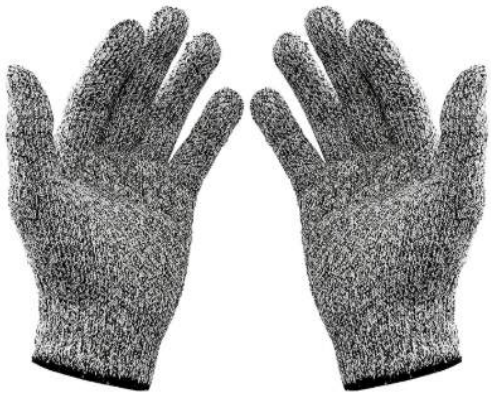

Figure 5: Cut-Resistant Gloves

2.3.3 Heat-Resistant Gloves

Heat-resistant gloves offer protection from any hot objects that may cause harm to one's hands, such as a soldering iron or a recently welded part. Figure 6 shows an image of heat-resistant gloves.

Use Heat-resistant Gloves when:

- Soldering
- Handling hot objects

Figure 6: Heat-Resistant Gloves

2.4 Eye Protection

2.4.1 Safety Glasses

Glasses are available outside of all workshops and should be worn before entering any workshop. Glasses used will resemble those depicted in Figure 9 and include features for proper fitting. All users of potentially hazardous equipment will be required to wear the safety glasses as well as any bystanders in a radius deemed to be potentially dangerous around a given hazard. Any user spotted without proper eye wear in the presence of a hazard will be verbally reprimanded and required to rectify the violation before continuing. Safety glasses should be worn when doing any construction in the workshop.

Safety glasses can be found in a cabinet outside and inside the workshop as seen in Figures 7 and 8, respectively.

Figure 7: Safety glass location outside the workshop

Figure 8: Safety glass location inside the workshop

Figure 9: Sample of safety glasses

2.4.2 Safety Goggles

Safety goggles should be used in place of safety glasses by users who already wear eyeglasses for vision. In any case where safety glasses would normally be required, a glasses-wearing operator would have the option to substitute goggle available for a better fit and interface with their current eye wear. The goggles are worn on top of the existing glasses for additional protection. Large sized goggles, such as those depicted in Figure 10, will be acquired to ensure good fitment for the majority of users.

Safety goggles should be worn when:

- Handling chemicals
- Producing vapor of a hazardous substance
- Engaging in an activity that results in splashing of a chemical
- When sanding, cutting, or any activity that may produce airborne particulates
- When cutting, drilling, using a dremel or any activity where components or material may come loose

Figure 10: Sample of safety goggles

2.5 Respiratory Protection

As per 29 CFR 1910.134, the OSHA Respiratory Protection standard, appropriate respiratory protection shall be used when one is “breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors.”

Dust masks can be found in the cabinets near the front of the workshop that are clearly labeled as seen in Figure 11

Figure 11: Storage of dust masks in the workshop

2.5.1 Dust Masks

Dust masks are provided in every workshop in labeled cabinets for ease of access. Dust masks are filtering face-pieces that are used to prevent potentially harmful dusts from entering one's lungs, such as dust from plastics, woods, or metals. Figure 12 shows an image of a dust mask.

Dust Masks should be worn when:

- Sanding
- Using the Techno Router
- Engaging in any activity with particulates in the air such as sanding, cutting, etc.

Figure 12: Dust Mask

By OSHA standards, unlike respirators, dust masks do not require a fit test nor medical evaluation.

Instructions on use of dust masks:

1. Hold the respirator in your hands with the nose piece towards your fingertips.

2. Position the mask over your mouth and nose.
3. Pull the strap over your head. The strap goes over the back of your head and above your ears.
4. Pull the shorter bottom strap over your head. The strap goes below your ears and around your neck.
5. If the respirator has a metal nose piece tab, use the fingertips of both hands and mold it to your nose.
6. Adjust the face piece and straps until a tight seal surrounds the mouth and nose.
7. When finished and in well-ventilated area, remove mask.
8. Dispose of mask properly.

2.6 Lab Coat

Laboratory coats can be found in the workshop along the back wall on the lab coat rack. Laboratory coats are often made of a fire retardant poly-cotton that protects the skin and personal clothing of its user from contact with hazardous materials, and prevent the spread of contamination. Figure 14 shows a image of a lab coat.

Lab coats can be found hanging on the rack towards the back corner of the workshop as seen in Figure 13.

Figure 13: Storage of lab coats in workshop

Use a Lab coat when

- Epoxying
- Painting
- Sanding
- Handling or using chemicals
- Any potentially-hazardous particulate is in the air

Figure 14: Laboratory Coat

2.7 Hearing Protection

As per 29 CFR 1926.101, the OSHA hearing protection standard, ear protection shall be provided if the noise exposure is in excess of permissible standards outlined by OSHA in Figure 16. Hearing protection will be provided as necessary in the form of ear plugs, and fitted by competent persons.

Ear plugs can be found near the front door of the workshop in a designated container above the emergency kits as seen in Figure 15.

Figure 15: Location of ear plug distribution container

Use Ear plugs when:

- Operating power tools or heavy machinery
- Performing a task that causes excessive noise

TABLE G-16 - PERMISSIBLE NOISE EXPOSURES (1)

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

Figure 16: Permissible Noise Levels

3 Material Safety

The most up-to-date MSDS Document can be found at this link.

3.1 OSHA/GHS MSDS/SDS

We will be using a Materials Safety Data Sheet (SDS) for each material that has a possibility of being used in construction, launch, or any other capacity. An SDS is a 16-section document outlining handling, first aid, and necessary PPE among other guidelines for using a materials.

Section 1 Identification of the chemical product and the company that distributes it. Also contains a signal word and identified hazards.

Section 2 Information and composition on ingredients, which identifies specific species and route.

Section 3 Hazard Identification of potential health effects from skin contact, skin absorption, eye contact, inhalation, or ingestion, WHMIS symbols also given.

Section 4 First aid measures in case of skin contact, eye contact, inhalation, and ingestion.

Section 5 Fire fighting measures including conditions, flammability, means of extinction, fire characteristics, hazards of combustible products, and NFPA standards.

Section 6 Accidental release measures for environmental and other protection in case of spill, leak, or other accidental release.

Section 7 Handling and Storage productive and equipment, also specifications of storage requirements.

Section 8 Exposure control and personal protection equipment specifications of limits of ACGIH TLV, OSHA PEL, or other specific engineering controls such as ventilation or enclosure. Also specifications of personal protection such as gloves, respirators, eye protection, footwear, clothing, and other.

Section 9 Physical and chemical properties such as physical state, appearance, density, distribution, and other properties.

Section 10 Stability and reactivity of the chemical under certain conditions, and hazards of decomposition products.

Section 11 Toxicological information such as effects of acute or chronic exposure, irritancy, and other toxicological effects.

Section 12 Ecological information such as aquatic toxicity.

Section 13 Disposal considerations for waste.

Section 14 Transportation information such as special shipping information, PIN, and regulations by TD, DOT, ICAO, IMO.

Section 15 Regulatory information from WHMIS classification, OSHA, SERA, TSCA and the products classification with CPR.

Section 16 Other Information

3.2 Material Handling Synopses

Table 3, below outlines important signal words, basic handling procedures, required personal protective equipment, and relevant first aid for materials used in construction of the rocket. All safety data sheets are located in the SDS document. Table 3 serves as a quick-overview of key information in each SDS document, and is not a substitute for the actual document. Appropriate personal protective equipment icons are located in the table when the required protection is mentioned.

Table 3: Material Safety Data Sheets Synopses

Material Name	Signal Word	Handling	Required PPE	Relevant First Aid
Acrylic Enamel Paint	Danger 	Keep away from flames and sources of heat. Residual vapors are very flammable. Only use outdoors or in a well-ventilated area. Wash hands thoroughly after handling. Wear long sleeves and impervious clothing when painting.	Respirator  Safety Goggles  Nitrile Rubber Gloves  Lab Coat 	**Ingestion**: Rinse mouth. Do NOT induce vomiting. Seek medical attention. **Eyes**: Flush with water for 15-30 minutes. Remove contacts. Keep eyes open while rinsing. Get medical attention. **Inhalation**: Remove to fresh air. Place victim in a position that makes breathing easy. **Skin**: Wash affected area with soap and water for 15-30 minutes. Remove contaminated clothing.
Aerotech Igniters	None	Keep away from flames and sources of heat. Keep in package until ready to use.	None	**Ingestion**: Induce vomiting. Seek medical attention. **Mild burn**: Apply first aid ointment. **Severe burn**: Immerse in cold water. Seek medical attention immediately.

Aerotech Motors	None	Keep away from flames and sources of heat. Keep in package until ready to use.	Nitrile Rubber Gloves 	**Ingestion**: Induce vomiting. Seek medical attention. **Mild burn**: Apply first aid ointment. **Severe burn**: Immerse in cold water. Seek medical attention immediately.
Black Powder (Potassium Nitrate)	Warning 	No smoking near product. Keep away from sparks, flames, friction, impact, and other sources of heat.	None	**Injury from Detonation**: Call 911. Seek medical attention immediately.
Carbon Fiber	Danger 	Do not get in eyes, on skin, or on clothing. Do not taste or swallow. Keep away from sources of heat or ignition.	Safety Goggles  Lab Coat  Nitrile Rubber Gloves  Heat-Resistant Gloves (when heating) 	**Inhalation**: Remove from exposure and move to fresh air. **Skin**: If there is a reaction, flush skin with lots of soap and water for at least 15 minutes. Remove contaminated clothing. Get medical attention if irritation develops or persists. **Eyes**: Flush eyes with lots of water for at least 15 minutes while lifting upper and lower eyelids. Get medical aid immediately. **Ingestion**: Do NOT induce vomiting. If able, rinse mouth and drink 2-4 cups of milk or water.

Electric Match Igniter	Danger 	Keep away from sources of heat or ignition. Store in a cool, dry place. Avoid prolonged contact with skin. Store in original packaging until immediately before use. Store in accordance with local requirements for explosives.	Safety Goggles 	**Inhalation**: Remove from exposure and move to fresh air. If not breathing, administer CPR. Get medical aid. **Eyes**: Flush using an eye wash station for at least 15 minutes, occasionally lifting both eyelids. Get medical aid immediately. **Ingestion**: Do NOT induce vomiting. Rinse mouth with 2-4 cupfuls of milk or water. Get medical aid immediately. **Skin**: If irritation on skin, flush with soap and water for at least 15 minutes. Remove contaminated clothing and shoes.
Elmer's Carpenter's Wood Glue	None	Use with adequate ventilation.	Safety Goggles 	**Eyes**: Flush using an eye wash station. Contact a medical professional immediately. **Ingestion**: Do NOT induce vomiting. Rinse mouth thoroughly with water. Contact Poison Control immediately. **Skin**: Wash with plenty of soap and water.

Elmer's School Glue	None	No guidelines.	None	**Eyes**: Find an eye wash station. Contact a medical professional immediately. **Ingestion**: Do NOT induce vomiting. Contact Poison Control immediately.
G10 Fiberglass	Warning 	Use dust control equipment at the point of generation in machining or sanding operations. Wash hands and other exposed areas thoroughly after handling. Keep away from sources of heat or ignition. Do not wear contacts when working with this product.	Safety Goggles  Lab Coat  Nitrile Rubber Gloves  Heat-Resistant Gloves (when heating materials) 	**Inhalation**: Remove from exposure and move to fresh air. If not breathing, administer CPR. **Skin**: Wash contaminated area with soap and water. Get medical attention if irritation develops or persists. **Eyes**: Flush eyes with lots of water for at least 15 minutes while lifting upper and lower eyelids. Get medical aid immediately. **Ingestion**: Do NOT induce vomiting. Get medical attention immediately.

JB Weld Steel Reinforced Epoxy	Warning 	Do not store below 35°C (95°F).	Respirator  Nitrile Rubber Gloves 	**Inhalation**: Remove victim to fresh air. Place in a position that is comfortable for breathing. Administer CPR if the victim is not breathing. Seek medical attention immediately. **Skin**: Wash skin with soap and water, remove contaminated clothing, rinse skin for 10 minutes. Seek medical attention. **Eyes**: Rinse eyes using eye wash station. Seek medical attention. **Ingestion**: Wash out mouth with water. If swallowed, drink small sips of water. Do not induce vomiting unless medically advised. Seek medical attention.

Lithium Polymer Battery	Warning 	Do not immerse in water. Do not disassemble or deform the battery. Do not expose to, or dispose of the battery in fire. Avoid excessive physical shock or vibration. Battery must be charged in an approved charger. Never use a modified or damaged charger. Store in a cool, dry and well-ventilated area.	Only required if cell has leak or vent: Respirator  Nitrile Rubber Gloves  Safety Goggles 	**Ingestion**: Wash out mouth with water. Do not induce vomiting unless medically advised. Seek immediate medical attention. **Inhalation**: Remove victim from chemical exposure to fresh air. Seek medical attention. **Skin**: Immediately flush with water. Seek medical attention. **Eyes**: Rinse eyes using eye wash station. Seek medical attention.
Makerbot PLA	None	Store in a cool, dry place. Store below 50°C.	None	**Skin**: Wash with soap and water. **Ingestion**: Rinse mouth with water. Seek medical attention.

Rocketpoxy Part A	Warning 	Store in a cool, dry place. Reseal partly used containers. Properly label all containers.	Nitrile Rubber Gloves  Safety Goggles 	**Eyes**: Flush eyes for 15 minutes. Seek medical attention. **Skin**: Wash with large amounts of soap and water. Remove contaminated clothing. **Ingestion**: Do not induce vomiting. Drink copious amounts of water. Seek medical attention immediately.
Rocketpoxy Part B Curing Agent	Danger 	Store in a cool, dry place. Reseal partly used containers. Properly label all containers.	Nitrile Rubber Gloves  Safety Goggles 	**Eyes**: Flush eyes for 15 minutes. Seek medical attention. **Skin**: Wash with large amounts of soap and water. Remove contaminated clothing. **Ingestion**: Do not induce vomiting. Drink copious amounts of water. Seek medical attention immediately.

4 Energetics

Energetics, such as motors, igniters, batteries, or separation charges can pose a potential hazard to personnel, bystanders or the environment if proper handling and disposal practices are not followed. With proper procedures, training, and equipment however, the risk that energetics pose can be mitigated to a safe level. All energetics will be handled by the NDRT mentor, Dave Brunsting.

4.1 Motors

The motors that NDRT uses are commercial solid rocket motors, professionally-built motors intended for use in amateur high-powered rockets. These motors have the rocket fuel and oxidizer pre-mixed in a fuel grain, which is loaded into the motor casing during assembly.

Motors are stored in climate controlled conditions, usually indoors or during flights, inside a climate controlled vehicle. Motors remain in their packaging until necessary assembly at launch. All motors are kept by Launch Manager Dave Brunsting.

Due to the sensitive nature of solid rocket motors, all motors that NDRT uses will be assembled and installed by the team mentor, Dave Brunsting. Dave possesses Level 3 High-Powered Rocketry Certification through Tripoli Rocketry Association, and has been launching high-powered rockets for several years, making him qualified to perform high-risk operations such as motor handling. During motor assembly and preparation, special care must be taken to follow all assembly instructions provided by the motor manufacturer. All motors are inspected for defects. Mistakes made during the motor assembly process, such as damaging a sealing ring or cross-threading the nozzle, can result in motor explosion, or similar catastrophic failure. Motor assembly is also included in Launch Procedures in order to verify proper motor handling.

After launch, the motor retainer will not be touched by any member of the team. Instead, the Launch Manager will handle the motor after launch, wearing proper hand protection when removing the motor as the motor may still be hot.

4.2 Igniters and E-Matches

Igniters and electronic matches (E-Matches) are pyrotechnic components used to ignite other energetics when activated with an electric current. This is done through a small circuit element, most often a small nicrome wire, that heats up when exposed to electric current. This heated element then ignites a small amount of pyrogen, which in turn ignites the associated energetic.

Igniters should only be installed in a motor once the fully assembled rocket is on the launch pad. Installing the igniter should always be the last step of rocket preparation, and an absolute minimum number of personnel should be near the pad during this step as designated in the Launch Procedures. Igniter instillation should only be done by the NDRT team mentor, Dave Brunsting. The leads that will connect the igniter to the launch controller should ALWAYS be checked before igniter instillation. This is typically done by touching the controller leads to each other; live controller leads will exhibit a characteristic spark, indicating live voltage. If the

contoller leads spark, stop igniter instillation and immediately notify the range LCO and RSO. If the controller leads are not live, proceed to insert the igniter in the motor and connect the launch controller leads. Mistakes in igniter instillation can cause premature motor ignition or issues during the motor burn, up to and including motor explosion. Care must also be taken to not damage the igniter during instillation. In the case that a motor fails to ignite, the team mentor should approach and remove the igniter in accordance with Troubleshooting procedures.

4.3 Black Powder

Black powder is an explosive that is often used to separate a rocket for parachute deployment. When lit with an E-match, a black powder charge will rapidly ignite, pressurizing the parachute compartment of the rocket with hot combustion gasses and producing the large bulkhead forces required to break the shear pins holding the rocket together and deploy the parachute. As with any sensitive explosive, mishandling of black powder can inadvertent ignition, leading to severe burns and injury to personnel. Black powder should be stored away from motors, igniters, E-matches, batteries, heating elements and other potential ignition sources.

Any black powder charge used by NDRT, for launch or for testing, will be measured and prepared by our team mentor, Dave Brunsting. After the charge has been measured, the E-match placed and the charge sealed, it will be placed in the charge well and wired to the altimeters and/or testing electronics. It is critical that the electronics are not energized while wiring the charge into the system.

In the event that a rocket returns to the ground with a live black powder charge, the first step is always to turn off the altimeters through the battery switch slots in the side of the rocket. Once power to the altimeters has been shut off, the recovery system should be removed from the rocket and the intact powder charge cut from the system. Any excess black powder from tests or launches should be disposed of through University Hazardous Waste procedures. More information on the University's Hazardous Waste procedures can be found in Section 10.3.

4.4 Batteries

Batteries are electrical devices used to power the components of the rocket, such as altimeters, servos, and micro-controllers among others. In particular, Lithium-Ion and Lithium-Polymer batteries will be used for many high-power electrical components, such as the payload and servo motors in the ACS. Lithium-based batteries have low weight, good

energy capacity and can produce the extremely high currents required to run high-powered electrical motors, however, they can be quite volatile. The chemicals contained in a lithium-based battery are flammable. Puncturing, overcharging, over-discharging, or heating of a lithium-based battery can cause a hard-to extinguish lithium fire. To mitigate the chance of battery combustion, batteries should be stored in a cool, dry location away from other energetics and heating elements. The workshop has a flammables cabinet where batteries and unattached electronics will be stored. Batteries will be housed in LiPo battery bags and electronics will be housed in electrostatic discharge bags.

5 Construction Safety

The construction of the rocket and its payloads brings with it some inherent dangers that must be addressed. Power tools, adhesives, and construction techniques such as sanding, cutting and drilling have the potential to pose serious risks to team personnel. With mitigations such as personnel training and established safety guidelines, however, the risk that rocket construction poses to team personnel can be minimized.

5.1 Construction Facilities Description

5.1.1 AIAA Workshop

The AIAA Workshop will be the primary construction facility for the NDRT. It is a small machine shop that is shared between Notre Dame Rocket Team and Notre Dame's Design/Build/Fly team. All team leads have access to the workshop. The AIAA worksop contains a variety of power tools, including dremels, power drills, a belt/disk sander, a drill press, and a laser cutter. Team personnel must receive Level 1 EIH certification before working in the AIAA workshop, but further tool-specific certifications are necessary before using all the equipment available (See Section 5.2.1 or 11).

5.1.2 Innovation Hub

The Engineering Innovation Hub (EIH) is a University-run machine shop that can be used by any certified student during operating hours. The EIH will be used when specialized tools that are not available in the AIAA workshop are needed. Level 1 EIH certification is required to work in the EIH, but further tool-specific certifications are necessary before using all the equipment available (See Section 5.2.1) or 11)

5.1.3 Senior EE Lab

The Senior Electrical Engineering Laboratory, room 205 in Stinson-Remick Hall, is where much of the electrical assembly and testing will be performed for subsystems like the payload, the Apogee Control System, and the Recovery system. It is outfitted with tables for component layout, soldering irons, and computers for software testing. No certification is required to work in the Senior EE Lab, however, all PPE and tool certification requirements must still be adhered to (ie. a team member cannot use a power drill unless they are certified to do so.)

5.1.4 213 Stinson-Remick

Room 213, in Stinson-Remick Hall, is where NDRT holds most of its full-team meetings. Mostly a design space, some light construction may take place here. The room is outfitted with tables, whiteboards, a laser cutter and several 3-D printers. No certification is required to work in Stinson-Remick 213, but all PPE and tool certification requirements must still be adhered to.

5.2 Tool/Machine Safety

5.2.1 Certifications

Team member certification to work with power tools and machinery will be handled by Notre Dame's Engineering Innovation Hub (EIH) lab technicians and personnel. All members must get re-certified each year to ensure workshop competency. Any member must prove their certification for the tooling they would like use by presenting their certification card to the Innovation Hub Manager or a Team Lead.

Figure 17: Certification cards for the 2019-2020 schoolyear

Level 1 EIH Certification is be required to work in either the AIAA workshop or the EIH. To obtain this certification, go to https://sites.google.com/nd.edu/eih-portal/home?authuser=1, fill out the Workshop Safety Quizzes online. Once these are completed, go to the EIH during appropriate office hours to perform the Safety Walkthrough and obtain a Level 1 EIH certification card.

Tool-Specific Certification is required to work with any of the more advanced tools, such as the band saw or drill press, in the AIAA workshop or the EIH. To obtain a tool-specific certification, first obtain a Level 1 EIH certification. Then, go to https://sites.google.com/nd.edu/eih-portal/home?authuser=1 and take the relevant safety quiz. Once the quiz is completed, a training session with the Innovation Hub Manager or workshop TA must be completed.

5.2.2 3D Printer

A 3D printer is a device that uses additive manufacturing to create three dimensional solid objects from a digital through a variety of methods. The Notre Dame Makerspace uses Makerbot Replicator+ 3D printers to print objects out of PLA plastic.

5.2.3 Band Saw

A band saw is machine used to cut materials into irregular shapes by moving a saw in continuous downward motion. The band saw can also be used to crosscut shorter parts. Materials commonly cut using the band saw are composites, metals, plastics, wood, and foam core.

5.2.4 Belt and Disc Sander

The belt sander is an electric device with two spinning wheels that can be adjusted to fit a belt. The belt can be sandpaper material of varying weights and grits. The disc sander is a circular sander rotated by one the spinning wheels of the belt sander. Both can be used interchangeably.

5.2.5 Dremel

A dremel is a general-purpose rotating hand tool for use in cutting and sanding applications. A a wide variety of cutting and sanding bits are available for a wide variety of light machining

tasks in wood and other materials. General shop rules and guidelines for power tool use apply to the dremel.

5.2.6 Drill Press

The drill press is a stationary bench-top motorized drill tool, composed of a drill head, a column, and a worktop. The spinning drill component is attached to the column, and is controlled vertically by a rotating handle.

5.2.7 Hand Saw

Hand saws are manual tools used to cut materials such as wood, plastic, or metal. Generally, hand saws are only used to cut straight lines. Hand saws are the least accurate saw available, especially compared to band and scroll saws.

5.2.8 Laser Cutter

The laser cutter is a tool that is mobile through its wheels, but usually maintains a similar spot in the workshop. The laser cutter is composed of an electronics frame, a cutting surface, and a computer screen in which the user can interact with in order to finely cut or engrave material. Common materials cut in laser cutters are wood, acrylic, or cardboard. Laser cutters will struggle to cut most materials that are greater than 0.25” thick. For thicker or stronger materials, like metals, the laser cutter can be used for engraving purposes.

5.2.9 Lathe

The lathe is a machine that rotates a work piece about this central axis, and provides the ability to cut, drill, face, turn or sand parts to extremely accurate requirements. Lathes can be used to manufacture parts out of a variety of materials, but the Notre Dame Rocketry Team mainly manufactures parts out of metal and plastic on the lathe.

5.2.10 Portable Drill

The portable drill is a handheld rotary tool that can spin at up to 2,000 rpm, which makes it very effective at creating holes. However, if proper procedures are not followed the high speed rotation of the drill bit could injure the user. There are many different types of drill bits available in a variety of sizes.

5.2.11 Scroll Saw

A scroll saw is a tabletop machine that moves a saw blade rapidly up and down in order to cut through a material. The scroll saw blade is generally thin, making curved cuts easier. The cuts of a scroll saw are more delicate and precise than other types of saws. Materials commonly cut on a scroll saw are wood, composites, metals, or plastics.

5.2.12 Soldering Iron

Soldering is the process of joining two metallic components together through liquid solder. This solder is melted using a hot soldering iron so that it can ply between the metals and form a strong, conductive connection.

5.2.13 Techno Router

A techno router is a computer numerical control (CNC) router used to machine flat sheets of material into 3D components. The machine rotates a spindle up to 18000 rpm in order to cleanly cut and contour materials such as wood, composites, acrylic, HDPE, aluminum, steel, or other plastics. Various different size router bits are available depending on the applicable scenario.

5.3 Construction Procedures

Established, well-written construction procedures can mitigate some of the inherent risk involved in the construction of a rocket by encouraging a measured, step-by-step approach. In addition, well-written procedures reduce the risk of potentially costly mistakes that could occur during the construction of the rocket.

Construction procedures must be created before construction of any major component of the rocket. These procedures shall be created with safety at the forefront, warning team members about potential hazards and trouble spots during the construction process and providing linear, step-by-step directions for the completion of the construction task. Procedures should be created in collaboration with a returning NDRT member and checked off by the relevant subteam lead as well as the Safety Officer before being published. After the construction procedure is finished, the relevant subteam lead must check off to ensure proper completion. All construction procedures will be compiled in the NDRT Standard Operating Procedures Document and will follow the standard testing format located in the same document.

6 Testing Safety

Conducting tests of rocket components throughout the mission life cycle is integral to making sure that the system will not fail on launch day. Therefore, lab equipment and specialized facilities must be utilized during the testing stages. Regardless of facility, all team members using equipment are expected to attain all proper certifications before entering the lab. All members in labs are expected to follow all posted signs and regulations, comply with all University and NASA requirements, adhere to guidelines in the Safety Handbook, and utilize appropriate PPE with applicable materials and machinery.

Safety glasses are to be placed on before entering the laboratory, whether or not a power tool is to be used or not. This precaution significantly reduces the chance of inadvertent injury if another group of students begin using power equipment in the same space. In addition to safety glasses, appropriate lab attire consists of a short sleeved t-shirt, tied back hair, long pants, and closed toe shoes.

Any required testing involving dangerous energetics such as igniters, black powder, or motors will be handled by the team mentor, Dave Brunsting. More information about energetics safety can be found at Section 4.

Before operating any machinery or beginning a test of system components, team members are expected to have a set plan for what they intend to accomplish. The team lead is responsible for verifying this plan. Any concerns regarding appropriate machine selection, operation, or calibration should be reported to the supervising TA or lab technician. If flying debris is a potential hazard, members should notify other students in the room.

In case of an emergency, team members are expected to know the location of the nearest shutoff switch, first aid kit, emergency eyewash station, defibrillator (AED) unit, and fire extinguisher. Should any mishaps occur in the lab, team members are expected to (1) notify the supervising technician for immediate assistance and (2) call Notre Dame Security Police (NDSP) from an in-room land line or from a cell phone at (574) 631-5555. These phones are clearly marked throughout each lab and have the NDSP phone number clearly identified. Do not call 911; it will result in a delayed response of up to 10 minutes, whereas the 10-digit number routes calls directly to on-campus emergency services.

6.1 Testing Facilities Description

The AIAA workshop and the Engineering Innovation Hub (EIH) are the primary work spaces for construction and testing of rocket components. The AIAA workshop is a lab space shared by NDRT and Notre Dame's Design Build Fly team. The EIH is a University-run lab space open

to students in the College of Engineering. Team members are expected to attain a minimum of a Level 1 certification from the EIH through the University, which is the minimum certification required for entry into either lab. A Level 1 certification includes successful completion of the Workshop Safety and Tools Quiz and a walkthrough of the EIH with University staff. In order to access higher level equipment in the EIH, additional certifications must be completed. More information about certification requirements can be found at Section 17 or 11.

In the event that specialized lab spaces are necessary, appropriate faculty sponsors will be notified to allow for their use. Team leads will be responsible for coordinating with faculty for the use of labs other than the EIH, including the University wind tunnels and solid mechanics labs.

6.2 Testing Procedures

Established, well-written testing procedures can mitigate the inherent risks involved in the testing of rocket components by encouraging a measured, step-by-step approach. In addition, well-written procedures reduce the risk of inconsistent testing, which can invalidate important tests of critical rocket components.

Testing procedures must be created before performing any major test on vehicle components. These procedures shall be created with safety at the forefront, warning team members about potential hazards and trouble spots during the testing process and providing linear, step-by-step directions for the completion of the test. Procedures should be created by members in collaboration with other members and the relevant NDRT design lead. The Safety Officer and Systems Officer will read and approve all testing procedures prior to testing beginning. After the test has been performed, the relevant subteam lead must check off to ensure proper completion. All testing procedures will be compiled in the NDRT Standard Operating Procedures Document and will follow the standard testing format located in the same document.

7 Launch Safety

Rocket launches pose many risks to the safety of the team, bystanders, and property, including but not limited to explosive chemistry, ballistic projectiles, and high temperatures. For this reason, extreme caution is required when conducting a launch. This section will discuss specific points of failure and how the team plans to mitigate them.

7.1 Pre-Launch Certification

Pre-launch walkthroughs will be mandatory for all members attending launch and attendance will be taken to verify this. These walkthroughs will consist of packing necessary tools according to the Pre-Launch Tool Checklist, running through necessary operations for the day to ensure efficient assembly on launch day, and review of safety concerns and procedures. The Launch Procedures will be followed except for components that include motors or energetics during the walkthrough.

Before each launch day, the Safety Officer will revise launch procedures for each design teams, which will be distributed to the teams on the day of the launch before departure. The Launch Manager will give a safety briefing before each launch due to his many years of expertise in high powered rocketry.

7.2 Identified Risks and Mitigations

All hazards will be assessed on the same scales of probability and severity to apply consistent, effective mitigations. Hazards considered include personnel hazards, failure modes and effects analysis (FMEA), and environmental hazards. Every hazard will be identified by a member of the Safety team and documented with appropriate causes, outcomes, mitigations and verifications. All hazards will be assigned a pre-assessment numerical value reflecting the combined probability and severity of the hazard before mitigation. Similarly, All hazards will be assigned a post-assessment value reflecting the combined probability and severity of the hazard after mitigation implementation. Mitigating hazards with larger pre-assessment values will be prioritized over hazards with smaller values, although the team is confident all hazards will be successfully mitigated. Table 4 displays the values and occurrence definitions for hazard probability. Additionally, Table 4 displays the values and definitions for hazard severity in multiple contexts, specifically personnel, vehicle, environmental, and mission success hazard.

Table 4: Probability Value Criteria

Definition	Value	Probability of Occurrence
Improbable	1	Less than 1% chance the event will occur
Rare	2	1 to 10% chance the event will occur
Sporadic	3	10 to 20% chance the event will occur
Likely	4	20 to 40% chance the event will occur
Frequent	5	More than 40% chance the event will occur

An overall assessment can be made by multiplying the values of probability and severity.

Table 5: Severity Value Criteria

Definition	Value	Personnel	Vehicle Damage	Environmental Effect	Mission Success
Negligible	1	Minor injury	Insignificant	Insignificant	Insignificant effect
Minimal	2	Moderate injury	Slight	Reversible	Slight mission failure
Dangerous	3	Serious injury	Severe	Somewhat reversible	Severe mission failure
Catastrophic	4	Critical injury	Loss of vehicle	Irreversible	Complete mission failure

Table 6 displays all potential combinations of probability and severity and their respective risks, as well as assigning color values to each combination. The key and definition for each color assignment can be seen in Table 7.

Table 6: Overall Risk Assessment

Probability	Severity			
	Negligible (1)	Minimal (2)	Dangerous (3)	Catastrophic (4)
Improbable (1)	1	2	3	4
Rare (2)	2	4	6	8
Sporadic (3)	3	6	9	12
Likely (4)	4	8	12	16
Frequent (5)	5	10	15	20

Table 7: Risk Assessment Color Code

Color	Description	Risk Value Range
Green	Low or No Risk	Less than 5
Yellow	Moderate Risk	Between 5 and 9
Red	High Risk	10 or greater

When risks are identified and prioritized, mitigations will be identified to decrease the potential risks of each hazard. To ensure these mitigations are implemented and adhered to, verifications will also be applied to each mitigation. Verifications may take the form of actions taken by specific individuals or resources provided to all team members. In this way, all mitigations will be properly carried out by informed, trained, responsible individuals, thus ensuring effective risk reduction.

7.3 Launch Procedures

Launch checklists have been approved by the Safety Officer, Technical Design Leads, the Systems Officer, and Team Captains such that together they outlines the necessary steps to complete a safe and successful test launch of the full scale rocket. Each checklist has been developed and verified by both the Safety Officer and the relevant Technical Design Lead,

among potential additional members. Checklists should be carefully read so that whenever noted, proper caution and cognizance can be exercised.

All launch procedure checklists can be located in Appendix A upon completion for FRR. Each checklist is printed out, completed, and signed off by the Safety Officer once all tasks have been completed. Should an event or situation that is not covered in the safety checklists be encountered during launch exercises, members should exercise their best discretion and approach an officer, the team mentor, the team's graduate student advisor, or the range safety officer for instructions on how to proceed.

8 Educational Outreach Safety

NDRT seeks to educate younger students in the South Bend community on the basics of aeronautics. While these events are on a smaller scale than the team's own launch, there are specific hazards that NDRT members are required to look out for while attending these events. When the students are working on their own projects, direct supervision by team members is always required. Students are expected to be following directions given by team members, not launching projectiles in the work space, and preventing students from harming themselves with scissors. Special care is to be taken with elementary aged students who are more likely to swallow materials (eg. glue) or suffocate on plastic linings (eg. parachutes).

Specific outreach events involve sub scale rocket launches. Students are never allowed to handle motors or their rockets when the motor is mounted inside. Team members are responsible for following pre-launch safety procedures outlined in Section 6.1 and ensuring that students are a safe distance away from the rocket. Any student found not following oral instruction will not be allowed to participate in the rest of the day's launches.

With concerns over the spread of COVID-19, NDRT prioritizes the safety of their members and the community above all else. During all in-person educational outreach events, NDRT agrees with and will comply with The University of Notre Dame's COVID-19 policies. Additionally, the following measures will be the responsibility of our Educational Outreach Leader and Safety Officer to enforce:

- All personnel, including both NDRT members and the young students, are expected to wear masks while indoors even if vaccinated
- NDRT will communicate with every organization and all NDRT members prior to the day of the event to ensure that everyone understands the rules and can agree to such safety protocols
- Disposable face masks will be present at every event in case any NDRT member or young student is not in the possession of a mask

Furthermore, virtual events may also occur this year, and such events pose zero theoretical risk of spreading COVID-19.

9 Environmental Considerations

The safety team is responsible for mitigating the effects the rocket poses to the environment as well as making sure the environment will not adversely affect the performance of the rocket. All SDS guidelines will be followed in conjunction with local, state, and/or federal guidelines and regulations regarding safe operation and disposal of hazardous compounds.

Weather dependent hazards pose considerable risk to the rocket's performance and can lead to soil, water, or air contamination in excess of anticipated impacts. Mitigating action consists of taking appropriate precautions during a weather delay, waiting for adverse conditions to subside, and following all guidelines put forth by NASA or launch site representatives. The Team Captain and Safety Officer will be responsible for clearing the rocket for launch when weather has passed.

10 Regulatory Compliance

10.1 NAR/TAR

The Notre Dame Rocketry Team will be taking several steps to ensure compliance with the National Association of Rocketry High Power Rocket Safety Code that has been effective as of August 2012. Table 8 below outlines each of the items in the safety code, and how the team and its mentors will comply with it.

Topic	NAR Description	Team Compliance
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.	Team mentors are Level 2 certified and the team will only use a maximum of L class motors.
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 design squads, especially the vehicle design squad, will refrain from using materials that do not meet the lightweight requirement. If there is uncertainty, the team will check with the NASA competition officials.
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, nor heat sources within 25 feet of these motors.	The team will not use any motors, other than those used by certifiable and trusted rocket motor manufacturers. Motor use will be supervised by team mentors, will be only for the purpose of launching the rocket, and will be under controlled and safe condition.
Ignition Systems	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 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.	The team’s mentors will install all ignition systems and will only do so properly, and according to the NAR regulations outlined here.
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.	Team mentors, Safety officer, and Captain must all approve any attempts to approach the rocket in the case of misfires. Even then, it will only be done well after a 60 second waiting period, and will be done only by the team mentors and essential personnel after the area has been determined to be safe.
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 team will follow all launch instructions given by the Range Safety Officer, and will comply with all rules stipulated here. Additionally, the Safety officer will give a 5 second warning to all personnel in the area prior to launch.
Launcher	I will launch my rocket froma stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and 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 therocket 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 and clear that area of all combustible material if the rocket motor being launched uses titanium sponge in the propellant.	The team will only use rails provided by NAR, and will fully comply with this rule.
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 highpower rocket motor(s) intended to be ignited at launch.	Rocket design and motor selection will comply with this rule.

Topic	NAR Description	Team Compliance
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.	Weather and wind conditions will be evaluated in the week prior to a launch day, as well as on launch day, if conditions are determined to be unsafe, the team will not launch. All necessary FAA waivers and notices will be acquired and in place prior to launch. The team will comply with all launch day determinations made by the Range Safety Officer.
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).	Team launches will only take place at NAR/TRA events. The Range Safety Officer has final say on all matters regarding safety issues.
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.	The team will comply with this rule and any determination the Range Safety Officer makes on the day of launch.
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 Recovery Design Squad will be responsible for designing, testing, constructing, and verifying a safe recovery system that will fully comply with this rule. A pre-launch checklist must be checked off by recovery and signed by the Captain and Safety Officer.
Recovery Safety	I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, 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 team will comply with this rule and any determinations made by the Range Safety Officer on launch day. If a safe recovery is not possible for the team, proper authorities will be contacted to ensure a complete and safe recovery.

10.2 Local, State, Federal Law

Three major sets of regulations apply to our rocket launch and the related events. The first code is from the National Fire Protection Association, NFPA 1127 “Code for High Powered Rocketry” (2018 edition). This document covers hazard mitigation in relation to rockets with the goal of protecting those involved with launch, as well as bystanders. It can be accessed at the following link:

https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1127.

The next set of rules is contained within the Electronic Code of Federal Regulations from the Federal Aviation Administration. Drilling down into the area of interest, the specific section pertaining to Amateur Rockets is Title 14, Chapter I, Subchapter F, Part 101, Subpart C. This area contains the definitions of amatuer rocket classes and governs where, when, and how such

rockets can be launched. The link to these standards is the following:

https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=14:2.0.1.3.15#sp14.2.101.c.

The final set of relevant regulations is from the Bureau of Alcohol, Tobacco and Firearms, Treasury. Title 27 is the applicable Code of Federal Regulation, specifically Part 55-Commerce in Explosives. Part 55 starts on page 742 of the document (page 752 of the psd itself). Our motor is classified as an explosive and would therefore be governed by these statutes. It can be read by following this link:

https://www.govinfo.gov/content/pkg/CFR-2001-title27-vol1/pdf/CFR-2001-title27-vol1.pdf

All of these rules are compiled here within this safety manual for the purpose of ease of accessibility by all team members. These regulations should be studied with the intention to be followed at all times, however team members should remain vigilant of any potential violations of the codes and alert necessary authorities if such an event occurs. At the launch events the chain of command is topped by the NAR officials and Range Safety Officer, followed by the team's Captain and Safety Officer. These individuals should be best versed on the previous statutes and be ready to act to remedy violations brought to their attention while promoting proactive safety. Additional launch policies will be implemented and presented to the team on a state-by-state basis as determined by launch location.

10.3 University

The Notre Dame Rocketry Team agrees with and will comply to the following University policy regarding hazardous waste:

"The University of Notre Dame Hazardous Waste Procedure establishes a formal written program for the safe and compliant collection, storage, and disposal of hazardous waste. The University of Notre Dame's recommendation is that all staff assume wastes are hazardous until proven otherwise, and request Risk Management and Safety (RMS) manage the waste. This applies to laboratories, shops, maintenance areas, or other Notre Dame facilities generating, storing, or handling hazardous waste."

The University of Notre Dame Office of Risk Management and Safety provides containers of various different sizes for hazardous waste to be disposed in. Additional information about disposing of hazardous waste on University of Notre Dame's campus can be found at

https://riskmanagement.nd.edu/assets/236531/hazardous_waste_procedure.pdf

The Notre Dame Rocketry Team also agrees with and will comply to all policies published by the University of Notre Dame Engineering Innovation Hub (EIH). All team members who touch any piece of the rocket during construction in a University of Notre Dame facility will be required to have the appropriate certification from the EIH. A certification card, issued by the EIH, will be required to participate in basic construction, while more dangerous tools and equipment will require other certifications, which are all outlined on the EIH website (https://sites.google.com/nd.edu/eih-portal/home?authuser=1). Training for these certifications will take place with EIH staff.

11 Safety Certification

11.1 Workshop Use

All team personnel that participate in rocket construction must be certified to do so through the University's Engineering Innovation Hub, or EIH, located on the first floor of Fitzpatrick Hall. Different levels of certification provide access to different tools in the workshop. Personnel must be certified on a tool before using said tool. More information on certifications can be found at:

https://sites.google.com/nd.edu/eih-portal/home?authuser=1

Level 1 EIH Certification is be required to work in either the AIAA workshop or the EIH. To obtain this certification, go to the following link:

https://sites.google.com/nd.edu/eih-portal/home?authuser=1

From there, fill out the Workshop Safety Quiz and Hand and Power Tools quiz, then print out and sign the Workshop Safety Rules form. Once these are completed, go to the EIH during appropriate office hours to perform the Safety Walkthrough and obtain a Level 1 EIH certification card. This certification level qualifies a person to work with only hand tools, such as drills and dremels.

Tool-Specific Certification is required to work with any of the more advanced tools, such as the band saw or drill press, in the AIAA workshop or the EIH. To obtain a tool-specific certification, a Level 1 EIH certification must be achieved. This link contains safety quizzes and documents for each tool. Complete the quiz and go to the EIH during appropriate office hours and perform a competency procedure, to show proficiency and knowledge of safe use, in order to receive tool-specific certification. All tools beyond basic hand tools require tool-specific certification.

11.2 Launches

Each member must take the safety quizzes in order to be able to attend a launch. A link to the view-only version is contained at this link. Quiz results will be kept by the Safety Officer as well as copies of all submissions of quizzes. The quizzes will be created by the safety officer prior to the launch and released to the team members prior to any launches. These quizzes are designed to ensure that all team members are prepared to handle hazards that may arise at sub-scale and full scale launches. Team members must score at least 90 percent correct in order to qualify to be present at a launch.

12 Team Agreement

12.1 Workshop Safety Agreement

All NDRT members are required to sign an AIAA Workshop Safety Agreement form before working in the workshop. On top of signing the bottom of the page, every member must sign off on each and every rule on the form as a measure to confirm they have read and understood each rule. It is the duty of the Safety Officer to enforce the completion of this form. On the other hand, it is the duty of all NDRT members to adhere to the rules on the agreement. The rules on the Workshop Safety Agreement form are listed in full below:

- I agree to comply with all updated policies and statements issued by the University of Notre Dame Student Activities Office in regard to public health safety and COVID-19.
- I agree to complete required tool and machine certifications before using the respective tools and machines. I understand that new training and certifications may require recertification for a specific tool during the same school year. I also understand that tool and machine training and certifications from previous years are no longer accepted and I must become recertified for the 2021-2022 season.
- I understand that I must receive a tool and machine certification card upon completion of the certification process in order to use the equipment. I also understand that the certification card must be in my possession at all times when using such equipment.
- I understand that a violation of appropriate tool or machine usage may result in a required recertification or restrictions on workshop tool and machine usage.
- I understand that I am only allowed to enter the workshop if a leader on NDRT is present in the workshop.

- I agree to wear safety glasses or safety goggles in the workshop at all times construction or any assembly is taking place. If I wear prescription glasses, I acknowledge that I must wear safety goggles over my glasses, or acquire appropriate safety side shields.
- I understand that I am unable to handle chemicals or hazardous materials while wearing contact lenses.
- I agree to wear a short sleeve shirt, long pants, and closed-toe shoes when in the workshop. I agree to tie my hair back while actively working if my hair is longer than shoulder-length.
- I understand and will comply with all guidelines noted in the Notre Dame Rocketry Team Safety Handbook, found on the NDRT website.
- I agree to report unsafe working practices to the Safety Reporting Form when spotted in the workshop. I understand the reporting of unsafe conditions in the workplace leads directly to eliminating minor and major injuries.
- I agree to maintain an inclusive environment, promoting academic achievement. I will not under any circumstance harass or discriminate another individual on the basis of race, color, religion, sex, sexual orientation, gender identity or expression, national origin, age, disability, marital status, citizenship, and genetic information.
- I understand that any discrimination or harassment in the AIAA Workshop should be reported non-confidentially to the SpeakUp Reporting website or confidentiality to the University Counseling Center. NDRT leadership are not properly equipped to act on serious instances of harassment and discrimination, but are available for support and guidance.

12.2 Enforcement

All members of the Notre Dame Rocketry Team will be expected to comply with the Safety Manual and all signed team agreements at all times.

For minor infractions, any offending members will be reminded of the rules in place and be expected to change their behavior so that it is compliant with the contents of the Safety Manual. If a member exhibits repetitive behavior in this category, more serious action will be taken against the offending member ranging anywhere from a reduction of personal responsibilities to a ban from the team.

For major infractions, serious action will taken on the first offense. Retraining will be required for any major infraction, occurring in a way that emphasizes compliance with the original offence. All major infractions will be subject to action ranging anywhere from a reduction of personal responsibilities to a ban from the team. Repeated major infractions will at minimum result in a one-year ban from the team.

The Safety Officer is responsible for enforcing the contents of the Safety Manual, and by extension, keeping officers of the team compliant. These officers are responsible for keeping their respective squads compliant. The blame for any lapse in compliance falls on the individual and those in charge of said individual.

The Safety Officer reserves the right to take any action he or she deems necessary to ensure the safety of the team. This ability overrides the authority of the President of the team, any other member of the team, or any written procedure. This measure is to ensure that safety is kept as the top priority of the team.

13 COVID-19 Precautions

13.1 University Precautions

The Notre Dame Rocketry Team agrees with and will comply with the University of Notre Dame's policies regarding COVID-19. A compiled list of updated university policies can be found at https://covid.nd.edu/policies/. All general information on the impact of COVID-19 on The University of Notre Dame can be found at https://covid.nd.edu/. The list of policies and general information urls are included in this handbook for accessibility and accountability; there are zero reasons as to why any NDRT member is not fully educated on the university's COVID-19 policies. Further information regaring the COVID-19 precautions for educational outreach evetns can be found in Section 8.