# 3. Safety

## 3.1. Safety Officer

The Safety Officer for the Purdue SL Team participating in the 2018 competition will be Michael Repella. As Safety Officer, this team member is responsible for the safety and well being of all personnel throughout the course of the competition. This involves ensuring that everybody is constantly aware of the safety plans and emergency procedures, as well as all necessary precautions and personal protective equipment (PPE) required. Once procedures and plans are set by the team, any amendments to them must be authorized by the Safety Officer. Michael will be required to be present at all meetings when fabrication, testing, or assembly is planned to occur. It will also be required of the Safety Officer to have a working knowledge of all facility, equipment, and organizational rules set outside the realm of the team and personnel. This includes adherence to the NAR and TRA high power rocketry safety codes, NFPA 1127, and Federal Aviation Regulations 14 CFR. The Safety Officer will be responsible for the following:

- Creating and maintaining risk analysis matrices to be used throughout the competition
- Creating preflight and postflight checklists to be carried out
- Enforcing all safety plans and procedures set by the team
- Ensuring that all team members are properly trained and supervised to be carrying out their current task
- Ensuring that all team members are wearing appropriate PPE for the task they are conducting
- Ensuring that all team members are following proper operating procedures for using facilities and equipment
- Enforcing all laws and regulations set for the team by authorities and governing bodies
- Attending all build sessions and launches
- Attending all educational opportunities or events where legal minors are expected to be present

## 3.2. NAR/TRA Personnel Procedures

Victor Barlow, the NAR mentor currently working with the team, will be responsible for the handling and loading of the rocket motors used during launches. He will also be responsible for the purchase, safe storage, and transportation of these motors when necessary. Professor Barlow will be on location whenever the rocket is being launched to serve as Range Safety Officer, will work with the Safety Officer to ensure that all team members follow the NAR High Power Rocket Safety Code during all launches, and will prepare motors and ejection charges during full-scale flights as needed, even though other team members have certification for such tasks.

## 3.3. Risk Assessment Matrix

The seriousness of a risk will be evaluated by two criteria: the likelihood of an event to occur and the impact of the event should it happen or fail to be prevented.

**Likelihood Of Event**

| Category | Value | Guage |
|---|---|---|
| **Remote** | 1 | Less than 1% chance of occurrence. |
| **Unlikely** | 2 | Less than 20% chance of occurrence. |
| **Possible** | 3 | Less than 50% chance of occurrence. |
| **Likely** | 4 | Less than 85% chance of occurrence. |
| **Very Likely** | 5 | Greater than 85% chance of occurrence. |

**Impact of Event**

| Category | Value | Guage |
|---|---|---|
| **Negligible** | 1 | Minimal injury, damage to equipment or facility, or environmental effects. Flight continues as normal. |
| **Minor** | 2 | Minor injuries, major reversible damage to equipment or facility, and minor environmental impact. Flight proceeds with caution. |
| **Moderate** | 3 | Moderate injuries, reversible failure, and reversible environmental impact. Flight is put on hold until effects are reversed. |
| **Major** | 4 | Potentially serious injuries, partial failure, and serious reversible environmental effects. Flight is scrubbed or put on hold until system is removed. |
| **Disastrous** | 5 | Potentially life threatening injury, total failure, and serious irreversible environmental damage. Flight is scrubbed or completely destroyed |

By cross examining the likelihood of an event with the impact it would have if it occurred, a new table is created that yields a total risk for our safety matrix.

| Category | Negligible | Minor | Moderate | Major | Disastrous |
|---|---|---|---|---|---|
| **Remote** | 1 | 2 | 3 | 4 | 5 |
| **Unlikely** | 2 | 4 | 6 | 8 | 10 |
| **Possible** | 3 | 6 | 9 | 12 | 15 |
| **Likely** | 4 | 8 | 12 | 16 | 20 |
| **Very Likely** | 5 | 10 | 15 | 20 | 25 |

**Personnel Hazards**

| Hazard | Likelihood (Cause) | Severity (Effect) | Risk | Mitigation |
|---|---|---|---|---|
| Power Tool Injury | 3 (Carelessness) | 4 (Possible Hospitalization) | 12, Medium | Secure loose hair, clothing, and jewelry; wear appropriate PPE |
| Dust Inhalation | 3 (Airborne Particulate Debris) | 3 (Short To Long Term Respiratory Damage) | 9, Medium | Wear appropriate PPE or respirator, work in well ventilated area |
| Eye Irritation | 3 (Airborne Particulate Debris) | 2 (Temporary Eye Irritation) | 6, Low | Wear appropriate PPE or protective eyewear, wash with water |
| Epoxy Contact | 3 (Resin Spill) | 3 (Exposure to Irritant) | 9, Medium | Wear appropriate PPE such as gloves or lab coats, wash with water |
| Workplace Fire | 1 (Ignition Of Flammable Substance) | 5 (Severe Burns, Loss Of Workspace, Irreversible Damage) | 5, Low | Have fire suppression systems nearby, prohibit open flames, and store energetic devices in Type 4 magazines |
| Hearing Damage | 2 (Close Proximity To Loud Noises) | 4 (Long Term Hearing Loss) | 8, Medium | Wear appropriate PPE such as ear muffs when using power tools |
| Burns From Motor Exhaust | 1 (Proximity To Launch Pad) | 3 (Mild To Moderate Burns) | 3, Low | Maintain minimum safe launch distances |
| Injury from Ballistic Trajectory | 3 (Recovery System Failure) | 5 (Severe Injury, Death) | 15, High | Keep all eyes on the rocket and call “heads up” if needed |
| Premature Ignition | 2 (Short Circuit) | 2 (Mild Burns) | 4, Low | Prepare energetic devices only immediately prior to |

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| | | | | flight |
| Launch Pad Fire | 2 (Dry Launch Area) | 3 (Moderate Burns) | 6, Low | Have fire suppression systems nearby and use a protective ground tarp |
| Recovery Related Injury | 2 (Uneven Ground, Poisonous Plants, Fast Moving Water) | 4 (Broken Bones, Infections, Drowning, Etc.) | 8, Medium | Do not attempt to recover from atypically dangerous areas |
| Power Lines | 2 (Rocket Becomes Entangled In Lines) | 5 (Death Via Electrocution) | 10, Medium | Call the power company and stand clear until proper personnel arrive |

**Failure Modes**

| **Hazard** | **Likelihood (Cause)** | **Severity (Effect)** | **Risk** | **Mitigation** |
|---|---|---|---|---|
| Failure To Launch | 2 (Lack of continuity) | 1 (Recycle launch pad) | 2, Minimal | Check for continuity prior to attempted launch |
| CATO | 1 (Motor defect, assembly error) | 5 (Partial or total destruction of vehicle) | 5, Low | Inspect motor prior to assembly and closely follow assembly instructions |
| Instability | 1 (Stability margin of less than 1.00) | 5 (Potentially dangerous flight path and loss of vehicle) | 5, Low | Measure physical center of gravity and compare to calculated center of pressure |
| Motor Expulsion | 1 (Improper retention methods) | 5 (Risk of recovery failure and low apogee) | 5, Low | Use positive retention method to secure motor |
| Premature Ejection | 1 (Altimeter programming, poor venting) | 5 (Zippering) | 5, Low | Check altimeter settings prior to flight and use appropriate vent holes |

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| Loss of Fins | 1 (Poor construction or improper materials used) | 5 (Partial or total destruction of vehicle) | 5, Low | Use appropriate materials and high powered building techniques |
| Ejection Charge Failure | 4 (Not enough power, electrical failure) | 5 (Ballistic trajectory, destruction of vehicle) | 20, High | Ground test charge sizes at least once before flight |
| Altimeter Failure | 3 (Loss of connection or improper programming) | 5 (Ballistic trajectory, destruction of vehicle) | 15, High | Secure all components to their mounts and check settings |
| Payload Failure | 3 (Electrical failure, program error, dead battery) | 4 (Disqualified, objectives not met) | 12, Medium | Test payload prior to flight, check batteries and connections |
| Heat Damaged Recovery System | 2 (Insufficient protection from ejection charge) | 4 (Excessive landing velocity) | 8, Medium | Use appropriate protection methods, such as Kevlar blankets |
| Broken Fastener | 1 (Excessive force) | 5 (Ballistic trajectory) | 5, Low | Use fasteners with a breaking strength safety factor of 2 |
| Destruction Due To Drag Forces | 1 (Poor construction or improper materials used) | 5 (Partial or total destruction of vehicle) | 5, Low | Use appropriate materials and high powered building techniques |
| Airframe Zipper | 2 (Excessive deployment velocity) | 5 (Partial destruction of vehicle) | 10 | Properly time ejection charges and use an appropriately long tether |
| GPS Lock Failure | 2 (Interference or dead battery) | 5 (Loss of vehicle) | 10 | Ensure proper GPS lock and battery charge before flight |
| Excessive Landing Speed | 3 (Parachute damage or entanglement, improper load) | 5 (Partial or total destruction of vehicle) | 15, High | Properly size, pack, and protect parachute |

**Environmental Hazards**

| Hazard | Likelihood (Cause) | Severity (Effect) | Risk | Mitigation |
|---|---|---|---|---|
| Drag | 2 (High air pressure, low temperature and humidity | 4 (Premature drag separation) | 8, Medium | Use appropriate amount of shear pins and vent holes |
| Landscape | 3 (Trees, brush, water, power lines, wildlife) | 5 (Inability to recover rocket) | 15, High | Angle rocket into wind as necessary to reduce drift |
| Humidity | 3 (Climate, poor forecast) | 1 (Rust on metallic components) | 3, Low | Use as little metal as possible, store indoors |
| Winds | 3 (Poor forecast) | 4 (Inability to launch, excessive drift) | 12, Medium | Angle into wind as necessary and abort if wind exceeds 20 mph |
| Temp. | 3 (Poor forecast) | 3 (Heat related injury) | 9, Medium | Ensure team is protected against the sun and stays hydrated |
| Pollution From Exhaust | 5 (Combustion of APCP motors) | 1 (Small amounts of greenhouse gasses emitted) | 5, Low | None |
| Pollution From Vehicle | 2 (Loss of components from vehicle) | 4 (Materials degrade extremely slowly) | 8, Medium | Properly fasten all components |

**Project Hazards**

| Hazard | Likelihood (Cause) | Severity (Effect) | Risk | Mitigation |
|---|---|---|---|---|
| Improper Funding | 3 (Lack of revenue) | 5 (Inability to purchase parts) | 15, High | Create and execute detailed funding plan properly |
| Failure To Receive Parts | 2 (Shipping delays, out of stock orders) | 5 (Cannot construct and fly vehicle) | 10, Medium | Order parts while in stock well in advance of needed date |
| Loss Of Work Area | 1 (Construction, building hazards, loss of lab privilege) | 4 (Temporary inability to construct vehicle) | 4, Low | Follow work area regulations and have secondary |

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| | | | | spaces available |
| Design Flaw | 2 (Program logic error, improper data entry, oversight) | 5 (Inability to complete objectives or construct vehicle) | 10, Medium | Collaborate and share design files for peer evaluation |
| Inactivity | 2 (Members are unable or unwilling to work) | 5 (Loss of team member and labor force, inability to construct vehicle) | 10, Medium | Train all members to work in all areas necessary |
| Injury | 2 (Members are unable to work) | 3 (Temporary loss of team member and labor force) | 6, Low | Keep first aid kit on hand at all times and train all members to follow procedures |
| Damage By Non-Team Members | 1 (Accidental damage of other workspace users) | 4 (Extensive repairs necessary, delay in construction) | 4, Low | Separate all components from other areas of the workspace as necessary |
| Damage During Transit | 2 (Mishandling) | 5 (Inability to fly rocket) | 10, Medium | Protect all components during transit |
| Calendar Conflicts | 3 (Overlap with classes) | 4 (Inability of team members to travel) | 12, medium | Inform professors and concerned persons about overlap ahead of time |

### 3.4. Plan For Compliance With Laws

The project team will follow regulations listed in NFPA 1127 and CFR 27 Part 55 and will store all motors, black powder, and other flammable materials in a Type 4 Magazine. These materials will only be removed immediately prior to flight. All launches will be conducted in an area with an active FAA waiver that extends beyond 5,623 feet, the projected altitude of the launch vehicle. All team members present at these launches will closely follow the NAR High Power Rocket Safety Code and the safety agreement in section 3.6.

### 3.5. Plan To Purchase, Store, Transport, And Use Hazardous Materials

Hazardous materials which will be used on this project include: black powder, ammonium perchlorate composite propellant, pre-made rocket motor igniters, and potentially compressed carbon dioxide. Hazardous materials will be stored off-site, within the Zucrow Labs research facilities adjacent to the Purdue University Airport. Certain members of the team working on project Goddard currently hold a Low Explosives User Permit (LEUP), and these are the members who will handle the acquisition, transportation, and storage of the hazardous

materials involved in this project. All team members will be given a briefing on the plan to properly purchase, store, transport, and use hazardous materials by the safety officer. This safety brief will provide knowledge of and access to Material Safety Data Sheets (MSDS) for all potentially hazardous substances which will be used on the project and will ensure the use of proper PPE when handling hazardous materials.

### 3.6. Team Safety Statement

The following statement will be printed out for all team members to sign:

As a member of Purdue SEDS Rocket Team, I agree to:

1. Adhere to any and all relevant local, state, and federal laws and regulations.
2. Adhere to the NAR High Power Rocket Safety Code.
3. Comply with all instructions given to me by the Safety Officer and by the Range Safety Officer.
4. Wear appropriate personal protective equipment whenever constructing or operating the launch vehicle.
5. Understand the hazards of each material or machine I plan to use or operate.
6. Never misuse the materials or equipment I will work with in this project for any reason.
7. Acknowledge that the Range Safety Officer will inspect the launch vehicle prior to all flights.
8. Acknowledge that the Range Safety Officer reserves the right to approve or deny the flight of the launch vehicle for any relevant reason.
9. Acknowledge that my team will not be allowed to fly if we do not comply with each of the aforementioned safety regulations.

My signature confirms that I have read and understood the aforementioned agreements. I recognize that any violation of these agreements may result in being unable to participate in Project Grissom or the NASA SL program.

Name_____

Signature_____ Date_____