Range Safety Guidelines

Preface

The following Guidelines are not meant to add to, subtract from, or supersede any of the Tripoli Safety Codes. While many of the guidelines presented here may seem obvious to those that have been in the hobby for a while, it is felt that new participants in the hobby can benefit from sharing of these practices that have evolved over the many years of organizing High Power Rocket launches.

Purpose:

This document is for **all** of our members, especially the members that give their time and energies into making sure that our rocket launches are organized and executed in the safest manner possible.

One important aspect of running a safe launch is the assignment of the various ***roles*** that need to be performed by the members of the hosting organization. It is not the purpose of this document to dictate how these roles are assigned to people but to share some examples of how others have organized launches. We will discuss the details of the roles and their respective responsibilities. In addition, these are guidelines, not rules per-say. As such, the hope is that they will augment our innate common sense using time tested practices.

Organization:

While safety is a responsibility of **all** members, there are certain ***roles*** that require different sets of skills and focus. Those roles will be specifically covered in more detail. The guidelines will focus on the following areas:

Range Operation Roles:

- Prefect
- Launch Director
- Range Safety Officer (RSO)
- Flier
- Flight Safety Review
- Launch Control Officer (LCO)
- FAA Authorization Holder
- Range Manager

Note: *While this functional categorizing of roles may make for a nice organization, it is probably true that when assigning these roles to people, most Prefectures may have functional overlap. For example, the Launch Director may be the FAA Certificate of Authorization Holder; there may not be any official Range Managers, etc. It is further expected that* ***it is the responsibility of the Launch Director to assign/delegate people to the roles needed to organize and run the launch.***

Another important consideration is that with all roles, the ***authority can be delegated to others***. That will be a reoccurring theme of this narrative as it allows for flexibility without sacrificing responsibility. But it is essential that there be people who know that they are responsible for these duties; otherwise responsibilities can '*fall between the cracks'* as they say. Forgetting to designate '*who is responsible*' is not a viable option for the long term health of our hobby."

Prefect

Careful observers of the Safety Codes will realize that the role of the Prefect is never specified. This is due to the fact that our Safety Codes are built on top of NFPA codes and therefore has no mention of a Prefect role.

That being said, the Prefect is the official representative of the Tripoli Rocketry Association within the Prefecture. As such, one important role is to make sure that the Safety Codes are followed to ensure that the Association's liability insurance is not put into jeopardy.

The role of the Prefect can vary with the size and complexity of the Prefecture as well as the size and complexity of a particular launch. For example, small Prefectures may have the Prefect doing many of the roles (e.g. FAA COA holder, Launch Director, etc.) while larger Prefectures may have a more a complex organizational structure where many of the organizational and launch roles are performed by others (e.g. President, VP, etc.).

Since the Prefect has responsibility of making sure that the Safety Codes are followed to ensure that the Association's liability insurance is not put into jeopardy, it makes sense to involve the Prefect in the decisions that assign other launch specific roles to other members. In fact, many Prefectures will have the Prefect handle the roles of Launch director as well as RSO; especially for smaller launches.

Launch Director

Unlike the Prefect, the position of Launch Director is called out in the Safety Code. The Launch Director has responsibility for the ***entire*** launch. Many Prefectures have the Prefect assume this role.

The primary role of the LD is to ensure that the requirements defined in the Safety Code for running a Sanctioned Launch (i.e. insured launch) are met:

1. The Launch Director shall be member of Tripoli in good standing.
2. Follows the appropriate Tripoli Safety Code.
3. Legal: All AHJ (e.g. FAA COA) requirements/regulations met and any required permits secured.
4. Landowner permission/constraints.
5. Informing Tripoli HQ on the intended use of the launch site (with dates) for Tripoli Sanctioned Launches.

The LD shall confirm that adequate safety equipment is on site including a portable fire extinguisher, first aid kit, and cellular communications.

The LD shall have contact numbers for local fire departments, police, emergency medical, and electrical power grid authority personnel.

The LD handles the assignment/delegation of subordinate role responsibilities (e.g. RSO). If the Launch Director chooses to not assign/delegate a particular role to someone else, then the LD shall assume those responsibilities onto themselves. Note: if the LD assumes the role of RSO, then the LD must be certified Level 2 or higher.

Most often, the LD and the RSO have a very tight relationship and either one can shut down the range for any reason (e.g. Safety, weather, change in AHJ approval, etc.)

Accident contingency plans:

In the event of a mishap causing significant damage to property or injury or death to persons, the Launch Director is responsible for:

- Attend to injured person(s); Notification of on-site medical resources.
- Call Emergency Services, as required
    - 911 (US)
    - Ambulance
    - Fire Department
    - Police
- Establish security of accident site - restrict site access, ensure site and debris are not disturbed pending accident investigation; Capture accident materials to facilitate forensics.
- Secure all documentation/evidence pertaining to launch operations;
- Notify responsible authorities, as required.
- Document names, addresses, telephone numbers of participants and witnesses
- Notify Tripoli Headquarters as soon as possible.

Accident Investigation:

The primary purpose of investigating accidents is to determine the cause, identify corrective actions and take preventative measures in future rocket launch operations.

The following procedures are suggested:

- Rescue of personnel shall always take precedence over safety investigations
- Secure the location of the accident
- Control access to the mishap scene/area
- A photographic record should be made if possible
- Collection of relevant physical materials for possible forensic analysis
- Get witness accounts, as they often provide important details
- Advise appropriate authorities
- Have technically qualified individual assist in evaluation
- Complete a written report detailing facts of occurrence as soon as possible, to keep details accurate

Range Safety Officer

Unlike the Prefect, the position of Range Safety Officer is called out in the Safety Code. Many Prefectures have the Prefect assume this role.

The role of the Range Safety Officer (RSO) is to minimize the risks to personnel and property involved in the handling, preparation, and launch operations of model and high power rocket launches. This role is can be assigned/delegated by the Launch Director to a very experienced member since the RSO's role encompasses all aspect of running a safe launch.

The flight safety goals are to review the intended flight of all vehicles, and attempt to prevent any incidents that might endanger human life, cause damage to property, or result in embarrassment to Tripoli and rocketry at large. Although the risk of such an incident can never be completely eliminated, the flight should be carefully reviewed to minimize the risks involved while enhancing the probability for attaining a successful launch.

The RSO is responsible for assuring that the Tripoli Safety Codes and RSO procedures are not violated during operations and to ensure that acceptable risks are understood and are within reasonable limits.

The Flight Safety Review is to be performed by a Range Safety Officer (or their delegate) prior to any launch at a sanctioned Tripoli event. This review assesses the quantitative and qualitative aspects of the proposed vehicle flight. If a flight is deemed unsafe, the RSO has authority to stop preparations, hold a launch, or terminate a launch. A flight deemed unsafe must not be launched under any circumstances.

Safety is the responsibility of all Tripoli Rocketry Association members. This idea must be instilled into all flyers and exemplified by Range Safety Officers. A concerted effort by all persons involved will minimize the risks inherent in performing rocket related activities.

It is important to note that the ***Range Safety Officer*** (RSO) has more responsibilities than the personnel that perform the ***Flight Safety Review*** procedure. While some Prefectures already have this separation of role (as well as both NAR and CAR policies), some Prefectures assign the role label of RSO to the ***Flight Safety Review*** which is a misnomer. In literal terms the role of ***Range Safety*** should be responsible the ***entire range*** and not just to reviewing the rockets before the flier heads to the flight line. This document attempts to highlight that the

responsibility of Launch/Range safety is larger in scope than rocket inspection (i.e. Flight Safety Review).

Many Prefectures separate the roles of LD and RSO, by having the LD more involved with organizing the event, while the RSO has more responsibility of organizing and operation of the range. Again, how those roles are staffed is up to the Prefecture and Prefect.

RSO REQUIREMENTS

The RSO must be a current member of Tripoli Rocketry Association in good standings, certified level two or above, experienced in high power rocketry, and knowledgeable about rocket theory, hobby rocket motors and the high power rocketry safety regulations (Tripoli Safety Codes, NFPA 1127, etc.).

The RSO should be familiar with the FAA Certificate of Authorization holder and must be approved to act on that person's behalf in the RSO capacity. Any discrepancies regarding the Range or Flight Operations should be brought to the attention of the FAA COA holder who will have the final decision making authority. The RSO shall be familiar with all the limitations and restrictions of the FAA Certificate of Waiver or Authorization that is effect for the launch including the standard and special provisions of the waiver.

CARDINAL PRINCIPLE: Limit the exposure to hazardous situations to a minimum number of persons for a minimum time, consistent with safe and efficient operations.

The RSO shall carry out the Cardinal Principle through their monitoring and execution of the Range Operations and Flight Operations outlined below. The FAA Certificate of Authorization holder, who has the ultimate authority to stop any or all launches, should address any questions or concerns.

Large Launch Provision

Should the size and scope of a particular launch be greater than the abilities of a single RSO to manage, these duties may be split amongst several persons. For example, if the range has separate launch areas (e.g. Away Cells), then it may make sense to delegate separate personnel to those areas to act in the RSO role (e.g. Away Cell RSO).

Range Operations

The RSO is responsible for determining the status of range operations. Before any launch begins, or in the event of a breech, the following criteria must be assessed. If not met, it is up to the RSO to halt any further launches until a safe condition is returned.

Site

The RSO shall make an examination of the Range area to ensure that adequate barriers, markings, and safety measures exist to prevent unauthorized persons from entering into the range and alert authorized person as to any hazardous situations.

The RSO shall be aware of the largest motor that can be supported by the site area given the table in the High Power Rocketry Safety Code.

The RSO has the authority to open and close the range to any and all personnel

Airspace

Where applicable (i.e. when entering controlled airspace):

1. The RSO must have knowledge that a current Certificate of Authorization issued by the FAA is in force and applies to the sections of the Federal Aviation Regulations that will be bypassed.
2. The RSO should have knowledge of the Special Provisions of the Certificate of Authorization and that they are being adhered to.
3. The RSO must have knowledge that a Notice to Airman has been issued for the date and times of the launch.

Weather

The RSO must have clear and convincing evidence that the following constraints are not violated.

1. Do not launch if ground level winds exceed 20 mph.
2. Do not launch if the planned flight path will carry the vehicle through any clouds
3. Do not launch if any type of lightning is detected within 10 miles of the launch site

GOOD SENSE RULE: Even when constraints are not violated, if any other hazardous weather conditions exist, the RSO may hold at any time based on the instability of the weather.

Launch Systems

The RSO shall familiarize themselves with the types of launch pads available ensuring that they do not approve any flight for which there isn't a sufficient pad.

The RSO shall make a cursory examination of the Range area to ensure that the pads available have been placed appropriately according to the Safety Code.

The RSO should become familiar with the launch control systems and ensure that sufficient safety interlocks are in place to prevent accidental ignitions.

Emergency

The RSO shall confirm that adequate safety equipment is on site including a portable fire extinguisher, first aid kit, and cellular communications.

The RSO shall have available to them contact numbers for local fire departments, police, emergency medical, and power authority personnel.

Flight Operations

The RSO (or their delegate) is to perform the Flight Safety Review (FSR) of all rockets intended for launch. ***The RSO can do this, or they can assign and oversee that operation using Flight Safety Review (FSR) personnel.*** Upon completion of the FSR the RSO will make a flight readiness decision. If the flight is approved this should be indicated by the RSO (or their delegate) initialing the flight card. If minor modifications will bring the rocket to flight ready status the flyer should be informed of the required modifications and asked to return only after taking appropriate corrective actions.

If a situation arises that the RSO is unfamiliar with and/or feels uncomfortable making a judgment call on, it is their obligation the find the ***Launch Director*** on the field to consult with.

Special Projects

Sometimes a ***special project*** will want to fly at a launch. Special Projects are subjective in nature, but often fall into the following categories:

- Extreme altitude that pushes the FAA COA.
- Complex cluster and/or staging
- Flight prep that is complicated and time consuming
- Innovative/experimental recovery mechanisms
- Innovative/experimental flight control mechanisms

Special consideration is not only limited to the actual project, but will also take into consideration the *unique characteristics of the launch site* (e.g. how much space is available, neighboring property considerations, number of spectators, etc.).

In order to get a handle on these kinds of projects, the Launch Director will often, in collaboration with the Range Safety Officer require a special review process be put in place.

The Launch Director should make all perspective participants aware of the special project review process that will be in place for a given launch. Typically this is done in concert with the launch announcement. This way, fliers are aware that their project will need special review that may involve their participation well in advance of the actual launch.

The RSO has the responsibility of reviewing the project, which can involve a team of senior/experienced fliers (often staffed with TAP members) to review and vet those projects. The review process can require the flier to present project documentation in advance of the launch. Sometimes the review team can make recommendations and/or requirements on the project in order to assure the safety of the flight.

Examples of special considerations that may be required/recommended:

- Staging inhibit logic on multi-stage flights.
- "Bonus" Safe Distance
- High current launch controller requirements for clusters.
- Project supplied launch system
- Remote flight preparation area
- Restrict use of "sparky" motors

Obviously this is just a sample of considerations that may arise during the review process but should provide guidelines for not only those involved with the Special Project, but also those involved with the review process.

Flier Responsibilities

Each flier has the responsibility that their actions and their flights adhere to the Tripoli Safety Code.

All fliers should realize that Tripoli insurance will cover them as long as ***they*** follow Tripoli Safety Codes. If an accident happens and the flier is found to have violated the Safety Code (e.g. Safe Launch Distances), it is the ***flier*** that is exposed without having Tripoli insurance coverage. Therefore it is very important that all fliers are familiar with the Safety Code and if they see an issue to bring it to the attention of the officials running the launch.

Stability:

Make sure that the rocket is of a stable design.

1. If it has flown in the current configuration with a similar motor and was stable it will likely remain stable.
2. If the design employs canards or unusually small fins be extra careful with the stability verification.
3. Providing the CP (center of pressure) calculation by Barrowman or other suitable calculation method should be compared to the CG (center of gravity) as found on the flight ready vehicle. If stability calculations indicate a CG, its accuracy should always be verified.
4. If no calculations are available or it is an untested design, use past experience or call upon the expertise of others at the launch in coming to consensus about stability. If the stability is uncertain on an unusual design, ask for proof of stability. Any marginally stable rockets should be treated with extra concern and additional launch safety precautions should be taken.

Propulsion:

Make sure that the total installed power does not exceed the limitations of the field or FAA COA.

Make sure, as best possible, that the vehicle is capable of withstanding the forward thrust that will be produced by the motor.

Make sure that the initial thrust of the motor chosen will provide at least a 3:1 thrust-to-weight ratio (higher is better). This can be done by one of three ways:

1. The flier can provide documentation that shows the initial thrust produced by the motor. This can then be compared to the GLOW (Gross Lift-Off Weight) of the rocket as presented.

2. The peak thrust of the motor can be assumed to be at least equal to the average thrust as indicated in the motor designation. In this case, the average Newtons produced by the motor should be converted to pounds and compared to the GLOW of the rocket as presented.

Recovery:

Make sure that the parachutes selected for recovery are rated for the weight of the vehicle and the expected conditions at deployment. Confirm that the parachutes intended for the final descent phase to the ground will not allow a decent rate that would represent a safety hazard.

Make sure that there is an adequate system in place to contain all of the separable parts of the rocket and parachutes at the forces anticipated during deployment. This includes adequate length of retaining cord, strength of retaining cord, and hard points for recovery system attachment.

Ensure that adequate protection is in place to prevent the hot ejection gases from causing burn damage to retaining cords, parachutes, and other vital components.

If motor delay is used to actuate recovery system, make sure that the delay length was properly selected for the motor/rocket system.

If electronics are being used to activate the recovery system, make sure that an externally controllable method is being used to turn electronics on and that a known good battery is in use.

Launch Safety Guidelines:

While there may be Range Managers assigned to assist the flier getting their rocket ready to launch, it is the ***fliers responsibility*** to make sure that the rocket's launch is safe. These guidelines should be followed by all filers as well as by Range Managers (if assigned).

- **Never** point rocket towards flight line while loading

- Launch rocket **away from flight line**. Take into account weather cocking so that rocket does not head towards flight line when launched.

- Always arm electronics ***before*** installing igniter(s) in motors.
- Use a stable platform (e.g. ladder), if needed, to reach electronics.
- Check that igniter wires are not "hot" (touch together, checking for ***sparks***) before attaching to igniter(s).
- Make sure that non-essential personnel are backed up before you hook-up igniter and perform a continuity check (if relay box is capable).
- In event rocket needs to be taken off the launcher for any reason, remove ignitor and disarm any onboard electronics ***before*** moving the rocket.
- Make sure all combustible materials have been removed from the ground surrounding the launch pad. When a sparky motor is to be flown, extra precautions (including the clearing of the ground for a much greater diameter around the pad) must be taken. In the event a fire cannot be prevented, the flyer should not launch this rocket/motor combination until such time as it is safe to do so.
- While in the flight range, it I the flier's responsibility to monitor communications with the range head, especially for safety related announcements (e.g. rocket coming in out on the range!). Fliers will ***follow*** safety instructions (e.g. heads up!) that come from the range head.

Safe recovery Guidelines:

- If a rocket lands in a location whose retrieval would present a safety issue (e.g. power line, building roof, etc.), the flier should inform the Launch Director and be given guidance on the appropriate assistance required before attempting retrieval.
- The flier is responsible for knowing the limits of the launch area, and if the rocket lands outside of the launch area, the flier should inform the Launch Director in order to be given guidance on what should be done (e.g. contact adjacent landowner) before attempting retrieval.

Flight Safety Review

Before a flier can proceeded to the pads to launch their rocket, the rocket ***and the flier*** must pass a preliminary ***Flight Safety Review*** station. The role of inspection is performed by the ***Flight Safety Officer – FSO*** prior to allowing the launch of the rocket. This process has had many names: Safety Check-in, Rocket Inspection, etc. Some Prefectures have used the misnomer of Range Safety Officer, but as we have discussed, Range Safety is much more encompassing than the more limited Flight Safety Review. The primary purpose of Flight Safety Review process is to make sure that the ***flier*** has followed the safety guidelines dealing with:

- Stability
- Construction
- Propulsion
- Recovery

Obviously, this review/inspection has a subjective component. Experienced fliers known to the Inspector may need minimal inspection. Novice fliers, or fliers that are attempting to acquire new skills (e.g. Clustering, Staging, Electronic recovery, etc.), should warrant closer inspection/review.

For complex projects, this review may be done at a remote location (i.e. Away Cell) and usually involves a very senior FSO.

Requirements:

- *The FSO should be at a certification level (or above) of the flier/rocket that they are reviewing. If a flier presents a rocket that is higher than the certification level of the FSO, then that FSO, need to illicit the help of a FSO with the appropriate certification level*

- *In addition, if the FSO is unfamiliar with an aspect (e.g. cluster, staging, electronics, etc.) of the rocket they is being presented for review, they should illicit the help of another FSO that has the appropriate skills.* ***Additionally, the FSOs have the responsibility of requesting that the RSO review any unusual flights before the flier can proceed.***

The FSOs should check that the rocket is compatible with the flier's certification level.

- Is the flier a member of an organization that provides insurance? Both NAR and Tripoli have member insurance. Minor children of Tripoli members are also insured

even if they are not members themselves. NAR does not have that same membership feature; the minor must be a NAR member.

- Is the flier 18 or more years old? If not, the flier cannot use high power motors, reloadable motors of any power class, or any motors that are classified as High Power (even certain F, and G motors!). Tripoli has a Mentoring Program (TMP) which allows Junior Members to participate in High Power, if accompanied by a certified Senior Member. Those Junior Members have a special membership card. Tripoli does not recognize NAR's Junior Certifications; minors must be TMP participants to participate in High Power.

- Is the flier certified to the impulse level being flown? The flier is often given an event badge at registration with the fliers certification level indicated. If not, ask to see their membership card to verify the certification level. Make sure that the membership card is current. Individuals flying rockets meeting the following criteria will ***require high power certification***:

    - Rockets powered by rocket motors not classified as model rocket motors per NFPA 1122, e.g.:
        - Average thrust in excess of 80.0 Newtons
        - Total impulse of 160.01 Newton-seconds or more
        - Contains in excess of 2.2 ounces (62.5 grams) of propellant
        - Hybrids (regardless of impulse)
        - Sparky Motors (regardless of impulse). **Note that some "F" and "G" motors fall into this category.**
    - Is propelled by a combination of *model rocket motors* having an installed total impulse of more than 320 N-Sec or
    - Is propelled by a combination of *model rocket motors* having more than a total of 125 g (4.4 oz) of propellant weight; or
    - Rockets that weigh more than 53 ounces (1500 grams).

- Is the motor certified? Certification lists are available on the Internet or in publications from the certifying organizations. Verify the motor certification status by consulting the certification lists. If the motor is not certified, then the motor can only be flown at a Tripoli Research Launch by a Tripoli member with a L2 or higher certification.
- Verify that an applicable flight card exists, is filled out in a legible manner, and indicates all of the pertinent flight data including but not limited to flyer name and

member number, physical vehicle parameters, motor configuration, and recovery systems.

- Ask the flyer if they have flown this particular rocket and motor combination. If they have, ask for the results of that flight. If not, ask if they have flown a similar rocket/motor combination and the outcome. Use the results of this line of questioning to determine into how much detail the remainder of the FSR will go. IMPORTANT: By no means does a response of "I've flown it just like this perfectly before" exempt the flyer from the remainder of the FSR.
- Special attention should be given to flights that are indicated as Heads-up or Certification. In the case of a certification attempt, verify the presence of associated certification authority.

Rocket Inspection:

- Is the motor appropriate for the rocket?
    - Does it provide enough initial thrust to get the rocket going fast enough to be stable as it leaves the launcher? A good Rule of Thumb is 3:1 thrust to weight ratio. Take into account ground wind speed (i.e. needs higher ratio if windy).
    - Is the motor too large for the launch equipment (e.g. high thrust motor on ¼" rod) or the FAA CAO?

- Ask the flier if they are using the motor ejection charge. If they are, verify that they installed the black powder. Some motors rely on a tape disk to retain the powder in its cavity. It is suggested that the flier backup the paper disk with masking tape around the edge to prevent it from coming free.

- Examine all "slip-fits", e.g. nosecone or payload shoulder, which are intended to separate in flight. Turn the rocket nose down. It is unacceptable if the nosecone (or payload) can separate under their own weight. Check that the nosecone, if used as part of a payload section, is firmly installed (e.g. screws). The object is to prevent loss of the nosecone and the payload contents in flight.

- Examine the launch lugs or rail buttons/guides. Are they firmly attached to the rocket without evidence of cracking in the joints? Are the guides adequately sized for the rocket? If using lugs, check the lugs for paint buildup or burrs inside the lug(s). Paint or burrs may cause binding on the launch rod.

- Examine the fins. Are the fins mounted parallel to the roll axis of the rocket? Attempt to wiggle the fins at their tips. There should be no movement and minimal deflection. If the fins deflect is the fin material appropriate for the rocket? Laminated or built-up fins should be checked for delaminations. Examine the fin roots for cracks; minor "hairline" cracks may be acceptable if the fins are not loose or if the fins are mounted using "through the wall" construction. Check the fins for warpage; there should be little, if any, warpage.

- Examine the motor installation. Verify, if possible, that the motor is what the flight card indicates. If in doubt, ask that the motor be removed from the rocket. Pull on the motor to make sure it is firmly restrained in the rocket. If the motor is friction fitted then it should not move when strongly pulled. A positive means of motor retention, e.g. motor clip, bolted washers, is preferred. Verify that the motor cannot deflect the retention device and then eject. A wrap of tape around motor clip(s) to restrain them against the motor is suggested.

- Can the motor "fly through" the rocket? Push on the nozzle end of the motor. The motor should not move forward in its mount nor should the mount move within the rocket. Try to determine the type and quantity of adhesive used in construction. Any evidence of "hot melt" adhesives should make the rocket suspect. Motor mounts should typically be mounted with epoxy adhesives with a sufficient quantity to form fillets at the centering ring to body tube joints.

- Is the rocket stable? Find the CG (center of gravity) of the flight ready rocket (motors installed, recovery system packed) by finding the rocket balance point. Where is the CG relative to the leading edge of the fins? On a single staged rocket with only a rear set of fins the CG should typically be forward of the forward root edge of the fins. Canards, wings, forward swept fins, and strakes will require the CG to be further forward. Multi-staged rockets must be evaluated for each stage. Ask the flier to show the CP (center of pressure) location on the rocket (and less each stage for a staged rocket). Request to see the calculations if in doubt. The CG must be a least one body tube diameter forward of the CP in each flight phase. Hybrid powered rockets must be examined carefully for stability. Unlike most solid fueled rockets the CG of a hybrid rocket may actually move aft during flight. The rearward CG shift may destabilize the rocket. To be conservative, determine the CG of a hybrid rocket with the solid fuel component in place but without the oxidizer loaded.

- If the rocket appears neglected or of marginal construction or the builder does not display good knowledge of rocket practices ask to inspect the recovery system. Pull on the shock cord several times. The shock cord must not be cracked, cut, frayed, or burnt. Discoloration from ejection operation is typically not a problem. Make sure that the shock cord is securely mounted in the rocket. Make sure any knots in the recovery system will not loosen or slip. Recovery system hardware, including screw eyes and swivels, needs to be strong enough for recovery loads, mounted to solid structure as necessary, and all fasteners are tight. Inspect “quick links” to verify that they are not likely to pull apart under recover loads. Is parachute protection from the ejection charge adequate and nonflammable? Verify that the parachute is undamaged including no loose suspension lines and no tears or burns which may spread during recovery. Is non-flammable, bio-degradable (no fiberglass) wadding being used?

- Does the booster section have a vent hole? Typically, a 1/8 to 3/16 inch hole is drilled in the booster section just behind the nosecone or payload shoulder area. This hole is intended to vent the rocket internal pressure to the outside. It is recommended practice on high performance (high altitude) rockets because it prevents the internal pressure from prematurely separating the nosecone or payload section.

The following items are relevant for Electronic Recovery:

- Ask if electronics are used in the rocket (e.g. for parachute deployment, staging). If the flier is inexperienced with Electronics, examine the electronics for items that may dislodge (e.g. ejection canister matches) or break during flight. Are heavy items, e.g. batteries, adequately supported to prevent coming loose from "g" loads. How did the flier verify the functionality of his electronics? When was the last time the electronics were checked? Are the batteries fresh? How has the flier verified its operation?

- Does the flier expose himself to accidental discharge during arming/disarming the electronics? Do the electronics indicate whether or not they are armed?

- Does the flier have a checklist or reminder to arm the system prior to flight and disarm the system upon landing?

- Make sure that the rocket does not use mercury switches or roller switches to initiate motor ignition.

The following items are relevant for cluster rockets:

- Make sure that the flier has not pre-inserted any of the HPR motor igniters. That needs to be done at the launch pad.

- Look for any open holes between the motor mounting tubes. Are the holes sealed to prevent ejection charge gases from venting out?

- If black powder and composite motors are mixed in a cluster are the composite motors the first to be ignited? Composite motors are harder to ignite than black powder.

- If the flier expects to ignite a mixed combination of APCP motors, recognize that the larger motors take longer to come up to pressure. Does the rocket have sufficient power to safely fly with only the smaller motors operating?

- Are the motors configured in such a way as to behave dangerously if one or more do not light (i.e. off-axis thrust)? If, for example, the cluster consists of two motors, inform the flier that the rocket needs to be on the pad so that the motors are aligned parallel to the flight line so that if only one motor lights, the rocket will not arc towards the flight line.

- Ask the flier if the motor igniters for the cluster wired will be wired in parallel (not in series)? Check for shorts which may prevent igniter function.

- Are the igniters "matched"? Igniters having different current requirements may not light at the same time. Igniters that light quickly may ignite their rocket motors prior to ignition of other motors.

- Does the launcher ignition system have enough power to ignite all of the igniters that need to be lit on the pad?

- If some of the motors are to be air started, make sure that the primary motor(s) are sufficient to safely power the rocket off the launch pad. Make sure that the electronics to initiate the air-start motors will only be armed once the rocket is on launch position.. Make sure that the same electronics can ***and will*** be disarmed if the rocket needs to be removed or lowered from the launch pad.

The following items are relevant for multi-stage rockets:

- Make sure that none of the HPR motor ignitors are installed until the rocket is at the launch pad.

- Make sure that the rocket will be stable during its entire flight profile: Ask the flier to show the CP of the fully assembled rocket (i.e. all stages assembled). Ask the flier to show the CP of the rocket after each staging event.

- Make sure the booster motor(s) have sufficient power to get the rocket stable.

- Make sure that the electronics to control the staging motor ignition will only be armed once the rocket is on launch position. Make sure that the same electronics can ***and will*** be disarmed if the rocket needs to be removed or lower off the launch pad.

- Ask the flier about the delay(s) that are used between staging events. Make sure that the delay is not so long as to happen if the rocket has arced over into an unsafe orientation. Ask to see flight simulation if there is a concern.

- Ask the flier if the stages are expected to "drag separate", or is there a separation charge to initiate separation prior to sustainer ignition. Depending on the location of the staging electronics (sustainer vs. inter-stage coupler), premature separation could prevent sustainer motor ignition.

- If the sustainer motor is used to initiate stage separation, check to make sure that the blast from the sustainer motor will not damage the booster's ability to safety recover.

- The upper stage(s) of HPR rockets ***must*** be using electronic recovery, and not rely on motor ejection.

- If required, make sure that the staging electronics have a feature to inhibit staging events if the rockets flight profile does not follow expected behavior.

Knowledge:

FSOs should have knowledge of the following documents:

- Tripoli Safety Codes

- FSO personnel shall be aware of the largest motor that can be supported by the site area given the table in the High Power Rocketry Safety Code

Experience:

FSOs should have applicable flying experience, such as:

- Understand how to calculate center of pressure (CP) and center of gravity (CG) to determine whether a given rocket is stable in flight;
- Can determine that the recovery system being inspected is appropriate for the size and type of rocket being flown;
- Have used computer software programs to determine a rockets expected altitude, location of CP and CG;
- Be able to recognize the best rocket motor for optimum performance and thrust computations.
- Some level of experience using Electronic Recovery.
- Be certified at least to the level of the rocket they are inspecting.
- *If presented with a situation which they have no personal experience, the FSO should ask other experienced FSO or the RSO for assistance.*

Launch Control

Actual flights operations are coordinated by the Launch Control Officer (LCO). Usually the LCO works with a team of personnel that handle various operational duties.

- Assigning fliers that have passed FSR, to specific banks of pads.
- Assisting those fliers by assigning Range Managers to supervise their activities at the pads.
- For large launches, coordination of the range to allow for rockets to be simultaneously launched and loaded from different banks.
- Management of flight cards to coordinate each with a particular launch pad.
- Operation of the Launch Control System
- Maintain control of access to the range
    - Make sure that spectators are not allowed on the range
    - Follow all Safety Rules governing who has access to the range.

- Be responsible for communicating to the other participants and spectators the launch status of a particular rocket. This is usually done using some kind of Public Address (PA) and/or wireless system. This includes:
    - Sharing of flight card information for each flight.
    - Countdown announcement.
    - Maintaining situational awareness of each flight so that any safety issues can be quickly communicated to all participants and spectators.
- It is the responsibility of the LCO to set the tone of the flight operations, to make sure that launches occur in a timely manner, and making sure that all operations are conducted with utmost safety. Given that responsibility, it is inappropriate for children to be involved with launch operations in any manner.
- Make sure that before each rocket is launched that the prior rockets no longer pose a safety hazard.
- Make sure that the sky is clear of aircraft and that the cloud cover would not interfere with the tracking of the rocket about to be launched.

Range Managers

If Range Managers are assigned, then these are some guidelines that are appropriate:

- Be familiar with both launcher and launch control operation
- Have appropriate tools available
- Have fire suppression capability available
- Make sure that the area around each pad has been cleared of combustible material per the Safety Code requirements.
- Make sure that all fliers follow Launch Safety Guidelines.
- Make sure all rockets are pointed away from the flight line while loading.

FAA COA Holder

In order to comply with FAA regulations, all Class 2 and Class 3 (as defined in Federal Aviation Administration Regulations, Part 101 (Section 307,72 Statute 749, Title 49 United States Code, Section 1348, "Airspace Control and Facilities," Federal Aviation Act of 1958) must have been issued an FAA Certificate of Authorization (COA). Historically this has been called a "Waiver" since it does waive some of the FAA's FAR rules. Recently the FAA has been using the term Certificate of Authorization to refer to this document.

This Certificate of Authorization will have specific constraints on what kinds of rocketry activities are authorized (e.g. maximum altitude, hours of operation etc.). The Certificate of Authorization has one or more names listed as being the responsible party(ies). It is the responsibility of that person(s) to make sure that all flight operations comply with the Certificate of Authorization.

Normal duties prior to and during the launch include: File NOTAM, Contact ATC at the beginning and end of flight operation. Have the ability to communicate to/from local ATC during launch operations.

As such, in addition to the LD, and the RSO, the Certificate of Authorization holder has the ***legal*** authority to cease ranger operations if they determine that the operations would be in violation of the Certificate of Authorization.

Sometimes the LD is the person that holds the Certificate of Authorization, other times it is another member of the Prefecture. In any case, the Certificate of Authorization holder has ***legal*** responsibilities to make sure that the range is operated according to the Certificate of Authorization.

The waiver holder shall have a copy of the Certificate of Authorization on hand and shall present it for inspection (when requested) to any authorized FAA Inspector or any state or municipal official charge with the duty of enforcing local laws or regulation.

NOTE: This document makes repeated reference to the FAA as the Authority Having Jurisdiction (AHJ) of the airspace we use. Obviously, Tripoli, as an international association, engages in launches where the FAA is NOT the legal AHJ. It would be difficult to make reference to all of the airspace AHJ's as well as awkward to do that repeatedly, so members should simply substitute their appropriate airspace AHJ for their launch site whenever they find a reference to the FAA in this document.

Summary

It is the responsibility of all participants and organizers of a launch to limit the exposure to hazardous situations to a minimum number of persons for a minimum time, consistent with safe and efficient operations.

In the pursuit of this ideal, we must adhere to the safety code and do our best to make sure that others around us do the same. In doing so, we will make our hobby as safe as possible for those involved and for spectators, thus ensuring the continued growth and enjoyment for all involved.

Never over-rule safety for the sake of friends, fun, or convenience.

Acknowledgements: This document contains practices that were gathered from multiple sources:

- Derek Deville (Tripoli Association of Rocketry)
- The section dealing with Safety Check-in Officer Guidelines is based on the National Association of Rocketry's Trained Safety Officer Guidelines:

  http://www.nar.org/pdf/TSO.pdf"