FAR-OUT: Friends of Amateur Rocketry - Oxidizers Uninhibited Tournament
2024-25 Official Competition Rules and Requirements

Rev. 2024-10-02

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Changelog

Rule changes are announced here. If teams find something that needs clarity or would like help understanding a section contact faroutcompetition@gmail.com so that we can share that guidance through this document. This is a living document and will change from time to time.

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<tr><td>Date Released</td><td>Rule Changes</td></tr>
<tr><td>August 6 2024</td><td>Initial release</td></tr>
<tr><td>October 2 2024</td><td>
- Extensive update 5.4 GSE Guidelines
    - Valve, pressure vessel, abort requirements
- Updated 5.7.6-5.7.10 Testing requirements
- Added deliverables
    - P&ID requirements
    - Added avionics schematics requirements
    - Video of integration/dry run
    - Recovery requirements
- Updated 1.5 Shipping Information
- Updated 1.6 Oxidizer Ordering
- Updated 5.5.5 Wiring and Switch requirements
- Updated 5.6.1 Recovery calculator
- Updated 6.4.1 Flag Hazard Communication
- Updated 6.10 commit criteria
- Updated 7.12 list of awards
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FAR-OUT: Friends of Amateur Rocketry - Oxidizers Uninhibited Tournament 2024-25 Competition Rules and Requirements

The main goal of the Friends of Amateur Rocketry - Oxidizers Uninhibited Tournament (FAR-OUT) competition is to provide student teams the opportunity to build and fly research hybrid or liquid engine or commercial-off-the-shelf (COTS) hybrid engine rockets capable of withstanding launch and recovery loads, as well as carry a payload as close to a specific simulated target altitude as possible, as well as provide a platform to showcase design and manufacturing work through poster and podium sessions.

PART 0: PURPOSE AND SCOPE

0.1 - Mission Statement

This competition is intended to provide hybrid and liquid collegiate rocketry teams with an appropriate and bespoke venue for showcasing their rocket designs in a manner that is best-suited for these types of engines. The competition, taking place from **May 28th through June 2nd, 2025**, is specifically designed around supporting such teams, from the requirements for design and testing to making appropriate planning for launch operations at the site that are tailored for each team's specific needs. The goal is to get as many rockets in the air as safely as possible, and provide every team with an environment that they feel welcome and supported in. Aside from launches, this competition also has a conference component centered around a poster session and podium sessions so that teams can learn from each other and showcase their design work to attendees.

This is also an event centered as much around competition as it is around camaraderie, teamwork, and mentorship. Hybrids and liquids are complex and collaborative efforts, and there are many ways to design filling systems and motors to achieve different goals. By bringing a diverse set of teams under the umbrella of one event it allows the invaluable opportunity for students from around the world to observe each other's designs, support each other's flights, and inspire each other to dream bigger and work harder to create more innovative and creative rocket system designs.

0.2 - Document Purpose

This document outlines the rules and scoring for this competition, up to and including the launch, as well as providing information regarding competition logistics. These rules and logistics could be subject to change but ideally as little change to this document will be made as possible. Any modifications to this document will be shared publicly with teams on Discord, along with a changelog kept in the document of any significant updates. This is a living document and if your team wishes to seek clarification we will add to this to provide guidance. If a team thinks of something that they want allowed we encourage them to reach out to modify these rules in an appropriate manner to allow for more innovative designs. If you see a contradiction assume the more restrictive rule is accurate and let us know so that the incorrect text is removed.

0.3 - Competition Categories

This competition has three different ranges of target apogees: 3,000’-15,000’ (Group A), 20,000’-50,000’ (Group B), and 50,000’ - 250,000’ (Group C) in order to account for different teams’ goals. Commercial-off-the-Shelf (COTS) hybrid engines, research hybrid engines, and research liquid engines are combined together in these Groups and are assessed via a scoring system that accounts for the challenges of each motor type while encouraging the research of high-efficiency engines. Across all targets there is a payload challenge component where each rocket is required to carry a payload of at least 1 kg. Teams wishing to fly above 120,000 feet can with extra paperwork.

These groups were split based on the relative technical complexity of building rockets to reach those altitudes. The physical and structural requirements for a rocket aiming to fly as close to a target apogee of 5,000’ differs greatly from a rocket aiming for 35,000’, which differs even more from a rocket at the upper limit of what student teams could be capable of aiming for 55,000’. This provides teams with a dynamic ladder to improve their abilities over the years without sealing them under an arbitrary ceiling. Furthermore, limiting Category A to 15,000 ft allows another launch day outside the high altitude windows of the weekend.

0.4 - Scoring Centered Around Contract Apogee

At the first Progress Update each team delivers a target altitude in their category range. This is the team’s quoted altitude that a significant portion of the final general score will be based off of which will be henceforth referred to as the team’s “contract apogee”. Instead of specifying a specific apogee that all rockets should be designed to, FAR-OUT choses to instead judge the successfulness of launch based on the ability to deliver the payload to the quoted contract altitude and how accurate your simulations predict your rocket’s trajectory the with weather forecast on the day. We believe that this allows teams the most freedom to design a rocket to a target altitude that they would desire to reach, rather than assigning target apogees to everyone. This score component measures a team's ability to build a vehicle that can deliver on initial design requirements. Consequently failing to meet this requirement is penalized and adjusting this “contract” altitude results in penalties. This allows teams to change altitude if needed but also judges those teams on whether they can follow through from design to fabrication, testing and flight. The rocket must be able to reach an altitude greater than 2500’ to be allowed to launch.

PART 1: SITE LOGISTICS

1.1 - Team Communication

Primary individual team communication will be via email, with cross-team communication being on a Discord channel where access will be provided upon acceptance to the competition. Important documents and the Entry Form will be made available through the FAR-OUT competition website (www.faroutlaunch.org). Forms for Progress Updates will be emailed to team leads along with being announced on the Discord.

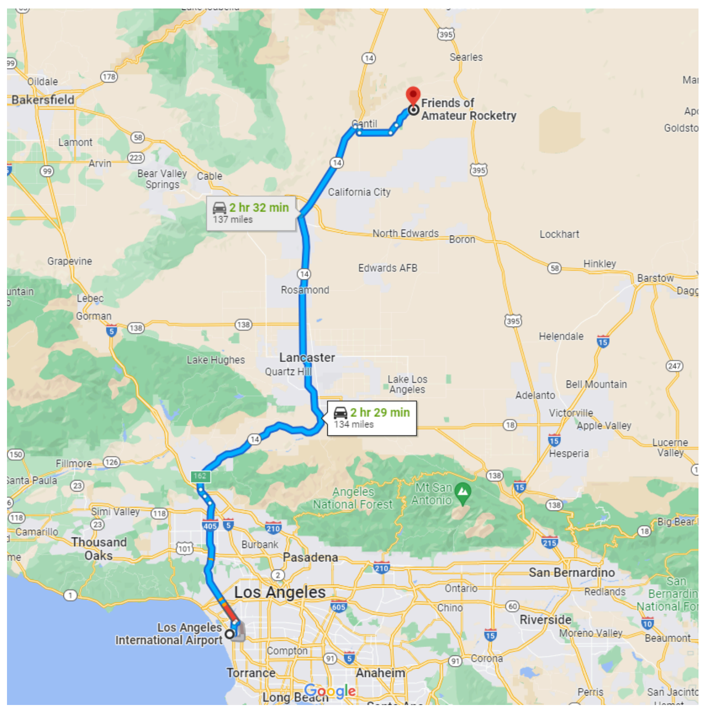
All important competition announcements will also be shared via social media channels listed below:
IG: @faroutcompetition
Facebook: @faroutcompetition
Websites: www.faroutlaunch.org , www.friendsofamateurrocketry.org

1.2 - Entry Fees

Teams will pay a base entrance fee of $500 USD, plus $60 USD per student attending the competition. The base entrance fee should be paid by December 1st after acceptance and the individual rocketeer fees are due at the third progress report. If new teammates are added after the final progress report, there will be a portal where extra fees per-added teammate can be added separately. Fee explanations can be found in the Documents section here: https://faroutlaunch.org/documents-links . Teams withdrawing before April 15th should review withdrawal policy in section 4.9.

1.3 - Launch Site

This competition is held in conjunction with the Friends of Amateur Rocketry, Inc., located in the Mojave Desert in California, USA. FAR's mission is to educate the public in science, technology, engineering, and mathematics (STEM) through the use of amateur rocketry; and to foster rocket technology by supporting individuals, hobbyists, student groups, businesses, and other like-minded nonprofit entities.



1.3.1 - Launch Site Location

The launch site will be at the FAR launch site outside Randsburg, California, specifically at (35.34723084964506 N, 117.81006429132387 W).

The first map shows the location of FAR with respect to the Los Angeles International Airport.

1.3.2 - Site Makeup

FAR consists of several main structures: viewing bunkers at least 250 feet from the launch pads, a blockhouse 50 feet from the test stand, several test stands, and a Quonset hut for gathering, as well as toilets and other facilities.

Viewing bunkers supply both protection and distance for the person witnessing a static firing or launch. The viewing bunker supplies protection in front, overhead, and behind. Frontal protection includes a concrete wall, buttress, and earth berm. This protection is in case a rocket or static stand explodes sending out shrapnel or a fireball. Overhead protection is made up of reinforced concrete and steel. This protects against falling debris, flaming parts raining down, and a ballistic rocket coming straight down. Protection from behind consists of a reinforced concrete block wall. This protects against partially fueled rockets impacting the ground behind the person in the viewing bunker. It protects against shrapnel and fireball resulting from the impact.

The blockhouse is within 50 feet of the static test stand or rocket launcher to allow adequate viewing and control of the static test or launch. To supply frontal and rear protection, the blockhouse is buried placing the occupant with eye-level at ground-level. This also avoids blocking the view from the viewing bunkers. Overhead protection is supplied by reinforced concrete. Viewing slots are supplied to give the occupants of the blockhouse 360-degree viewing of the whole facility. Polycarbonate window panes can be placed in the viewing slots to give added protection from shrapnel and blast effects.

Information about available test stands and launchers are available on the FAR website.

1.3.3 - Launch Safety at FAR

Operations at FAR are managed by California State Fire Marshal licensed pyrotechnic operators. These operators and other FAR volunteers will be tasked with assisting with safety and directing at the launch site, but all attendees should also be aware of their own safety and make sure that you and people around you are safe. The FAR staff will ensure that:

All personnel are:

- Safe during leak and functional testing.
- Safe during propellant handling, compounding, and loading.
- Safe during igniter insertion.
- Safe during pressurization.
- Inside of a viewing bunker or blockhouse before an static firing or launch commences, or downrange.

For a launch:

- The launch rail is strong enough, stable, and will not move or fall over.
- The launch rail is long enough to ensure the rocket has stable flight.
- The launch rail is suitably positioned to ensure that the rocket is unlikely to land in unsafe areas.
- The visibility is good enough to see approaching aircraft.
- The wind is not above safe limits.
- The launch is not into the clouds.
- There are no visible aircraft in the launch area.
- There are no vehicles approaching on the road.
- The surrounding area is free of flammable materials.
- Personnel are safe during recovery system loading.
- Personnel are safe arming recovery systems.

For a static firing:

- That the static stand is strong enough, stable and will not move or fall over.
- There are no vehicles approaching on the road.

- The surrounding area is free of flammable materials.

The above information is taken out from this section of the FAR site:
https://friendsofamateurrocketry.org/how-does-far-keep-you-safe/
More information, including FAR-provided Hazard Matrices per-hazard is provided in this PowerPoint by FAR: https://2aff63.a2cdn1.secureserver.net/wp-content/uploads/2018/03/Rocket-Safety-Hazards.pdf

1.3.4 - Desert Safety

Teams should also look out for their own safety around rockets and in the desert. The FAR site has desert life which includes: ants, bugs, snakes, rodents, spiders, scorpions, desert tortoise, and more. It is recommended that a FAR visitor not disturb any of the desert wildlife and look first before putting hands or feet in holes.Sleeping directly on the ground is not recommended; campers should sleep on a cot or inside a tent. When eating food it is important that all unwanted or waste food be properly put in the trash and removed from the site. Food left on the ground attracts unwanted critters. During the summer it may be necessary to have a tent or fly netting for sleeping, and bug repellant to fend off flying bugs.

FAR is also located in a corner with BLM land on two sides. This BLM land is considered a type 1 critical habitat for the desert tortoise. It is illegal to disturb a desert tortoise. To help preserve the site and the surrounding natural habitats, site users are encouraged to control their paper and wrappers, pick up all of their trash as the day progresses, and take their trash home with them.

More desert information and rules are found here: https://friendsofamateurrocketry.org/the-desert/

1.3.5 - Onsite Camping

The FAR site provides an excellent place to camp. This site is cleared of brush and is relatively flat, which allows you to pitch tents and have campfires. The site also has potable water for dishwashing. Since the site is located in a valley shielded by two mountains blocking nearby city lights, the night is unusually clear with little light pollution promoting stargazing. Rules on camping at FAR can be found here:
https://friendsofamateurrocketry.org/camping

1.3.6 - Forecasted Weather, Wind, and Clouds

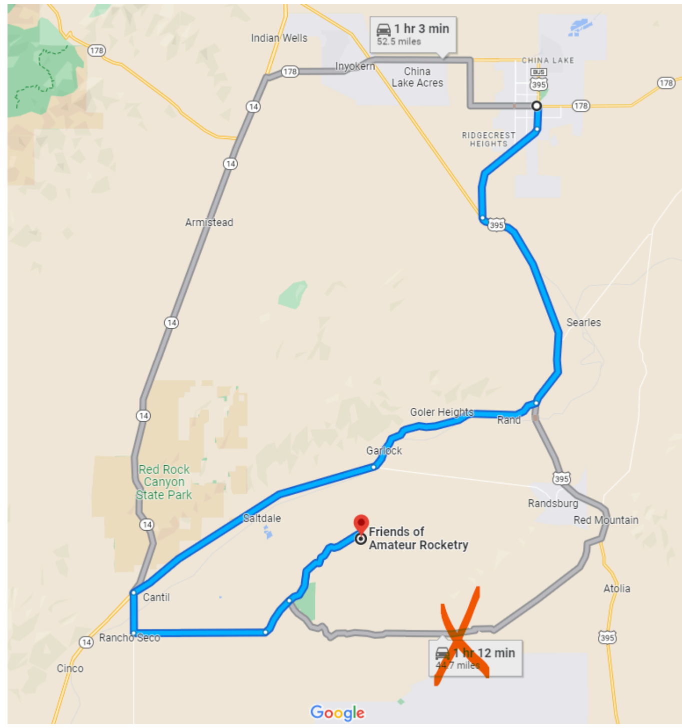
In the Month of May the average accumulation of precipitation is 0 mm. Average temperatures range between 72 F and 94 F, perfect for nitrous oxide. Wind speeds average around 10 mph with gusts going to 30 mph and changes by the day. More weather information can be found here:
https://www.wunderground.com/dashboard/pws/KCACANTI2

1.3.7 - Wind Policy at FAR

Wind speeds are often much lower than 5 mph at waiver open and high-altitude attempts should be made early in the day. Launches will not occur in winds over 20 mph, non-gusting.

1.3.8 - Travel to Site

For North American teams, road trips are a great option for transporting teams and rocketry-related items to competition, but groups are advised to have multiple alert drivers - the front passenger is encouraged to be awake and alert with the driver. For foreign teams and those who can not drive, there are many airports in the Southern Californian Las Vegas area. Make sure to try to find the cheapest option realizing the larger airports might not necessarily be the cheapest option. There also are train options available, arriving in Los Angeles. It may be a way to save money for transporting large teams.



For airports we suggest looking at:
Los Angeles International Airport
Las Vegas International Airport
John Wayne Airport
Ontario Airport (in California)
San Bernardino International Airport
Palm Springs International Airport
Hollywood Burbank Airport

When driving to the launch site, please *do not* take the road crossed out in red; it is impassable and not a real road. We won't be able to get you unstuck.

1.4 - FAA Apogee and Local Requirements at FAR

The team's rocket should supply less than 40960 Ns of Total Impulse. This limit can be exceeded in category C with extra documentation but cannot exceed 889644 Ns. The site hard waiver for Saturday and Sunday will be 250,000 feet, and on Monday the hard waiver will be 18,000 ft. This line must not be crossed or come close; if the rocket crosses this line, the team will be disqualified and will not be welcomed back to the facility and competition. Teams wishing to make an exhibition flight or a flight in category C must follow a separate process if they wish to fly a motor exceeding 40960 Ns. Teams are required to show the uncertainty of their motor's performance does not push the upper bound of performance over 40960Ns unless they know they will be over and are flying an exhibition flight or category C only. Teams may not disperse radiological sources or toxic pollutants, and all sources must comply with all relevant NRC and EPA regulations. No live animals may be launched. Rockets will be launched away from the crowd within 20 degrees of vertical. Read NFPA 1127 for more details.

1.5 - Shipping Information

1.5.1 - General Shipping Guidelines

While complying with all DOT shipping regulations, you can ship your rockets and equipment (arriving up to 1 month in advance). Rockets will <u>not</u> be stored past the competition. Crates will be stored outside, exposed to temperatures and unlikely rainfall as typically experienced in southern California. If you wish to have a tent assembled or your crates covered in a tarp, please ship the required tent and tarp separately with a note in the invoice. All crates must be marked on all sides with the name of your University. Applicable logos and team names may also be marked, but all sides must be marked with the name of your university. We recommend cutting a stencil and spray painting your logo or insignia onto the crate. Any shipped container that cannot be lifted by two individuals (Allowing for a maximum capacity of 100 lbs) and slid into the back of a 4' by 8' pickup bed will require transportation arranged by the team. All large crates (with a dimension longer than 4') not picked up by the team and under this 100 lb maximum must have their center of gravity marked so that it can be properly loaded into the back of a truck.

In the unlikely event a team doesn't show up to the competition, they must make arrangements to store or ship their rockets and equipment offsite. Otherwise, the Wednesday after the competition, abandoned rockets, ground station equipment (GSE), and launch towers left at FAR will become property of FAR.

Rockets requiring a shipping address should be shipped in advance to:
John Newman Propulsion
20836 Schout Rd
Tehachapi, CA 93561

1.5.2 - International Shipping Documentation

Shipments into the United States are typically subject to import fees, duty fees, and often California use tax. In order to avoid fees when shipping your equipment from another country, please look over the following information. Please note that this is not legal guidance; for more information regarding shipping temporarily to the United States please look at Customs and Border Protection (cbp.gov) or contact your home country's trade administration.
The necessary documentation is as follows:

- An **ATA carnet** from your home country. This is a document for "temporary imports" into another country and should be submitted with anything shipped into the country This document allows you to forgo import fees with the caveat that anything that got shipped in must be shipped out within a year. If your country does not support carnets, it is advised to check with a freight forwarder or see what other options your country provides for duty-free importation.
- A **bill of lading**. This should include all of the items and their prices for what you are shipping. Make sure to keep your receipts for purchases throughout the year to make this process smoother.

File your documentation as necessary when shipping and keep a copy of all of your documentation in a folder or binder to present to U.S. customs upon entry of the team into the United States.

Here are some useful links to assist:

Customs & Border Protection Carnet FAQs:
https://www.cbp.gov/trade/programs-administration/entry-summary/ata-carnet-faqs

trade.gov Carnet FAQs:
https://www.trade.gov/ata-carnet

Participating countries for carnets:
https://www.atacarnet.com/carnet-countries

1.6 - Oxidizer Supply

FAR is not responsible for ensuring that teams have their proper fuels. It is best to shop around FAR in advance - otherwise, the cost to a team could be astronomical. Any bottles that the team needs should be ordered *at least* two months in advance, as bottles are not always readily available in nearby gas supplier locations and they may have to ship it in. Teams should order for *at least* two full fires in the likely case of at least one abort.

Teams should first ask their universities to be able to order with the university account (likely with Airgas or Linde), which should give good rates. Each team will be required to get their own account for Airgas and Linde. West Air is another option in the area, and welding supply shops in the area may also sell quantities of air, nitrogen, carbon dioxide or helium. Teams should also coordinate with FAR if delivering their bottles directly to FAR; currently, Airgas, West Air and Linde will ship directly to FAR. If teams require a siphon or dip tube, make sure that is included on the invoice. Teams should provide invoices of what they have ordered to FAR-OUT by email so we can tell whose bottles are whose.

Bottles should be delivered to the Friends of Amateur Rocketry Site:
https://goo.gl/maps/NEvyXt5LmFQJruPWA
If your team has arranged for bottles to be picked up or delivered elsewhere make sure to follow all DOT regulations for transportation to and from the site.

In the case that your university does not have an Airgas or Linde account or cannot order from any other providers in the area for one reason or another, please speak to FAR-OUT staff for other options.

1.7 - Fuel Supply

FAR is also not responsible for ensuring that teams have their proper liquid fuels. It is best to shop around FAR in advance. Home Depot, Lowes, and Ace Hardware have kerosene. Ace Hardware has 100% isopropyl alcohol. Local gas stations have 85% ethanol (E85) and Diesel #2. Mojave Airport has Jet-A and 100 Octane aviation fuel. Some gas stations are dealers for VP Racing Fuels such as 99.8% ethanol (X98) and 100% methanol (M1). Please call ahead for VP Racing Fuels; not all dealers have on hand X98 and M1. VP Racing Fuels come in 5-gallon cans. Teams should order enough for *at least* two full firings in the likely case of one abort.

1.8 - Supplies for Propellant Actuated Devices

Contact FAR-OUT staff for information on recovery and ignition consumables.

PART 2: LIABILITY AND WAIVERS

2.1 - Liability Waiver

All people from every team must sign the FAR User Agreement (liability waiver) with no exceptions. Team members attending competition who do not sign this waiver will not be permitted to enter the launch facility. Link also found here:
https://friendsofamateurrocketry.org/wp-content/uploads/2023/08/FAR-User-Agreement-Rev-B.pdf

To the extent permitted by law, the Team / University shall indemnify and hold harmless FAR from any and all claims, lawsuits, liabilities, damages and/or injury of any kind whatsoever (including but not limited to monetary loss, property damage, personal injury and/or wrongful death), whether brought by an individual or other entity, or imposed by a court of law or administrative action of any federal, state or local governmental body or agency, arising out of any acts, omissions, negligence or willful misconduct on the part of the Team or University or Team's or University's officers, owners, personnel, employees, agents, contractors, invitees, or volunteers. This applies to and includes, but is not limited to, the payment of all penalties, fines, awards, fees and related costs or expenses.

2.2 - School Participation Letter

Every team by the third Progress Report (see Section 3 for exact date) should supply a School Participation Letter to FAR staff, which will be supplied to teams upon acceptance to the competition. Without this document, teams will not be allowed to compete. Teams based outside the United States are recommended to submit this document with the entry form so that we can draft a letter acknowledging your team's acceptance into the competition and your team's membership.

2.3 - Foreign Teams and Seeking a Visa

For many foreign teams that we have seen before, a visa should be sought out upon acceptance. Realize that some members of your team may not be citizens of the country that your university resides in. For that reason upon acceptance into the competition file for your visas immediately. If an individual on your team is from a country that has difficulties in acquiring a visa be sure to cross train replacements if they are unable to attend competition. Make sure they get their paperwork in immediately so they can come to competition in person rather than an effigy affixed to their control panel.

2.4 - Insurance Requirement

Each team must obtain their own insurance during launch. Teams must secure insurance through their school(s) or through a third party that does not prohibit launches by other universities. A Flyer of Record or person responsible is highly recommended for these teams, for most schools this will need to be an employee of the University. These policies are often made through or acquired by Risk Management at your institution. It may be by a different name but your institution will have a legal department that should be able to point you or your advisor to the right people.

If a team is unable to secure insurance through their school or otherwise, they will have to pay a fee (to be determined, but on the order of $1000 or more) to a joint FAR-OUT insurance plan that will be put in place for all teams without insurance. This fee will have to be paid by the end of the calendar year 2024. In the case that a rate can be found lower after that or a sponsorship can cover these fees, teams will be refunded.

2.5 - Requirement of Flyer of Record for NAR-Insured Launches (COTS Hybrids Only)

If the team is launching a commercial off-the-shelf (COTS) hybrid motor, NAR insurance is acceptable. If getting insurance through NAR, the Flier of Record must be intimately aware of all components of your rocket. This person should be an active NAR member that is certified to the level of the motor that the team will fly. They shall also be an active member of the team. However, if they are a mentor from outside of the team's school, they must be updated regularly so they know what they are signing off on and will be liable in case of an accident. If they are not part of your institution they are not allowed to construct or design your rocket but can provide advice and consent to the team's designs.

2.6 - Insurance Coverage Documentation

Teams are required to provide their own insurance coverage and to provide documentation of coverage by the 3rd progress report. The required documentation is written proof, in English, of comprehensive general liability insurance, including advertising liability and premises liability, of no less than $1,000,000 US Dollars. Note: individual, personal, or travel insurance policies do not qualify under this position. Teams without documented insurance coverage will not be allowed to fly. FAR is not responsible for and cannot assist in finding suitable insurance policies. For an example of what should be covered see: http://www.tripoli.org/Insurance. Note that TRA will not be a valid insurance for this launch due to the tolerance of liquid rocket engines and research materials other than aluminum in proper use which is outside the scope of their insurance policy.

2.7 - Insurance Coverage Proof Deadline

Proof of Insurance must be provided by 15 April 2024. This is a hard deadline. We strongly encourage that teams seek out this insurance through their University's legal office, council office or risk management office whatever it may be called. We recommend that teams seek out this policy after acceptance in the competition before the vehicle is built as waiting until the deadline will likely result in failure to receive a policy in time. We recommend once the documents are finished they be immediately sent to faroutcompetition@gmail.com. If we find any issue with it before that deadline we have the ability to work with you to fix it. If a team waits until the last minute there is the potential for an issue that cant be resolved by competition. This type of insurance was acquired at the last minute for another competition many of our volunteers had to deal with, but the complaint made by the school's risk management offices was that they needed more time. Since that competition similar policies have usually been obtained within two weeks of request with many emails back and forth. It is highly suggested that teams deal with insurance immediately after being accepted to competition

2.8 - ITAR

US Persons on US Teams are responsible for ensuring that all information shared with other teams does not violate laws regarding ITAR (The International Traffic in Arms Regulations). International teams should avoid asking questions about design, test, or implementation if a US person considers that line of dialogue as containing information that might potentially fall under ITAR. Non-US persons may discuss such topics at their own discretion so long as they do not risk violating the laws of their home country.

2.9 - Social Media Consent

During the competition, there may be photos and videos taken by FAR staff that may be shared by official competition media or used for sponsorships. By participating in this competition, any attending persons consent to being in photos or on video and consent to potentially appearing in social media or marketing material. Any media material that teams share prior to the competition or take themselves will only be reshared by FAR-OUT or used in marketing material with explicit consent from the involved parties.

2.10 - Local, State, Federal, and International Laws

Please follow all local, state, federal and international laws regardless of their duplication or omission in this document.

PART 3: TEAM GUIDELINES

3.1 General Team Composition Requirements

The team must bring sufficient people to launch and recover their rocket, but there is no limit to how many students can work on the rocket prior to competition. All members must be enrolled in or recently graduated from a college or university that has agreed to allow said team to participate in this competition. Members may be undergraduate or graduate students. Joint teams between colleges are permitted, but those schools must agree to be on the same team realizing that there is only one award. Each team should seek out a mentor to aid in design review and keep them informed on your design progress and issues that may arise, preferably someone with flight experience or at least ground testing of your chosen propulsion system. All participants must be over the age of 18.

3.2 - Team Positions

Each team is at minimum required to have a team lead, secondary team lead, a safety lead, and a listed faculty advisor. Given the weight of these launch vehicles, recovery of such rockets usually takes at least 5-6 people, so the minimum team size we consider to be acceptable is at least

3.2.1 - Team Leads, Secondary Team Leads, Safety Leads

Team leads and secondary team leads should have sufficient knowledge of all rocketry systems and subsystems and should be available to FAR staff as reliable points of contact prior and during the competition. A safety lead is required to assure that the team is following all proper safety protocol and no team member is putting themselves or others at risk. It is also recommended to have subteam leads but that information does not need to be submitted.

3.2.2 - HAM Licensed Individual

If a team will be using any HAM-licensed frequencies, teams must also have a team member at competition with the proper HAM radio certification. Failure to bring a HAM-certified individual to competition will result in an inability to transmit on your team's assigned frequency.

3.2.3 - Point of Contact/Team Liaison

Prior to competition the team must choose a Point of Contact or Team Liaison to serve as the person FAR Staff can ask about launch readiness or to bring in to spread news. This person should have intimate knowledge on all aspects of the rocket and its launch systems. This person must be on the Critical Flight Personnel (defined in 6.1.2) and onsite during launching. This person may be routinely pulled away from team operations to coordinate with FAR staff. This person can hold any position on your team but you should select someone that can step away from the work and not hinder your efforts to proceed with launch. Any duty they have must have a very capable deputy that can immediately step in. This should be a senior member that can make command decisions for your team without consultation.

3.3 - Mentorship

Rocketry is a complex, specialized and highly multidisciplinary field of engineering and tends to involve a steep learning curve, particularly for newer teams, or those branching out into advanced areas such as experimental propulsion. As in industry, experience can go a long way towards ensuring that teams are safe and successful, and helping them avoid common "rookie mistakes" that can come from inexperience, while a lack of experience is a very common cause of launch delays, last-minute rework or failures at competition.

As a result, it is very strongly recommended that teams seek out one or more mentors with relevant experience to provide guidance and help them to avoid the more common pitfalls that can come from a lack of experience. Typical FAR-OUT rockets have a lot of overlap with the more advanced end of hobby high power rocketry (HPR), and both in the US and internationally there is an active community of experienced individuals who are knowledgeable about practices such as airframe and fin design and construction, propulsion research, recovery system design, avionics and telemetry, etc. These people will often be members of rocketry organizations such as the Tripoli Rocketry Association (TRA), Canadian Association of Rocketry (CAR), or National Association of Rocketry (NAR). FAR-OUT teams are strongly encouraged to seek out such individuals to serve as a mentor, preferably one from the local area who is able to work directly with the team.

FAR staff are also happy to provide their feedback to teams over the course of the year, both in the context of official competition deliverables and upon request to support design reviews, etc. But there is often no substitute for somebody local who can work directly with the team on an ongoing basis. For teams who lack a mentor, FAR is happy to help find a suitable individual.

3.4 - Non-University and Corporate Involvement

Companies may sponsor a team and / or sponsor the competition. They can enter into a public-private partnership with a university where the students do the research but the students have to design, build, test and integrate their motor into a flight vehicle. Companies can provide valuable mentors and advisors and help direct research like any Principal Investigator at a university, but the work must be done by students. If a certified rocket motor is used, then designing, building, and testing are only referring to the vehicle and not the motor. An untested experimental motor may not be handed off to a student team to fly. The students operating the motor must be intimately knowledgeable about the ins and outs of its design and its operation. A black box understanding leads to very dangerous situations. This is an engineering design competition and it is expected that students do the work and when facilities do not permit they can have components fabricated to their specifications.

3.5 - Competition Category Change

Competition category changes may be made until the second Progress Update. Teams changing categories are required to arrange a second Virtual Design Discussion with FAR staff to discuss the feasibility of finishing by deadlines in a rushed schedule. Decisions by FAR-OUT can be in the form of acceptance of change, denial of upgrade, or transfer of entry fees to a subsequent year. These allow teams struggling to take more time to finish a project, teams that are ahead of schedule to take on a greater challenge, and for staff to be able to provide meaningful advice to allow teams to produce the best rocket they can under changed expectations.

3.6 - Team Withdrawal

Withdrawals prior to 1 December will be fully refunded. If a team withdraws between 1 December and 15 April, their Team Entrance Fee will be transferred to the next year only. Teams that delay projects beyond the second year will have to pay a new entry fee. Rocketeer Fees are non-refundable and non-transferrable. Withdrawals after 15 April will not be refunded or transferred. It is highly suggested that any team withdrawing should continue to work on their research programs to give the team the best chance in the following year. It is strongly suggested that withdrawn teams send a delegation of team members that will be returning the next year to learn from other teams to help build experience and operational knowledge. FAR-OUT would appreciate it if these team members volunteered to assist the competition. This is a great opportunity to help teach underclassmen and build a knowledge base that can last for years.

3.7 - Disqualification from Consideration for Any Award

In extreme cases where teams deviate from rules regarding safety standards while handling rockets and safe range operations they will be disqualified from the competition. Teams that disregard the FAR-OUT rules and develop an unsafe or unregulated technology will also not be considered for any awards. In special circumstances where teams display extremely disrespectful behavior and disregard the wellbeing of others, they may be disqualified from the competition. Judges and event staff reserve the right to log, report and evaluate these circumstances. Overshooting the waiver defined by the FAA COA will result in disqualification and can result in legal action by the FAA. Teams that do not send delegates to the awards ceremony forfeit any awards or prizes. Their performance places will not be forfeited but any prizes will be redistributed to attending teams.

PART 4: DELIVERABLES

4.1 - Entry Form

The Entry Form is rolling admission Starting on 1 September with first acceptances on 1 October. Entry closes on October 31st. The Entry Form is a Google Form. No payment is due at time of entry.

4.2 - School Participation Letter Submission along with Entry Form for International Teams

Foreign teams should submit the School Participation Letter mentioned in Section 1 *with* the Entry Form so that acknowledgment of individuals' entry into the competition can be made by FAR and so that teams can seek visas. Applications for visas should be made on the day of acceptance to allow for maximum time for processing. Updates on personnel for foreign teams should be sent to FAR staff by email as soon as possible, listing the entire delegation attending competition.

4.3 - Virtual Design Discussion/Meet and Greet

A Virtual Design Discussion and Meet and Greet video conference will be scheduled with teams after admission to the competition so that teams can familiarize themselves with the FAR staff and ask questions early on in the process. This is an opportunity to create an open dialogue channel with FAR staff that teams feel encouraged to reach out during the entire design, build, and test process. In this meeting we will also discuss with the team safety leads what is expected of them at competition.

4.4 - Progress Updates

There will be three Progress Updates submitted per team due prior to the competition in order to track team progress on design and testing. These forms will ask for various specifications such as airframe, propulsion, electronics, recovery, and payload designs, as well as static testing.

These Progress Updates are meant to be short and concise. Teams may be emailed afterwards with concerns, but we must stress that accuracy of the reports is *vital*; rockets deemed to be unsafe *will not be allowed to fly* and we would much rather give teams as much of an opportunity to fix issues prior to coming to competition as teams' workshops are much more suited for remediation than it would be in the desert. These are check-ins to determine whether something flight worthy is being constructed.

Progress reports are only scored for completion, but this information should be as accurate as possible to what the team is designing and building. Scoring is entirely numeric and the numbers submitted in their reports are used for scoring calculations, so it is in your team's best interest to make sure that these reports are accurate and precise, especially for the final progress report in May. The numbers and data that are sent are used to determine safety factors which will be checked upon arrival.

4.4.1 - Submission of Progress Updates

The Progress Updates will be a single Google Form that teams fill out what they intend to build and fly at FAR-OUT. For each Progress Update, teams will resubmit on the same form for different Progress Updates and receive emailed receipts of their responses. Teams can submit for each given Progress Update as many times as they would like before the deadline. The Excel spreadsheet behind this Google Form is automated to check for changed information between submissions. If a section's information does not change between updates, teams should input a "No" as a response. A response of no change since last report is perfectly acceptable but it should be understood by competing teams that consistent progress must be made throughout the year across subteams or the rocket will not get finished. Teams must also use the measurement units specified for each question; otherwise, our error-checking may not be accurate.

4.4.2 - Progress Update Deliverables

With each progress update the following supporting documentation will be asked for. Teams may not necessarily have something to submit in the initial updates, but each of these deliverables will be mandatory for the final update. The earlier your team submits these, the more feedback FAR-OUT staff can give as the design is iterated upon.

- Propulsion
    - P&ID diagram of the rocket and ground support system
- Avionics + GSE
    - Schematics of any custom-designed PCBs
    - Electrical schematics of the rocket including but not limited to propulsion control, Recovery control, payload wiring, or active control wiring.
    - Electrical Schematic the Ground Support Equipment
- Airframe
    - OpenRocket or other flight simulation of the rocket
    - Fin flutter analysis
- Payload
    - Schematics of any custom-designed PCBs
- Team-wide
    - Checklists (described in section 4.5)
    - Video of dry-run
- Recovery
    - Layout of Recovery System with lengths of tethers and working loads
    - CD and diameters of parachutes
    - List of working load limits for swivel, quicklinks, eyebolts, releases, tethers, U-bolts

4.4.3 - First Progress Update

The first Progress Update will be due on 27 November 2024. The purpose of the initial Progress Update is to let us know of your team's preliminary design.

4.4.4 - Second Progress Update

The second Progress Update will be due on 24 February 2025. The purpose of the second Progress Update is to let us know of any updates on rocket specifications and finalizing the design, as well as any updates to potential hydrostatic, static, or recovery testing that has been completed since the previous report.

4.4.5 - Third Progress Update

The third and final Progress Update will be due on 15 April 2025. This final update should be a finalized build and test system report. This will include any static fire and recovery testing data, as well as under what conditions these tests were performed. School Participation Letter is due for all teams listing all team members coming to competition. This is the final document acknowledged for team composition.

4.4.6 - Late or Insufficient Progress Update Policy

If a progress update is late or information is lacking, the team lead and secondary team lead will be emailed within the first week. After that second week, we will make one last attempt to reconnect; beyond this point it will be assumed the team has withdrawn and notification will be sent of this assumption to the advisor.

4.5 - Team Checklists

Along with the final Progress Updates finalized launch operations checklist should also be provided. At competition, every team member should have a copy of this checklist, and it should be written in a clear and concise manner that any team member should be able to follow. This checklist needs to cover all operations on site including but not limited to setup, vehicle integration, arming, filling, launch, tracking, and recovery. Your team's instructions should be sufficient to give to a member of another team and have them successfully fire or navigate any foreseeable failure mode. Below is a sample list of operations that should be included but not limited to:

Prearrival: Packing order for the vehicle/trailer/crate, packing list, required tools
Arrival: Tower Assembly, GSE setup, GSE testing, GSE troubleshooting, unpacking order for the vehicle/trailer/crate, tent setup and tools packed, rocket sub-component testing, parachute packing, battery swap, payload tests, rocket final integration, launch control system setup, launch control testing, GPS telemetry testing, practice drills for the team to perform prior to leaving rocket in ready state, ready state positioning (valves, arming keys, igniter clips, fill lines / umbilicals), ejection charge testing (if needed)
Launch Day: ready state bootup procedures, final connections, final checks requires, final simulation updates, GPS lock, fill procedures, fill failure recovery procedures, hold procedures, abort procedures, valve failure procedures, recycling procedure, pad safing procedure after abort, pad safing procedure after launch, rocket recovery procedure, extraction of payload for weighing.
Breakdown: Breakdown of launch equipment, crating of materials

4.6 - Final Video Conference

The Final Video Conference for each team will be scheduled in late April and will be a virtual safety meeting regarding what has been built. This will be the first real opportunity for FAR staff to look at the rocket and ask proper design questions, as well as give a final review of any potential yellow flags that may present issues for safely flying during the competition. We will schedule an at least 45-minute video meeting with each team for this purpose. There is also no scoring for the video conferences; we are not looking for quantity of data but rather as accurate of information as possible.

4.7 - Poster Sessions, Podium Sessions, and Technical Reports

There are several deliverables due near or at the competition itself that are not required to be submitted prior to the competition, pertaining to conference material and other deliverables.

4.7.1 - Poster Sessions

Posters brought to the competition should describe in brief with proper photos and diagrams your design, build, and testing processes. Teams should at least have one standard-size poster (36”x48”) that covers a general overview of these categories and are free to bring more presentation materials if desired.

4.7.2 - Podium Sessions

Teams are also encouraged to participate in podium sessions at competition where teams can choose a part of their rocket design or testing process to present. Each podium session will be capped at around 20 minutes. Topics are open-ended; teams can choose to present on anything from a unique injector design to their test stand construction to their electronics UI, or anything other project-related topic. More details will be provided closer to the competition. Podium presentations will not be considered for general competition scoring, but depending on potential sponsorship opportunities there *may* be a separate award dedicated to podium presentations.

If teams wish to present any electronic accompaniment during their podium session (i.e. a video or PowerPoint) it should be sent to faroutcompetition@gmail.com as a shareable link at least one week prior to the competition.

4.7.3 - Technical Reports

Final technical reports will be due one week prior to the competition. For the purposes of the general competition scoring, these will be scored on completion. However, we do have a separate scoring and award specifically for best technical reports called the Best Technical Report for those teams who do wish to be recognized for outstanding effort in writing a technical report. If students wish to participate in this, there is a separate document called “FAR-OUT Technical Report Instructions” on the FAR-OUT website describing the general outline of what should be included in the Technical Report in order to be considered. Even if not aiming for the Best Technical Report award, we encourage that students still be as thorough as possible in these reports, as these can also be submitted to conferences outside of this competition.

PART 5: TECHNICAL REQUIREMENTS

5.1 - Airframe and Aerodynamics

5.1.1 - Aerostructures

The use of metals should generally be minimized for your team's own benefits to overall vehicle mass fraction, cost, vehicle mass, and safety in recovery or motor failure events. The use of composite materials such as fiberglass, Kevlar, carbon fiber, et al. as appropriate are strongly suggested. The use of natural composites such as wood, cardboard, hemp fiber composites, bamboo composites, etc. should be examined for effectiveness and appropriateness. A K motor launching a 1kg payload can probably be accomplished with a cardboard and wood rocket but that wouldn't be appropriate for a O class motor pulling 40 g's. It is recommended that you test material properties for composite materials produced in house. Your fins should not be wobbly or loose. To accurately determine safety factors or fin flutter and aeroelastic divergence (see section 5.1.9) the assumption is that the fins are rigidly attached so that must be enforced. The rocket must be built to a standard of quality such that it does not fall apart under thrust or prior to launch.

5.1.2 - Joining of Airframe Sections

PEM nuts are highly recommended for providing anchored threads in metal and composite parts for joining of two components by bolts. If your team is capable of producing rigid radax style joints that is also appropriate. Coupler tubes joining two sections of the airframe that are not intended to separate in flight must extend half of a caliber (but should extend 1 caliber) into each airframe segment. A rigid overwrapped joint between two airframe segments that cannot separate should have at least a quarter caliber into each airframe segment for centering prior to overwrap, but temporarily inserting a rigid mandril during the joining of such tubes or tube to tail cone would be favorable.

5.1.3 - Separation Points

Coupler tubes joining two sections of the airframe that are intended to separate in flight must extend one caliber (but should extend 1.5 caliber) into each airframe segment. Nylon shear pins should be used of sufficient number and strength such that a 15-psi difference against a bulkhead does not shear the shear pins. You should not rely on bleed holes working. To produce consistent results those shear pins should be inserted into PEM nuts or into a threaded hole. This means that BP and CO_2 ejection charge systems should exceed 20-psi to properly shear those shear pins and the total force on the bulkhead must exceed the total strength of the shear pins by at least a safety factor of 3 for that recovery bay.

5.1.4 - Rail Exit Velocity

Rail/tower exit velocity must exceed 85 ft/s. Teams should design their rockets to leave their chosen rail above 100 ft/s. It is recommended that the rocket's thrust to weight exceeds 10 to meet this requirement with a short rail.

5.1.5 - Rocket Stability

Rocket must be stable during ascent. No barrel rolls or other aerobatic maneuvers on ascent. Glide recovery vehicles can make maneuvers to bleed off kinetic energy as necessary. Your rocket must maintain a minimum static stability margin of at least 1.5 calibers during the entire ascent. Your rocket should be sufficiently damped to be able to deal with wind gusts of up to 30 mph while we will not launch over 20 mph to produce a safety factor of 1.5.
Your rocket will not be launched with surface wind speeds exceeding 20 mph or at an angle greater than 20 degrees. If your angle is adjusted by FAR staff so that ballistic entries and recovery zones are downrange, your simulation lead will be allowed to update the predicted altitude at that time. It is suggested to keep a fully charged laptop ready to run flight sims as conditions change on the ground.

5.1.6 - Rocket Labeling

Your University Acronym must be visibly labeled on every separate part of the rocket airframe in case someone else discovers your rocket so they can identify it. For publicity reasons University and Sponsor logos should be clearly visible on camera form distances of 100 ft or more. 3" tall lettering is recommended somewhere on the rockets to be visible by the cameras.

5.1.7 - Recovery Bay Venting

Venting of recovering bays is required unless the shear pins that are used can handle a 15 psi pressurized chamber over atmospheric. Most 4-40 pin shear pin setups can handle this.

5.1.8 - Electronics Bay Venting for Air Sampling

Electronics bays using barometric altimeters or altimeters that use accelerometers that calibrate with barometric data should have 4 evenly spaced air sampling holes. The rockets must have more than 3 evenly distributed holes about the circumference such that:

Total air sampling hole area ≥ $[\text{Airframe Diameter[in]}]^4 * [\text{Recovery bay Length [in]}]^2 * 2*10^{-6}$
For 4 hole air sampling

Hole Diameter [in] ≥ $[\text{Airframe Diameter [in]}]^2 * [\text{Recovery bay Length [in]}] * 0.0008$

For n holes where n >=3

Hole Diameter [in] ≥ $[\text{Airframe Diameter [in]}]^2 * [\text{Recovery bay Length [in]}] * \frac{0.0016}{\sqrt{n}}$

5.1.9 - Fin Flutter and Aeroelastic Divergence

A well designed rocket should not fall apart during boost or coast. This generally occurs when there is a sudden and dramatic change in angle of attack. With proper hydrotests and test fires the likelihood that these research motors would cause an airframe failure is highly improbable. The most likely cause of this is fin failure due to fin flutter or aeroelastic divergence. Rockets don't just fall apart, through some simple calculations and appropriate safety factors the leading cause of failure during ascent can be removed.
For the calculations used it is assumed that the fins are fixed to the airframe. This can be accomplished by sufficient bolting supports, tip to tip layups, through the wall fin mounts and other methods producing a rigid bond with the airframe. So long as the fins stay on and the rocket maintains stability, the rocket will reach apogee without problems. After that it's a matter of electronics and a recovery system reliability.

Fin Flutter is a cyclical loading failure issue as the fin oscillates about its root chord. There are techniques for reinforcing the fin by dampening harmonics with layers of variable height and length built into a tip to tip layup. Aeroelastic divergence occurs when the torsional flutter effects leads to a localized change in angle attack leading to an sudden transient increase in the force on an individual fin leading to a sudden failure of a fin. It is very hard to mathematically characterize such effects but it can be benchmarked through meticulous study. Since amateur rocketry competitions lack the resources to perform such a study we have to use conservative methods based on fin dimensions, airspeed, and launch conditions. For your convenience we have made a calculator that your team can use to calculate your safety factors for fin flutter and aeroelastic divergence. It has a host of materials to select from or you can take an independent measurement of your shear modulus and input a direct measurement instead of literature values for commonly used materials. In the case of composite sandwich panels we ask that you independently measure your shear modulus but in the event a team does not have access to such instruments we will make the generally supported assumption that a sandwich panel's shear modulus tends to be less than but roughly equal to the modulus of the material forming the other layers of the panel. This assumes that the outer layer is sufficiently thick that the fibers of each layer are able to interact with the adjoining layers to act as a sufficiently rigid plate on their own and that the sandwich material does not flex independently of the outer layers.

If you would like to read more about flutter see:
https://ntrs.nasa.gov/api/citations/19930085030/downloads/19930085030.pdf

5.2 - Propulsion

5.2.1 - Allowable Propulsion Systems

For this competition there are two allowed general motor types: hybrid and liquid engines. Your rocket must not mix fuels and oxidizers until the range is active and you have been given authorization to launch.

A hybrid engine is defined for this competition as a propulsive device using only nitrous oxide (N2O), oxygen, or air as the chemical oxidizer held in a liquid or gaseous state separated from the solid fuel. AP-doped hybrids cannot exceed 10%wt (of the fuel grain) AP. The fuel can be made out of any solid material (that can withstand the temperatures of late May/early June in the Mojave Desert without refrigeration) that burns in the presence of the chosen oxidizer. The fuel can be made of any solid or mixture of solids that will combust with your chosen oxidizer that are not mutagenic, teratogenic, carcinogenic or illegal to release in the environment of California.

A liquid engine is defined for this competition as a propulsive device using only nitrous oxide (N2O), oxygen, or air as the chemical oxidizer held in a liquid state separated from the liquid fuel until injection into a combustion chamber. The fuel can be made of any liquid or combination of liquids that will combust with your chosen oxidizer that are not mutagenic, teratogenic, carcinogenic or illegal to release in the environment of California.

All engines must be weighed by FAR-OUT staff with the scale reading photographed failure to do this during check in will result in having to de-integrate your propulsions system for a subsequent weigh-in.

Please confirm with the judge that they did get the photo with a clear number with units. This is how we determine mass fraction which is a significant contribution to your points.

5.2.2 - Pressure Vessel Requirements

The combustion of combinations of fuel and oxidizer occurs at higher temperatures and pressures and consequently a suitable pressure vessel must be used. A design burst pressure safety factor of 2 must be used for all pressure vessels. If the pressure . vessel is designed to be pressurized next to people it must have a design burst pressure safety factor of at least 4

FAR allows the use of commercial or research fabricated aluminum, stainless steel, fiberglass, carbon composite, composite overwrapped metal lined vessels provided they have been adequately pressure tested to 1.5 MEOP if filled remotely (2 if filled manually). This shall be done by hydrostatic testing the vessels prior to first use - see Section 5.6.1 on Hydrostatic Testing.

5.2.2.1 – Maximum Expected Operating Pressure Definition A Designed and As Built

Maximum Expected Operating Pressure (MEOP) is defined as the pressure at which operations at any higher pressure would force the abort of any launch attempt or test, but below which the rocket would achieve safe flight. It is suggested that Nominal Operating Pressures (NOP) be below your MEOP. Your MEOP should likely be 1.25-1.5 your NOP. Any automated or passive pressure relief device must be set to this design MEOP. If a relief valve cannot be acquired or set to this MEOP the MEOP must be raised or lowered to an available set pressure of the relief device. This may redefine engine parameters and testing requirements. The fact that small light weight pressure relief devices sometimes do not operate at exactly the quoted pressure requires testing of the pressure relief device and for Nominal operation of the engine to be lower than than the MEOP. Any pressure above MEOP must result in an abort by your procedures and if your controls are unable the passive relief system.

An example of this would be a nitrous oxide oxidizer system with a design MEOP of 750 PSI, but only a 600 PSI or 800 PSI relief device can be acquired. A team's propulsion subteam must determine whether procedures dictate that 600 PSI MEOP and subsequent feed rates are safe for operation or whether a 800 PSI MEOP would be acceptable in regards to proof testing at 1200 PSI (1.5 MEOP). In the case of the 600 PSI MEOP redesignation, once the system hits 600 PSI in operations the team would have to abort or vent to drop pressure to normal operating pressures. In the case of the 800 PSI MEOP redesignation, the team can operate under their original procedures for NOP of 750 PSI but they now have a margin of 50 PSI where abort is not required above their designed operating pressure.

5.2.2.2 – Relief Valve Requirements

Any sealed system must have a pressure relief device. If any normally closed actuated valve or a check valve closes part of your plumbing system, it is considered a separate system requiring pressure relief.

In a hypothetical system a mother bottle is connected to a fill valve which is connected to the rocket through a fill line which passes a normally closed valve into the oxidizer tank. You have three potentially sealed systems each requiring a pressure relief valve. In the case of higher working load rated plumbing between the mother tank and the fill valve a dump is not necessary but would help in your operations, while the potential for over pressurizing the line between the mother bottle and the fill valve exists so a pressure relief valve is required to be set at the MEOP of that closed subsystem so you do not feed higher pressure into the rest of the system. In the event of an abort prior to removal of the fill line the rocket side normally closed valve could be held open and would allow purging of oxidizer through the fill line dump valve in addition to the rocket oxidizer tank dump system, thereby decreasing the abort time. In the case of abort after removal of the fill line, the rocket side oxidizer dump system would have to complete the abort by itself. This requires a dump valve capable of draining the entire onboard tank within the abort time requirements (30 minutes for <41kNs, 60 minutes for >= 41kNs).

5.2.2.3 – External Pressure Fed Propellant Tank Requirements

Propellant tanks that are pressure fed from a pressurant source greater than the proof test pressure of that tank, shall have a relief device, a remote operated vent valve, and pressure monitoring transducer. The relief device (relief valve or burst disk) relief pressure shall be set at or below the propellant tank proof test pressure. Only commercial relief valves or burst disks shall be used.

5.2.2.4 - Cryogenic Propellant Tank Requirements

Propellant tanks that will contain cryogenic propellants where the vapor pressure can exceed the tank proof test pressure, shall have a relief device, a remote operated vent valve, and pressure transducer. The relief device (relief valve or burst disk) relief pressure shall be set at or below the propellant tank proof test pressure. Only commercial relief valves or burst disks shall be used.

Any sealed segment containing cryogenic or liquified gas propellants must have a pressure relief device. If any normally closed valve or a check valve closes part of your plumbing segment, it is considered a separate segment requiring pressure relief.

In a hypothetical system where a mother bottle is connected to a fill valve which is connected to the rocket through a fill line which passes through a normally closed valve into the oxidizer tank. You have three potentially sealed segments which each may require a pressure relief valve. In the case of higher pressure rated plumbing between the mother tank and the fill valve a relief valve is not necessary. While the potential for over pressurizing the fill line between the rocket and the fill valve exists so a pressure relief valve is required to be set at the MEOP for that closed segment. The normally closed valve into the oxidizer tank is another sealed segment that requires a relief valve set at MEOP.

5.2.2.5 - Combustion Chamber

The combustion of combinations of fuel and oxidizer occurs at high-temperatures and pressures and consequently a suitable pressure vessel must be used. Ablative liners are highly suggested to deal with the high temperatures inside the combustion chamber. Destruction of the motor's pressure vessel during the burn is not a successful test.

5.2.2.6 - Pressurant Bottle

Pressurant bottles shall be commercially fabricated, DOT rated, and operated at a pressure below its rated pressure. Pressurant bottles shall have temperature and pressure monitoring sensors.

5.2.3 - Single-Use Combustion Chambers

Single use combustion chambers are allowed but they cannot lose their structural integrity during the first burn. Disposable components must be successfully tested a minimum of twice. If a consumable nozzle or combustion chamber is used two tests must be performed to demonstrate that your fabrication methods are consistent enough to ensure safe operation of the flight article.

5.2.4 - COTS Hybrid Testing Exceptions

If a team chooses to use a COTS hybrid, they have already been tested and as such test performance documentation does not need to be provided. COTS Teams are strongly encouraged to do a test flight or test firing to familiarize yourselves with a system you may not yet have experience with.

5.2.5 - Permitted Oxidizers

You must use Nitrous Oxide (N2O) or Liquid Oxygen (LOX) as an oxidizer. Other oxidizers may be approved on an individual team basis provided they do not present a hazard to other teams or the State of California. This includes mixes of allowed propellants. You must make accommodations to have your oxidizer in sufficient quantities delivered to site; FAR is not responsible for arranging delivery of your chosen oxidizer or fuel. Options for oxidizer delivery at the site are described in 1.6.

5.2.6 - Research Pressure Vessel Material Restrictions

All research pressure vessels must be proof-tested without damage or deformation to 1.5 MEOP for twice the sum of the durations of the fill to fire time and abort. There are no material requirements so long as pressure vessels are tested. It is recommended not to use non-frangible materials and to stick to 6061-T6 Aluminium. If a team wishes to experiment with composite pressure vessels that is highly encouraged but any pressure vessel must be pressure tested to 1.5 MEOP. It is expected that operating pressures for self pressurizing motors could reach 900 psi nominally for a nitrous system thereby requiring a pressure test in excess of 1350 psi and hold for twice the time for a system to fill and abort which is the longest expected time of pressurization.

5.2.7 - Proper Oxygen Cleaning of Vessels and Plumbing

Use of ASTM G93 “Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments” to apply to proper cleaning of vessels and plumbing is suggested. This is a well-known and well-used standard for oxidizer cleanliness. Another guide could be ASTM G88 Standard Guide for Designing Systems for Oxygen Service.

In order to ensure proper operation for a commercial-of-the-shelf or research motor, it must be well maintained and result in an underperforming or a non-operational motor and may pose a potential safety risk. Potential issues may include, but are not limited to:

1. Coking, which refers to the build-up of carbon deposits on the walls of the combustion chamber.
2. Insufficient Oxidizer Flow through plumbing, which can lead to incomplete combustion
3. Oxidizer Contamination, which can cause erratic burning, unstable combustion, and may even lead to a catastrophic failure of the motor.

4. Ignition Issues, which may also lead to ignition problems, such as faulty igniters or improper ignition procedures. An unreliable ignition can cause a delay in motor startup or, in worst cases, a failure to ignite the motor at all.

To ensure the safe and efficient operation of a hybrid or liquid motor, regular maintenance and inspection are crucial. Proper storage, handling, and manufacturing practices should be followed to prevent coking, contamination, and other issues that could affect the motor's performance. Additionally, adherence to safety guidelines and best practices is essential to minimize the risks associated with hybrid or liquid research.Teams need to clean your plumbing to the degree required by their oxidizer. Greenwise, isopropyl, acetone and rags over paper towels.

5.2.8 - Inflight Detanking

In an effort to dial in altitude the oxidizer and potentially fuel feed may be shut off intentionally in some designs. This would leave pressurized fuel, oxidizer and potentially pressurant gasses on board which could create a significant hazard on touch down. Volatile fuels must be dumped prior to landing. Oxidizers must be dumped prior to landing. For self-pressurizing propellants this could be accomplished with a normally open valve that is held closed by limited onboard and ground power prior to launch. If your flight valve is meant to shut keeping pressurized propellants on board a manual valve should be included on the tank that is shut prior to flight.

In the event depressurization fails a rope should be attached to the handle of this manual valve by the recovery team. No other operations should take place in recovery until the tanks are depressurized. Over the recovery radio system alert FAR-OUT that you are preparing to depressurize the tank. Once your recovery team fans out securing the area (preventing other recovery teams coming within 100 ft) the propulsion expert on your recovery team should actuate the valve from a safe distance via the rope. Once all pressurized tanks are depressurized, report over the radio that the tanks are safed and proceed with recovery efforts.

5.3 - Payload

Each rocket is required to contain a payload. This payload can be a research experiment or dry mass if necessary. The payload must be an independent system from the rest of the rocket and not part of the critical aerostructure, unless it is a glider or air-brake. All payloads must be weighed by FAR-OUT staff with the scale reading photographed failure to do this during check in will result in having to de-integrate your payload for a subsequent weigh-in. Please confirm with the judge that they did get the photo with a clear number with units.

5.3.1 - Payload Dimensions

Each rocket must carry a payload that weighs at least 1 kilogram. Scientific experiments are encouraged, but for the purposes of scoring this competition only the weight will be judged. The dimensions of the payload will not be judged. Payloads may not impact the ground faster than 30 ft/s. At the competition, judges will weigh the payload prior to being put into the rocket and will photograph this on their own cameras for posterity purposes. Make sure to check that such photographs display the masses and units.

5.3.2 - Gliders, Air-Brakes, Active Aerodynamic Surfaces as Payloads

To encourage the development of active aerodynamics systems such as air brakes or stabilization systems for keeping the rocket moving up (no remote control on ascent or descent (while ballistic), teams using such systems can count the weight of these systems towards payload mass. The true bonus will come in the form of increased scores in flight performance and simulation performance. For active aerosystems, these systems must be pre programmed and may not steer off vertical trajectories for compliance reasons.

Gliders and glide recovery systems weights will comprise any part of the structure of the rocket that is returned via this method. If your entire rocket is returned as a glider then the empty mass of the rocket will count towards payload weight. Such systems must be controlled remotely to prevent glide ratios from leaving the sides of the waiver cylinder. Gliding out of the waiver can result in disqualification and potential legal action by the FAA.

5.3.3 - Payload Component Restrictions

Payloads must not be intended to cause harm to humans or property and may not include any animals. Payloads can include plants, fungi, or any safe organic/inorganic material. Any payload failing to meet one of these criteria is not allowed. Payloads, especially dense boilerplate payloads, must be rigidly secured to prevent damage to other subsystems or people or property on the ground.

5.3.4 - Water Ballast Payloads

FAR has worked hard to encourage the development of water ballast payloads to decrease landing mass while limiting altitude. To encourage mass-efficient systems a payload bonus is given for the mass fraction of dispensed water ballast from altitude. This bonus is outlined in the Scoring section. To get full points without a water ballast 10 kg of payload are needed, with an efficient water ballast system this payload mass can be decreased to roughly 4 kg. You are not required to seek a payload greater than 1kg but that would leave points on the table. The payload will be weighed before and after flight to collect this data.

5.3.5 - Eggs

A point bonus of 10 points per unbroken egg launched and returned to recovery undamaged will be granted, not exceeding the total Payload points of 500 points. FAR staff has to mark each egg so be sure to check in early.

5.3.6 - Drones

For deployable payloads controlled, autonomous or passive make sure the insurance covers it. As long as it’s deployed from the rocket after apogee then it went up by rocket. Remote controlled systems must abide by FAA Part 107 and FCC Part 97.

5.3.7 - Other Payloads

For non standard payloads check with competition officials during the design process in case there are any other restrictions that might have to be placed on it.

5.4 - Ground Support Equipment and Filling

Ground Support Equipment (GSE) must be provided by the teams. FAR will not have available hybrid GSE systems, let alone one that works with your specific motor. Teams must purchase a COTS unit or design, build and test their own.

5.4.1 - Definition of Fill-to-Fire (F2F) Times

The fill-to-fire (F2F) time of a rocket is defined for the purposes of this competition to be the entire duration from when the button is first hit to start filling the rocket to when the rocket is ignited. This time includes pressurization and any applicable operational checks.

5.4.2 - Filling Rules at FAR

F2F for each Class 2 rocket, under typical desert conditions during the time of the competition, *must* be less than 30 minutes. In order to account for changing conditions and to debug any work problems, an extra 15 minutes *may* be allowed during a launch attempt at the discretion of the pad manager, but rockets should not be designed to have F2F times past 30 minutes nominally. Teams will be told to abort or launch if F2F exceeds the allowed time.

In such a case, the team should determine prior to competition partial fill altitudes in case of partial fill. In continuously vented motors like UC valve hybrids and pyrovalve hybrids this is a relatively fast process. For motors that have to pressurize on the pad after filling at a lower pressure and temperature, the time to pressurize must fall within the total F2F limit. All Class 2 rocket motors must fill within 30 minutes.. *In other words, the maximum time for pressurized vehicles with Class 2 motors to be unapproachable is capped at 60 minutes during normal operation and worst-case abort procedures.*

Class 3 motors may take up to 1 hour for F2F, but it is preferred to stay in the 30 minutes to not cause issues with launch operations for other teams. Abort times for complete depressurization must take less than 30 minutes.

For non-self-pressurizing-propellants that are filled manually at ambient pressure, pressurization must occur remotely and within the same time constraints. This may require the use of a secondary pressurant gas or pumps. No tank shall become pressurized until the critical flight personnel have all retreated to safety in the shelters and FAR staff have authorized fill and pressurization for your team. Waiting for propellant to boil off is not acceptable.

5.4.3 - Fill Monitoring

Teams must have a fill monitoring system that alerts when the rocket has reached the desired fill state, whether that is a partial fill or a full fill. It is recommended that a calibrated cantilever load cell is used to accurately measure and transmit to the launch controller the actual fill state. Other methods can be used, but assuming that the condensation plume from a full motor can be seen in the Mojave Desert is not acceptable. There are simple methods such as using a temperature sensor or a commercial-off-the-shelf detector from Contrail Rockets. Filling times and fill status detection must be tested prior to arrival at competition.

5.4.3.1 - Engine State Detection

The propellant loading state of the rocket in all operations (including, but not limited to, filling and aborting) must be available to launch control personnel at all times. For example, this could be accomplished by a load cell on the launch rail measuring the rocket's mass, a capacitive measurement of propellant level, etc. Any developed system must be tested and tuned prior to arrival at competition and checked after pad setup in case anything was damaged or calibration was lost in transit. Given the history of these systems, load cell measurements are the most likely to work reliably and integrate easily into launch control systems. Development of another method carries the risk of a low starting technology readiness level. Pressure measurement of the oxidizer tank is also required to make sure the vehicle is safe to approach.

5.4.3.2 - Mother/Supply Bottle State Detection

For all fill systems, the pressure of the mother (also referred to as the "supply") bottle(s) must be readily available to both pad and launch control personnel at all times. This may include the use of pressure transducers for transmission to LCO and mechanical gauges for people conducting operations at the pad for leak tests, final launch setup and safing operations.

If using active heating or cooling systems on the mother bottle(s), the mass of the mother bottle(s) must be available to launch control personnel at all times. As stated also under rules for MEOP definition, any sealed system must have a pressure relief device at the assumed maximum expected operating pressure. If you are heating a mother bottle that isn't supposed to supply N_2O to your system at say 1000 psi, you would require a 1000 PSI pressure relief valve to prevent overpressurization due to overheating. If the team intends to conduct temperature control autonomously, they must also have a PID control loop to control power to any heater or chilling unit to prevent over or under pressure on your supply. A team member can be designated to watch valves and form a human version of this programming by turning on and off a heater or chiller. The PID/human loop must be tuned or trained to the acceptable pressure ranges of your engine to prevent operation outside expected pressure ranges which would trigger your pressure relief valves and lead to loss of propellant.

5.4.4 - Fail-Safe GSE Design

Ground supports must be designed to fail safely such that the motor pressure will not build until a tank is burst. We recommend commercial burst disks, pressure relief valves, fill lines designed to fail before pressure vessel failure (nylon lines), and normally open purge valves on the vehicle. It is strongly suggested a normally open solenoid valve be included as a purge method in the event power or control to GSE is lost. Additional methods such as burst disks and pressure relief valves on the GSE might also be desirable. GSE shall be designed and built with commercial plumbing, valves, relief valves, fittings, and tanks where their operating pressures do not exceed their commercial pressure rating. Team designed valves must be tested to a burst pressure safety factor of 4 as they will be considered pressure vessels that people might be around. They must be proof tested to a safety factor of 2, but must actuate at pressure of 1.5 MEOP. No experimental pressure vessels or components may be used in the GSE without specific approval after proof testing to a safety factor of 4. Actuation devices for manual valves may be designed and built by the team so long as they do not modify the pressure rating of the valve. This specifically allows for servo modification of a manual valve assuming that the actuation is rigorously tested. For rockets with onboard active pressure relief methods. The rocket shall have a pull-off electrical umbilical that has the wires for the remote operated vent valves, pressure monitors, and temperature monitors. The electrical umbilical shall have enough slack such that the rocket must move 12-inches up the launch rail before the umbilical disconnects.

5.4.4.1 - Use of Pilot Run or Dump Valves

Piloted lines require a second solenoid to depressurize the actuation line. Piloted dump valves must be normally open with the pressurant actuator valve set up to vent (resulting in a dump) in the de-energized state. Piloted run valves must be normally closed with the pressurant actuator valve set up to vent (resulting in a shutdown) in the de-energized state. Note that these two are opposite requirements for two different use cases of a valve.

5.4.5 - Umbilical Fill/Purge Systems

For umbilical fill/purge systems, in the event the umbilical is removed before liftoff the ability to drain the flight must be maintained until the rocket is leaving the ground under thrust with the flight valve open. Otherwise, umbilical systems that separate upon liftoff must allow for the removal of the detanking system from the rocket so long as the umbilical cannot be removed before the rocket is under thrust with positive upwards and increasing velocity.

Specifically for top-filled motors a dip tube for self pressurizing propellants is required such that in an abort the liquid is forced out under its own vapor pressure. This can be accomplished with a normally open valve attached to a plumbing T onboard where the umbilical disconnect is also attached. This is the same dip tube for filling that can be used for the abort after disconnect. In the event of onboard power being lost the valve would be immediately opened.

For top-filled motors without a self pressurizing propellant if the propellant is slowly volatile but not self pressurizing where it could drain itself through a dip tube like liquid oxygen a bottom valve must be included in the design to dump after loss of power.

5.4.5.1 - Umbilical Retraction Operational Timing

Pressure umbilical connections must remain attached for as long as possible into the launch sequence. This minimizes the time secondary abort systems on the ground side are not attached to the flight tank allowing a second means of abort. Efforts should be made to extend ground power capability until launch. Efforts should be made to allow for remote reattachment of umbilicals to aid in abort capability.

5.4.5.2 - Minimization of Check Valves

The use of check valves will be heavily discouraged. There should not be any check valves on high flow lines for their flow restriction properties alone. They create separate pressurant systems that require dump, vent, manual dump, and pressure relief requirements that add weight and complexity to your rocket. They also complicate abort procedures. Check valves in nitrous systems are not flash arrestors. A higher pressure difference will prevent mixing upstream. Designs using unnecessary check valves will be penalized for poor design, as they create unnecessary hazards and risks. That being said, there are reasons for the use of check valves in some cases.

Many cases for a check valve can be replaced with a solenoid with ground power in the case of an umbilical, where the power could be provided through a magnetic electric cable that is disconnected in launch or via onboard power, among other solutions that do not restrict abort capabilities prior to takeoff. Solutions also include normally open valves that are powered closed at the time of umbilical release or the use of a piloted valve with similar function.

In the event a check valve is used for an umbilical connection the check valve must be capable of being opened with a rod from the outside of the rocket. No check valve may be used to seal the line after umbilical retraction that is not inline and actuatable through the connector. Putting a check valve on the other side of a 90 degree bend to save space is not acceptable.

5.4.5.3 - Plug in to Vent

In the event that a check valve or quick disconnect is used for an umbilical with a sealing fitting, there is a potential method of manual abort where a simplified connector similar to the umbilical arm can be manufactured to press open the check valve on the rocket. Such a jig can be made and given to FAR-OUT staff as a method of manual abort rather than having a manual valve or fitting. Only the umbilical quick connect check valve can be used and a manual plug can be provided to range personnel that when inserted holds the check valve open while the intervening staff can depart. The jig must have a 8-inch straight pipe attached that is insulated to allow manual insertion.

5.4.6 - Hold Time Requirements

Hold times, or the duration that FAR staff asks you to wait with a full pressurized ready to fire rocket are expected to be at least 10 minutes. If the skies remain clear and the winds remain low, we will have you fire when ready. In the event of a sudden gust of wind, unscheduled air traffic, or someone wandering into the exclusion zone, we would have you hold until the threat to a safe launch is removed. While being able to hold for 10 minutes is not a strict requirement, if a team is not able to meet this requirement then the team will be asked to partially recycle or fully abort in the case that a launch hold is ordered. If that forces a partial recycle to a lower pressure state that will be accommodated in time, but if that forces a full detanking then that is what will be ordered. Under no circumstance will a team launch during an ordered launch hold. We do not expect this kind of issue to persist for times exceeding 10 minutes. In the event that you are not able to hold at a ready state until the hazard has been cleared your team would have to abort your fill or transition to a less than ready state depending on the issue.

5.4.7 - Remote Abort Requirement

Remote abort systems are required for all team abort procedures. Systems outlined in 5.4.8 are not for team use. Teams must maintain the ability to remotely actuate the necessary valves to drain and depressurize all non-DOT rated flight tanks, fill lines and GSE up to the primary fill valve. To be clear this means the line between the supply bottle and main valve is allowed to still be pressurized. To return to a safe to approach state all oxidizers must be offloaded from the vehicle and any self pressurizing liquid or gaseous fuels.

5.4.7.1 - Dump Valve

A dump valve is a valve designed to allow flowing saturated liquid oxidizer through it to depart the rocket under the pressure in the oxidizer tank. This is accomplished by placing the dump valve at the bottom of the tank and plumbing the connector on the other side of the valve from the tank outside the airframe. In the event that the underside of the oxidizer tank is inaccessible due to its design, a top mounted dump valve is possible through the installation of siphon tube, where the pressure of the boiled off oxidizer or pressurant gas is sufficient to push the sat. liquid oxidizer up the siphon tube and out of the rocket. In the case of an unobstructed fill line through the combustion chamber such as in a UC valve hybrid the lowest point of the rocket side oxidizer tank pressure system is not actually on the rocket and it can be drained from the ground side dump valve on the fill line side of the fill valve. Your team is required to be able to quickly drain the liquid oxidizer from your rocket in the case of an abort which requires the removal of liquid oxidizer through the flow of the liquid out of the pressure vessel and not by boil off and gaseous removal.

The dump valve can not dump through the combustion chamber unless the dump line is sealed and plumbed from the combustion chamber and out of the nozzle. Actuation of a dump valve must always be able to be actuated independently of tank or fill state.

The effective orifice of any plumbing used for purging the tank must be in excess of the area of a single ⅛” diameter orifice for oxidizer tanks over 100mL, ¼” for oxidizer tanks over 2L, ⅜” for oxidizer tanks over than 10L, ½” for oxidizer tanks over 25 L commensurate with a discharge coefficient of at least 0.3. If you are unable to determine your discharge coefficient of your entire abort pathway use the orifice standards above. These dimensions are roughly set to meet the abort time requirements. This is repeated in multiple places to avoid any potential confusion.

5.4.7.2 - Vent Valve

A vent valve is a valve designed to lower the pressure of the oxidizer tank by allowing gasses to escape. A vent valve is not a primary abort valve. Generally its operation slows the rate of an abort by dropping the pressure over the liquid oxidizer slowing the flow rate out of a dump valve. In abort procedures the dump valve should be the primary abort valve until it fails or there is no liquid oxidizer left at which point both the dump and vent would be fully opened to quickly drain pressure. In the event of a dump valve freezing, the vent operation is needed to lower the pressure. This allows the chilling of the remaining liquid oxidizer during any manual intervention operation or for boil off if state detection of oxidizer mass shows a level that is minimal. Since the vent is used for venting gas, it is not subject to orifice sizing constraints. The size of your vent valve orifices is rather unique to your rocket and sized to prevent gas buildup and allow for adequate depressurization.

5.4.7.2 - Constricted Vent Fitting

For some designs, rather than incorporating an actuated valve to seal the onboard oxidizer tank, a vent constrictor is used to allow gasses to escape during the fill of saturated liquid in the flight tank. This constricted vent is tuned in the design process to allow for a fast fill and some amount of hold time before launch is required due to loss of pressure. The rocket can be topped off by the higher pressure mother bottle for some period of time, but the use of this style of vent constrictor allows for quick, less complicated operations. For the use of a constantly vented tank there is no requirement for a vent valve. The dump valve is still required.

5.4.7.3 - Pressure Relief Valve (PRV)

Any sealed system must have an automatically actuating pressure relief valve. The pressure at which this valve opens must be set at your MEOP. This valve can be as simple as a pressure relief poppet valve or even a burst disk. By choosing an actuation pressure below your designed MEOP it would actuate below your MEOP redefining your MEOP to the actuation pressure. The realities of finding COTS relief valves means that you might have to select a slightly different relief pressure than your design calls for. The important part is that by selecting this different relief pressure you are redefining the MEOP. By selecting an actuation pressure above a defined MEOP, pressure can climb to the release pressure and thus the Maximum Expected Pressure would be this set pressure. Therefore, you have to select a relief pressure near your defined maximum operating pressure for optimal operation of your engine.
If any actuated valve or a check valve closes part of your plumbing system, it is considered a separate system requiring pressure relief. Every segment of line or pressure vessel that can become separated is considered a closed system.

For vehicle mounted PRVs, it is imperative that the released gasses or liquids are plumbed out of the airframe. Venting into an airframe section is known to freeze internals which could lead to issues in abort operations.

5.4.8 - Manual Abort Requirement

This is a last-resort depressurization system for FAR staff to use only. The use of this valve will result in temporary grounding of the team's vehicle until GSE is demonstrated to be working nominally which may prevent that team from launching during the competition. Use of this valve by FAR staff will result in point deductions. Your system must not consider this as an acceptable failure mode. This is a last resort if all other systems fail and FAR staff is forced to drain your flight tanks. Failure to include this valve or even the line will result in massive point deductions and if not rectified it will lead to disqualification. The manual abort requirement exists for any section of your plumbing system that may become isolated in any phase of operations until the rocket is under thrust and has begun moving up the launch rail / tower. The rope must be attached to any manual valve remaining on the ground at the time your team leaves the tower. The line must be laid out on the ground and be able to be quickly attached to any system that would remain on the flight vehicle, so if necessary FAR-OUT staff can attach it quickly and retreat.

5.4.8.1 - Manual Relief Valve

If at any point in the operation of a launch vehicle and its ground support equipment, a section of the plumbing is isolated behind a valve or check valve for any amount of time, it is considered an isolated system. If that isolated system in time and flow has a working pressure less than 4 times that system's MEOP then it is required that it possesses a manual relief valve to depressurize it in the case that primary flow control fails to function nominally. If an umbilical is released using a sealed valve to seal behind it, that creates a closed system separate from the fill system. If a check valve is used in such a way that it seals off a manual relief device from the system it seals, then that system in that transient must have a manual relief device. All manual relief devices must be accessible from the outside of the rocket in its fully assembled state, such that no disassembly is required for its operation. The Manual Relief Device must be on the bottom of the oxidizer tank or connected to an internal siphon at the top of the tank (this is not a preferred location due to the need for a ladder). In the case of UC valve hybrid or umbilical hybrid without any flow restriction, such as a check valve that would prevent backflow in the opposite direction of fill, the manual relief device can be located off the rocket and this is a preferred method as it pulls safing staff off the rocket in the event of manual intervention. The effective orifice of any plumbing used for purging the tank must be in excess of the area of a single ⅛" diameter orifice for oxidizer tanks over 100mL, ¼" for oxidizer tanks over 2L, ⅜" for oxidizer tanks over than 10L, ½" for oxidizer tanks over 25 L commensurate with a discharge coefficient of at least 0.3. If you are unable to determine your discharge coefficient of your entire abort pathway use the orifice standards above. These dimensions are roughly set to meet the abort time requirements. This is repeated in multiple places to avoid any potential confusion.

A socket fitting plug on a T is an acceptable manual relief valve but not preferred. A manual ball valve with a carabiner attachment point is acceptable so long as a 250' rope can actuate it if pulled normal to the axis of the rocket and such rope and carabiner is provided to range safety prior to retreat for launch ops. A panel with no more than two bolts may be used to protect from the airstream only if a cordless driver with the proper bit and a magnetic parts tray is given to the range safety operation leader at the time prior to retreat for launch ops. Any other manual relief option suggested for approval requires quick intervention at the pad or preferably the GSE side of the setup followed by retreat and actuation. Pyro valves are an option as well, although building such a valve into your remote control system would be more effective. Failure to include this valve or even the line will result in massive point deductions and if not rectified it will lead to disqualification. The manual abort requirement exists for any section of your plumbing system that may become isolated in any phase of operations until the rocket is under thrust and has begun moving up the launch rail / tower.

In the case of liquid oxygen given the duty cycle of valves all LOX tanks must have a manual valve constantly open when not conducting filling or pressurization operations under red flag.

5.4.9 - Abort and Vent Plumbing for all Relief Devices

All dump and vent outlets must exit the airframe in such a manner that if they were capped they would hold pressure. Must be rated for MEOP. They must not be capped for flight. This could be accomplished by screwing in a pipe nipple to a female connection from the outside of the airframe. Drainage must be present at the bottom (lowest point) of all airframe sections that have oxidizer plumbing present to prevent pooling of liquid oxidizers on top of a baffle and further cooling of an airframe section, especially if it contains electronics or valves. Oxidizer plumbing must be separated from recovery bays to avoid filling a space with energetics (especially black powder) from experiencing enhanced yield or to prevent pressurization of a recovery bay potentially pneumatically opening it. If this requires moving through a tank wall above the pressure vessel then this must be present at the time of hydrotesting.

The average oxidizer flow rate during abort must be measured in testing, and data of this test must be provided to FAR-OUT staff. The effective orifice of any plumbing used for purging the tank must be in excess of the area of a single ⅛" diameter orifice for oxidizer tanks over 100mL, ¼" for oxidizer tanks over 2L, ⅜" for oxidizer tanks over than 10L, ½" for oxidizer tanks over 25 L commensurate with a discharge coefficient of at least 0.3. If you are unable to determine your discharge coefficient of your entire abort pathway use the orifice standards above. These dimensions are roughly set to meet the abort time requirements. This is repeated in multiple places to avoid any potential confusion.

5.4.10 - Nitrous Line Filters

Nitrous filters are not to be used in place of proper chemical hygiene nor as covers to exposed orifices. This rule is being introduced under an abundance of caution to prevent potential blockages and concentration of contaminants potentially depositing in the filter forming something similar to a catalytic bed.

5.4.11 - Liquids-Specific Filling Procedures

Loading with LOX is different from loading N2O. LOX can be loaded manually with people directly beside the loading procedure. A reliable procedure is to:

1. Move the LOX dewar into place, connect the transfer line to the LOX loading port valve assembly.
2. Open the LOX loading valve, at the LOX tank's bottom and open the LOX vent
3. The dewar liquid port valve is opened. LOX will start to flow. First, the lines and tank begin to chill down. Gas flows out the vent. Note that the tank mass is constantly being monitored. Once the lines and tank have cooled enough, liquid will begin to fill the tank.
4. When the tank is at a certain mass load the dewar valve is shut off.
5. The transfer hose is slightly loosened at the dewar. This loosening is ¼ to ¾ of a turn, no more.
6. Once the hose nut is loosened it is immediately retightened.
7. The LOX tank load valve is then shut.This traps the LOX in the transfer line.
8. As the LOX load valve is shut, the transfer line nut is unscrewed. This takes 3 complete turns.
9. The LOX in the hose flashes to gas. This sounds exciting but in reality, there is very little sound and almost no frosh seen in the air.
10. The transfer line is then disconnected from the LOX tank and stored.
11. The dewar is then moved to a safe distance.

At any point in the operation, loading can be stopped. The risks are low because the pressure in the tank during loading is 100 to 150 psi.

The process is similar to what every commercial LOX loading station uses. Typically additional LOX is loaded to give the loading crew time to disconnect and store equipment and leave the test stand area. All sensors are actively monitoring the load process continuously. After the loading crew is at a safe location, the test team waits for the LOX to boil off to the desired mass. For a typical system, the boiloff rate is 0.45 lb/min. Automated loading is not specifically needed to be safe. All loading personnel are trained using LN2. Loading rehearsals using LN2 ensure safe and efficient procedures as well as testing for sensor and control function.

For liquid motors that are not prefilled with a fuel that remains liquid up to 140 F, the ability to discharge the liquid propellant is required. For those that can remain stored onboard that is highly recommended until the unfired rocket can be taken off the pad. The discharge point must be 50' away from the discharge point for the oxidizer. If the fuel is gas at 90F it must be burnt off with a flare tower. If the fuel is liquid a miscible in a non flammable liquid like water and can be diluted below its proof concentration then a non pyrotechnic disposal is allowed. Examples: methane will have to be burnt off, ethanol or methanol can be diluted but it is preferred that it stays onboard, RP1 should remain on board but the use of a collection oil can would be acceptable.

5.4.12 - Other GSE Logistics

Teams must practice controlling their GSE at ranges equal or greater than 2000 ft. It is recommended that antennas for GSE radio antennas sit atop masts with heights at least 10 feet so shrubbery does not interfere with signals.Teams must also provide a fluid plumbing circuit diagram diagramming all valves, inlets, and outlets and their controls in their Technical Reports.

5.4.13 - Launch Rails

Teams are highly encouraged to bring their own launch rails. In the case that a team cannot bring their own launch rail, FAR does have several launch rails of different sizes that may suit your team depending on rocket size. Some of these launch rails require specific rail buttons, so please make sure to contact FAR for more information regarding the special requirements for using a particular rail. Not if you are using a FAR rail if you fail to launch you may have to remove your rocket from the rail and let another team attempt. For that reason, if you are using a FAR rail or tower make sure you have a portable GSe preferably on a cart or dolly that can be rolled out to the tower and rolled away to simply pad operations. Come early on Wednesday to reserve a FAR rail or tower for opening salvo on saturday. We will be conducting a survey or rail usage in your entry form and will coordinate use of each rail type with teams long before competition. For smaller rockets the ability to use either 1010 or 1515 rails will increase your flexibility.

Available launch towers at FAR: https://friendsofamateurrocketry.org/launchers/
Quick reference of available launchers:
x4 10’ 1010 Rail
x2 10’ 1515 Rail
x2 20 1515 Rail
x1 Adjustable Tower 48” by 48” by 20’
x1 T Slot 60’ Rail (~20m not a typo)

Team rails must be equipped with a blast deflector or absorber utilizing a trough of water to catch any igniter preventing it from bouncing off the deflector pad and starting a fire outside of your engine. Blast deflectors will deflect exhaust between 10ºNofW and 10ºEofS. Exhaust should not be deflected past these bearings

Team provided launchers must be able to angle in elevation of 0-5º of Vertical with azimuth +-20 degrees of slots for teams will be 40’ squares laid out With NS and WE demarcation lines

5.5 - Electronics

Rocket electronics include any GPS and altimeter components. All rockets must have at least one COTS GPS and one COTS altimeter. This COTS altimeter will be used for altitude determination.

5.5.1 - GPS Requirements

For GPS, a COTS system must be used to determine the position from the designated touchdown point. More than one system may be used but all frequencies must be identified, and if necessary, a properly licensed individual must be available at the launch site for frequencies requiring an FCC license. A GPS is required for each separately recovered section of the launch vehicle. If a team is unable to bring someone with the proper FCC license they must use a GPS system using the ISM band, preferably the 900 MHz ISM band. Teams must practice pulling telemetry off their rockets at ranges equal or greater than 40% greater than their expected apogee. Category C flights require GPS altitude recording for scoring as barometric based systems are not accurate enough above 60,000'.

Acceptable systems include:

Manufacturer	GPS Tracker	Frequency	Maximum Functional Altitude for tracking [ft] (Categories Approved for altitude determination)	Link	Unit Cost
Multitronix	Kate 1/3	900MHz Variable ISM	550,000 LOS A, B, C, HI-EXH	https://www.multitronix.com/kate-3-transmitter.html	$1440 + $1525 GPS Receiver
Featherweight	GPS	900MHz Variable ISM	262,500 LOS, Relay A, B, C, HI-EXH	Featherweight GPS Tracker - Featherweight Altimeters	$165 + $190 GPS ground station
Missileworks	RTx/GPS	900MHz Variable ISM	160,042 A,B,C, LO-EXH	RTx (missileworks.com)	$200 + $200 Base Station $90 Logging no transmission
	RTx/GPS Logger	None	160,042 A,B,C, LO-EXH Only for Alt Determination not tracking	RTx (missileworks.com)	$90
	T3	Baro	160,042 A,B,C, LO-EXH	T3 (missileworks.com)	$160/$200 + $140 Base Station
Eggtimer	Eggfinder TX	900 MHz ISM	Final Position Only not for Altitude determination	Eggfinder GPS Tracking System | Eggtimer Rocketry	$70 + $35⁺ Receiver
	EggFinder Mini	900 MHz ISM	Final Position Only not for Altitude determination	Eggfinder GPS Tracking System | Eggtimer Rocketry	$75 + $35⁺ Receiver
	Quasar	900 MHz ISm 869 MHz Or 70 cm HAM	Final Position Only not for Altitude determination	Altimeters & AV Bay Stuff | Eggtimer Rocketry	$100
Big Red Bee	2m 5W APRS	2m HAM	Final Position Only not for Altitude determination	Documentation and Programming Utilities – BigRedBee	$265 + $119 Receiver
	70cm	70cm HAM	Final Position Only not for	Documentation and	$259 + $119

	100mW GPS/APRS		Altitude determination	Programming Utilities – BigRedBee	Receiver
	BRB Iridium SBD	Iridium NLOS	Final Position Only not for Altitude determination	Documentation and Programming Utilities – BigRedBee	$409+ Data plan
Entacore	Aim XTRA	70cm HAM	100,000 A,B, C	AIM XTRA GPS flight computer | Entacore Electronics- Advanced GPS tracking flight computer / rocket altimeter.	$325 + $125 Base Station

Other GPS units can be approved if it is deemed a viable option.

5.5.2 - Specifying Team Frequencies

After the third Progress Update, teams will specify their tracker frequencies. Teams may be told to change frequency to a different channel if there is overlap. Final frequencies will be posted in the Discord channel for all teams' awareness and will be displayed on a board at competition.

5.5.3 - Flight Computer Requirements

For altitude determination, two systems are required to be functioning at the time of launch, determine the flight's apogee and initiate recovery events. At least one COTS altimeter must be used and functioning at the time of launch. Altitude determination will be made by the average of the COTS altimeter measured altitudes recorded during flight. Barometric / Accelerometer altitudes within the same altimeter will be averaged before being averaged between altimeters. Teams must be able to disarm altimeters from the outside of the rocket while it is still vertical. This may involve a ladder which your team is obligated to bring if the switch cannot be reached by the second tallest member of your team attending the competition. This is in case something happens to the tallest. Altimeters must be armed once the rocket is vertical and before igniter leads are connected.

Category A and B can use altimeters and/or GPS Report all COTS systems and we will average them for determined altitude.

Examples of acceptable systems include
Category Deployment Altimeter altitude recommendations for allowable altitudes given in MSL (AGL at FAR - MSL -2kft)

Manufacturer	Deployment Altimeter	Measurement Method	Maximum Functional Altitude for deployment [ft] (Categories Approved for deployment and conditions)	Link	Unit Cost
Multitronix	Kate 1/3	GPS / Acc/ Baro	550,000 A, B, C, HI-EXH	https://www.multitronix.com/kate-3-transmitter.html	$1440 + $1525 GPS

					Receiver
Featherweight	Blue Raven	Baro / Acc	105,000 A,B,C Condition[1]	https://www.featherweightaltimeters.com/store/p25/Blue_Raven_Permalink.html	$175
	Raven 4	Baro / Acc	105,000 A,B,C Conditional[2]	https://www.featherweightaltimeters.com/raven-altimeter.html	Legacy
Perfectflite	SLCF	Baro	100,000 A,B,C Conditional[3]	http://perfectflite.com/SLCF.html	$60
	SL100	Baro	100,000 A,B,C Conditional[4]	http://perfectflite.com/sl100.html	Legacy
MissileWorks	RRC3x	Baro	100,000 A,B,C	RRC3 Altimeter Xtreme - Madcow Rocketry	$88
	RRC3 Sport	Baro	40,000 A,B	RRC3 (missileworks.com)	$80
	RRC2+	Baro	40,000 A,B	RRC2+ (missileworks.com)	$55
Eggtimer	Quasar	Baro	60,000 A,B, Low C Conditional[5]	Altimeters & AV Bay Stuff | Eggtimer Rocketry	$100
	Proton	Baro	60,000 A,B, Low C Conditional[6]	Altimeters & AV Bay Stuff | Eggtimer Rocketry	$80
	Quantum	Baro	60,000 A,B, Low C Conditional[7]	Altimeters & AV Bay Stuff | Eggtimer Rocketry	$40
	Quark	Baro	60,000 A,B, Low C Conditional[8]	Altimeters & AV Bay Stuff | Eggtimer Rocketry	$20

[1] Must apply a dab of epoxy under capacitor to prevent capacitor from twisting or bending off board in high g flight
[2] See 1
[3] See 1
[4] See 1
[5] Since these are kits assembled by the customer. Teams must conduct a vacuum chamber test or full flight test with another altimeter from the list to compare pressure data curves and ensure deployment relays work.
[6] See 5
[7] See 5
[8] See 5

Entacore	Aim XTRA	GPS/Acc/Baro	100,000 A,B,C	AIM XTRA GPS flight computer | Entacore Electronics- Advanced GPS tracking flight computer / rocket altimeter.	$325 + $125 Base Station
	AIM USB	Baro	38,000 A,B	AIM USB Rocket Altimeter | Entacore Electronics- High reliability dual ejection rocket altimeter.	$115
Rocketronics	Altamax G4	Baro / Acc	102,000 A,B,C	Altimax G4 Altimeter for model rockets (rocketronics.de)	$105
MARSA	MARSA4, MARSA54, MARSA54L	Baro / Acc	Limited Documentation A, B	https://onebadhawk.com/marsa-systems.html	$199-$219

Other altimeters can be approved if it is deemed a viable option.

Research altimeters are highly encouraged, but cannot be used as a primary or for altitude determination. Ideally, these should be flight-tested prior to competition on a smaller rocket if possible.

5.5.4 - GPS Flight Data for Backup Scoring

In the case of unsuccessful recovery where altimeter data cannot be read, GPS data can be used as a backup for assessment of motor performance points only. GPS altitude will not be publicly recorded, but it will be hidden in the scoring sheet so a score is still calculated. This number will be modified according to the following rules so no points are given to contract apogee or simulation precision. In this case, there are three scenarios which can arise (in this case, the scorable “contract apogee region” ranges from 50% of the contract apogee to 150% of the contract apogee):

- If the GPS data is below the minimum altitude where contract apogee points would begin to be given, the GPS data will be used. i.e. if a rocket’s contract apogee is 100 feet, altimeter data is lost, but the GPS says it went 10 feet, it will be considered 10 feet for scoring purposes.
- If the GPS data is above the minimum altitude where contract apogee points but below the simulated altitude would be given, the lowest threshold of the contract altitude region will be used. i.e. if a rocket’s contract apogee is 100 feet, altimeter data is lost, but the GPS says it went 80 feet, it will be considered 50 feet for scoring purposes.
- If the flight overperformed the simulated altitude for scoring, the top of the contract apogee region would be used. i.e. if a rocket’s contract apogee is 100 feet, altimeter data is lost, but the GPS says it went 10,000 feet(!!!), it will be considered 150 feet for scoring purposes.

5.5.5 - Wiring and Switch Requirements

In order to give your team the ability to change out electronics in case something fails and to ease assembly. Teams should make cable management a priority. Wiring and switches must be secured to prevent pull out during launch and recovery events. During parachute release and boost your rocket will experience high-G loads which can tear out wiring or toggle switches that are not secured in their ON positions. Teams must ensure that switches will remain armed during flight and not accidently turn off during flight events.

For exterior wire harnesses potentially connecting an abort valve to a control board placed forward of the propellant tanks or otherwise, they must be protected and secured from abrasion along the tower and from airflow. In the event of a severed exterior wire harness, the attached electrical control system must fail in a way that there is no effect outside the now-isolated bay. Any now-isolated board should detect this loss of connection and automatically abort.

The primary COTS flight computer must have a truly independent electrical circuit. No electric match may be shared with any other deployment device. The CO2 or black powder ejection system to be activated by the COTS system shall not be shared with any other deployment device. Any remote disarming switch for the COTS flight computer shall be solely used for that COTS flight computer. The power supply and switching for the COTS flight computer cannot be shared with any other avionics.

5.6 - Recovery

Two-phase recovery is required. A drogue parachute or other first stage recovery system must be activated to keep the descent velocity between 50 and 150 ft/s below 30,000’. Due to low pressure at high altitude a inflated drogue may have a higher descent rate. The activation or deployment of the first system must happen at apogee to prevent the rocket from passing 150 ft/s on descent under 30,000’. At some point during descent below ⅓ of the target altitude and above 1000 ft above ground level, the descending velocity must be lowered to below 30 ft/s. Main openings or descent retardation below 50 ft/s occurring above ⅓ of the target altitude will be considered to be premature and teams will lose recovery points due to the likelihood of leaving the field.

5.6.1 Traditional Parachute-Based Recovery

We highly recommend traditional parachute-based recovery systems. The majority of flight failures occur in recovery and generally speaking it is better to keep recovery simple if so many of your points directly or indirectly rely on your rocket being recovered successfully.

https://docs.google.com/spreadsheets/d/1LE_d95PaHsUiwQnRAvsjZpDDBTU7H9Bp5S6zsbRvEoI/edit?usp=sharing is a new recovery calculator. It has a parachute calculator, an ejection charge calculator, working load table, and minimum parachute size recommendation table. The descent rate tab has two tables of drogue descent and rocket mass for 20fps and 30fps touchdown. The recovery hardware table is color coded for 500 lb (paracord), 1500 lb moderate swivel ratings, 3000 pound and 8000 pound which is the largest hardware we have been able to find. Red requires custom hardware that will likely not be produceable.

5.6.1.1 Recovery Material Restrictions

Recovery hardware must be chosen to withstand the load from the main parachute opening which can be calculated by the quadratic drag equation. A safety factor of at least two must be applied to the calculated drag force when the main parachute is fully open calculated at the velocity predicted equal to the simulated descent velocity under drogue.

5.6.1.1.1 Eye bolts, eye nuts and U bolts

Eye bolts must be the fully closed type, either welded or cast. U bolts are preferred over eye bolts due to their higher loading capacity than an eyebolt due to the distribution of forces under shock loading. The plate that distributes the load across the bulkhead must be used to distribute the shock load for the U bolt while reducing the chance of tearout. In the case of eye bolts, washers should be used to help distribute shock loads. Removable thread locker should be used on the nuts.

5.6.1.1.2 Quick Links

Quick links should be the barrel type; carabiners with swing arms are not allowed. Safety wire should be used to prevent spin out. Soft Kevlar quick links can be used as well when their load rating is appropriate.

5.6.1.1.3 Swivels

Swivels save rockets. A swivel should be present on each parachute. A swivel should be present on every shock cord or recovery harness. These prevent rotational forces from spinning parachutes closed and from spinning open quick links.

5.6.1.1.4 Shock Cords and Recovery Harnesses

Shock cords or recovery harnesses must be rated to withstand more than the failure loads of the above mentioned recovery hardware. Elastic is not an appropriate material for a shock cord given the weight of these rockets. Nylon harnesses are cheap and strong but they are not fire retardant. Sufficient fire retardant material such as aramid (Nomex or Kevlar) sheathing is needed to prevent burn through of nylon harnesses. Nylon is also more elastic than Kevlar so it is less likely to zipper the airframe. Kevlar is expensive, fireproof, incredibly strong and rigid. It can zipper the airframe but yield a highly desirable strength to weight. Tubular Kevlar and tubular nylon provide significant strength improvements over flat ribbon and should be sought out.

Knots in such material are believed to reduce the load capacity of these harnesses by a factor of two but that may be suitable for your design. It is recommended that attachment points on these harnesses are sewn on with sufficient Kevlar thread to handle hard openings. In case of stitch failure, quick links should be attached so that the main harness and not the sewn loop run through the quick link, such that the quick link should remain on the harness.

5.6.1.1.5 Flame Protection

Aramid (Kevlar, Nomex, etc.) blankets, deployment bags and sheathing are highly recommended for protecting harnesses and parachutes from the heat of black powder charges. Note that such insulation can also help with humid parachutes being frozen by CO_2 ejection systems. In the case of the smallest possible competitive rockets in the 5,000’ to 15,000’ category the use of dogbarf (cellulosic insulation treated with a flame retardant that looks like a flakey gray substance hence the name) may be appropriate, cost effective, and simple to use. The use of deployment bags helps the deployment of parachutes and minimizes the complexity of parachute packing or folding. The use of baby powder helps prevent moisture build up and helps lubricate the parachutes.

5.6.1.1.6 Parachute Materials

Generally speaking, COTS parachutes should be used. If your team wants to design or build their own parachutes, again they have to be tested. This doesn't necessarily have to be done with a rocket; teams have had success dropping test articles out of balloons, planes and helicopters. There are a variety of materials that can be used but generally ripstop materials that have stronger sticking in a grid pattern prevent ripping across the entire canopy in shock loading. Dynema and nylon make great materials for the canopy. There are flame retardant and slippery coatings that are sometimes applied to these to facilitate opening. Your canopy must be designed to handle the pressure spike on opening and properly distribute that load into tension in the gores, lines and/or risers into the attachment point. These lines need to be able to handle uneven loading and a safety factor here should be applied otherwise a cascading failure of lines could snap all of your lines.

5.6.1.2 Single Bay Dual Deployment

Single bay deployment systems run several risks but are the most compact recovery systems short of hard lithobraking. They generally require the binding of the main chute such that the main canopy is either not exposed to the airstream or so it cannot open. These systems, COTS or research, should be rigorously tested by your team. All pressurization systems for opening parachute bays must have fully redundant systems with separately wired altimeter flight computers to separate e-matches to separate black powder charges or CO_2 systems.

5.6.1.2.1 Reefed Parachutes

Reefed parachutes in this section refer to actuated reefing systems. Passive systems consisting of a steel ring around the gores and lines of a standard parachute above the swivel that is slid to the bottom of the canopy are a great addition to a recovery system. Upon opening the main canopy, this temporarily cinches the lines' attachment points to the canopy together. This forms a sphere out of the canopy such that it acts like a ballute. Once your rocket slows down, the force on this ring decreases and the ring falls slowly down the lines, allowing the parachute to open wider and wider increasing the drag gradually. It is a great countermeasure for hard openings due to drogue failure or drogue-less descent.

Actuated reefing systems tend to use a reefing wire and some sort of release mechanism that loosens that wire allowing the parachute to fully open. This can be pyro-activated or servo-actuated. Many such systems have been implemented. These systems have to be tested but provide excellent benefits in weight and space savings.

5.6.1.2.2 Tender Descenders

For a general overview of what a Tender Descender is see the manual for non-redundant use below.
https://www.tinderrocketry.com/_files/ugd/b73de9_78a48252cb114335b9f6b4da4e9f292a.pdf
For this competition and many others critical recovery hardware has to be redundant. Tender Descenders can be made redundant by using them in parallel or in series. The series solution is the easiest to understand as one device is connected to the next in series and so long as one fires the parachute will be released. The parallel method uses a strap between each Tender Descender with both devices connected on the other end to an eye bolt or U bolt at the other end of each device. Around the strap is the restraining loop for the harness length holding in the main parachute. In the event only one device fires, the strap is released on one end releasing the harness. If both fire it releases the strap. For this device it is important to make sure it does not fall free and such that the sliding lock is attached to the central

chargewell by kevlar string through the loop attached to the eyebolt. Many placements of these devices retrain the parachute against a bulkhead preventing exposure of a deployment bag to the air stream. This shortens the length of the required e-matches to set them off. The shortening of these lengths reduces the chance of tearout during descent under drogue which can be chaotic and violent. These are mechanical linkages that can rub against each other quite a bit and that can also tear out the matches.

5.6.1.2.3 Line Cutters

Line cutters are simple pyro-actuated guillotines that cut zip ties (cable straps) holding the parachute closed. Redundancy is simple: you add more. The issue lies with the placement of the main parachute on the harness and its distance from the electronics bay that fires the e-matches in these devices. When the harness goes tight e-match can get ripped out, so sufficient slack is required. Sometimes the e-match wires are run up the the center of a tubular nylon or kevlar harness to keep them from winding up in a rotating rocket or being jerked out of the terminals. Placement of e-matches is the most common failure mode of this system.

5.6.1.2.4 AARD

The Rattworks Advanced Retention Release Device cannot be beat. They can also be made yourselves if they cannot be accessed. It works quickly and can handle extreme loads. It can be used either with or without pyrotechnics. See link below for a picture and either try to get your hands on one or make one. Everything else in this section is less reliable.
https://aeroconsystems.com/cart/launch-recovery/rattworks-aard-advanced-retention-release-device/

5.6.1.2.5 Jolly Logic Chute Release

These systems are highly reliable for small rockets less than 15 pounds. Between 15 and 25 pounds there is a significant probability of the parachute being ripped out of the elastic bands. After 20 pounds of rocket weight it is almost guaranteed. High cross-range velocities at apogee will rip off the main from this device. It is easy to add these together in series to make an effective main parachute retention system for small rockets. This will not be allowed on any rocket whose prefill weight exceeds 15 pounds. It is not outright banned as it is possible to compete with a rocket of this weight and they can be used in the recovery of ejected payloads.

5.6.1.3 Dual Bay Dual Deployment

This is the easy method that everyone tells you to do because it is simple and it works. It is not space-efficient but it doesn't really matter if you change your contract altitude to what works for your motor. The added benefit of this is that your local RSO will suggest that you do this regardless of what dual deployment system you choose. One thing to consider is that an aggressive firing of the charge in the drogue bay can hammer open the main. You need to test your recovery system with a fully weighted rocket horizontally on the ground to make sure this doesn’t happen. All pressurization systems for opening parachute bays must have fully redundant systems with separately wired altimeter flight computers to separate e-matches to separate black powder charges or CO_2 systems. Make sure that the drogue charges from each altimeter only go to the drogue recovery bay and the main charges only go to the main recovery bay. If you are sarcastically singing “the leg bone is connected to the leg bone” because you think this is pedantic you have no idea how many times this has been done by teams in a hurry and we wish to spare you of this embarrassment.

5.6.1.4 Auxiliary and Backup Recovery Systems

If a team wishes to add a second parachute or parachute system in case of failure of the primary canopy or just wants more redundancy that is allowed but largely unnecessary. This is a design choice and a safer one but it adds unnecessary complexity, weight, and cost.

5.6.2 Unconventional Recovery

Unconventional recovery systems will be reviewed by the judges on a case-by-case basis, however they are in general not recommended due to being complicated, risky, or against the regulations of the competition.

5.6.2.1 Gliders and Steerable Parachutes

Regardless of whether glider recovery is used for the payload, any part of your rocket or the entire rocket, you must maintain control over the entire descent. There is a dry lakebed in the waiver, and gliders must land there due west of the launch pads. Touchdown velocity must be lower than 30 ft/s. Aerodynamic surfaces designed for glide must be tucked away in a fairing so they do not deploy during ascent.

5.6.2.2 Propulsive Landing

Propulsive landing could be accommodated with extensive testing. We highly encourage you to develop such a system over many years before attempting this at a competition. This would require in depth conversations and permissions, but we will not outright ban it.

5.6.2.3 Aerobraking or Drogue-less Descents

For airframes that separate near the center of the rocket, it is often observed that due to tumbling a drogue parachute is not required prior to main opening. We cannot simulate the chaotic motion of such a descent. Consequently if a flight test is performed in this manner and the drogue-less descent is observed fully below 150 ft/s and the main parachute successfully deploys without damage to any part of the recovery system it will be allowed. It is recommended that this is attempted first with a subscale vehicle. Rockets have been designed after motor burnout to fall more or less flat. This can aid in aerobraking and dropping the descent rate in the initial descent but will not suffice for producing a safe touch-down speed. Such belly-flop maneuvers are common in lower density long rockets with lower cg’s that are common with simple hybrid rockets without significant payload mass above the lower airframe. This might be observed with an ejected payload. Deployed aero-control surfaces such as speed brakes or canards can move up CP to help a rocket fall flatter.

5.6.2.4 Primary Lithobraking

Lithobraking as a primary recovery method is not allowed. Hard lithobraking will occur if all other recovery methods fail, likely resulting in shovel recovery. Teams will not receive points for this type of recovery. Teams will not receive altitude-based points unless altimeter data is retrieved from a COTS altimeter. It may be beneficial to design a protective housing to maximize the survivability of a COTS altimeter without impairing its function. To clarify this means that these altimeters have proper air sampling while having a load bearing breathable crash cage around it. Data recovered after competition will not be updated resulting in score changes if the data is not readily extractable at check in. In the event of a failed belly-flop maneuver that has failed to deploy the main parachute, the rocket generally breaks up upon impact but more electronics survive internally because of the slower descent velocity. This is also much more preferential than the traditional ballistic lawn dart, involving a rapidly accelerating descent.

5.6.2.5 Final Lithobraking

Eventually all returning rockets lithobrake. To do this safely trajectories must be designed to impact no greater than 30 ft/s. It is highly recommended that rockets do not impact greater than 20 ft/s. Your rocket should be designed to handle impact trajectories in excess of your intended landing speed. Impacts greater than 30 ft/s will be considered a hard landing regardless of damage. A team could even possibly add landing legs to cushion the impact.

5.6.2.6 Into the Wild Blue Yonder - Losing Your Rocket is Sad!

Slender high mass fraction rockets have been known to disappear. If not found by a team by the end of the competition it will be assumed to be lost and gone forever with an uncertainty of whether it left the waiver. Consequences of leaving any waiver are not good. Without knowing any details about your rocket, we would not be able to assign any points. If as a parting message we received bits of video on ascent before telemetry was lost we would grant video points. There are obviously not that many points that can be awarded without a returned rocket. Analogous to the Spartans, your rocket comes back on its recovery system, with its recovery system (as pieces get wrapped up in it as it's dragged across the desert floor), or not at all.

5.7 - Testing

There are several tests outlined below that must be followed. If your team wishes to implement a new design or some other system not outlined in the document, first ask if we had forgotten to include it and if there is anything that would strictly prohibit implementation or pose a significant safety risk. If a decision is made to implement you must test adequately that such a system to prove it will work and that it will be safe.

5.7.1 - Hydrostatic Testing

All pressurized systems must also be hydrostatically tested to a minimum of 1.5x (2x if people present at fill) the maximum expected operating pressure (MEOP). Tanks must be designed beyond a safety factor of 2 for burst pressure (4x if people are present). This can be accomplished via a hydraulic pump or through regulated flow of high pressure gas with all research components filled with water.

5.7.2 - Static Testing

For research motors, at least one full-scale (full-load, full-pressure, with flight hardware that is to be flown at competition) test fire must be completed by the May Progress Update, with more at teams' discretion. If a team shows up with an untested motor to the competition they will not be able to fly or compete.

Thrust data for full burn duration is required for any flight motor. We highly recommend pressure taps for motor diagnostic reasons but they are not necessary. If you take the data please submit it with the thrust data so we can better understand your engine.

Prior to static test teams should test their igniter and preheater outside of the engine to ensure it works. A sample preheater and igniter must be brought to competition for batch testing of what the team intends to use to light their engine. This will insure that the preheater and igniters for your flight will work preventing delays and aborted flights.

If static testing reveals that the engine is underperforming but will result in a safe flight the thrust curve for the lower performance must be used for calculations for rail exit velocity and stability as that indicates the worst case. Altitude determination should be based on your expected performance except in the case of Monday launches, where the best performance, theoretical or tested, has to be used to make sure the waiver is not exceeded.

5.7.3 - Assistance with Static Testing

If the team's test site is not open before this time, please reach out to FAR staff to see if we can help you find a site to test your motor. Otherwise, teams should work to secure a test site and stand. Teams will be welcome to come to FAR in the weeks and months prior to the competition on a regular FAR day to run a test of their motor, If a team is having trouble locating a testing site the FAR team will help to point out local options as well. Teams helping other teams test will be rewarded for sportsmanship.

Available static test stands at FAR: https://friendsofamateurrocketry.org/static-stands/

5.7.4 - GSE Testing

At a bare minimum the GSE must include ways to remotely fill the motor, remotely dump the motor, ignite the motor, and indicate the fill level of propellants. GSE must successfully demonstrate the required functionality in one of the following ways:

1). A full wet dress rehearsal with the GSE to be used at competition.
2). A static fire of their competition engine using their competition GSE.
3). A flight test of their rocket using their competition GSE.

The entire GSE testing process and tower assembly, mounting of the rocket and erection shall be recorded or live stream and posted on youtube so our safety personnel can look for potential issues.This shall be done prior to the withdrawal deadline of April 15th. If your team cannot launch the rocket should be put into a flight position and secured to a rail or tree with ratchet straps with everything setup. This provides the team with valuable practice for setting up their system and helps identify potential problem areas in pre-launch procedures.

Teams in Category B that do not launch on the last day of Category B and C launches (Sunday) can decrease their fill state if their fill monitoring system has been tested to be accurate within 10% of oxidizer mass with are target altitude less than 15,000 ft, if the altitude and fill state are within the safe operational envelope given to FAR-OUT staff. Category C teams may not use this decreased fill state method for a Monday launch. It is unlikely that a team in the higher end of Category B would be able to safely use this method as well but for teams targeting altitudes near 20,000 ft with sufficient fill state detection this may be an option if the flight is delayed.

5.7.5 - Electronics Testing

Teams are strongly recommended to perform tests on all recovery and tracking electronics, both research and COTS. Recovery electronics should demonstrate the ability to fire an electronic match or power parachute ejection charges. Tracking electronics should be tested in a “Fox Hunt” in which the tracker is hidden at some distance up to the expected recovery distance and other members of the team attempt to locate the device. Other recommended tests include endurance testing to see how long electronics can operate while idle on the pad as well as how long after launch trackers will be able to communicate. Teams must practice pulling telemetry off their rockets at ranges equal or greater than 40% greater than their expected apogee.Teams must practice controlling their GSE at ranges equal or greater than 2000 ft. It is recommended that antennas for GSE radio antennas sit atop masts with heights at least 10 feet so shrubbery does not interfere with signals.

5.7.6 - Abort Testing

An Abort test must be made from a full tank after a ten minute hold or quoted maximum hold time. This can be made after a failed ignition in a failed static fire or with an oxidizer simulant. If multiple failed static fires occur be sure to test primary and secondary abort systems.

5.7.7 - Cold Gas Thrust Measurement

Determine the thrust your engine would experience if the run valve was opened without ignition. This can be done with a cold flow test with CO_2 but an ignition failure resulting in dumping the entire tank in a static test will suffice. Determine whether the duration of the blow down would get your rocket to an altitude above 400’ where COTS flight computers would set off deployment charges.

5.7.8 - Valve Testing

All valves need to be tested; they can be tested statically with the intended pressurant or a simulant on a bench top (although not in the building) with proper safety procedures based on the working pressure and temperature of the testing jig.

5.7.8.1 - Duty Cycle / Hold Time Requirement

Hold time refers to the time that a monostable valve, either normally closed or open, can hold a desired position when actuated. For electrically actuated valves, this is determined by the time the valve can remain energized without the changing position. In the case of a solenoid valve, this is the time it can be held in its energized state without the coil burning up. In the case of a piloted valve, which includes a solenoid actuated pilot valve and a pneumatically actuated main valve, this is the time that the pilot valve can be energized to supply pneumatic pressure that holds the main valve in the open position. Some valves have long hold times and bistable valves can hold their last actuated position indefinitely. Normally closed Dump and Vent Valves must have a hold open time and normally open Emergency Vent Valves must have a hold closed time of 3 times the abort time or operational time whichever is more. Normally closed Fill Valves must have a hold open time of 2 times the fill time or operational time whichever is more. Normally closed Run valves must have a hold open time of 10 times the run time but remember the run time of your engines tends to be very quick.

5.7.8.2 - Experimental Valve Testing

Experimental valves offer many advantages including mass reduction, high flow rates, fast opening, etc. Experimental valves should be tested for discharge coefficient to help diagnose potential thrust reduction in tests or to give accurate figures for engine simulations. Because of the criticality of flight and abort valves and the safety of the entire launch system, experimental valve testing requires a demonstrated probability of failure below 5% with at least 20 benchtop test cycles without changing the test setup. If a test cycle fails and it is determined that procedures or mechanical changes are needed for operation, a minimum of 20 tests will be repeated. These are for valve actuation tests, not full pressurant tests. These tests must be performed at 1.5 MEOP, and propellant temperature used in your system. Additionally, low-pressure tests can be performed to help diagnose low risk issues like low-pressure leaks from improperly seating sealing surfaces.

5.7.9 - Flight Testing

It is strongly recommended when possible that teams perform a flight test of their rocket, electronics, motor and payload. This is not a strict requirement but can alleviate doubts in the quality of construction and or launch procedures. Subsystems can be tested on rockets other than your competition vehicle if the fields in your vicinity do not have the necessary COA's for the altitude of your flight or if your engine does not conform to the rules of the fields nearby.

5.7.10 - Operational Envelope

Teams must define the operational ranges their engines can launch under in terms of fill percentage and oxidizer pressure.

An unsafe combination of fill state and pressure is defined as a launch condition that is either:

1. Under requirements for rail exit velocity
2. Under requirements for stability
3. Under the minimum altitude for altimeters to register a launch

This data should be organized into a table of expected altitude and rail exit velocity for fill state and pressure of your oxidizer tank. The team might even want to keep a few different charts with wind speeds to help with altitude determination for scoring.

PART 6: COMPETITION

6.1 - Attendee Types

There are several types of permitted attendees, and everyone who will be attending the competition will be required to wear a badge identifying their attendance type. Any attending team member will be required to pay a Rocketeer Fee of $60, though these are split by type. Otherwise, Spectator Fees will be available for non-team-affiliated spectators. More information on fees is found in the "Explanation of Fees" document on the FAR-OUT website.

6.1.1 - Onsite Badges

All attendees are required to wear a badge or other identification at all times while attending the competition. Failure to wear a badge could result in infractions for teams or a request to leave for spectators.

6.1.2 - Critical Flight Personnel

Critical Flight Personnel are team members who will be allowed under RED FLAG to the site. This falls under the Rocketeer Fee category for payment purposes, and of the Rocketeer Fees that the team purchases, the first 10 will be of this type.

6.1.3 - Priority Rocketeers

Priority Rocketeers are team members who will be allowed under YELLOW FLAG to the site and who must evacuate at red flag. This falls under the Rocketeer Fee category for payment purposes, and after the Critical Flight Personnel, the next 15 badges will be of this type. These badges are not linked to anyone's name so these can be passed around the team as-needed to have proper personnel working on GSE during a YELLOW FLAG period prior to a salvo.

6.1.4 - General Rocketeers

General Rocketeers are team members who are allowed at the site but must evacuate at YELLOW FLAG. There is no limit to how many numbers this will be, and should be the rest of the team members attending.

6.1.5 - Spectators

Teams are more than welcome to bring friends and family who do not work on the rockets, who will have to pay a Spectator Fee of $10 a day, If over 18 and attendance is free ages 12-18. No more than one child under 12 per adult is allowed; rockets can be dangerous and we want to limit the amount of small children close to them. Every Spectator is required to have a Spectator tag or badge for identification purposes. Further explanation of this fee is in “Explanation of Fees” on the FAR website.

6.1.6 - Badge Swapping

The above-mentioned badges are not linked to anyone's name so these can and should be passed around the team as-needed to have proper personnel arming their rocket and GSE for flight. Each member must have a badge at all times.

6.2 - Escorting Spectators to Rockets

When avionics and engines are unarmed during a GREEN FLAG, during non-flight operations spectators will be allowed to watch from the shelter areas. For safety purposes, spectators may proceed to the rockets only if escorted by a properly-badged Rocketeer. Only a Rocketeer from a given team may escort visitors to that team for touring. This prevents spectators from disturbing flight operations. We would recommend no more than 3 spectators per student for crowd control. Small groups will be easier to manage. If the attention of the badged rocketeer is required elsewhere the badged rocketeer must return the spectator to the spectator area. This will be permitted so long as the launch preparation area is not overly crowded.

6.3 - FAR Launch Prep Personnel Limits

If the total number of persons in the launch prep area passes 200, first Spectators will be removed from the launch area to the spectator area downrange to facilitate team operations. If the total number of rocketeers somehow passes 200 spectators will be fully restricted to the downrange spectator area. Teams will be asked first to relocate recovery teams and non-essentials downrange to set up secondary tents for tracking or prepositioning recovery teams. If the overcrowding problem persists then teams will be capped at 25 people down range at any given time. Those allowed down range will be the Critical Flight Personnel and Priority Rocketeers only. We don't foresee this overpopulation issue to become a problem given historical team sizes. We highly recommend friends and family wanting to see the rockets visit the pads during the setup days when the number of personnel on site will probably be minimized. Without overcrowding all rocketeers will be allowed at the launch prep area.

6.4 - Safety at Competition

The competition will be held at Friends of Amateur Rocketry, a launch site in the Mojave Desert in California (details found in Section 1). There are several environmental risks that teams could potentially face during the length of the competition. This includes but is not limited to dehydration, heat exhaustion, energetics and other rocket-related injuries, interactions with flora and fauna, and other injuries. There will be some staff on-site who will be first aid-trained and available to help but teams should be primarily providing assistance in cases of minor injuries and teams should bring their own first aid kits as well as provide proper hydration and support for their teams. At competition, there will be a Safety Meeting on the first day where each Safety Lead and a primary or secondary team lead will be briefed on risks that exist during the duration of the competition.

6.4.1 - Flag Hazard Communication

FAR-OUT will be using A GREEN FLAG/YELLOW FLAG/RED FLAG hazard communication system like other competitions. Operations will typically go GREEN FLAG -> YELLOW FLAG -> RED FLAG -> YELLOW FLAG -> GREEN FLAG.

GREEN FLAG
Entrance criteria: All systems are safe, no deployment or pyro electronics turned on, no systems are pressurized.
Exit criteria: Teams are ready to begin their launch procedures
Under intervals of normal setup the range will be held at GREEN FLAG. Rocketeers can come and go and prepare their rockets and launch equipment. Spectators can walk to the pads while accompanied with a Rocketeer or a FAR-OUT volunteer with team permission. Low pressure operations under 150 psi can be conducted after the team coordinates with FAR-OUT Launch staff and their neighboring teams. Tours while under a low pressure test are not allowed to that specific pad.

YELLOW FLAG
After a GREEN FLAG:

Entrance criteria: Teams are ready to begin their launch procedures, and a vote to initiate a salvo has passed.
Exit criteria: All electronics are turned on, supply bottles open to fill and pressurization systems, and teams are ready to begin filling.
All non-critical-badged rocketeers evacuate to the spectator area. Final flight checks will be performed. Non-launching teams should close up containers and prepare for rockets launching around their equipment during this time. People in the spectator area should prepare to move into the bunkers, but are not yet required to do so.

After a RED FLAG:
Entrance criteria: The round of launch attempts is completed. All vehicles that failed to leave the ground have been fully aborted.
Exit criteria: All rockets and GSE are safe to approach
Critical-badged rocketeers may approach the rocket in order to safe electronics.

RED FLAG
Entrance criteria: Teams are ready to begin filling
Exit criteria: The round of launch attempts and aborts have been completed
When the range goes RED FLAG all rocketeers except the critical-badged rocketeers have departed. All rocketeers and spectators are required to be in the bunkers and the road to enter the FAR site will be closed. Once departed, the critical-badged rocketeers will arm electronics and then arm and open plumbing systems. Afterwards all critical badged rocketeers and FAR staff will retreat to shelters and bunkers and begin launch procedures. In the case of a “quick fix” to a system, we will remain at RED FLAG for longer durations while critical-badged rocketeers and FAR-OUT staff approach the rocket. Spectators will remain in bunkers until YELLOW FLAG. Spectators that leave the bunker under any circumstance will be ordered back into the bunkers and may be asked to leave the launch area at the discretion of FAR Safety Staff.

6.4.2 - Personal Protective Equipment

Safety is very important. When assembling the tower or erecting the rocket on the rail hard hats must be worn. When black powder charges are around or any cutting is being performed safety glasses must be worn. When handling even mild cryogens like nitrous oxide, face shields and cold insulated gloves must be worn with long sleeves or a smock or lab coat with long sleeves that can be taken off once everything is tightened down sufficiently. Failure to wear these will not end well. Teams are required to provide adequate PPE for their members.

6.4.3 - Emergency Response Plan

Clear abort and safing procedures that a member of any other team should be able to understand and follow with ease. Prepare a briefing for FAR staff that will be made available to neighboring teams so when something goes wrong they understand what is going on. FAR staff will manage said procedures, but in any case it is best to be prepared for any situation that may arise.

6.5 - Team Conduct

It is the responsibility of every team lead to ensure that their team conducts themselves in a safe and professional manner. There is a list of point deductions per occurrence that is set prior to the competition for various types of infraction, ranging from not clearing an area in time when a salvo is announced to providing false information on a report. We take team conduct very seriously; while this is a competition, it should still remain respectful and teams should strive to follow the rules of the competition as closely as possible.

If a member of a team notices someone on their team or another team being unsafe or behaving unprofessionally, please alert a FAR staff member, who will try to rectify the situation. If there is an inter-team disagreement at the competition, please let a FAR staff member know. Dangerous or inappropriate actions by teams and/or their members may be subject to penalties up to and including removal from competition.

Teams are not to tell others their altitude until awards. If that number gets out you could face sportsmanship penalties. This is to prevent teams from setting their go/no-go fill states based on performance of other teams' flights, which has led to failed aborts in the past trying to get past another team in altitude. This has happened even in the case of competitions without the same altitude target akin to this competition. So keep that information close and don't disclose it except to the data collection team.

6.6 - Competition Schedule

The competition schedule will be updated independently of this document on the FAR-OUT website, under "Important Documents and Links." This is considered a non-crucial document, so only if there are significant changes in scheduling will teams be notified of its updating. Versioning will be utilized as-needed.

6.7 - Team Readiness Evaluation

Team readiness will be determined by a GREEN TEAM/YELLOW TEAM/RED TEAM system throughout the check-in and flight safety review process. RED TEAM indicates that a team is not fit to fly at that given time, YELLOW TEAM indicates that progress has been made towards being prepared to fly but is not completely cleared, i.e. the team still must go through final safety review. GREEN TEAM means that the team is cleared to fly and can launch whenever they are prepared to do so. GREEN TEAMs and YELLOW TEAMs can work towards changing their status based off action items.

6.8 - Readiness Procedures

At competition, there will be several procedures that teams will have to complete in order to be cleared to a GREEN TEAM. Failure to complete any of these will prevent movement towards a GREEN TEAM.

6.8.1 - Arrival Procedure

Upon arrival at FAR, the entire team will check-in with FAR staff, who will give out badges and identify the location of where the team can set up ground station equipment. The badges given are required to be worn at all times while at the FAR launch site.

6.8.2 - Arrival Safety Check

Also upon check-in, flight-critical measurements will be made and checked against prior-submitted reports. Discrepancies will be addressed at this time to allow the opportunity to rectify any errors prior to flight, if possible. Once this step is completed and all issues have been addressed, the team is moved from RED TEAM to YELLOW TEAM. At YELLOw status, teams can start setting up any ground station equipment they have brought themselves (towers, trailers, cooling stations, etc.).

6.8.3 - Ejection Testing

An area near the team setup area will be provided for black powder and CO_2 ejection system testing. These tests must be conducted prior to competition but can be conducted in case of a change of deployment system under flight remediation requirements.

6.8.4 - Leak Testing

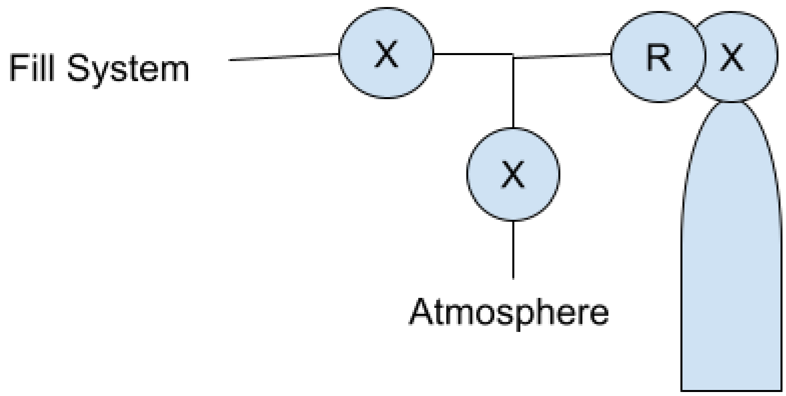
During setup days, leak tests can occur at 150 psi by removing people from your team's pad area and restricting personnel on that pad to those who have passed pressure vessel safety training. Every two hours starting at 8am high pressure leak tests can be done when the range is restricted to those who have passed pressure vessel safety training. If teams do not wish to perform leak tests then the range will not be restricted. Teams will be given flags to indicate leak testing status of Red for at High Pressure, Yellow for Low Pressure and Green for Depressurized. Leak tests during active launch days can be done during the salvo times under the same rules. Waivers must be signed by team lead and individual rocketeers attesting to training and understanding the risks.

6.8.4.1 - Pressure Testing Supply System Rules for Air Compressors

150 psi tests with an air compressor must have an inline oil/water filter to prevent contaminating oxidizer lines. A regulated nitrogen set up is preferable to prevent oil and water from being blown into the oxidizer tank.

6.8.4.2 - Pressure Testing Supply System Rules for Air Compressors

Regulated pressure from a supply bottle of compatible gas. No fuels in oxidizer lines (only N_2, CO_2, or Noble Gases, O_2). No oxidizers in fuel lines (only N_2, CO_2, Noble Gases). In order to use a regulated gas the team must prepare a plumbing system that allows the setting of the regulator prior to connecting to the fill system. This is accomplished with a manual valve after the regulator and before the fill system. The regulator pressure will be set against the valve to prevent overpressurizing any part of the fill system or allowing the motor to go to full pressure prior to minimal personnel. 150 psi is allowed when restricting personnel to safety certified team members in your team pad area. Full pressure tests cannot occur unless under a red flag. Prior to the red flag the left and bottom valves should be closed and the regulator should be set to the desired pressure for the test. If you wish to pressure your system gradually make sure the set pressure of the regulator is at zero. Be sure to label the direction on your regulator for + or - pressure if it isn't already; in the heat of the moment people miss these things.



6.8.5 - Final Flight Safety Check

Upon the rocket being ready on the launch pad, a final flight safety check will be made. If there are issues the team can make remediations and be checked for flight again. Once the team has been cleared, their status will move to Green and they can proceed to set up on FAR towers and rails or set up their rocket on their own rail to launch.

6.9 - Launch Procedures

Once you have readied your rocket to begin filling, the team lead will notify FAR staff to be added to a displayed salvo. Further guidance will be provided for that salvo. Once the decision is made to proceed with a salvo, teams setting up will be told to get to a stopping point and retreat to the covered shelters within 15 minutes. Filling and Launch Operations will commence and the team's launch team will communicate with FAR staff on fill status. If an abort or hold is in order for any safety reason, the team must comply with that order. A hold means that a team can hold at pressure and if they cannot they must abort. An abort means that all motors must be depressurized. You are not specifically limited on the number of potential attempts, but rather via a formula for commit criteria of a specific salvo, described below.

6.10 - Salvo Commit Criteria

The Salvo Commit Criteria is a system for determining whether a launch salvo will occur. A salvo is defined as a launch attempt where multiple rockets fill simultaneously but due to their unequal F2F times their launches become staggered. Teams should coordinate between each other to determine the best fill commencement time. The Morning, Noon, and Afternoon salvo times are not set in stone for exact time. When teams think they will be ready for a specific time they should coordinate with other teams to determine what time they wish to vote on. A board will be provided to state an expected launch time for each team so when a coalition of teams calls for a vote for a state fill commence time the vote will be made. At the end of a launch day there will exist a distribution of vote values. It is recommended that Team leads use their votes strategically and diplomatically, and perhaps more importantly learn to not require votes to take place. A negotiated agreement between teams preserves vote value. Arriving earlier than other teams to conduct tests, therefore not requiring a vote, preserves vote value. Historically teams can expect that voting will likely take place for two launch slots in the day. Teams can negotiate outside the vote to conduct testing but if that is agreed upon by the teams any evacuation for testing or launch has to be under unanimous consent and has to be communicated to the Launch Manager. If it is not unanimous a vote must take place.

6.10.1 - Salvo Commit Summary

1. Salvos will be scheduled as roughly a morning, noon, and afternoon launch (weather pending).
2. Teams are given magnetic tags to place on a magnetic white board to represent their vote as to whether or not to attempt a salvo.
3. If there are enough votes, the teams will be evacuated at the designated time and a salvo will commence. If there are not enough votes, the salvo will be canceled.
4. Teams that fail to launch in a salvo or teams which choose not to attempt a launch will have less voting power in the next salvo.
5. Teams that were present on the pad that voted for a launch or test will preserve their vote values at the end of the day.
6. Teams that were not present on the pad will see their vote values drop to the mean vote value of the new day.
7. Teams that were present that did not vote in favor of any launch or test will drop in vote value by half.
8. In the unlikely event of a tie which becomes less and less likely as the week moves on, the Launch Manager will cast the tie breaking vote on whatever reasoning he deems reasonable. This might be based on perceived capability to launch, historical discrepancy between quoted test time and actual test time, weather, or even culturally significant binary decision making (coin flip) relying on rotational dynamics of stamped metal disks accepted as currency or resembling metal disks accepted as currency if metallic currency cannot be found.

6.10.2 - Rules for Votes

1. All teams start with 2 infinitely divisible votes. For a given salvo, these votes will be used to determine if the “launch commit criteria” is met.
2. Votes can be Yea, Ney or Abstain
3. If an individual team launches, their remaining votes are removed and only the votes among un-launched teams will be counted.
4. If an individual team casts a vote for a salvo but does not fly, their remaining vote value will be cut in half.
5. If any given salvo fails to have enough votes or is canceled due to weather or other externalities, teams that wanted to fly in that salvo will be moved to the next.
6. If the vote for a salvo fails, the teams that voted against the salvo loose half their vote value. If a vote for a salvo passes, the teams that voted against the salvo loose half their vote value. Teams that abstain in a vote due to ambivalence about the time but engage in any remote operations including but not limited to launch or pressure testing loose half their vote value.
7. Abstention votes result in no change to vote value if they do not attempt operations.

6.10.2.1 - Special Testing Rules and Forced Extension Voting

Teams wishing to conduct a high pressure test or similar test that requires evacuation of other teams to bunkers can call for a vote with a specific start time and duration. Forced Extension Voting happens in the event that a test runs longer than the agreed upon duration. The team can either end the test immediately or an immediate vote is called on whether to extend the test by the originally proposed duration of the test. The testing team(s) can call for less time for extended duration but if they do not wish to immediately end their test their votes will be registered as for the extension by a duration no longer than the original agreed upon duration. This leads to a situation that results in teams misjudging their testing time losing vote value accordingly. It also allows frustrated teams waiting for a test to end, the means to stop a test that is prolonging a work stoppage. It is best to ask for a likely duration of testing and not try to undersell the time your test will likely run. So asking for 45 minutes to run a 15 minute test is preferred to requesting 15 minutes for a 45 minute test and dropping almost an order of magnitude in vote value.

6.10.2.2 - Voting Value of Grounded Teams after a Failed abort or Otherwise

Grounded teams that have not remediated a range safety issue will not have their votes counted in the launch commit criteria. A failed abort is defined as an abort procedure that does not completely safe the rocket. In most cases, this is due to oxidizer still pressurizing the rocket's tank. A failed abort requiring intervention by FAR OUT staff requires temporary grounding until root cause can be determined and remedied. A team does not have voting privileges until the grounding is removed. After intervention leading to a successful abort, if the field is too busy for investigation by the relevant safety staff then that investigation will wait until after the pad is closed for the day and all other vehicles have been safed from any remaining salvo. Vote value is dropped to the lowest value of any other team on the field once at the time the grounding is revoked. A second failed abort requiring intervention will result in permanent grounding. This should be taken into account when determining the level of testing your team wishes to make.

6.10.3 - Rules for Launch Commit

1. Majority rule of a vote. Teams without a preference can abstain and preserve vote value.
2. At the start of competition teams will place their tags on the white board based on when they think they will fly and how long they need from red flag to launch.
3. If there are not enough votes, that salvo will be canceled and the teams which voted for that slot will be moved to the next.

6.10.4 - Reasons for this Salvo Commit Proposal

1. This is designed to be a completely objective way to decide when to clear teams out of the launch area, an action that can cost those teams which are still preparing valuable time and potentially prevent a team from making a launch attempt.
2. In addition to the time each salvo takes away from launch preparations from non-flying teams, teams have been incentivized to take every opportunity they can to launch rather than standing down if there are doubts and being absolutely sure they are ready.
3. By having a voting system, all teams are collectively giving feedback on whether or not they feel it is worth halting preparations to let teams fly. If there are only one or two teams ready, but each salvo takes an hour out of their prep time, this could be the difference between teams requiring more prep time flying or not flying.
4. By having votes lose value with each day wasted, or each salvo where a launch is attempted but not made, teams with chronic issues in their systems will be pushed towards the back of the line to allow them more time to work out issues. Conversely, teams that are ready to go from the start can push to the front of the line and make their attempts, knowing they will lose voting power with each failed attempt.

6.11 - Recovery Procedures at Competition

Each team is required to have a designated recovery team at competition. This should consist of two people plus a maximum of one person per 20 lbs of recoverable material. For desert safety reasons a minimum of two people is required to retrieve a rocket. After each salvo there will be open time for recovery during which teams can look for pieces of the rocket. All portions of the rocket should be recovered in order to count for scoring.

Once the rocket is retrieved, it should be brought to the FAR official in charge of check-in to determine its airworthiness afterflight and collect data on payload and altitude achieved. Teams will sign off on the points their teams are given. If a point grievance is made you'll be asked to justify and then a final decision with justification will be made. If it is a question of airworthiness, the only way to appeal this decision is to fly it again within the time frame of the competition.

DO NOT ATTEMPT TO RECOVER A ROCKET THAT BELONGS TO ANOTHER TEAM - IT MAY STILL BE ARMED! If you find other rockets that are not part of this competition, report the location to FAR by recording the GPS location and taking photos of any debris. You will find many out there.

<u>6.11.1 - Team Member Tracking and Check-In/Check-Out Procedure</u>

Team Member Check-In and Check-Out:

- All recovery teams are required to check in and check out using the radio every 15 minutes.
- To ensure convenience and efficient tracking, check-in times will be staggered.
- This check-in process must be maintained until all team members have returned safely.

Personnel Rules:
During recovery operations, the following rules apply to any discovered rockets or rocket parts, regardless of the team they belong to:

1. Documentation:
    - A photograph of the discovered rocket or part must be taken.
    - The Latitude-Longitude (Lat Long) location must be accurately recorded.
2. Submission to Recovery Check-In:
    - All data, including photographs and location information, should be promptly submitted to the recovery check-in team.
3. Sportsmanship Points:
    - If a team discovers another team's rocket through this process, and it was not previously found, they may earn sportsmanship points.
        - Record the precise location.
        - Capture a photograph.
        - Submit this information to the flight check-in team.
4. Data Utilization:
    - The collected data will be used for:
        - Validating the recovery area.
        - Enhancing simulations for anticipated landing zones and ballistic zones in future competitions.
5. Self-Discovery:

- When a team locates their own rocket, they must:
    - Record the precise location.
    - Capture a photograph.
    - Safe the rocket
    - Pack up the rocket for the journey back
    - Submit this information to the flight check-in team along with the rocket

By following these rules and procedures, we aim to ensure efficient team member tracking and data collection during recovery operations, promoting a fair and competitive environment in our competitions.

PART 7: SCORING

7.1 - General Scoring

There are 5250 points available. There are deductions that can occur at the discretion of judges for safety issues or serious unsportsmanlike conduct. While it might be an interesting challenge, not all points have to be attempted; this challenge is meant to be very open-ended. A team not able to attempt the full motor design points or full payload points shouldn't be discouraged from flying. The scoring is all mathematical, coming from data from teams' submitted progress reports and flight data; this is for transparency for the teams and ease of judging. There is no scoring for the progress reports. However, if they are not submitted on time, there will be point deductions. If proper critical information is not provided and the rocket cannot be accurately judged off of the given expected information, your team can be disqualified. The reports are meant as a touchpoint to make sure that teams will show up to competition with a safe rocket that will demonstrate their school's abilities.

The breakdown of the 5250 points is as follows with details below:
1000: Points for Rocket Motor Performance Bonus (Bonus points are possible)
1000: Distance from Contract Altitude Accuracy
500: Distance from Simulation Precision
500: From Payload
500: Video capture
250: Points for Launch Readiness Bonus
100: Points for timely launch bonus
100: Points for timely recover bonus
100: From unscathed recovery
100: Sportsmanship / Team Cohesion
100: Completion of Poster Session/Podium Presentations/Technical Report/Checklists

7.2 - Hybrid/Liquid Motor Performance Bonus

There are more than 1000 points possible but it's meant to be hard to get over 500 points. If you are able to have a mass fraction over 66% and a isp over 190s you will get over 1000 points from this bonus. Example: a 85% mass fraction motor with an isp of 220s would yield 1476 points. A mass fraction of 66% and an isp of 190 points would yield the targeted 1000 points. A flight performance modifier is added such that delivered performance is what is graded. There is no bonus for overshot altitude and the

modifier is capped at 1. An example of a 160s motor with a mass fraction of 50% and undershooting by 90% would receive 568 points
Engine

$$Performance\ Subtotal = 1500 * \left| \frac{[Lesser\ of\ Actual\ or\ Predicted\ Altitude]}{[Predicted\ Altitudes]} \right| * \left| \frac{[Mass\ of\ Oxidizer]+[Mass\ of\ Fuel]}{[Total\ Motor\ Mass]} \right| * \frac{[Impulse\ from\ static\ test\ in\ Ns]}{([Mass\ of\ Fuel\ in\ kg]+[Mass\ of\ Oxidizer\ in\ kg])*9.8m/s/s*190s}$$

7.3 - Altitude Accuracy

The FAR-OUT competition is broken into a Group A, Group B, and Group C category corresponding to a potential range of altitudes. The proximity to a declared “Contract Altitude” will account for up to 1000 points. The Group A category is geared towards students who have never flown hybrids or liquids or have limited experience and want to attempt flights on either a COTS or small Research motor and is defined as a target altitude of between 3,000 and 15,000 feet AGL. The Group B category is geared towards teams with moderate experience flying hybrids or liquids, with a target altitude of between 20,000 and 50,000 feet. The Group C category is designed for teams with exceptional experience in hybrid or liquid rocketry and well thought-out projects, with the goal of allowing these teams to demonstrate advanced manufacturing techniques and high performance propulsion systems at a target altitude of at least 50,000 feet and up to 250,000 feet. The categories A and B will restrict flights to a total delivered impulse of 40,960 N-s in order to fly under an FAA Class 2 Waiver. The Advanced category will allow for Class 3 projects provided the students run dispersion analysis for 1 and 2 σ (with multilevel winds and parameters of their simulation) for the following trajectories by their third progress report: Nominal, Main at Apogee, No Main, and Ballistic. Within each of these categories, teams will designate a “Contract Altitude” no later than the first progress update which will serve as the official altitude target for the team. Points for altitude will be given by the following formula where rockets within 50% of target altitude will be awarded points.

Section Points

$$Apogee\ subtotal = 1000 - 2000 * \left| \frac{[Actual\ Altitude]}{[Contract\ Altitude]} - 1 \right| >= 0$$

7.4 - Simulation Precision

Simulation points will be a positive submission no more than 500 points. Points are given to teams within 10% of apogee. Simulation points will be awarded according to the expected apogee given during the last progress report due 1 month before competition. (Note: this expected altitude does not have to match the stated Contract Altitude, as the simulation precision is judged separately from accuracy). It should be noted that the team should aim to reach the target altitude but having precise and accurate simulations is also important.

$$Simulation\ subtotal = 500 - 5000 * \left| \frac{[Actual\ Altitude]}{[Projected\ Altitude]} - 1 \right| >= 0$$

7.5 - Payload

Payload points are capped at a maximum of 500 points and are awarded as a collection of bonuses.

- Payload in excess of 1 kg - 50 Points
- Payload in excess of 1 kg:

$$Payload\ bonus\ subtotal\ =\ 50\ *\ ([payload\ mass\ in\ kg]\ -\ 1\ kg)$$

7.5.1 - Egg Drop Bonus

Bonus 10pt / undamaged marked egg. Note that padding weight is counted towards standard ballast mass as is the total mass of the eggs. Average chicken egg is 50g. 40 average eggs without padding would weigh 2kg yielding 100 points and a maximum of 400 points if all eggs are undamaged. This would total 500 points for 2kg of payload. The packing fraction of eggs would leave a lot of empty space that hypothetically could be filled with open cell foam and an integrated water ballast. Water is an incompressible fluid.

7.5.2 - Water Ballast Payload Bonus

- Water ballast payloads are added to points from other bonuses and overall mass points. There is a modifier for mass fraction of the water ballast. The more non water mass in the release device will reduce the factor for the water ballast bonus.

$$Water\ ballast\ bonus\ subtotal\ =\ 50\ *\ \frac{[Discharged\ Water\ Mass]}{[Water\ Discharge\ System\ Mass]}\ ([Discharged\ Water\ Mass\ in\ kg])$$

7.5.3 - Scientific Payload Bonus

- We do not have a scientific payload bonus at this time. It is not something we have judges for within our current staff and would be highly subjective if we did. Therefore it was chosen not to reward scientific payloads beyond standard payload scoring. In order to facilitate actual scientific payloads there is no form factor bonus. If significant volunteers were required of diverse scientific backgrounds there might be a point bonus of no more than 50 points judged on a binary scale between 50 and 0 points of “is scientific and is studying something” or “is a reason to have a dense brick”. In future years this could change but is unlikely to change in values, scaling might switch out of a binary format. The competition is focused on delivering high performance.

7.6 - Video Bonus

The total amount of video bonus points will not exceed 500 points total. Videos must be submitted the same day as the rocket is recovered. Note, a single video can take multiple of these bonuses. Such as live 360 from the rocket would be 400 points, whereas 360 video from the rocket retrieved after flight would be 250 points.

Video format must be submitted electronically with a minimum resolution and frame rate of 1080p and 30 frames per second respectively in order to accept your video submissions.

- 250 Live Video from the rocket in flight
- 100 Points for usable onboard video recovered after flight
- 150 Points for usable 360-degree onboard video recorded during flight
- 100 Points for usable launch video (from the ground, from the bunker, from the top of the rail, etc.)
- 50 Points for each extra camera angle we haven't considered or not listed above and not effectively identical to another submitted video. In other words, 10 cell phone camera shots from the same bunker would only be 100 points.

7.6.1 - Drones

FAA drone rules apply, they will be allowed in the airspace. Our only additional rule is that the exclusion zone around all launchers, not just yours, comes off as a 45 degree cone from the tip of the launch tower, projected upwards. Drones must not be flown in this cone. This really restricts drones from flying over teams during pads during launch ops and puts them at the perimeter mostly.

Remote controlled systems must abide by FAA Part 107 and FCC Part 97 of the FAA Regulation. Failure to comply with this exclusion zone will result in a strict conversation and if your team continues to do so, your team will be heavily penalized and/or disqualified.

7.7 - Launch Bonuses

Launch on Saturday receives 100 bonus points.
Launch Readiness bonus to encourage sustained launch readiness and develop strategies for waiting for optimal weather conditions with 250 points if the rocket is launched in the first salvo of the competition.

7.8 - Recovery

A recovered rocket that is undamaged and ready to fly again adds 100 points to the Trajectory Subtotal.
Finding another team's rocket will give a 10 point bonus to the team that finds it if the launching team loses GPS lock. But this is awarded in sportsmanship even if you are technically finding a rocket that is not your own.
First day's recovery bonus is 100 points. This is separate from the launch bonus and the safe recovery bonus. If you launch and recover safely and bring it back to data recovery on the first day then there are a total of 450 points between the 3 bonuses listed here and above.

7.9 - Sportsmanship / Team Cohesion Bonus

The total amount of sportsmanship bonus points will not exceed 100 points.
Examples you could receive sportsmanship points for:

- Hosting a team at your test stand so they can compete
- Letting another team use your launch tower or GSE
- Providing medical attention to another team’s members
- Running into a dust devil to help people being injured by falling rockets
- Helping smaller teams recover their rocket
- Finding other teams’ rockets and reporting positions
- Preventing Peter from seeing a venomous creature without telling him why
- Pointing out the location of venomous creatures to FAR staff and not having Peter find out about it. He doesn't want to know, but other staff need to know. Seriously not a joke do not let Peter know. Note: Showing Peter a venomous creature alive or dead is negative 100 points. Seriously not a joke .. don’t. Obviously prevent Peter from going near it.

Examples you won’t receive points for but would be appreciated:

- Helping us - we would appreciate it but sportsmanship is a matter of helping those you are competing with and we will not reward helping us with points.
    - Please actually volunteer with us when you graduate or if you drop out of the competition

    - Please help clean up after competition because it's the right thing to do not because it gives you points
- Altering the climate of Southern California to be more like hm idk a nice 75 degrees and cloudless but somehow less UV rays hitting the ground and people. Assuming you don't get caught by the State of California.

For team cohesion it is a subjective look at how your team moves and delegates tasks effectively. If you are seen to be exceptionally streamlined and methodical, then points for this bonus would be awarded.

7.10 - Poster Session / Podium Presentations / Technical Report / Checklists

For the general scoring, poster sessions, podium presentations, technical reports, and checklists will be graded for completeness. Posters and podium presentations will not be scored, but depending on potential sponsors awards *may* be given for these categories in the future. Technical reports have a separate scoring for a Best Technical Report award that is described in the "FAR-OUT" Technical Report Instructions" document.

7.11 - Miscellaneous Deductions

- 1st and 2nd Progress Report Delay - 100 points deducted per week late
- Progress Report Lacking Material - 50 points deducted per section if missing / lacking section information not submitted after request per week late. It is better to be late if multiple sections are lacking than submitting unfinished.
- Late 3rd progress reports will not be accepted and will disqualify the team from competition. Please prepare and submit them early. We need to read these prior to the video meetings to have productive feedback. We highly recommend that you assume that this report is due two weeks earlier.
- Category change or contract altitude change - 250 Points each change
- Misrepresenting or hiding key safety data, not wearing PPE, not using checklists all carry defined penalties; you must not commit these infractions as they will be severe, up to and including removal from competition.

7.12 - Subjective and Miscellaneous Awards

We will also be offering the following awards that will be judged separately and not judged on the same guidelines of the competition. For all of these awards, prizes will be determined closer to the competition as they are dependent on sponsorships.

7.12.1 - Best Technical Report

The best technical report should adhere well to the Technical Report Guidelines included on the website, and should be a well-written, thorough document. We heavily advise not to write an extremely long document because there is a high chance that we will go through it and find inconsistencies.

7.12.2 - Best Technical Presentation

An excellent technical presentation will be clear, concise, and touch on all of the steps of the design and implementation process taken for the project being presented, as well as adhere to the rest of the technical presentation rules.

7.12.3 - Most Interesting Payload

This is a fairly flexible award - we are looking for payloads that are innovative and intriguing, as well as well-executed. We may also consider very well-performing payloads that go under other categories such as the egg drop or water ballast payloads.

7.12.4 - Launch Operations Award

This award focuses on the efficiency and success of a team's particular launch operations. This could be the team taking the opportunity to set up everything beforehand, show up quickly and fire, proper and effective team communication, or any other innovations in launch operations that can improve the efficacy and efficiency of the launch process.

7.12.5 - Ground Support Equipment Award

This award focuses on the innovation of a team's GSE that simplifies setup or improves performance.

7.12.6 - Other Awards

Other non-point-awarding awards will be given out but they will be a secret, your school might not really care about these but it's a bit of fun for the teams competing and the judges. These aren't really awards that you want to try to aim for them but… well you will see.

7.13 - Certificates of Score and Awards

Certificates will be given to all teams electronically indicating their place in their category, rank in efficiency, overall rank in the competition and for any award given (even the secret fun ones). That way teams can display the certificate with the actual Prize or Trophy.

Glossary

If you are unsure what something means try Googling it first, Wikipedia deep-dive second, and if you still have questions email faroutcompetition@gmail.com

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CAR -Canadian Association of Rocketry
FAR -Friends of Amateur Rocketry
FAA - Federal Aviation Administration
COTS - Commercial Off The Shelf
MEOP - Maximum Operating Pressure
NAR - National Association of Rocketry
TRA - Tripoli Rocketry Association
F2F - Fill to Fire
PPE - Personal Protective Equipment
GSE - Ground Support Equipment
AP - Ammonium Perchlorate
N_2O - Nitrous Oxide
CO_2 - Carbon Dioxide
Isp - specific impulse measured in seconds
kg - kilogram
mm - millimeter
cm - centimeter
‘ or ft - feet
“ or in - inch
s - second
min - minute
hr - hour
psi - pounds per square inch
mph - miles per hour
FAA Class 2 Rocket - having an impulse less than or equal to 40960 Ns
FAA Class 3 Rocket having an impulse over 40960 Ns but less than 200,000lbs (889644.32 Ns)

“This is America and we deal with metric and imperial units interchangeably.
- Peter Tarlé, 2023 like for real he actually said “pound symbol” and then corrected himself saying “wait they call it hashtag now right?”

Units

Frequently Asked Questions

1) Where can I ask questions?
    a) faroutcompetition@gmail.com for competition-related questions, friendsofamateurrocketry@gmail.com for other FAR questions
2) What is your favorite fish?
    a) Obviously a whale shark it's so incredibly small, really one of the most incredibly tiny objects in the Universe.