2024-2025

NASA's Space Grant (in-the-)Midwest High-Power Rocketry Competition Handbook v4 – posted 1/13/2025

High-Thrust Challenge

Informational videocon: Mon. Sept. 9, 2024 (videocon repeated on Thurs. Jan. 9, 2025) from 7 to 8 p.m. CST

(Contact James Flaten <flate001@umn.edu>, MN Space Grant, for call-in information)

Notice of Intent to Compete: Sept. 15, 2024

(Non-binding, but required from all institutions, including those starting in the winter/spring.)

Registration Payment Due: January 31, 2025

Launch Competition in Minnesota: Sat. & Sun., May 17-18, 2025** (Rain date: Mon., May 19, 2025)

**** If Minnesota has a particularly wet spring, the competition dates may need to shift. This will be announced in as far in advance as is practical. See details later in this handbook.**

Main contacts:

James Flaten, flate001@umn.edu, MN Space Grant Consortium, U of MN – Twin Cities
Gary Stroick, president@offwegorocketry.com, Technical Advisor, Tripoli Minnesota High-Power Rocketry Club

Web site:

http://dept.aem.umn.edu/msgc/Space_Grant_Midwest_Rocketry_Competition_2024_2025/

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Competition Objective

NASA's Space Grant (in-the-) Midwest High-Power Rocketry Competition is intended to provide student teams from colleges and universities around the nation with an opportunity to demonstrate engineering and design skills through practical application. Teams will conceive, design, document, fabricate, and fly custom high-power rocket(s) to accomplish specific goals which vary from year to year. Restrictions are placed on rocket motors and dimensions so that knowledge, creativity, and imagination of the students are challenged. The end result is an engaging aerospace experience for college/university students that might not be available to them during their normal course of studies.

Rocket Design Objectives

Here is a description of the 2024-2025 "High-Thrust Challenge."

Student teams will design and construct single-motor, single-stage, high-power rocket(s) and fly twice during the competition. This year the challenges are:
(A) have the first flight (may be single-deploy or dual-deploy) go to exactly 1000 feet above ground level on an Aerotech H550 DMS motor and
(B) have the second flight (must be dual-deploy) go as high as possible on an Aerotech H550 DMS motor and
(C) have both flights carry a "non-commercial" (i.e. not sold for rocketry) data-logging sensor suite and use it to deduce altitude, speed, and acceleration during ascent, all as a function of time (not just maximum values), in three independent ways (barometric pressure, 3-axis acceleration, and gps) at as high a sampling frequency as possible, then analyze the pros and cons of the different approaches.

All competition flights will use an Aerotech H550ST-14A (high-thrust) DMS motor. Bonus points will be given to (1) teams whose member(s) increase their certification level(s) using individually-built rockets (in parallel with the (team-built) competition rocket(s)), (2) teams that also implement a 2-pressure-sensor pitot tube system as a fourth performance characterization approach, and (3) teams that do both flights using a single rocket – internal modifications (parachute, ballast, etc.) are allowed between flights, but not external modifications (to merit bonus points in this category). Additional details about the competition are included in a handbook, including due dates and report content/page limits. Note: All fabrication work on the rocket(s), except for possibly machining of plastic and/or metal parts, must be performed by students.

Additional expectations:

1. All team members who have not already participated in building a high-power rocket need to build and fly (hopefully successfully) different model rockets and report on the experience (1 page per rocket, including photos) submitted before, or along with, the PDR. If a team has more than 5 students who need to demonstrate a model rocket build, teams are allowed to build and fly just 5 different model rockets as long as every new-to-rocketry student is significantly involved in building and flying at least one model rocket.
2. Teams must conduct two remote inspections with the competition organizers, with their certified mentor on the call for both inspections. The "50% inspection"

will be held when there is a near-final design and all the parts have been acquired (or at least are on order), though the build has not yet begun (or certainly not progressed very far). This first remote inspection must occur after receiving written feedback on a Draft of Design(s), but before the PDR is due (so it must occur no later than early March). The "90% inspection" will be held when the build is essentially complete, but before any test flights (and hence before the FRR is due) (so it will probably happen no later than mid April).

3. Teams are required to have in-person or videocon meetings with their L2-certified non-student mentor at least monthly (preferably more frequently) once the team is working on a design. Teams are required to increase the frequency of meetings with their certified mentor to at least every second week once the build starts or at the end of January 2025, whichever comes first, until the build is complete (perhaps by early/mid April).
4. All students attempting to earn Level 1 certification for bonus points must take and pass (2 tries allowed, for full bonus credit) an informal L1 written test. This written test will be offered during the competition safety/oral presentation gathering in May, which might be after the L1 certification flight itself. All students attempting to earn Level 2 certification for bonus points must take and pass (1 try allowed, for full for bonus credit) the Tripoli or NAR Level 2 written test in advance of their L2 certification flight attempt. Note: 50% of the available bonus credit will be awarded to students who successfully certify, even if they do not pass the Level 1 test in two tries or pass the Level 2 test on the first try.
5. Teams must compose (and follow!) a pre-flight checklist and a post-flight checklist, both of which need to discuss how to "safe" a rocket(s) that contains unexploded charges prior to handling it. Teams must present both checklists during their "90% inspection" and do an explicit launch/recovery dry run, using both checklists, with their certified mentor before coming to the competition. Teams must present both checklists during the safety checks the day before the competition flights and use them on the competition flight day.
6. All competition flights are required to carry a Jolly Logic Altimeter Two or Altimeter Three data logger. (Note: These are just data loggers - they cannot fire ejection charges.) If you don't own either type, Altimeter Two units (one per team) may be borrowed from the competition organizers.
7. All team-installed ejection charges need to be fired by a commercial altimeter, with the motor-eject serving as back-up for a (required) apogee parachute deployment. Teams who wish to remove the motor-eject from the provided H550 competition motor must (A) get explicit advance permission (during the Draft of Design(s) phase) from the competition technical organizer and (B) install a fully-independent commercial-altimeter-based ejection charge system to serve as apogee-parachute-eject back-up instead.
8. The competition rocket (or at least one competition rocket, if you elect to build two) should be test-flown on a high-power motor (perhaps the H550 Aerotech motor required for the competition) at least once prior to the competition. During the test flight(s) the rocket should carry dummy mass (appropriately located) of any competition items not actually flown, to mimic the expected performance as closely as possible. Motor(s) for test flight(s) should be ordered when you submit the Notice of Intent, to give Gary Stroick adequate time to acquire the motor(s).

Teams that do not manage to test-fly any rocket are still welcome to compete, but will lose points in the Flight Readiness Review report. Suggestion: Don't wait until the last minute (i.e. until late April, just before the FRR is due) to attempt a test-flight, lest bad weather prevent you from flying or a crash prevent you from having adequate time to re-build the rocket before the competition date.

9. All certification flights and all flights expected to exceed 2000 feet AGL at apogee are required to carry a radio tracker. Tracking radios (one per team) may be borrowed from the competition organizers, upon request. Prepare to mount such a tracking radio in your nosecone (access hatch in shoulder required) or firmly strapped to your recovery harness.
10. Since the launch window on the competition date only runs from 9 a.m. till about 4 p.m., all teams must prep for their first flight (without sacrificing safety!) and be in the RSO line for a safety check no later than 11 a.m. (earlier would be better). After recovering the rocket after the first flight and checking it in with competition organizers, all teams must prep for their second flight (again, maintaining high safety standards) and be back in the RSO line for another safety check no later than 2:00 p.m. (again, earlier would be better). Modest late deductions will be applied to teams running later than these deadlines.
11. All team members (and faculty advisers and certified mentors) must watch informational videos posted by the competition organizers about overall high-power rocketry safety, differences between (AKA "transition between") model rocketry and high-power rocketry, and tips on building techniques specifically for high-thrust motors and for minimum-diameter rockets.
12. The competition rocket(s) must be team-built by the current team – no flying previously-built rockets. On the other hand, team members seeking certification may do so using previously-built (individually-built, of course) rockets. All rocket(s) that a team plans to fly at the competition (or in advance, for L1 bonus points) must be included in the Draft-of-Design(s) report, to be submitted before building any rockets (or at least any scratch-built rockets), so that competition organizers can steer teams away from potentially-unsafe options, including those listed below.

    The following extra rules apply to the team-built competition rockets (mostly for safety reasons, in a competition that may include inexperienced fliers): (1) no multi-stage rockets, (2) no multi-motor (AKA cluster) rockets, (3) no air-starts, (4) no canards (fin-type objects forward of the CP) nor piggy-back devices (like a space shuttle configuration), (5) no gimballed nozzles, (6) all rockets must have a fully-operational motor-eject recovery system to ensure deployment of at least one parachute near apogee (7) all rockets must use 10-10 rail buttons or rails guides, have a reasonable thrust-to-weight ratio upon launch (3:1 allowed; 5:1 (or more) preferred), and leave the 8-foot rail at a reasonable speed (45 ft/s or faster) (see Design and Safety Review Section), (8) all rocket parts must land still tied together and at a reasonable speed (35 ft/s or slower required; 25 ft/s or slower – the "old" threshold – preferred)) (see Competition Engineering Section) under parachute – no streamer-only recovery systems nor drogueless descent allowed, (9) deployment <u>and full unfurling</u> of a safe-landing-speed parachute must occur at least 500 feet above ground level – if using a chute release, be sure to open a safe-landing-speed parachute at least by 500 feet AGL, (10) all rockets at the

competition must fly on Cesaroni or Aerotech high-power motors – see motor specifications for the two competition flights in the handbook and bear in mind that most motors (except for Aerotech DMS motors) require reusable metal cases which must be purchased separately and can be somewhat pricey. Metal fins, nose cones, and airframes are not permitted except (A) nose cones may have aluminum tips and (B) in the case of a minimum-diameter rocket, the portion of the airframe that serves as the motor case may be made of metal.

BONUS OPPORTUNITY 1: To encourage team members to get certified, or increase their certification level, teams will be offered up to a 5% overall bonus as follows (here and below "overall" means "added to the total score" – not just 5% of a partial score, such as the Flight Performance score):

1% for every successful new Level 1 certification
2% for every successful new Level 2 certification
3% for every successful new Level 3 certification

No single student may claim more than one of the above, so a student going for Level 2 certification does not merit 1% for the Level 1 certification they need to earn on their way to Level 2. Certifications flights must occur after the team signs up for the competition, but no later than the competition flight date in May 2025. Uncertified students seeking Level 2 certification at the competition should do their Level 1 certification flight before the competition date. Do not attempt to earn Level 1 and Level 2 certification flights on the same date (though such certification flights could potentially be done using the same rocket, if the design is up to it).

Caveat: All students attempting a Level 1 certification must take and pass (2 tries allowed, for full competition credit) an informal written test delivered by the competition organizers, the night before the competition, so possibly after the actual Level 1 cert flight. (Note: This is specific to this competition; it is not a normal requirement for Tripoli or NAR Level 1 certification.) All students attempting a Level 2 certification must take and pass (1 try allowed, for full competition credit) the Tripoli Level 2 written test in advance of their certification flight attempt. 50% bonus credit will be awarded to students who are able to receive an L1 certification, but do not pass the informal written test within 2 tries. 50% bonus credit will be awarded to students who are able to receive an L2 certification, but do not pass their L2 written test on the first try. (Retakes offered at the discretion of the club members offering the test.)

Note – since the main competition rocket(s) must be team-built, it(they) cannot serve as a certification rocket for any team member.

BONUS OPPORTUNITY 2: Teams may receive up to 5% overall bonus (judges' discretion) for implementing a 2-pressure-sensor pitot tube system as a fourth performance characterization approach. Clarification: Such a system might involve two independent pressure sensors or possibly a single "differential" pressure sensor. Partial bonus credit may be granted to teams who implement a pitot-tube hardware system and convince the judges that it works, at least in ground testing, even if it doesn't work properly on the competition flight(s).

BONUS OPPORTUNITY 3: Teams may receive up to 5% overall bonus (judges' discretion) for using the same rocket to fly both the 1000-ft mission and the as-high-as-possible mission. To merit these bonus points, the rocket must appear identical from the outside upon launch, though internal details (such as ballast, parachute size, etc.) may differ between flights, as may operational details (like flying single-deploy vs dual-deploy).

Judging Categories

Teams will be judged on their engineering acumen including, but not limited to, their design documentation, performance simulation, project construction and aesthetics, test plans and execution, launch and recovery operations including safety, as well as the demonstration of their rocketry knowledge and ability to communicate effectively. Teams will be evaluated based on their design reports, test flight results, presentations, competition flight, post-flight reports, as well as outreach activities.

The total score for each student team will be based on the following parameters. Note: A Draft of Design(s) (described later) is expected and there will be a 20% overall deduction if it is not submitted by its due date. Similarly, there will be a 10% overall deduction for teams who do not satisfy the *"50% inspection"* videocon on time and with mentor present, as described above, and another 10% overall deduction for teams who do not satisfy the *"90% inspection"* videocon on time and with mentor present, as described above. Some community outreach (described later) is also expected and there will be a 10% overall deduction if not performed and reported before or on the Flight Readiness (Written) Report due date.

Preliminary Design (Written) Report & Model Rocket Flight Documentation	30%
Flight Readiness (Written) Report	15%
Flight Readiness (Oral) Presentation	15%
Competition Flight Performance	20%
Post-Flight Performance Evaluation and Data Collection (Written) Report	20%
Total	100%

Competition Engineering Parameters

Student teams will be required to design and team-build one or more rockets capable carrying out the challenge goals. All motors used in the Midwest competition must be Cesaroni or Aerotech commercial motors. Both disposable motors (no case required) and reloads (require a case), are allowed.

All rockets must be fin-stabilized, with a static margin between 1 and 5 at launch, and designed to land safely. Each rocket must use a commercial altimeter to produce rocket separation and the deployment of an "apogee parachute" at or just after apogee. If the rocket is dual-deploy (but possibly advantageous to minimize drift on descent to help ensure the rocket lands on the sod), the second (AKA main) parachute must be deployed and fully unfurled at least 500 feet above the ground. No streamer or drogueless descent is allowed, though achieving dual-deploy using a chute release is allowed.

The recovery system must safely land the vehicle (or each separate part of the vehicle, if it is not all connected together at landing – separate landing not allowed for this year's challenge) at a descent speed not to exceed 35 ft/sec (the current value in the Tripoli Safety Code). The motor ejection charge must remain in place, to serve as a back-up to the electronic deployment of the apogee parachute, or else a second, fully-independent, commercial altimeter system (including independent power, wiring, and ejection charge(s)) must be used to back up deployment of the apogee parachute. If using motor eject, use simulations to ensure the delay grain is long enough for the rocket to reach apogee before the motor eject fires.

All structural components and materials must be obtained from reputable high-power rocketry vendors or an engineering analysis demonstrating their suitability must be included with the design.

Top scores for the flight portion of the competition will be awarded to team(s) whose rockets all complete safe and successful flights – see details below about how "Successful Flights" are defined.

On the competition date, teams may make multiple attempts at each type of flight if they have pre-ordered motors (within reason – the launch waiver closes at 4 p.m.) and teams may select which flights are to be judged after the fact. However, bear in mind that rocket motors can vary ±10% from the manufacturer, so if aiming for specific performance perhaps consider rocket designs that can deal with variation in motor impulse from nominal values (or at least concede uncertainties in performance in your predictions).

All rocket flights must carry a commercial Jolly Logic AltimeterTwo (will be lent out) or AltimeterThree (if you own one) data logger – even rockets which are not using electronics to fire charge(s) for recovery purposes. This will provide a minimum amount of performance data on every flight, such as maximum altitude, maximum velocity, maximum acceleration, etc. Commercial "genuine altimeters" (as opposed to the AltimeterTwo and AltimeterThree units, which are just data loggers) must be used to fire team-installed ejection charges. Teams must also build and fly a "non-commercial" data-logging sensor suite – log sensor data that will allow you to do the calculations required of this competition. In this context, "non-commercial" means "not intended/sold for use in rocketry."

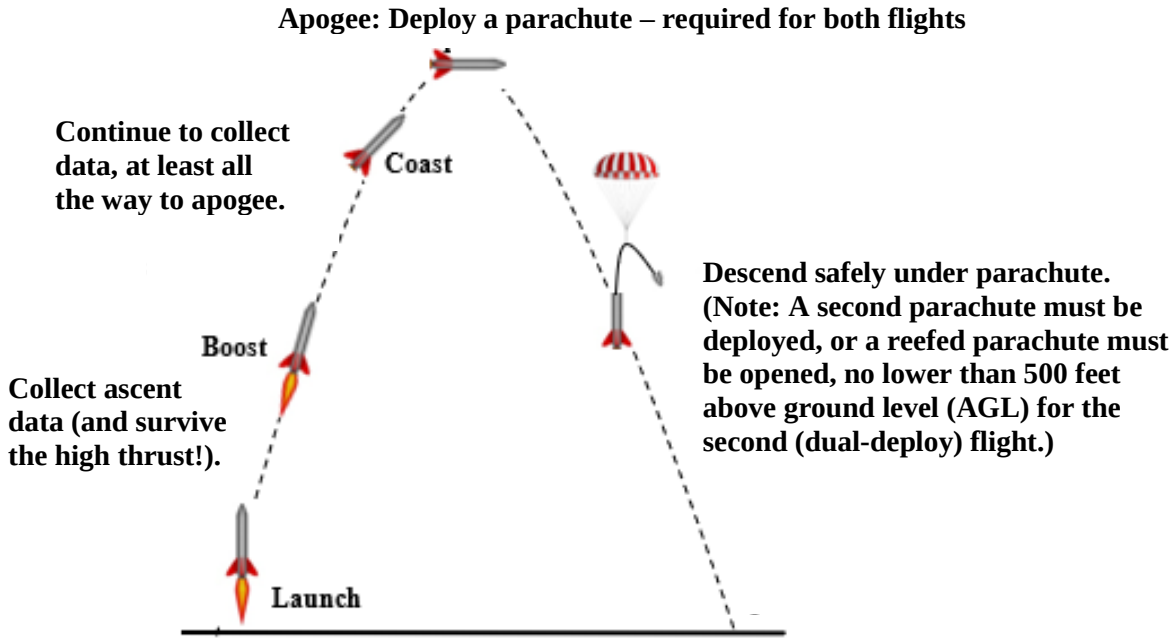
Be aware that motors from different companies require different cases and closures and need to be assembled in different ways. Aerotech motors are (typically) more complicated to assemble than Cesaroni motors (except for "disposable (case-less)"

Aerotech motors). Work with your certified mentor to learn how to assemble the motors you select – motor assembly errors may lead to motor CATO events!

Aerotech "single use" motors (AKA "the Aerotech DMS (disposable motor system)") do not require an external metal motor case – they slide directly into the motor-mount tube and have a thrust ring to keep them from going in too far (but they still require motor retention to keep them from coming out when the motor eject goes off). Although disposable motors are easier to use, the selection is much more limited than reloadable motors which go into metal cases.

Please contact Gary Stroick with any questions. For the 2024-2025 competition the registration fee covers the cost of the two competition Aerotech H550 DMS motors. Requests for additional motors that you intend to use at North Branch (for test launch(es) and/or for cert attempts) must be explicitly listed along with the Notice of Intent and paid for (if being ordered from Gary Stoick) along with the registration fee, by the end of January 2025. Teams from other parts of the country should place motor orders in early-fall as well, from a high-power rocketry vendor who serves high-power launches in their part of the country.

Figure of flight profile for a single-deploy flight in the "High-Thrust Challenge."



Flight Mission	⊢ Build (as a team) a rocket (or two) to attempt the "High-Thrust" challenges (some of which are bonus). ⊢ The rocket must carry a "non-commercial" sensor suite that logs ambient pressure, 3-axis acceleration, and gps (at least), at as high a logging rate as is practical.
Recovery System	⊢ Leave the motor eject in place to eject a parachute at (or just beyond) apogee on all flights (see caveat below).

- Electronic ejection of a parachute at apogee is required. Ejecting a parachute and/or breaking open the rocket during the ascent (i.e. prior to apogee) is not allowed. A fully-independent back-up for the apogee parachute is required. This may be either a motor eject (most common) or else a second, fully-independent commercial altimeter ejection charge system.
- A dual deploy recovery but may assist in ensuring the rocket lands on sod (at North Branch). For dual deploy rockets, the main parachute must be deployed, and fully unfurled, at least 500 feet above ground level.

Rocket Constraints on the Competition Day

- Each rocket must carry a competition-provided Jolly Logic AltimeterTwo data logger. Make its mounting location accessible! Competition judges may want to clear the device memory prior to each flight and will definitely want to see the device read-out after each flight. If your team owns a Jolly Logic AltimeterTwo or AltimeterThree, you may consult with the competition organizers about using your own device(s) for competition flights.
- The launch window will run from 9 a.m. (plus about 15 minutes for an on-site launch briefing at the start of the day) until 4 p.m.
  (A) All Level 1 certification rockets to fly on the competition day (some fliers may have flown their L1 cert flights in advance, which is allowed) must be ready to fly and in the RSO line for inspection by 11:00 a.m.
  (B) All first flights of competition rockets (the 1000-ft flight) must be ready to fly and in the RSO line for inspection by 11:00 a.m.
  (C) All Level 2 certification rockets must be ready to fly and in the RSO line for inspection by 1:00 p.m.
  (D) All second flights of competition rockets (the max-apogee flight) must be ready to fly and in the RSO line for inspection by 2:00 p.m.
  (E) Any undamaged rocket intended to fly more than once must be re-prepped and back in line for RSO inspection within one hour of being released from the post-flight check-in table (after the rocket has been recovered, passes a post-flight inspection, and any requested flight data has been extracted).
  (Note: If a rocket has an unsuccessful flight but is reparable and re-flyable, the one-hour timer will begin after the rocket has been repaired – don't rush that!)
- Modest point deductions will be made for taking longer than the times stated above to prep a rocket but DO NOT JEOPARDIZE SAFETY FOR TIME. The way to make this work is to have checklists, assigned roles, and

	to practice. Be organized and efficient but don't rush, lest you make mistakes! - The last flights of the day need to be in the RSO line no later than 3 p.m., so as to be launched by the time the launch window closes at 4 p.m. - The static margin of the rocket must be between 1 and 5 at launch (i.e. at maximum rocket weight). - The (average) thrust-to-weight ratio for each flight must be no less than 3 to 1 at launch (i.e. at maximum rocket weight), with 5 to 1 at launch being preferred. - Specific points will be awarded for avionics bay design – make it "tough, but user friendly." No more comments from judges like "It looks like it was thrown together with parts from the junk drawer!" This will entail a careful presentation of the av-bay design in pre-competition written reports as well as possible in-person judging of open av-bays at the competition itself. Judges will be evaluating component organization (including battery orientation), wiring layout, switch positioning, ease of use, and methods of securing components and layout of the sled within the av-bay, etc.
Expectations Related to Students Seeking Certification	- Certification rockets must be individually built, so the team-built competition rocket cannot serve as a certification rocket for anyone. - Students seeking both Level 1 and Level 2 certification may potentially do it using the same rocket (though not on the same day), as long as the rocket is tough enough for both types of motors. - All students attempting a Level 1 certification must take and pass (2 tries allowed, for full competition credit) an informal written test (written and delivered by the competition organizers – this is stricter than either Tripoli or NAR for Level 1 certification). All students attempting a Level 2 certification must take and pass (1 try allowed, for full for competition credit) the Tripoli Level 2 written test in advance of their certification flight attempt. Tests will be offered at the team oral presentation event the evening before the competition flight date. Note: 50% bonus credit will be awarded to students who are able to certify, but who do not pass the tests in the number of tries mentioned above.
Expectations Related to Certified Mentors	- Teams are required to have in-person or videocon meetings with their certified mentor at least monthly (preferably more frequently) as soon as the team starts to work on a design. - Teams are required two increase the frequency of meetings with their certified mentor to at least every

second week once the build starts or at the end of January, whichever comes first, until the build is complete (perhaps by early/mid April).

- Teams must conduct two remote inspections with competition organizers, with their certified mentor on the call for both. The **"50% inspection"** is when there is a near-final design and all the parts have been acquired (or at least are on order), though the build has not yet begun (or certainly not progressed very far). This first remote inspection must occur after receiving written feedback on the Draft of Design(s), but before the PDR is due (so it might happen around early March). The **"90% inspection"** is when the build is nearly complete, but before the rocket is test-flown (and hence before the FRR is due) (so it must happen probably no later than mid-April).

Draft of Design(s)

- Before you begin to build any rockets (or at least before you begin to build any scratch rocket(s)) you must submit a "Draft of Design(s)" report which includes OpenRocket or RockSim simulations of the design basics, plus details about build materials and planned commercial altimeter(s) for each rocket. See Appendix A-6 for required details. This document should be shown to your team's faculty adviser, certified mentor, and also to Gary Stroick, the competition technical adviser. Heed any feedback they provide!

Model Rocket Demonstration Flights

- Each team member who does not have high-power rocketry build experience must assemble and fly (hopefully successfully) at least one model rocket, different from the models built by their teammates. If a team has more than 5 students who need to demonstrate a model rocket build, teams may limit their members to building just 5 different models, as long as every student gets significantly involved in building and flying at least one model rocket. Report on the experience (1 page per student, including photos) submitted before, or along with, the PDR (Preliminary Design Report). Teams whose members all have previous high-power rocketry experience may request a waiver (by e-mail) of this requirement from the competition's Technical Advisor. Teams may also satisfy this requirement by building (as a team) and flying and successfully recovering a (non-competition) high-power rocket, rather than a set of model rockets, if they wish. But remember that high-power launches are regulated, so don't try this approach unless you are sure you can get a launch opportunity.

Pre-Competition Test Flight(s)	⇤ Each team must assemble, fly, and successfully recover a team-built competition rocket on a high-power motor (i.e., H-class or above) prior to the competition. We recommend test-flying the rocket on planned H-class motor for the competition itself. (Note – teams that do not satisfy this requirement may still compete, but will lose some points in the Flight Readiness report and the oral presentation.) ⇤ Individuals seeking Level 2 certification at the competition will need to earn their Level 1 certification in advance, potentially on the same rocket. That said, those rockets will need to fly (on Level 1 motors) in advance of the competition date (perhaps on a test-launch date for a team-built competition rocket). ⇤ If you elect to do any test flight(s) without all of the electronics in place – especially custom electronics that would be hard to replace if things don't go well), be sure to replace them with dummy weights so the rocket's performance is as realistic as possible. ⇤ Teams are strongly encouraged to fly an Altimeter Two data recorder (the competition organizers will lend you one in advance, upon request) on the test flight(s) (and possibly on model rocket flights too), to become familiar with how they work.
Rocket Design and Safety Reviews	⇤ In addition to a faculty adviser, every team is required to have a non-student mentor with high-power rocket experience (i.e. a Tripoli or NAR member with a Level 2 or higher certification). This mentor must evaluate the safety of your design both prior to, and during, the build process and provide some brief written commentary to the competition organizers, due at the same time as the team's two pre-competition written reports. The faculty adviser and the rocketry mentor (this potentially could be the same person, if the faculty adviser is certified appropriately) are encouraged, though not required, to attend the competition at North Branch, MN, in May. ⇤ Analysis of non-"pre-qualified" components must be included in written reports and also must be made available at all safety reviews. ⇤ In addition to the two remote reviews mentioned above, each team, with their rocket, must participate in the Safety Review by Tripoli MN on the evening before the competition launch date – which is the same day as the team oral presentations to the judges. ⇤ Each rocket must also pass the Range Safety Officer's Inspection on the day of the launch (repeated before every flight) before it will be allowed to fly.

Educational Outreach	⇤ Each team must share information pertinent to their competition rocket design/build/fly experience with at least 10 individuals (typically in group setting) who are not involved in the competition. For purposes of this competition, Outreach will be scored simply as "completed" or "not completed". Teams that do not complete the Outreach and submit the required documentation by the scheduled due date, as verified by their state's Space Grant, will receive a 10% deduction from their final overall score.
Successful Flights	⇤ Only "successful" flights can count toward flight day points. Flights will be deemed "successful" based on the criteria listed below: ⇤ Rocket ascends vertically (except for acceptable amounts of weather cocking – judges' discretion) ⇤ Rocket flies stably throughout ascent ⇤ "Apogee parachute" is deployed at (or just past) apogee, either by electronics or by the motor eject back-up backup ⇤ The main parachute, if rocket is dual-deploy, must be deployed and fully unfurled no lower than 500 feet above ground level. ⇤ Landing descent rate for all rocket parts is deemed reasonable (≤ 35 ft/sec) – based on judges' observation, not sensor values. ⇤ All parts of the rocket are recovered in re-flyable condition, which means that if given another motor, the rocket could be re-flown without requiring repairs. Note: non-critical or minor or cosmetic or unlucky-landing damage may be given point deductions rather than unilateral disqualification, but must be repaired to the RSO's satisfaction if the rocket is intended to fly again – judges' discretion. ⇤ Notice that failure of non-flight-critical on-board electronics (e.g. a non-commercial sensor suite to collect data) will not automatically result in an "unsuccessful" flight rating. ⇤ However, note that "landing without damage" is NOT the same thing as having a "successful flight" – judges may disqualify a rocket based on safety reasons, like failure to satisfy one or more of the critical criteria listed above, even if the rocket is recovered in re-flyable condition. Rockets that are disqualified may be proposed for re-flight, if undamaged (and if a motor is available), as long as the RSO is convinced that safety issue(s) is(are) resolved.

Required equipment:

Competition Rocket Motors (registration fee pays for the two H550 motors for the competition date; team pays for all other motors separately)	⇤ Teams must fly their first flight on an Aerotech H550 DMS motor and attempt to reach as close to 1000 ft AGL as possible. ⇤ Teams must fly their second flight on an Aerotech H550 DMS motor and attempt to go as high as possible. Note: Thrust curve data can be found at: http://www.thrustcurve.org/searchpage.jsp ⇤ Note: As of September 2024 an Aerotech H550 DMS 38 mm diameter Super Thunder motor cost $62.99 each (and does not require a case) from Off We Go Rocketry (the website price is out of date).
Radio Tracking	⇤ The Tripoli MN club requires on-board radio tracking electronics (not just an audio beeper) on all flights that will go higher than 3000 feet above ground level (AGL). We are even more strict – we require radio tracking on all competition flights expected to reach 2000 feet AGL, as well as on all certification attempts. Tracking must include at least one commercial tracking device that may be either a radio "beeper" or else a commercial GPS tracking unit (rugged enough for rocketry) that transmits GPS location to a ground station or to the internet. (There is fairly good cell phone service at the North Branch launch site to get on-line with smart phones to check for data posted to the internet.) Prof. Flaten and/or the Tripoli MN rocket club can lend teams radio beepers and also directional ground receivers for radio beepers operating in the 222MHz to 224MHz range from Communication Specialists < http://www.com-spec.com/rcplane/index.html>. ⇤ Note: Even though the launch field is on a sod farm, there are woods and fields of corn and soybeans (which will be planted and actively growing in May, though not too high yet) near the launch site which rockets sometimes drift into, making them hard to find without radio tracking. An audio siren is also a good idea, but optional for this competition. If the competition happens to shift later than May, audio sirens at North Branch become a genuine must (but never are allowed to replace radio trackers).
Competition Flight Data Recorder (for every flight)	⇤ Jolly Logic AltimeterTwo (just a data logger – not capable of firing ejection charges; has internal battery). ⇤ 1.93" long x 0.64" wide x 0.47" high. ⇤ 0.24 ounces (6.7 grams). ⇤ This data recorder will be independent from the team's own commercial rocketry altimeter(s) controlling the electronic deployment system(s).

- This data logger will be inserted just prior to each launch to record max altitude (and other performance data).
- Teams may borrow one AltimeterTwo from the competition organizers and/or use their own.
- AltimeterThree units, also from Jolly Logic, are allowed instead (but are not available to be borrowed). Though more expensive, they have the advantage that their data can be accessed remotely by bluetooth.

Additional Comments:

Interested students with questions about the capabilities of high-power motors or seeking help in getting started are highly encouraged to contact the competition's Technical Advisor **Gary Stroick** (president@OffWeGoRocketry.com) of the Tripoli Minnesota Association (a high-power rocketry association); or a high-power rocketry association nearer to them. Students interested in gaining information or experience by observing high-power rocket launches are encouraged to contact Gary and/or to attend one of the regular high-power rocket launches held in North Branch, MN, by the Tripoli MN High-Power Rocketry Club, or a comparable launch nearer them. Additional information, launch site maps, and launch schedules are posted at http://www.tripolimn.org (and comparable websites for other clubs).

Competition Schedule

- August 31, 2024 – Announcement of the 2024-2025 academic year competition
- September 9, 2024, 7 to 8 p.m. Central Time – Informational videocon (for teams starting in the fall and also for faculty advisers (at least) who expect to form teams after the fall) and posting of handbook
- September 15, 2024 – (Non-binding, but a hard deadline this year – no late-adds) Notice of Intent to Compete and "sponsorship" by a Space Grant required of all teams, including those starting after the fall – this document will include listing all certification flight motor(s) and test-flight motor(s) to be ordered from Gary Stroick (the vendor who serves the North Branch high-power rocket launches)
- BEFORE YOU START TO BUILD (or at least before you start to build scratch rocket(s)) – Submit Draft of Designs (specs & sim)
- Test flight motors and certification flight motors need to be ordered along with the Notice of Intent (i.e. by mid-September), then can be paid for at the same time as the registration fee which is due at the end of January. The registration fee covers the cost of the two Aerotech H550 competition motors (a value of just over $100). Teams who want to purchase additional motors from Off We Go Rocketry (the vendor serving Tripoli MN launches in North Branch) must include payment with their registration. All high-power motors must be purchased from a high-power rocketry vendor and paid for in advance.
- January 9, 2025, 7 to 8 p.m. Central Time – Repeat of informational videocon (especially for teams starting in the spring, but anyone may call in)
- January 31, 2025 – Formal Team Registration and payment of $400* registration fee due (*tentative value – might possibly go up or down (a little), depending on the number of teams that sign up and depending on our success in raising funding from outside sponsors)
- January 31, 2025 – date by which states will identify their judges – one judge per state fielding two or three teams; two judges for states fielding four or more teams
- February 10, 2025 – Declaration of Competition Attendance due
    - Specify Number of Team Members Attending Launch
    - Specify Number of Hotel Rooms and Dates Required
- February 10, 2025 – Last possible date to get credit for Draft of Design(s)
- Late February (approx.) – "50% inspection" (remote – with Gary, mentor, & faculty adviser) after receiving Draft of Design feedback but before building rocket(s) (at least any scratch rocket(s)) and before PDR is due – do this inspection when "design is done and parts are in hand (or at least are on order)"
- March 10, 2025 – Preliminary Design (Written) Report due (see rubric below)
    - Must explicitly state the type and number of motors that have been ordered for test flights and for certification flights.
    - This report must also include the Model Rocket Demonstration Flight documentation (or waiver)
- Early April (approx.) – "90% inspection" (remote – with Gary, mentor, & faculty adviser) after building is substantially complete but before test-flying the rocket(s) and before FRR is due
- March and April 2025 – likely times for test flight(s), at least one of which should be on a high-power motor (possibly the Aerotech H550 DMS motor to be used during the competition). Level 1 certification flights also need to be done in advance of May for anyone who will seek Level 2 certification on the competition

date. It is strongly recommended that teams conduct test flight(s) **well before the end of April** – early enough to reschedule, if weather is not cooperative, and also early enough to potentially have time to repair (and maybe even re-fly) the rocket(s) prior to the FRR due date (see below), if things don't go as planned.

- May 5, 2025 – Flight Readiness (Written) Report and Educational Outreach form due (Note to MN teams – this is before the May public launch at North Branch.)
- May 17-19, 2025 – Competition**
    - Saturday, May 17 – Mid-afternoon into the evening: Flight Readiness (Oral) Presentations and Safety Checks – probably in the Twin Cities
    - Sunday, May 18 – Competition launch all day (North Branch, MN) and evening social event, with announcement of partial results[1]
    - Monday, May 19 – Alternative competition launch (Rain Date) (so don't make travel plans that prevent you from sticking around through May 19, if conditions don't allow flying on May 18 – if the launch date is delayed to May 19, that will be announced no later than the evening of May 17)
- June 2, 2025 – Post-Flight Performance Evaluation and Data Collection Report due
- Final competition results will be reported on or before June 16, 2025.

** If Minnesota has a particularly wet/snowy winter and it becomes apparent that rocket flights won't be possible at North Branch even by mid-May, much less in March or April (for test flights), the competition organizers reserve the right to unilaterally shift the competition dates (possibly as late as mid- or late-September 2025). Such a "drastic" decision will be made no later than the end of April 2025. If teams assemble in May and do oral presentations but are unable to launch due to wet conditions on both May 18 and 19, the competition organizers will provide an alternative mechanism (which will not require a second trip to Minnesota for teams from other states) for teams to finish the competition at their home fields and submit their final report remotely.

Note that reports, motor orders, forms, etc. are due to the Technical Advisor by e-mail by 5:00 p.m. Central Time on the dates specified above. Scores for late reports will be reduced by 20% for each portion of each day that they are late, so DON'T BE LATE!

[1] At this event we expect to announce, and celebrate, the top teams in selected categories. This may include peer-judged awards like "Best Rocket Build" and/or "Best Instrumentation" and/or "Coolest-Looking Rocket." All teams are strongly encouraged to stay into the evening following the primary launch day so that they can attend this event, and also in case we need to launch on the alternate/rain date. If the launch needs to be held on the alternative date, teams that don't stick around will be disqualified from eligibility for judged 1st/2nd/3rd place awards, but will still be encouraged to complete their flights at their home field and submit their results for judges' feedback. If we are unable to fly at all at North Branch, even on the alternative date, teams will be given a specific deadline by which to complete their competition flights at their home field and instructions on how to submit their results for judging.

Safety and Construction

Setting the Tone

It is understood that this experience may be the first time many of the competitors have designed, built and flown a high-power rocket. To aid in making it a safe as well as educational aerospace opportunity, attention to safety will be held paramount. All teams will therefore be held to Code for High Power Rocketry as laid out in NFPA 1127 and further enhanced by the Tripoli Rocketry Association.

Table 1. FAA Model Rocket Classification

Limitation	**Class 1**	**Class 2**
Rocket weight	1500 grams (3.3lbs)	No limit
Motor limit	4.4 oz. of fuel (mid-size H motors)	40960 N-sec total thrust
Altitude limit	None - may be set by local agreement.	No Limit FAA Waiver Required
Other	Clear of clouds (all classes)	5 miles visibility, Clouds less than 5/10ths coverage (Clear of clouds) FAA Waiver required and Notice to Airmen filed (NOTAM) Between Sunrise and Sunset

Table 2. Tripoli Certification Requirements and Limitations

	Rocket / Motor Limitations			
Certification required	None	Level 1 HPR	Level 2 HPR	Level 3 HPR
Total Combined Impulse	320 N-sec (2 G Motors)	640 N-sec (H, I)	5120 N-sec (J, K, L)	40960 N-sec (M, N, O)
Combined propellant mass	125 grams (4.4 oz.)	No Limit		
Single Motor Impulse	160 N-sec (G motor)	No Limit		
Single Motor propellant mass	62.5 grams (2.2 oz.)	No Limit		
Single Motor Average Thrust	80 N-sec	No Limit		
Sparky Motors	Not allowed	Allowed		
Total Rocket Mass	1500 grams (3.3 lbs)	No Limit		
Field distance requirements	Per Model rocket safety code	Per HPR safety code		

The purpose of NFPA 1127 the Tripoli Safety Code and the NAR Safety Code are to:

- Provide safe and reliable motors, establish flight operations guidelines and prevent injury.
- Promote experimentation with rocket designs and payload systems.
- Prevent beginning high power hobbyists from making mistakes.

NFPA 1127 Code for High Power Rocketry
National Fire Protection Association
http://www.nfpa.org/1127

Tripoli Code for High Power Rocketry
Tripoli Rocketry Association
https://www.tripoli.org/content.aspx?page_id=22&club_id=795696&module_id=520420

I. All Launches:
   A. Must comply with United States Code 1348, "Airspace Control and Facilities", Federal Aviation Act of 1958 and other applicable federal, state, and local laws, rules, regulations, statutes, and ordinances.
   B. A person shall fly a rocket only if it has been inspected and approved for flight by the RSO. The flier shall provide documentation of the location of the center of pressure and the center of gravity of the high-power rocket to the RSO if the RSO requests same.
   C. The member shall provide proof of membership and certification status by presenting their membership card to the Launch Director or RSO upon request.
   D. A rocket with a predicted altitude in excess of 50,000 feet AGL requires review and approval by the TRA Class 3 Committee.
   E. Recovery.
      1. Fly a rocket only if it contains a recovery system that will return all parts of it safely to the ground so that it may be flown again.
      2. Install only flame-resistant recovery wadding if wadding is required by the design of the rocket.
      3. Do not attempt to catch a high-power rocket as it approaches the ground.
      4. Do not attempt to retrieve a rocket from a power line or other place that would be hazardous to people attempting to recover it.
   F. Payloads
      1. Do not install or incorporate in a high power rocket a payload that is intended to be flammable, explosive, or cause harm.
      2. Do not fly a vertebrate animal in a high-power rocket.
   G. Weight Limits
      1. The maximum lift-off weight of a rocket shall not exceed one-third (1/3) of the average thrust on the motor(s) intended to be ignited at launch.
   H. Launching Devices
      1. Launch from a stable device that provides rigid guidance until the rocket has reached a speed adequate to ensure a safe flight path.
      2. Incorporate a jet/blast deflector device if necessary to prevent the rocket motor exhaust from impinging directly on flammable materials.
   I. Ignition Systems
      1. Use an ignition system that is remotely controlled, electrically operated, and contains a launching switch that will return to "off" when released.
      2. The ignition system shall contain a removable safety interlock device in series with the launch switch.
      3. The launch system and igniter combination shall be designed, installed, and operated so the liftoff of the rocket shall occur as quickly as possible after actuation of the launch system. If the rocket is propelled by a cluster of rocket

motors designed to be ignited simultaneously, install an ignition scheme that has either been previously tested or has a demonstrated capability of igniting all rocket motors intended for launch ignition within one second following ignition system activation.

4. A rocket motor shall not be ignited by a mercury switch or roller switch.

J. Install an ignition device in a high-power rocket motor only at the launch pad.

K. Launch Operations

1. Do not launch with surface winds greater than 20 mph (32 km/h) or launch a rocket at an angle more than 20 degrees from vertical.
2. Do not ignite and launch a high-power rocket horizontally, at a target, in a manner that is hazardous to aircraft, or so the rocket's flight path goes into clouds or beyond the boundaries of the flying field (launch site).
3. A rocket shall be pointed away from the spectator area and other groups of people during and after installation of the ignition device(s).
4. Firing circuits and onboard energetics shall be inhibited until the rocket is in the launching position.
5. Firing circuits and onboard energetics shall be inhibited prior to removing the rocket from the launching position.
6. When firing circuits for pyrotechnic components are armed, no person shall be allowed at the pad area except those required for safely arming/disarming.
7. Do not approach a high-power rocket that has misfired until the RSO/Launch Control Officer (LCO) has given permission.
8. Conduct a five second countdown prior to launch that is audible throughout the launching, spectator, and parking areas.
9. All launches shall be within the Flyer's certification level, except those for certification attempts.
10. The RSO/LCO may refuse to allow the launch or static testing of any rocket motor or rocket that he/she deems to be unsafe.

II. Commercial Launches

A. Use only certified rocket motors.

B. Do not dismantle, reload, or alter a disposable or expendable rocket motor, nor alter the components of a reloadable rocket motor or use the contents of a reloadable rocket motor reloading kit for a purpose other than that specified by the manufacture in the rocket motor or reloading kit instructions.

C. Do not install a rocket motor or combination of rocket motors that will produce more than 40,960 N-s of total impulse.

D. Rockets with more than 2560 N-s of total impulse must use electronically actuated recovery mechanisms.

E. When more than 10 model rockets are being launched simultaneously, the minimum spectator distance shall be set to 1.5 times the highest altitude expected to be reached by any of the rockets. Tripoli Rocketry Association Safe Launch Practices

F. When three or more rockets (at least one high power) are launched simultaneously, the minimum distance for all involved rockets shall be the lesser of:

1. Twice the complex distance for the total installed impulse. (refer to V. Distance Tables)

2. 2000 ft (610 m)
3. 1.5 times the highest altitude expected to be achieved by any of the rockets.

G. When more than one high power rocket is being launched simultaneously, a minimum of 10 ft (3 m) shall exist between each rocket involved.

MINIMUM DISTANCE TABLE

Installed Total Impulse (Newton-Seconds)	Equivalent High-Power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	Minimum Personnel Distance (Complex Rocket) (ft.)
0 -- 160.00	G or smaller	N/A	30	30
160.01 -- 320.00	H	50	100	200
320.01 -- 640.00	I	50	100	200
640.01 -- 1,280.00	J	50	100	200
1,280.01 -- 2,560.00	K	75	200	300
2,560.01 -- 5,120.00	L	100	300	500
5,120.01 -- 10,240.00	M	125	500	1000
10,240.01 -- 20,480.00	N	125	1000	1500
20,480.01 -- 40,960.00	O	125	1500	2000

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

Design and Safety Review

Endeavoring to have all teams perform their flights in a safe and controlled manner, each team must have a Level-2-Certified (Tripoli or NAR) non-student mentor that reviews the design and construction of their rocket in advance of the competition flights and calls in to both the "50% inspection" and the "90% inspection." If you need assistance in finding a certified high-power rocketry mentor, please contact the competition Technical Advisor and they will help you with this task. A Safety Review Meeting will occur the evening before the competition launch date that will be mandatory for all teams.

Interacting with your certified mentor is required, not optional – see earlier notes about monthly then twice-a-month in-person (or at least videocon) meetings. The mentor must submit a form (see APPENDIX A-5) discussing their interactions with the team along with each of the first two written reports. Teams – make sure your mentor has something to say (and make sure it is positive)!

At the safety review the team must be prepared to discuss the design of their rocket(s) and systems. In addition, the teams must be able to demonstrate/exhibit:

- Their rocket(s) in various state of assembly, including full exposure of the av-bay(s) – internal structure – and other custom mechanisms (if any)

- Diagram(s) of the rocket(s), indicating the configuration of main components
- Flight simulation(s) showing max altitude and launch rail departure velocity(ies) (speed at the end of a 8 ft launch rail – this speed should exceed 45 ft/s) – build all rockets to fit on 10-10 rails
- Familiarity with all commercial rocketry altimeter(s) used for data logging and, even more importantly, for ejection charge deployment (study the user manuals!)
- A Pre-flight Checklist
- A Launch Pad and Flight Arming Checklist
    - Must include notes about all altimeter ready/standby tones
- A Recovery/Post-flight Checklist
    - Must include procedure to "safe" unexploded deployment charge(s) (if any) and instructions about how to turn off payload(s), if needed for safety reasons

Pre-flight Safety Inspection

On flight competition day, all teams must have their rockets inspected before they will be allowed to proceed to the launch pad. The teams must be prepared to discuss their rocket designs and deployment systems. In addition, the teams must display:

- Each rocket, readied for launch
    - Center of Gravity (CG) for each flight and Center of Pressure (CP) must be clearly marked on the rocket's exterior
- Pre-flight Checklist (showing that all steps have been completed up to launch)
- Launch Pad and Flight Arming Checklist
    - Must include all altimeter ready/standby tones
- Recovery/Post-flight Checklist
    - Must include procedure to "safe" unexploded deployment charge(s) (if any) and instructions about how to turn off payload(s), if needed for safety reasons

Post-flight Check-in

Following the team's competition flights, the team must follow their Recover/Post-flight Checklist to insure a safe recovery. After each flight the team will then proceed to the recovery check-in station with:

- The team's rocket
- Recovery/Post-flight Checklist
    - Must show that all steps in the recovery procedure were completed before approaching the check-in station

At this check-in the rocket will be inspected and flight data, including flight video (if any) will be downloaded before the rocket is released (potentially to be prepped for additional flight(s)). For rocket(s) that are to be re-flown, the one-hour prep timer (for successful flights only) will start when the rocket is released from the post-flight check-in station. If a rocket has an unsuccessful flight but is reparable and re-flyable, the timer will begin <u>after</u> the rocket has been repaired – don't rush that!

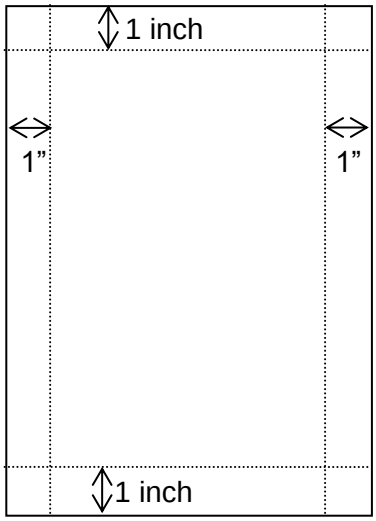
Preliminary Design (Written) Report

Design Report Objectives

The purpose of this design report is to evaluate the engineering effort that went into the design and construction of the rockets, with their diverse features, and how that effort meets the intent of the competition. The document that illustrates the best use of engineering principles to meet the design goals and the best understanding of the design by the team members will score the highest.

Report Format

The design report can be no longer than twenty-five (25) single-sided pages in length. This, and all written reports, must be in a font not smaller than 12 pt and no less than single-spaced. All margins must be no less than 1 inch from each edge of the page. All pages (except for the cover page) must be numbered in the upper righthand corner. Each section of the report must be clearly delineated with a heading. All section headings must appear in a table of contents. Reports must be submitted electronically in *.pdf* format.



Material that must be included, as a minimum:

- Separate Cover Page (counts toward page limit) which includes (at least) Team Name, School Name, Certified Non-student Team Mentor, Team Faculty Adviser (with contact information including both e-mail and cell phone), Student Team Lead (with contact information including both e-mail and cell phone), and a listing of all Student Team Members
- Separate Table of Contents page (1 page max, counts toward page limit)
- Separate Executive Summary page (1 page max, counts toward page limit)
- Labeled figures showing features of rocket airframe and custom mechanism(s)
- Design features for addressing challenges - especially on-board electronics (i.e. commercial altimeter, data logger, video camera(s), non-commercial electronics, etc.)

    - Usability and reliability design features of avionics bay(s) (i.e., ease of assembly/use, sled layout, power layout, wiring layout, switch positions, etc.)
- Diagram of each rocket identifying the dimensioned locations for the:
    - CP (center of pressure)
    - CG (center of gravity when fully loaded (i.e., with rocket motor installed))
- Anticipated basic flight performance – including information about how each value was estimated (typically using simulation software)
    - Estimated leave-the-rail velocity
    - Estimated maximum altitude (remember that radio tracking is required on all certification flights and on all competition flights expected to go higher than 2000 ft AGL)
    - Estimated peak velocity
    - Estimated peak acceleration
    - Estimated (landing) descent speed
- Discussion of sensor data to be collected (multiple types) any how each will be used to deduce altitude, speed, and acceleration during ascent all as a function of time (not just maximum values). State assumptions/external information required for each type of analysis, pros/cons of each type of analysis, and impact of data collection rate. For example, for a barometric pressure analysis you might report that you need to look up how pressure varies with altitude and you might concede that such an approach could potentially be "blind" to non-vertical motion and also might be troublesome if the rocket approaches/exceeds the speed of sound.
- Budget (planned) including model rockets, kit high-power rockets, scratch components, build materials, motors, cases/closures, electronics, as well as registration fee and estimated cost of competition travel
- Mentor Report Form (see Appendix A-5) will be collected from mentor directly

Evaluation Criteria

Reports and design will be evaluated on content, organization, clarity, completeness, and professionalism of the material. The criteria are detailed in Appendix A-1 "Preliminary Design Report Judging."

Scoring Formula

The scoring of the Preliminary Design Report is based on the average of the Preliminary Design Report Judging forms. There is a maximum of 100 points from the Preliminary Design Report Judging form that will be scaled for the final competition weighting.

Flight Readiness (Written) Report

Flight Readiness Report Objectives

The team will report on flight readiness for all rockets and on test flight(s) for all rockets flown in advance. This includes, but is not limited to, sensor logging, video recording (if any), and recovery system operation, landing system operation. Comparison of actual fight performance to predicted performance shall also be included, to demonstrate the team's knowledge and understanding of the physics involved. This will be presented in the form of a brief report which shall include a discussion of the results, especially any differences between the actual performance and predicted values.

Report Format

The flight readiness document should follow the same formatting guidelines as the Preliminary Design Report and be no longer than twenty-five (25) single-sided pages in length and must be submitted electronically in *.pdf* format.

Material that must be included, as a minimum:

- Separate Cover Page with information requested for PDR (updated, if need be) (counts toward page limit)
- Separate Table of Contents page (counts toward page limit)
- Summary of rocket design – especially unique airframe features, av-bay layout, electronics, etc.
- Budget (actual; with comments about changes since planned budget)
- Construction photos of all rockets, including photos of av-bay and custom mechanisms (if any)
- Explicit discussion of any special features/construction techniques (e.g., special surface finishes, lay-ups to strengthen fins, etc.)
- Photographs of completed/assembled rocket
- Links to video clips from test flight(s),
- Test flight(s) sub-report
    - Actual flight performance (as compared to simulated/desired performance)
    - Recovery system performance
    - Table of flight characteristics (mass, motor, max altitude, max velocity, …)
- Discussion of results
    - Analyze and discuss “altitude, speed, and acceleration during ascent, all as a function of time (not just maximum values),” as deduced by the sensors on your non-commercial sensor suite.
    - Compare the results between your sensors and also discuss how your results compare with the values reported by the commercial devices: AltimeterTwo (reports max values only, based on pressure) and “real” altimeter (the data it gives, and how it was collected, depends on the altimeter type).
    - Compare predicted and actual apogees, predicted and actual peak velocities, and predicted and actual peak accelerations. Describe differences and explain possible reasons for differences, if any.
    - Compare predicted and actual (landing) descent speeds. Describe and explain possible reasons for differences, if any.
- Planned changes/improvements, if any, prior to the competition flights

- Mentor Report Form (see Appendix A-5) will be collected from mentor directly
- (Outside of page limits given above): Appendix with full listing of micro-controller flight code for non-commercial sensor suite and/or other micro-controller-run electronics

Evaluation Criteria

Reports will be evaluated on how closely the predicted results compare to the actual results, how well the team explains any differences, plus clarity, completeness, and professionalism of the material. The criteria are detailed in Appendix A-2 "Flight Readiness Written Report Judging."

Scoring Formula

The scoring of the Flight Readiness Written Report is based on the average of the Flight Readiness Written Report Judging forms. There is a maximum of 100 points from the Flight Readiness Written Report Judging form that will be scaled for the final competition weighting.

Educational Outreach

Educational Outreach Performance (EPO)

An “Educational Outreach” event is expected in which each team presents information related to their work on this competition with at least 10 people, typically in a group format, who are not involved in the competition. For purposes of this competition, outreach will be scored as "completed" or "not completed." Outreach possibilities could include, but are not limited to:

- Meet with a K-12 class or college/university student organization to explain how rockets work (including discussing your rocket designs and/or your actual rockets and/or your test flight results).
- Make a presentation in the community or to a group on campus to describe this year’s rocketry competition and your team’s designs, rockets, results, etc.

Evaluation Criteria

At the completion of the outreach event the team will need to have a representative from the invited group complete an EPO (Education/Public Outreach) form (located on the last page of this handbook). The team must then submit that form to their state’s Space Grant and to the competition organizers by e-mail.

Scoring Formula

Teams that do not complete the Educational Outreach and submit their EPO form by the due date will receive a 10% decrease in their team’s overall score.

Flight Readiness (Oral) Presentation

Presentation Format

In the late afternoon or evening of the first day of the competition, one or (preferably) more team member(s) will deliver an oral presentation to a panel of judges. All team members who will deliver any part of the presentation, or who will respond to the judges' questions, must stand in the podium area when the presentation starts and must be introduced to the judges. All team members who are part of this "presentation group" may answer the judge's questions, even if they did not present material during the presentation itself.

Oral presentations are limited to a maximum of ten (10) minutes. The judges will have read the written reports in advance, so you don't need to take a long time introducing the rocket from scratch. The judges will stop any presentation exceeding eleven (11) minutes. The presentation itself will not be interrupted by questions. Immediately following the presentation there will be a question-and-answer session of up to three (3) minutes. Only judges may ask questions (at first). Only team members who are part of the "presentation group" may answer the judges' questions. If time allows, there may be an opportunity to take additional questions from the audience. If questions are asked by the audience, a designated competition official will determine if the question is appropriate and, if so, will allow the team to answer.

In addition to the 10-minute presentation described above, each team will also do an oral safety check with a representative of Tripoli MN and show one or more judges their full-opened av-bay(s) (which does count toward their FRR score). These will not be timed events, but the examinations will need to be fairly quick – probably no more than 5-10 minutes to show off your rocket and answer any questions.

Evaluation Criteria

Presentations will be evaluated on content, organization, visual aids, delivery, and the team's response to the judges' questions. The scoring criteria are detailed in Appendix A-3 "Flight Readiness Oral Presentation Judging." The criteria are applied only to the team's presentation itself. The team that delivers the best oral presentation, regardless of the quality of their actual rocket, will score highest for the oral presentations.

Scoring Formula

The scoring of the Oral Presentation is based on the average of the Oral Presentation Judging forms. There is a maximum of 100 points from the Oral Presentation Judging form that will be scaled to meet the final competition weighting.

Competition Flight

Review ***Pre-flight Safety Inspection*** and ***Post-flight Check-in*** (earlier in this handbook) to ensure eligibility for competition flights.

Launch and Flight Format

The launch will take place at the Tripoli MN launch site near North Branch, MN, which is about a 1-hour drive north of Minneapolis. (See maps at www.tripolimn.org). Each rocket must pass a safety inspection before each flight and any additional equipment must be cleared by the Range Safety Officer (RSO) before entering the launch area.

The competition flight data recorder, a Jolly Logic AltimeterTwo, will be placed in the rocket by a competition official or designee or, minimally, proper placement and arming will be verified by such an official prior to each flight. Note: AltimeterTwo data loggers can time out if they don't detect a launch soon enough after they are armed, so be sure to design your rockets so the AltimeterTwo can be armed and inserted just before launch (and is accessible enough to be re-armed easily, if need be).

Only registered student team members (cost is $20 per student to register with Tripoli) may accompany the rocket into the launch area. All certification-seeking students need to register prior to the date of their certification attempt. Each team must have at least two members (and preferably all members) registered so they may assist with rocket launch set-up on the pad, overseen by a member of the Tripoli MN club. Each team must also have a recovery subteam that will follow the directions of the RSO or designee regarding when/how to recover the rocket after it lands.

All rockets must be designed so that they can be prepared for flight within one hour. Therefore, the following additional requirements are in effect:

- The launch window will run from 9 a.m. (plus about 15 minutes for an on-site launch briefing at the start of the day) until 4 p.m.
- All Level 1 certification rockets to fly on the competition day (some fliers may have flown their L1 cert flights in advance, which is allowed) must be ready to fly and in the RSO line for inspection by 11:00 a.m.
- All first flights of competition rockets (the 1000-ft flight) must be ready to fly and in the RSO line for inspection by 11:00 a.m.
- All Level 2 certification rockets must be ready to fly and in the RSO line for inspection by 1:00 p.m.
- All second flights of competition rockets (the max-apogee flight) must be ready to fly and in the RSO line for inspection by 2:00 p.m.
- Upon completion of providing flight data to the flight operations recorder after each flight, the time will be recorded. If a rocket is intended to fly again, it must be in ready-to-fly condition and back in the RSO line within one hour of that time.
- (Note: If a rocket has an unsuccessful flight but is reparable and re-flyable, the one-hour timer will begin <u>after</u> the rocket has been repaired – don't rush that!)
- Teams that do not meet these prep-for-flight time requirements will be allowed to fly but will be subjected to (modest) late-flight penalties. Remember, safety is

more important than timeliness. Meet the prep time deadlines by practice, not by rushing.
- The last flights of the day need to be in the RSO line no later than 3 p.m., so as to be launched by the time the launch window closes at 4 p.m.

To be considered a safe and (nominally) successful flight, the rocket must:
- Launch
- Rocket flies vertically (the launch rail itself will be vertical)
- Rocket is stable throughout the ascent
- Recovery system (apogee parachute only, or drogue plus main parachute, if dual deploy) is successfully deployed
- Landing speed is deemed reasonable (≤ 35 ft/sec) for all parts, still tied together
- Rocket must be recovered in flyable condition (see note below)
- Note: Failure to log sensor data, for example, will not, in and of itself, constitute a unsuccessful flight if the conditions above are met. For example, there will not be an explicit deduction or disqualification if part of the recovery system is ejected successfully by the back-up charge rather than by the primary charge. A dual-deploy rocket that lands at a safe velocity and is undamaged, even if both parachutes didn't deploy exactly as planned, will not be subject to automatic disqualification (but might sustain a point deduction). However, in dual-deploy rockets failure to fully deploy a main parachute may well, depending on the size of drogue parachute, result in a too-fast landing, meriting disqualification, even if the rocket is undamaged (judges' discretion).

The stability condition (i.e., "static margin between 1 and 5 on launch (max weight)") is a safety consideration. Safety decisions (associated with stability, among others) will be made by the launch-site judges. If need be, the judges may use "instant replay" (i.e., ground video footage of the launch and/or on-board footage from the rocket itself, if available) to assist them in making their decision. Rockets (or parts thereof) that go unstable during ascent, may be subject to disqualification on safety grounds, even if they aren't actually damaged upon landing.

Flyable condition is defined to be that if the flyer were handed another motor, the rocket would pass RSO inspection and could be put on the pad and flow again safely without requiring repairs. Note: non-critical or minor or cosmetic or unlucky-landing damage may be given point deductions rather than unilateral disqualification, but must be repaired to the RSO's satisfaction if the rocket is intended to fly again – judges' discretion.

The entire rocket must be returned to a designated location for post-flight inspection by the RSO or designee.

A flight performance report sheet will be filled out by a designated flight operations recorder. The flight operations recorder will record the AltimeterTwo data following each flight and possibly request a copy of the on-board sensor log(s), at least from rockets that plan to be re-flown. Upon completion of the post-flight data download, a team member must sign their initials of acceptance before the rocket will be released to the team.

Rockets flown for certification must be declared in advance to the RSO (and a written test taken in advance, in the case of Level 2 certification attempts), so that certification observers may be appointed. *(Level 1 certification tests – a unique feature of this competition – need not to be taken in advance of the date of the Level 1 cert flight, but will be offered the night before the competition.)* All certification rockets need to be examined post-flight by the RSO, or an appointee, in addition to the competition post-flight check in. Certification flight results will be recorded separately from scoring of the competition rocket itself. Team members who merit certification are expected to accept it and pay for a one-year membership at a student rate. Maintaining active membership beyond that time, which will incur an annual membership fee, is encouraged but is a personal decision, unrelated to the competition.

Evaluation Criteria

Finishing order for of the competition flights will based on:

- Having timely launches and safe flights
- Having successful flights and recoveries, as defined above
- Accomplishing the full number of flights planned (two, minimum, for the team-built competition rocket(s), plus additional certification flights (optional))

Scoring Formula (Figures of Merit)

Competition flight scores will be based on the following formulas:

Figure of Merit 1 (FM1) (a point value between 0 and 35) (only applies to rockets with a fully-successful or-partially-successful Flight 1 (i.e. not disqualified)):

Define MISS (in feet) as absolute value of the actual apogee (in feet, as reported by the competition AltimeterTwo (and hopefully confirmed by other devices)) minus 1000 ft (the target apogee).

If MISS $\leq$ 25 feet	FM1 = 35 points
If 25 feet < MISS $\leq$ 50 feet	FM1 = 30 points
If 50 feet < MISS $\leq$ 75 feet	FM1 = 25 points
If 75 feet < MISS $\leq$ 100 feet	FM1 = 20 points
If 100 feet < MISS $\leq$ 200 feet	FM1 = 10 points
If 200 feet < MISS	FM1 = 0 points

Figure of Merit 2 (FM2) (a point value between 0 and 35) (only applies to rockets with a fully-successful or-partially successful Flight 2 (i.e. not disqualified)):

Define MAX at the highest apogee (in feet) for any successful flight in the competition (so this value won't be known until after all rockets have flown).

FM2 = 35 points * flight 2 apogee (in feet) / MAX

Note: Be sure to download raw data between flights (before the 60-minute timer starts) (you should do this anyway, if the rocket is to be re-flown, just in case the rocket crashes on the second flight) and be ready to provide it to the judges upon request.

Flight Score = 0 (AKA disqualification) if rocket is not recovered in flyable condition or if the flight is deemed "unsafe" or in violation of competition rules, even if the rocket is undamaged. Rockets may be disqualified for events like unstable ascent, too-fast descent, not deploying recovery systems, etc. Rockets that are disqualified may be launched again later in the day if the disqualification issue(s) can be resolved to the RSO's satisfaction (and if motors are available).

Total Flight Score (if not disqualified) = 5 points for each timely flight (loss of 1 point per 15 minutes beyond requested prep time (not to exceed a loss of 5 points per flight))

PLUS

20 points (10 points each) for completing two safe (fully or partially-successful) flights

PLUS

FM1

PLUS

FM2

Notice that up to 30 points will be awarded to rockets that are prepped in a timely manner and safely complete two flights and are recovered in flyable condition, even if they don't perform perfectly. There is a maximum of 100 points for the Competition Flight Score that will be scaled for the final competition weighting. If any rocket is flown more than once during the competition, the best flights (one of each type) will count (even if one or more other flights are disqualified). However, there is a finite launch window and the Tripoli MN members running the launch might not allow you to launch a rocket that appears to them (in advance) to be fundamentally unsafe, so don't expect to bend the safety limits nor bet too heavily on the prospect of flying more than twice (total).

If weather conditions – particularly low cloud cover – allow for Flight #1 but not Flight #2 for some rockets on the primary flight day, additional flights will be allowed on the weather-delay date. If weather prevents flights (of either type) altogether on both dates, teams will be given options to complete their flights at their home field at a later date and submit their flight results to the judges remotely.

Post-Flight Performance Report

Performance Comparison

The comparison of the fight performance to the predicted performance will help to demonstrate the team's knowledge and understanding of the physics involved. It will be presented in the form of a brief report that will include a "Flight Performance Comparison Sheet" and discussion of the results, especially any differences between the actual and the predicted values.

Performance Comparison Format

The performance comparison document should follow the same guidelines as the Preliminary Design Report and be no more than fifteen (15) single-sided pages in length and must be submitted electronically in *.pdf* format.

Material that must be included, as a minimum:

- Separate Cover Page with information requested for PDR (updated, if need be) (counts toward page limit)
- Flight Performance Results
  - Table of Flight Characteristics (mass, motor, max altitude, max velocity, max acceleration, etc.)
  - Plots vs time from commercial altimeter (if it logs that sort of data) and from non-commercial sensor suite sensors: raw data and/or deduced values such as acceleration, velocity, altitude, etc.
- Flight Anomaly Discussion
  - Identify all anomalies that occurred during the flight. Discuss the possible causes for each anomaly and the analysis for identifying the root cause or causes.
  - For each anomaly, present mitigation activities that may have prevented the anomaly. Note that these mitigations may be in the planning, design, build, testing, flight preparation or any other phases of your project.
- Discussion of Flight Results vs Flight Predictions
  - Compare predicted results with actual results as measured by on-board electronics. Discuss (at least) apogee, peak velocity, peak acceleration, main deployment altitude for dual-deploy flight(s) (if known), and landing speed – describe and explain possible reasons for differences. The competition-provided AltimeterTwo data logger will give some, but not all, of this information.
- Discussion of non-commercial sensor performance
  - Briefly discuss how all your sensors fared on the competition flights and what you learned about the pros/cons of trying to characterize flight performance in various ways.
  - Based on your experiences, and perhaps what you observed about other teams, make at least some comments about what you might do differently/next if you were to continue to work on this challenge.
  - Optional – not for explicit points, but an active field of research: discuss how you might merge data from different sensors to try to come up with an even-

better “solution” than any one sensor can provide. Hint – look up “Kalman filter.”

- (Outside of page limits given above): Code Appendix (but only if code changed since FRR – describe changes and include updated code listing)

Evaluation Criteria

Reports will be evaluated on how closely the predicted results compare to the actual results, how well actual values from various sources agree with one another, how well the team explains any differences, how well the team discusses their understanding of the pros/cons of using different types of sensors to characterize basic flight performance, as well as clarity, completeness, and professionalism of the material. The criteria are detailed in Appendix A-4 “Post-Flight Performance Report Judging.”

Scoring Formula

The scoring of the Post-Flight Performance Report is based on the average of the Post-Flight Performance Report Judging forms. There is a maximum of 100 points from the Post-Flight Performance Report Judging form that will be scaled for the final competition weighting.

APPENDIX A-1

PRELIMINARY DESIGN WRITTEN REPORT JUDGING

Score the following categories according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
¼ Max Value = attempted but below expectation
½ Max Value = average or expected
¾ Max Value = above average but still lacking
Max Value = excellent, perfectly meets intent

_____ **OVERALL TEXT RELEVANCE (16 pts)**

- Executive Summary (4 pts)
- Thorough and organized presentation about approach to competition challenges (4 pts)
- General description of rocket general features / functions (4 pts)
- Discussion of how the rocket's unique features / functions will help achieve competition objectives (including mention of bonus elements being pursued, if any) (4 pts)

_____ **ROCKET MECHANICAL & ELECTRICAL DESIGNS (32 pts)**

- Airframe and propulsion system specifications (with dimensions) (4 pts)
- Recovery system design specifications (4 pts)
- Avionics/payload system design specifications (8 pts)
- Discussion of alternative approaches to data logging sensor suite and computations including assumptions and external information required for each type of analysis, pros/cons of each type of analysis, and impact of data collection rate. Discussion of sensor data collection types and how each will be used to deduce altitude, speed, and acceleration during ascent as a function of time (not just maximum values). (8 pts)
- Planned construction solutions and techniques (4 pts)
- Structural analysis of scratch-built parts, if any, and overall risk mitigation analysis (4 pts)

_____ **PREDICTED PERFORMANCE FOR FLIGHT (20 pts)**

- Launch analysis (4 pts)
- Flight analysis (altitude vs time, velocity vs time, acceleration vs time, etc.) (4 pts)
- Recovery analysis (4 pts)
- Overall stability analysis (4 pts)
- Environmental conditions analysis (4 pts)

_____ **SAFETY (16 pts)**

- Rocket design for safe flight & recovery (4 pts)
- Documentation of materials-handling procedures (4 pts)
- Planned build and launch assembly procedures (4 pts)
- Planned pre- & post-launch procedures (4 pts)

_____ **REPORT AESTHETICS (16 pts)**

- Followed specifications (4 pts)
- Consistent formatting; correct spelling and grammar (4 pts)
- Documented figures and graphs (4 pts)
- References and labeling (4 pts)

_____ **TOTAL PRELIMINARY DESIGN REPORT POINTS (100 points maximum)**

COMMENTS:

APPENDIX A-2

FLIGHT READINESS WRITTEN REPORT JUDGING

Score the following categories according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
¼ Max Value = attempted but below expectation
½ Max Value = average or expected
¾ Max Value = above average but still lacking
Max Value = excellent, perfectly meets intent

_____ **OVERVIEW OF APPROACH (8 pts)**

- Thorough and organized presentation of approach to challenge (including mention of bonus elements being pursued, if any) (8 pts)

_____ **DISCUSSION OF COMPETITION ROCKET BUILD (8 pts)**

- Documentation of team-built competition rocket (8 pts)

_____ **RECAP OF ROCKET DESIGN (24 pts)**

- Designs and dimensions (4 pts)
- Construction techniques implemented (4 pts)
- Av-bay design(s) – tough, but user-friendly (4 pts)
- Construction details regarding safe flights & recovery (4 pts)
- Stability analysis (4 pts)
- Discussion of changes made since Preliminary Design Report (4 pts)

_____ **ROCKET OPERATION ASSESSMENT (20 pts)**

- Launch, boost, and coast phase analysis (6 pts)
- Analysis of non-commercial sensor suite data captured during ascent for altitude, speed, and acceleration (all versus time) determination (6 pts)
- Recovery system and descent phase analysis (4 pts)
- Pre- & post-launch procedure assessment (4 pts)

_____ **ALL TEST LAUNCH(ES) (INCLUDING LEVEL 1 CERT. FLIGHTS FOR TEAM MEMBERS SEEKING LEVEL 2 CERT. AT COMPETITION, IF ANY): ACTUAL VS PREDICTED PERFORMANCE (12 pts)**

- Peak altitude, velocity, and acceleration comparison(s) to expectations (4 pts)
- Recovery system performance comparison(s) to expectations (4 pts)
- Other in-flight sensor data collected: barometric pressure, acceleration, and GPS (for altitude, speed, and acceleration determination), other logged sensor data (if any), performance

of in-flight mechanisms besides recovery system (if any), etc. (4 pts)

_____ **FINDINGS AND FUTURE WORK (12 pts)**

- Key findings (4 pts)
- Potential design changes / improvements (4 pts)
- "If we were to do it again" – things you are <u>not</u> able to change / improve, but wish you could (and explain why) (4 pts)

_____ **REPORT AESTHETICS (14 pts)**

- Followed specifications (4 pts)
- Consistent formatting; correct spelling and grammar (4 pts)
- Documented figures and graphs (4 pts)
- References and labeling (2 pts)

_____ **CODE APPENDIX (2 pts)**

- Code running on non-commercial sensor suite (link to posted code or printout – does not count toward page limit)

_____ **TOTAL POST-FLIGHT PERFORMANCE REPORT POINTS (100 points maximum)**

COMMENTS:

APPENDIX A-3

FLIGHT READINESS ORAL PRESENTATION JUDGING

Score the following categories according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
¼ Max Value = attempted but below expectation
½ Max Value = average or expected
¾ Max Value = above average but still lacking
Max Value = excellent, perfectly meets intent

_____ **ENGINEERING & DESIGN CONTENT (30 pts)**

- Discussion of engineering methodology (5 pts)
- Use of design tools (5 pts)
- Thorough presentation of how rocket design addresses the competition objectives (including bonus elements being pursued, if any) (15 pts)
- Use of analytical data – comparison of test flight(s) performance to expectations (5 pts)

_____ **ORGANIZATION (20 pts)**

- Logical organization & structure (5 pts)
- Presentation clarity (5 pts)
- Use of visual aids as support material (5 pts)
- Balance & transitions among presenters (5 pts)

_____ **VISUAL AIDS (10 pts)**

- Appropriate use of text (2 pts)
- Informational charts & illustrations (2 pts)
- Appropriate design and use of graphics (2 pts)
- Use of supporting physical materials (2 pts)
- Appropriate use and formatting of slides (2 pts)

_____ **SET OF ROCKETS EXTERNAL/OVERALL APPEARANCE (12 pts)**

- Visual appearance (6 pts)
- Quality of construction (everything except the av-bay) (6 pts)

_____ **AV-BAY(S) (UNTIMED SAFETY CHECK) (8 pts)**

- Appropriateness of design (tough, yet user friendly) (4 pts)
- Quality of av-bay construction (4 pts)

_____ **COMMUNICATION SKILLS (12 pts)**

- Verbal projection / articulation (4 pts)
- Eye contact / body language / poise / presence (4 pts)
- Adherence to time constraints (4 pts)

_____ **QUESTION & ANSWER (8 pts)**

- Active listening skills (2 pts)
- Answer relevance / correctness (4 pts)
- Response confidence / persuasiveness (2 pts)

_____ **TOTAL ORAL PRESENTATION POINTS (100 points maximum)**

COMMENTS:

APPENDIX A-4

POST-FLIGHT PERFORMANCE WRITTEN REPORT JUDGING

Score the following categories according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
¼ Max Value = attempted but below expectation
½ Max Value = average or expected
¾ Max Value = above average but still lacking
Max Value = excellent, perfectly meets intent

_____ **ROCKET OPERATION ASSESSMENT (20 pts)**

- Propulsion system assessments (4 pts)
- Targeted altitude ("flight 1") approach assessments (4 pts)
- Maximizing apogee ("flight 2") approach assessments (4 pts)
- Recovery system assessments (4 pts)
- Pre- & post-launch procedure assessments (4 pts)

_____ **ROCKET ANOMALY ASSESSMENT (10 pts)**

- Flight anomalies analysis (5 pts)
- Discuss flight mitigation options for each anomaly (5 pts)

_____ **ACTUAL VS PREDICTED PERFORMANCE (40 pts)**

- Peak altitude, peak velocity, peak acceleration, and landing speed comparison to expectations for competition rocket (10 pts)
- Non-commercial sensor measurements and determination of altitude, speed, and acceleration compared to, and graphed against, available commercial-altimeter data plots (15 pts)
- Discussion of what the team learned about characterizing flight performance using different sensors and techniques from the non-commercial sensor suite, including an evaluation of pros/cons (10 pts)
- Discussion of other in-flight results (data available may vary from team to team): other logged sensor data; performance of other in-flight mechanisms (if any), etc. (5 pts)

_____ **FUTURISTIC DISCUSSION (10 pts)**

- Discussion of the way forward, were team to keep working on the challenges (hint: include a discussion about possibly merging data from multiple sensors to obtain an even-better solution) (10 pts)

_____ **REPORT AESTHETICS (18 pts)**

- Followed specifications (6 pts)
- Professionally written (6 pts)
- Accurate representation of events (6 pts)

_____ **UPDATED CODE APPENDIX (if any changes since FRR) (2 pts)**

- If no changes, state that explicitly to earn full points.

_____ **TOTAL POST-FLIGHT PERFORMANCE REPORT POINTS (100 points maximum)**

COMMENTS:

APPENDIX A-5

MENTOR REPORT FORM

Mentors are to use this form to report their interaction with their teams. Mentors must submit this form to the Technical Advisor by the date and time specified for each report. We anticipate that mentors will spend at least a few hours with each team prior to each report – and possibly more than a few hours for less-experienced teams. We thank you in advance for your time!

Mentor Name: _____ TRA/NAR #: _____

Team Name: _____ School Name: _____

Current phase of the competition: ☐ Preliminary Design ☐ Flight Readiness

For the current phase of the competition indicate:

In person:
Dates of interactions: _____ Number of interaction hours: _____

Remote videocons (not just e-mail or phone calls – you need to see what they are up to):
Dates of interactions: _____ Number of interaction hours: _____

Topics discussed (across all interactions): _____

General comments about team interactions & mentoring discussions:

General comments about difficulties / obstacles with team interactions & mentoring:

APPENDIX A-6

DRAFT OF DESIGN(S) FORM

Submit this to your faculty advisor, your certified mentor, and to the competition Technical Adviser BEFORE YOU START TO BUILD (or at least before you start to build any scratch rockets). Definitely do this no later than February 10, 2025, and possibly well before that if you start working on this competition in the fall of 2024. Expect feedback from Gary Stroick within one week. Pay attention to it!

- Discuss your main competition rocket(s), including your tentative design plans for achieving the competition goals of making one flight go to a specific altitude and making the other flight go as high as possible.
- Include simulation files (OpenRocket or RockSim) for the main competition rocket(s) (and all certification rockets). Include details about the basic airframe and the cert, test flight, and competition motors. Be sure to fully describe any extra items you plan to install – don't just call them "mass objects."
- List basic specs for each rocket being built, including certification rocket(s) {if any rockets are kit rockets, state which kit (rocket name, vendor) then limit your discussion to modifications made to the kit, if any} (especially material and dimensions (including thickness)) of fins, airframe, coupler tube (if any), centering rings and bulk plates, nose cone, recovery harness, eyebolts (forged or not), parachute(s), plus attachment materials such as shear pins, rivets, epoxy joints, etc.
- Briefly discuss how the motor will be retained (in both directions), how recovery harness will be attached, how fins will be attached (and possibly reinforced), etc.
- Briefly discuss what commercial altimeter(s) you will use and what they will be called up to do (log what sort of data, make what sort of decisions (about when to fire ejection charges), etc.).
- Briefly discuss what other (custom) electronics will be onboard and what it will do.
- State explicitly which team members are building which rockets (individually) to attempt to certify at what level. Also mention which team members, if any, are already Level 1 or Level 2 certified. Remember that earning a Level 1 certification is a pre-requisite for attempting a Level 2 certification, and Level 1 should be done in advance – not on the same day as the Level 2 certification. We plan to offer the Level 2 certification test the evening before the competition flights, and you need to have passed your Level 1 certification, *including taking a competition-specific written test,* before being allowed to take the Level 2 test (and you must pass the Level 2 test before being allowed to attempt a certification flight, so be sure to study for it).

2024-2025 NASA's Space Grant
Midwest High-Power Rocketry Competition
Education/Public Outreach Documentation Form

The Minnesota Space Grant Consortium (MnSGC), on behalf of NASA, would like to thank you for giving our Midwest High-Power Rocketry Competition participants a chance to provide educational outreach to your organization. Please take a moment to fill in some information below to verify the students' participation. A portion of their competition score is based on their outreach activities, so your willingness to let them present to you is appreciated.

One main goal of Space Grant activities nationwide is to "raise awareness of, or interest in, NASA, its goals, missions and/or programs, and to develop an appreciation for and exposure to science, technology, research, and exploration."[1] Space Grant Consortia in every state promote science, technology, engineering, and math (STEM) fields through educational opportunities for college/university students, such as this rocketry competition. We are also grateful for your involvement in this mission. If you have any questions about the Midwest High-Power Rocketry Competition or about NASA's Space Grant program, please contact the MN Space Grant Consortium (MnSGC), which is running this competition, by writing to mnsgc@umn.edu, or else contact your state's Space Grant Consortium directly. Web sites can be found at:

http://www.nasa.gov/offices/education/programs/national/spacegrant/home/Space_Grant_Consortium_Websites.html

Activity 1 (required)

Name of Organization	Supervisor Name	Phone or e-mail
Duration of Activity (hrs)	Signature	Date
Approx. # of Attendees	Brief descrip. of attendees	Brief decrip. of activity

Activity 2 (optional)

Name of Organization	Supervisor Name	Phone or e-mail
Duration of Activity (hrs)	Signature	Date
Approx. # of Attendees	Brief descrip. of attendees	Brief decrip. of activity

1 – Source: *Explanatory Guide to the NASA Science Mission Directorate Education & Public Outreach Evaluation Factors*, Version 3.0, April 2008