



Screenshot from

<https://www.youtube.com/watch?v=4ac-VFPAqlo>

NASA'S SPACE GRANT 2022-2023 MIDWEST HIGH-POWER ROCKETRY COMPETITION – THE “PRECISION LANDING CHALLENGE”

MAY 2023 COMPETITION LAUNCH
NEAR NORTH BRANCH, MN

HOSTED BY THE MN SPACE GRANT
CONSORTIUM AND BY THE TRIPOLI
MN HIGH-POWER ROCKETRY CLUB

Informational telecon: Monday, September 19, 2022, 7 p.m. CST
Repeated: Thursday, January 12, 2023 7 p.m. CST

Introductions

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- MN Space Grant Organizer

James Flaten, U of MN Twin Cities

flate001@umn.edu

- Technical Advisor

Gary Stroick, Tripoli MN

president@offwegorocketry.com

- Round Robin Introductions

Number of Teams Participating

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- Teams competing in 2021-2022
 - 13 teams registered, mostly from the Space Grant “Great (Lakes) Midwest” Region, but this competition is open to colleges/universities across the entire nation
 - 10 teams made it to the fly-off. MN (5), WI (2), IA (1), IL (1), ND (1)
 - The other 3 teams made some progress, but ultimately had to withdraw before the fly-off in May 2022.
- This year we are hoping to attract up to 20 teams to attempt the “Precision Landing Challenge.”

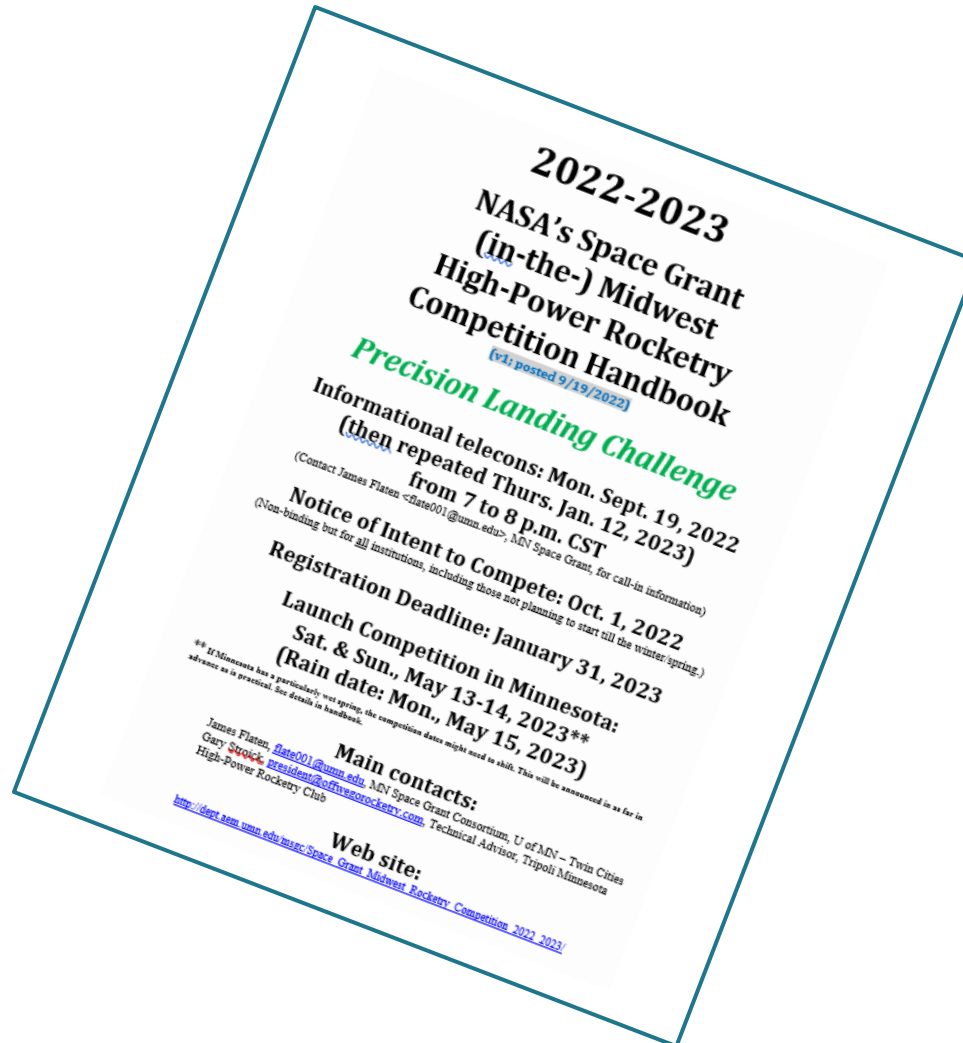
What you need to know

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- Competition Handbook
- Fees & Supplied Equipment
- Schedule
- Competition Parameters
- Pre-Competition Requirements
- Five Aspects of the Competition
- Flight Safety
- Judging
- Q & A

Competition Handbook & Website

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Fees & Supplied Equipment

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- ❑ Registration Fee: \$400^{*†} (due Friday, Jan. 31, 2023)
- ❑ The Registration Fee Covers (on Launch Day):^{**}
 - (LOANER) Competition Flight Data Recorder (A Jolly Logic “AltimeterTwo” data logger) to monitor altitude and other basic parameters like peak altitude, velocity, and acceleration. (Note: An AltimeterThree, if you own one, is allowed instead.) However, remember that AltimeterTwo and AltimeterThree data loggers cannot fire ejection charges, so you will still need to fly a “genuine” (commercial) altimeter for any charges other than motor eject. (Motor eject is required as a back-up, to get out at least one parachute near apogee.)
 - Up to \$100 for Competition Motors from Off We Go Rocketry (Tripoli MN vendor)
 - Cesaroni 273H225-14A “White Thunder” (2-grain, 38 mm diameter) motor for the first flight
 - Any Cesaroni or AeroTech I-class or J-class 54 mm diameter motor for the second flight
 - Team must pay the difference, if their competition motors total more than \$100
 - Note: Teams are allowed to bring additional motors or purchase more motors (to pick up at the competition), then try to fly their rocket more than twice within the launch window, but only till about 4 p.m., with priority given to rockets than have not yet flown twice.

**Tentative value – might possibly go up or down (a little) depending on the number of teams that sign up and our success in finding outside sponsors – changes to this fee, if any, will be announced by December 31, 2022.*

†Teams that paid \$400 for the 2019-2020 competition which was called-off before the fly-off in the spring of 2020 due to COVID-19 and did not use their registration credit in 2021-2022 are allowed to apply that fee to this competition (but not beyond this year), so they do not need to not pay another registration fee.

***If we garner enough outside sponsorship support, we may be able to provide more things or possibly reduce the registration fee. Additional details, if any, announced no later than December 31, 2022.*

Space Grant “Sponsorship”

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To help us keep tabs on participants for Space Grant Reporting, we require that every team contact their state’s Space Grant for “sponsorship.” We are not telling Space Grants what “sponsorship” should mean – this is to be negotiated on a case-by-case basis. Note that it doesn’t necessarily entail full (or even partial) financial support, so most teams will need to find other sources of funding.

However, we hope that Space Grants will at least consider helping with some basic competition expenses such as:

- (a) registration fee (\$400)
- (b) travel to MN for the competition launch in May 2023 (cost varies widely)
- (c) building and instrumenting the rocket (cost will vary; about \$500 to \$1500)
- (d) building certification rocket(s) for bonus points (about \$200 to \$500)
- (e) paying for motors (beyond the \$100 provided) and casings and closures (cost will depend on the motors selected; about \$100 to \$500)
- (f) buying motor(s) for at least one pre-competition test launch of the actual rocket and, potentially, L1 certification flight(s) before attempting L2 cert flights at the fly-off itself (about \$40 to \$120)

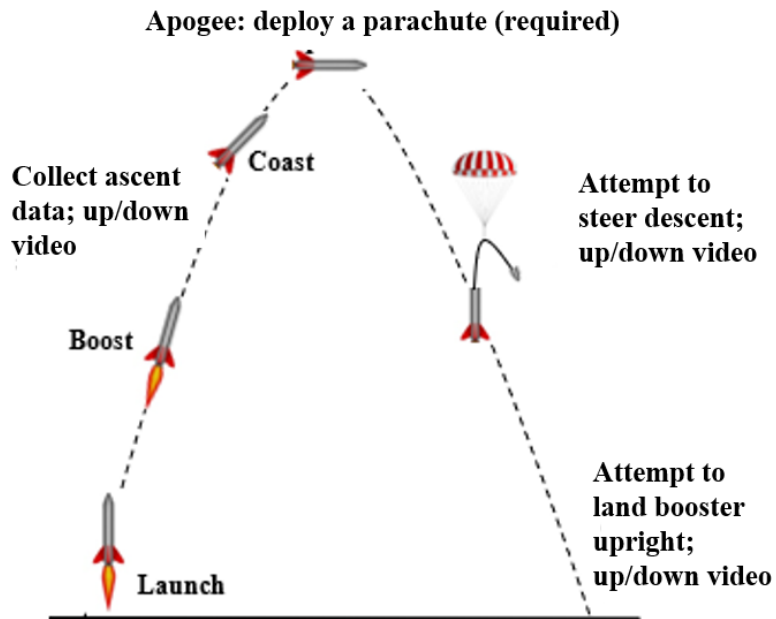
2022-2023 Competition Description

The “Precision Landing Challenge” (summary description)

In this competition, college/university student teams will design and construct a single motor, single stage, high-power rocket that will fly twice during the competition. The challenge is **(A) to use a steerable parachute during a totally-unpowered descent to guide the rocket booster to land as close as possible to a specified ground target**, probably about 1000 ft from the launch pad, and **(B) to land the booster so that it remains upright**. (Aside: The booster is allowed to separate from, and descend independently from, the upper section of the rocket, as long as all parts of the rocket land at safe speeds and are recovered in re-flyable condition.) Rockets will fly first on a Cesaroni 273-H-225-14A “White Thunder” (2-grain, 38 mm diameter) motor, and must exceed 1000 ft AGL (Above Ground Level). The second flight will have a target apogee of 3000 ft AGL and can be on any Cesaroni or AeroTech I-class or J-class 54 mm diameter motor. The rocket must carry a “non-commercial” (i.e. not sold for rocketry) data-logging sensor suite to characterize flight performance, including logging at least once a second GPS, av-bay pressure, 3-axis acceleration, and 3-axis rotation. The booster must also contain a look-up and look-down camera system to collect video of the rocket motor boosting, the rocket separating, the steerable parachute in action, and the rocket landing. Bonus points will be given to teams whose members increase their certification level using individually-built rockets (which will be unrelated to the team-built competition rocket). Additional details about the competition will be included in a handbook. Note that all fabrication work on the rocket(s), except for possibly machining of plastic and/or metal parts, must be performed by students.

2022-2023 Competition Constraints

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RULES/CONSTRAINTS

- All teams are required to have a non-student Level 2 (or higher) certified mentor, a faculty adviser, and explicit “sponsorship” by their state’s Space Grant.
- All teams must team-build a rocket to attempt one or both of the precision landing challenges, carry a non-commercial sensor suite, and carry an up/down camera system – see handbook for details.
- Receive feedback on a “Draft of Designs” before starting to build.
- First competition flight on a pre-specified H-class 38 mm diameter motor to at least 1000 ft ASL. Second flight with a 3000 ft ASL altitude target on a team-selected I- or J-class 54 mm diameter motor from Cesaroni or Aerotech. Consult Gary Stroick of Off We Go Rocketry about motor availability & cost.
- Do at least one test flight of the team-built competition rocket on a high-power motor with steerable parachute installed (if attempted) prior to the fly-off. L1 cert flights (to prep for L2) may also need to be done prior to fly-off date.
- All rockets must have an “apogee parachute” deployed at apogee (or just after apogee). If any rocket is dual-deploy, the main parachute must be deployed no lower than 500 feet above ground level. Chute releases are allowed. Release of parachute upon landing is allowed, but all parts must be recovered.
- All parts of recovery systems that are electronically deployed must use commercial altimeters. The motor eject must remain in place or a second independently-powered commercial altimeter must back-up parachute deployment at apogee.
- One competition data logger will be provided – a Jolly Logic “AltimeterTwo.”
- Radio-tracking of rockets is required by Tripoli MN for some flights (and recommended by this competition for all flights) - see handbook for details.
- Rocket must have $1 \leq \text{static margin} \leq 5$ at launch. All pieces (which are allowed to be disconnected in flight) must land traveling less than 35 ft/sec.

Pre-Competition Requirements

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Draft of Designs

▣ Purpose

- To give your team's mentor and Gary Stroick an early look at your designs and specifications BEFORE YOU START TO BUILD.*

▣ Due date

- Submit as early as possible – definitely before you start to build the rocket(s)* (so this might need to be submitted well before the PDR is due)
- If planning to build “late” (i.e. possibly even after getting feedback on your designs through the PDR process), still submit this Draft of Designs no later than 5 p.m. Central Time on Friday, Feb. 10, 2023 (4 weeks before the PDR is due)

▣ Contents

- This document must include a list (at least) of all major functional components of the rocket (selection of parachute, recovery harness, rail buttons/guides, altimeter, etc.) plus simulation files (OpenRocket or RockSim) including basic details about the dimensions and materials to be used for the fins, airframes, and nose cones, connections, commercial altimeter(s) planned for ejections, etc. for all rockets (competition rocket; certification rockets, if any)
- Gary Stroick will provide feedback within one week regarding any concerns he may have, especially regarding potential fin flutter and/or divergence issues and/or appropriateness of altimeter(s).

▣ Failure to complete by Feb. 10, 2023: 20% Overall Score Reduction

* You are allowed to build kit-rockets, but not scratch rockets, prior to getting this feedback. However, document all rockets in your Draft of Designs.

Pre-Competition Requirements

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Model Rocket Demonstration Flight

▣ Purpose

- Demonstrate a minimum knowledge of rocketry

▣ How to do it

- Purchase a model rocket flight kit
- Assemble it
- Successfully fly and recover the rocket
- Document the flight with before and after photos of the rocket and the team “in the field”
- E-mail photos to the MN Space Grant along with flight date and location no later than 5 p.m. Central Time on Friday, March 10, 2023 (the PDR due date)

▣ Potential Waivers

- If your whole team has high-power rocketry experience, you may request a waiver by e-mail from this requirement from Gary Stroick
- If you prefer to team-build and fly a (non-competition) high-power rocket instead of a model rocket to fulfill this requirement, that is acceptable, but it must be a different rocket than the one you will use to compete

▣ Failure to complete by March 10, 2023: 10% Overall Score Reduction

Pre-Competition Requirements

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Educational Outreach (see form at end of handbook)

- ❑ Collected/validated by each State's Space Grant Coordinator or Director (note – your team's faculty advisor can provide contact information for the Space Grant Coordinator or Director in your state)
- ❑ Form must be completed and submitted to your state's Space Grant no later than 5 p.m. Central Time on Monday, May 1, 2023 – also send a copy to the Technical Adviser, Gary Stroick
- ❑ Tell your state's Space Grant office to notify the Technical Adviser that they have received and validated the form
- ❑ **Failure to complete by May 1, 2023: 10% Overall Score Reduction**

5 Judged Aspects of the Competition

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- ❑ Preliminary Design (Written) Report (30%)
- ❑ Flight Readiness (Written) Report (15%)
- ❑ Flight Readiness (Oral) Presentation (15%)
- ❑ Competition Flight Performance (20%)
- ❑ Post-Competition Flight Performance Report (20%)

Note 1 – There are overall percentage reductions if you do not complete the Draft of Designs, the Model Rocket Demonstration Flight, and/or the Educational Outreach component on time.

Note 2 – Written reports are due by e-mail (or by another mutually-agreed upon means) to the Technical Advisor by 5:00 p.m. Central Time on the dates specified in the schedule. Scores for late reports will be reduced by 20% for each day (or portion of a day) that they are late. If you are unsure about whether or not you can get documents the size of your reports to the Technical Advisor, you should practice by submitting comparably-sized sample documents in advance.

Note 3 – Mentors must submit report forms as well, by the same report dates specified in the schedule. Mentor reports can go directly to the Technical Advisor by e-mail – they do NOT need to be collected by teams, nor included with the team reports.

5 Judged Aspects of the Competition

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Preliminary Design (Written) Report (30%)

- ▣ Communicate the engineering and design effort
 - Provide detailed designs and diagrams
 - Plans for camera system, non-commercial sensors suite, steerable parachute control mechanism (if any), landing mechanism (if any), etc.
 - Analysis of predicted performances
 - Analysis of non-“pre-qualified” components
 - Addresses issues raised from Draft of Designs submission, if any
- ▣ Estimated Budget
- ▣ 25 pages MAX
- ▣ Due by 5 p.m. Central Time on Friday, March 10, 2023

5 Judged Aspects of the Competition

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Flight Readiness (Written) Report (15%)

- ▣ SHOW the construction and completed rocket(s)
 - Construction pictures, diagrams, etc.
 - Discussion of camera system, non-commercial sensors suite, steerable parachute control mechanism (if any), landing mechanism (if any), etc.
- ▣ Test Flight(s) (at least 1 test flight of the team-built rocket on a high-power motor with the steerable parachute (if attempted) installed – perhaps some L1 cert flights (as L2 cert flight prep) too)
 - Flight Performance Analysis
 - Flight Results Discussion
 - Improvements planned, if any, prior to competition
- ▣ Actual Budget
- ▣ 25 pages MAX (plus “Code Appendix” – no page limit)
- ▣ Due by 5 p.m. on Monday, May 1, 2023

5 Judged Aspects of the Competition

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Flight Readiness (Oral) Presentation (15%)

- ❑ Communicate the design and engineering effort
- ❑ Organization and presentation
- ❑ Rocket construction (especially av-bay(s) and special mechanism(s) for this year's challenges)
- ❑ VISUAL AIDS
- ❑ 10 minutes for presentation, plus up to 3 minutes for Q & A
- ❑ Separate time for safety check and to show judges the inside of your av-bay(s)
- ❑ Saturday afternoon into the evening, May 13, 2023 (quite possibly delivered in a venue in the Twin Cities – different from past years)

5 Judged Aspects of the Competition

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Competition Flight (20%) (see handbook for more details)

- ❑ Each successful flight requires:
 - Rocket launches, flies vertically, flies stably all the way to apogee
 - Recovery system(s) successfully deployed at appropriate altitudes
 - All parts of rocket land safely at < 35 ft/sec descent speed
 - All parts of rocket are recovered in re-flyable condition
- ❑ Flight Scoring:
 - All rocket(s) have successful flights (see above)
 - Timely prep of rocket(s) (see details in handbook)
 - See handbook for scoring formulas incorporating the “distance to target” and “landing upright” aspects of the challenge
 - Flight disqualification decisions will be announced on the spot (based on observations, not logged data). Flight(s) may be re-tried as long as the RSO agrees the rocket is safe and there is adequate time in the launch window.

5 Judged Aspects of the Competition

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Post-Flight Performance (Written) Report (20%)

- ▣ Flight Performance Comparison
 - Actual vs simulated flight performance analysis
 - Graphs, charts, links to posted videos or stills (if any), etc.
 - Performance results; discrepancy discussion; failure analysis, if needed
- ▣ 15 pages MAX (plus “Code Appendix” – only include if code has changed since FRR – no page limit)
- ▣ Due by 5 p.m. Central Time on Friday, May 26, 2023

Safety Reviews

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- Each team must go through a safety review with their certified mentor in their home state prior to coming to the competition
- Each team will go through a safety review with Tripoli MN the evening of their oral presentation
- On the day of the launch:
 - Each rocket must be examined for flight safety by the Range Safety Officer (RSO)
 - **The Tripoli MN RSO has the final word on flight safety! If they won't allow a rocket to fly, they will explain why (and may be able to provide suggestions on changes that could be made to try to bring the rocket up to safety-par).**

Judging

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- Separate from safety checks by Tripoli MN, the written and oral reports and the performance in the competition flights will be evaluated according to the rubrics in the handbook by a panel of judges from industry and/or academia.
- **Each Space Grant sponsoring more than one rocket team will be expected to provide one judge. (States fielding four or more teams may be asked to provide two judges.)**
- If you don't have someone from your state you would like to send to MN for the competition dates, contact Gary Stroick about possibly retaining a member of the Tripoli MN club to serve as "your" judge. Typically, judges' travel expenses are reimbursed (at least). Please select and confirm your judge(s) no later than Jan. 31, 2023.

Schedule Summary

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- ❑ Oct. 1, 2022 – Notice of Intent to Compete (non-binding)
 - ❑ DUE BEFORE YOU START TO BUILD – Draft of Designs (specs & sim)
 - ❑ **Order motors 3 months in advance. Test flight motors should be ordered ASAP (before mid-Jan.). Competition flight motors should be ordered by mid-Feb. 2023.**
 - ❑ Jan. 31, 2023 – Team registration fee is due (pay \$)
 - ❑ Jan. 31, 2023 – All states' judges identified
 - ❑ Feb. 10, 2023 – Declaration of Competition Attendance
 - ❑ Feb. 10, 2023 – Last possible date to get credit for Draft of Designs (specs & sim)
 - ❑ March 10, 2023 – Preliminary Design (Written) Report (PDR) along with Model Rocket Flight documentation
 - ❑ Late April – Test flight(s) completed. Better still, do these in March or early April
 - ❑ May 1, 2023 – Flight Readiness (Written) Report (FRR) along with Educational Outreach form
 - ❑ May 13-14, 2023 – Competition (includes Oral FRR) – weather delay date: 5/15**
- **Competition organizers reserve the right to shift the competition dates – see handbook.
- ❑ May 26, 2023 – Post-Competition Flight Performance (Written) Report (PCFPR)
 - ❑ June 9, 2023 – Competition Results Announced

$$v_x = v \cos \theta$$

$$v_y = v \sin \theta$$

$$x = v \cos \theta \cdot t$$

$$y = \left(v \sin \theta - \frac{g}{2} t \right) \cdot t$$