Screenshots from
https://www.youtube.com/watch?v=Hxd-pOwUZMQ

NASA'S SPACE GRANT 2023-2024 MIDWEST HIGH-POWER ROCKETRY COMPETITION – THE "IN-FLIGHT CHARACTERIZATION CHALLENGE"

MAY 2024 COMPETITION LAUNCH NEAR NORTH BRANCH, MN

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

Informational videocon: Monday, September 18, 2023, 7 p.m. CST
Repeated: Thursday, January 11, 2024, 7 p.m. CST

Introductions

- 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

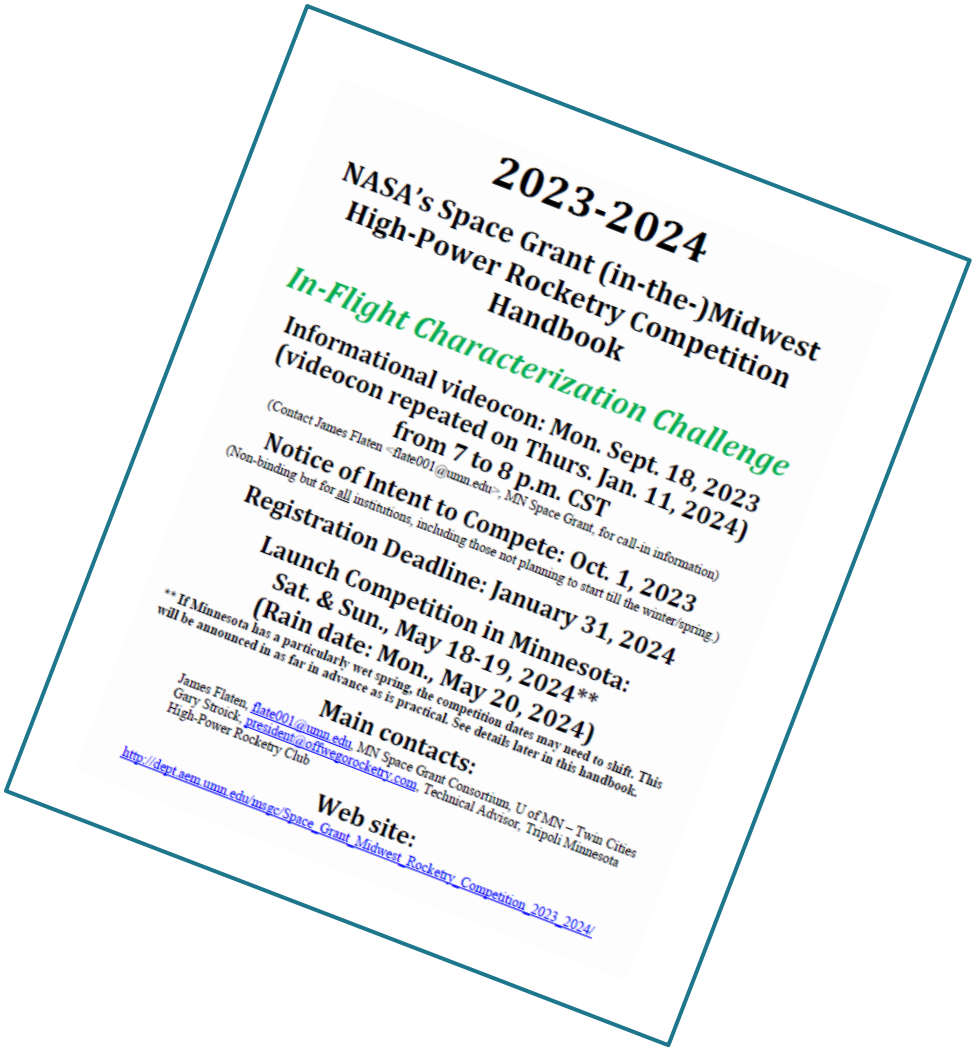
Number of Teams Participating

- Teams competing in past years
  - 10 - 15 teams typically compete, mostly from the Space Grant Great (Lakes) Midwest Region, but the competition is open to colleges/universities across the entire nation
  - Last year 11 teams registered and 9 made it to the fly-off. MN (6), WI (1), IA (1), VA (1)
  - The other 2 teams made some progress, but ultimately had to withdraw before the fly-off in May 2023.
- This year we are hoping to attract up to 20 teams to attempt the "In-Flight Characterization Challenge."

What you need to know

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

Competition Handbook & Website



2023-2024

NASA's Space Grant (in-the-)Midwest High-Power Rocketry Competition Handbook

In-Flight Characterization Challenge

Informational videocon: Mon. Sept. 18, 2023 (videocon repeated on Thurs. Jan. 11, 2024) 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: Oct. 1, 2023

(Non-binding but for all institutions, including those not planning to start till the winter/spring.)

Registration Deadline: January 31, 2024

Launch Competition in Minnesota: Sat. & Sun., May 18-19, 2024** (Rain date: Mon., May 20, 2024)

** 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@ofrivegorocketry.com, Technical Advisor, Tripoli Minnesota High-Power Rocketry Club

Web site:

http://dept.aem.umn.edu/msgc/Space_Grant_Midwest_Rocketry_Competition_2023_2024/

Website: http://www.aem.umn.edu/msgc/Space_Grant_Midwest_Rocketry_Competition_2023_2024/

Fees & Supplied Equipment

- Registration Fee: $400* (due Dec. 31, 2023 – earlier than usual)
- 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 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 15, 2023.

**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 15, 2023.

Space Grant "Sponsorship"

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 2024 (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 competition rocket and, potentially, L1 cert flight(s) before attempting L2 cert flights at the fly-off itself (about $40 to $120)

2023-2024 Competition Description

The "In-Flight Characterization Challenge" (summary description)

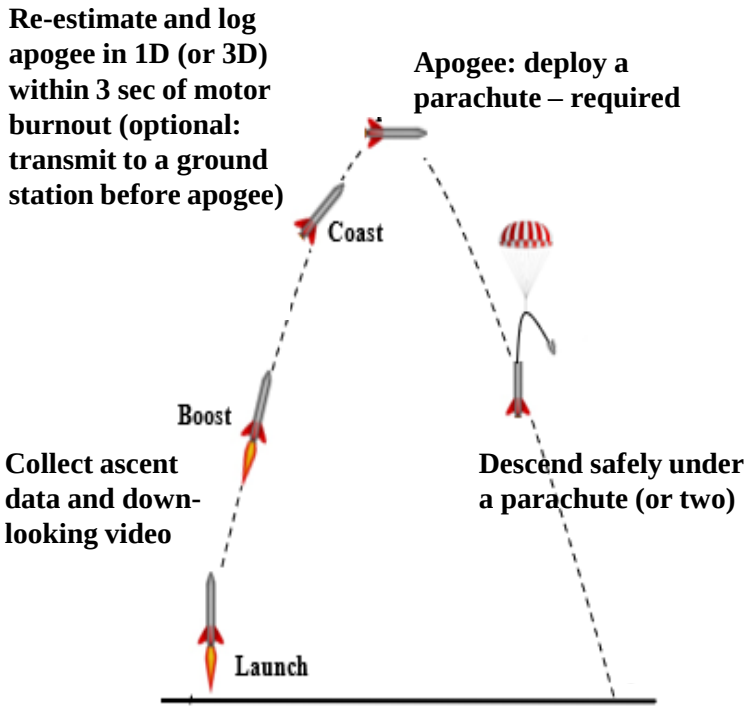
In this competition, *college/university student teams will design and construct a single motor, single stage, high-power rocket that will fly twice during the competition. The challenges are:*

(A) minimize roll during the middle 50% of the coast with no moving parts (roll will be documented using a look-down camera, backed up with gyro sensor(s)), and

(B) carry a "non-commercial" (i.e. not sold for rocketry) data-logging sensor suite to monitor vehicle performance so as to make an in-flight estimate of peak altitude (AKA apogee) within 3 seconds of motor burnout (i.e. before the rocket reaches apogee). Sensors should be selected to deduce the actual air friction on the vehicle (to replace the estimated air friction value used by simulation software) and the actual total impulse of the motor (which might vary from the total impulse printed on the label by up to 10%).

All rockets will fly first on a Cesaroni 273-H-225-14A "White Thunder" motor, followed by a second flight which can be on any Cesaroni or AeroTech I-class motor. Both flights must reach at least 1000 ft AGL (above ground level), but not exceed 3000 ft AGL. Internal modifications (parachute, ballast, etc.) are allowed between flights, but not external modifications. Bonus points will be given to (1) teams whose member(s) increase their certification level using individually-built rockets (in parallel with the (team-built) competition rocket), (2) teams that can make a 3D prediction of apogee (including relative lateral position with respect to the launch site and/or absolute position (gps) – this will require additional sensors), not just a 1D apogee estimate) within 3 seconds of motor burnout, and (3) teams that can transmit their estimate(s), and other performance data, to a ground station using a "non-commercial" radio telemetry system before the rocket reaches apogee. Note: All fabrication work on the rocket(s), except for possibly machining of fiberglass, carbon fiber, and/or metal parts, must be performed by students.

2023-2024 Competition Constraints



RULES/CONSTRAINTS (see handbook for more)

- All teams are required to meet regularly with a non-student Level 2 (or higher) certified mentor, plus have a faculty adviser and Space Grant "sponsorship."
- All teams must team-build a rocket to attempt the in-flight characterization and roll-mitigation challenges (some optional), carry a non-commercial sensor suite, and carry a down-looking camera system.
- Receive feedback on a "Draft of Designs" before starting to build.
- First competition flight on a pre-specified H-class motor and second flight on a team-selected I-class motor from Cesaroni or Aerotech. Both flights must go between 1000 and 3000 ft AGL. 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 prior to the fly-off date. L1 cert fights (in preparation for L2 cert attempts on the fly-off date) also must be done prior to the 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 fully unfurl no lower than 500 feet above ground level. Chute releases are allowed.
- All parts of recovery systems that are electronically deployed must use commercial altimeters. The motor eject must remain in place or else a second, independently-powered commercial altimeter must back-up the parachute deployment at apogee.
- One competition data logger will be provided – a Jolly Logic "AltimeterTwo."
- Radio-tracking is required for all competition flights (and also on all cert flights going higher than 3000 ft AGL).
- Rocket must have $1 \leq$ static margin ≤ 5 at launch. Thrust-to-weight ratio at launch must be at least 3:1. All parts must remain tied together during descent and the rocket must land traveling less than 35 ft/sec.

Pre-Competition Requirements

Draft of Design(s)

- **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. 9, 2024 (~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. 9, 2024: 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 Design(s).

Pre-Competition Requirements

Model Rocket Demonstration Flights

- **Purpose**
  - Demonstrate a minimum knowledge of rocketry
- **How to do it**
  - Purchase model rocket flight kits (**all different**) (students are allowed to double up, if team has more than 5 model rocket builders)
  - Assemble rockets and fly them (hopefully successfully)
  - Document each flight with before and after photos of the rocket and the builder(s) "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 11, 2024 (the PDR due date)
- **Potential Waivers**
  - If your whole team has high-power rocketry build 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 kit rocket instead of multiple model rockets 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 11, 2024: 10% Overall Score Reduction**

Pre-Competition Requirements

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 6, 2024 – also send a copy to the Technical Adviser, Gary Stroick
- Tell your state's Space Grant office to notify the Technical Advisor that they have received and validated the form
- **Failure to complete by May 6, 2024: 10% Overall Score Reduction**

5 Judged Aspects of the Competition

- 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 Design(s), the Model Rocket Demonstration Flights, and/or the Educational Outreach component in a timely manner.

*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, practice by submitting comparably-sized dummy 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

Preliminary Design (Written) Report (30%)

- Communicate the engineering and design effort
  - Provide detailed designs and diagrams
  - Plans for camera system, non-commercial sensor suite, etc.
  - Analysis of predicted performances
  - Analysis of non-"pre-qualified" components
  - Addresses issues raised from Draft of Design(s) submission, if any
- Estimated Budget
- 25 pages MAX
- Due by 5 p.m. Central Time on Monday, March 11, 2024
- Model rocket mini-reports (1 page per rocket, with photos – does not count against the 25 page limit for the PDR)

5 Judged Aspects of the Competition

Flight Readiness (Written) Report (15%)

- SHOW the construction and completed rocket(s)
  - Construction pictures, diagrams, etc.
  - Discussion of camera system, non-commercial sensor suite, etc.
- Test Flight(s) (at least 1 test flight of the team-built rocket on a high-power motor – 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 6, 2024

5 Judged Aspects of the Competition

Flight Readiness (Oral) Presentation (15%)

- Communicate the design and engineering effort
- Organization and presentation
- Rocket construction (especially av-bay(s) and custom details for this year's challenge(s))
- 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 18, 2024 (probably held at a venue in the Twin Cities – location TBA)

5 Judged Aspects of the Competition

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 related to various 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

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 31, 2024

Bonus Opportunities

Bonus points are available to

- teams whose member(s) increase their certification level using individually-built rockets (in parallel with the (team-built) competition rocket).
  - Students seeking Level 1 certification need to take a written test from the competition organizers (unrelated to Tripoli and NAR certification regulations).
  - Students seeking both Level 1 and Level 2 certification need to do their Level 1 flight before the day of the competition, not try both flights on the same date.
- teams that can make a 3D prediction of apogee (including relative lateral position with respect to the launch site and/or absolute position (gps) – this will require additional sensors), not just a 1D apogee estimate) within 3 seconds of motor burnout.
- teams that can transmit their estimate(s), and other performance data, to a ground station using a "non-commercial" radio telemetry system before the rocket reaches apogee.

Safety Reviews

- Each team must go through two (remote) inspections with competition organizers (attended by their certified mentor) 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

- 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 <u>one</u> judge. (States fielding four or more teams may be asked to provide <u>two</u> 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, 2024.

Schedule Summary

- Oct. 1, 2023 – Notice of Intent to Compete (non-binding)
- DUE BEFORE YOU START TO BUILD – Draft of Designs (specs & sim)
- Dec. 31, 2023 – Team registration fee is due (pay $) (EARLIER THAN IN THE PAST)
- **Order motors 3-4 months in advance.** Test flight motors should be ordered **ASAP** (before 2024.). Competition flight motors should be ordered by mid-Jan. 2024.
- Jan. 31, 2024 – All states' judges identified
- Feb. 9, 2024 – Declaration of Competition Attendance
- Feb. 9, 2024 – Last possible date to get credit for Draft of Designs (specs & sim)
- March 11, 2024 – Preliminary Design (Written) Report (PDR) along with Model Rocket Flights documentation
- Late April – Test flight(s) completed. Better still, do these in March or early April
- May 6, 2024 – Flight Readiness (Written) Report (FRR) along with Educational Outreach form
- May 18-19, 2024 – Competition (includes Oral FRR) – weather delay date: 5/20**

  **Competition organizers reserve the right to shift the competition dates – see handbook.
- May 31, 2024 – Post-Competition Flight Performance (Written) Report (PCFPR)
- June 14, 2024 – Competition Results Announced

$$v_x = v\cos\theta$$

$$v_y = v\sin\theta$$

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

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

Comments or Questions?