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Competition Objective

The Wisconsin Space Grant Consortium's (WSGC) Collegiate Rocket Competition is intended to supply teams of affiliated university students with the opportunity to demonstrate engineering and design skills through direct application. It allows the teams to conceive, design, fabricate and compete with high powered rockets. The restrictions on rocket motors and dimensions are limited so that knowledge, creativity and imagination of the students are challenged. The end result is a great aerospace experience for students that would not otherwise be available in the region.

Rocket Design Objectives

The objective of the WSGC 2024 Collegiate Rocket Competition entries can be stated simply as:

Student teams will be required to design, construct, and fly a high-power, one-stage rocket that, following apogee, will be recovered safely and in flyable condition, predict the rocket’s flight performance, collect down-looking on-board video during the flight up, and at or after apogee, capture a detailed image of a designated ground target. All work on the rocket must be performed by students.

Judging Categories

To truly evaluate the engineering behind the designs, the teams will be judged on the demonstration of their knowledge, the performance of their design, their ability to communicate effectively and the workmanship of the fabrication. This will be accomplished in six parts; a design report, a presentation to a selected group of judges, the flight of the rocket, an examination of predicted vs. actual performance for the rocket, project management, and an educational outreach activity.

The total score for each student team will be based on the following parameters:

<table>
<thead>
<tr>
<th>Category</th>
<th>Format</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Design and Flight Readiness Reports</td>
<td>Written</td>
<td>25</td>
</tr>
<tr>
<td>Flight Readiness Presentation, and Quality of Fabrication</td>
<td>Oral</td>
<td>15</td>
</tr>
<tr>
<td>Competition Flight</td>
<td>Flight</td>
<td>25</td>
</tr>
<tr>
<td>Post-Laungh Analysis Review Report</td>
<td>Written</td>
<td>15</td>
</tr>
<tr>
<td>Project Management</td>
<td>Form</td>
<td>10</td>
</tr>
<tr>
<td>Educational Outreach</td>
<td>Form</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
**Competition Engineering Parameters**

Student teams will be required to design, construct, and fly a high-power, one-stage rocket that, following apogee, will be recovered safely and in flyable condition, predict the rocket’s flight performance, collect down-looking on-board video during the flight up, and at or after apogee, capture a detailed image of a designated ground target. Additional rocket parameters include the use of a rocket motor from a specified list, and dual-deploy, electronic recovery with motor-charge backup. The rocket is required to use electronic deployment of the recovery parachute and must include motor deployment as a backup. A downed rocket location aid must be included. All structural components and materials for the rocket must be obtained from reputable high-powered rocketry vendors or an engineering analysis demonstrating their suitability must be included with the design. The winner of the flight portion of the competition will be the team whose rocket completes a safe, successful flight with a combination of best apogee as well as accuracy of their predicted apogee.

![Flight Path of Rocket](image)

*Figure 1  Flight Path of Rocket*
### Table 1 Competition Parameters

| Flight Mission | Successful fly
|                | Avionic system that will
|                | Monitor and record
|                | ▪ Altitude
|                | ▪ Acceleration
|                | Capture an image of a ground target at or after apogee
|                | ▪ With ability to note altitude of image capture
|                | ▪ Imaging system may not be an “Off the Shelf” system designed for rockets or Unoccupied Aerial Systems (UAS, a.k.a. drones).
|                | WSGC designated ground target
|                | will be located near the general vicinity of the launch area.
|                | It will be comprised of various colors, which must be discernable in the captured image
|                | Will cover approximately 1600 sqr ft
| Altitude Required | Apogee of between 2500 and 3500 ft
| Target Altitude | Each team determines their own target altitude with the required altitude range
|                | Value must be presented in the FRR Report and Presentation
| On-board Video | A video recording device must be incorporated in the rocket, collecting down-looking on-board video.
| Recovery | Electronic, dual-deploy recovery deployment (required as primary)
|           | Motor recovery deployment (required as backup)
|           | Parachute (required)
|           | Downed rocket location aid (required)
| Rocket Constraints | Minimum 5:1 thrust to weight ratio
|                   | Each team must prepare a mounting location for the competition flight recorder in their rocket
|                   | Each team must indicate (mark and label) the Center of Pressure (CP) and Center of Gravity (CG) on the outside of their rockets airframe.
|                   | CP and CG for fully loaded rocket
Tripoli Rocketry Association

- ALL members of the competition team MUST be members in good standing of Tripoli Rocketry Association
  - www.tripoli.org

NASA STEM Gateway

- ALL members of the competition MUST be registered on NASA STEM Gateway. https://stemgateway.nasa.gov/

Low-power Rocket Demonstration Flight

- Each team must purchase, assemble, fly and successfully recover a “low-power” rocket. Pictures of the team at their launch site with the rocket, before and after their launch, along with a video capturing the launch, must be posted to WSGC’s Facebook page when the budget is submitted.
- Examples: Estes Alpha, Quest Astra or comparable model rocket kits.

Rocket Design and Safety Reviews

- Each team must work with the WSGC to identify a Rocketry Mentor. The mentor must hold a current High Power Level 2 certification and cannot be a member of the team. At minimum, 3 design reviews must be held with the mentor.
- Each team, with their rocket, must participate in the Design and Safety Review meeting approximately one month before the competition launch.
  - Rockets must be 90% of ready to fly – **Teams without rockets at this level of construction will not be allowed to continue in competition.**
  - Analysis of non “pre-qualified” components must accompany the rocket at the Design and Safety Review
  - Each rocket must pass the Range Safety Officer’s Inspection the day of the launch, before it will be allowed to fly.

Educational Outreach

- Each team must share information pertinent to aerospace with a group or audience. For purposes of the competition, teams will be scored as "completed" or "not completed".

Safe Flight

- Launch followed by stable ascent
- Rocket’s successfully deploys recovery (or motor backup deploys successfully)
- Rocket must be recovered safely and in ready to fly condition

Successful Flight

- Safe Flight
- Electronic, dual-deploy recovery system functions successfully
- Attains an apogee within the required altitude range
In addition to the budget support, the WSGC will provide each team with the following equipment:

<table>
<thead>
<tr>
<th>Required Competition Rocket Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor must be selected from the following:</td>
</tr>
<tr>
<td>38mm I140W Aerotech Single use motor</td>
</tr>
<tr>
<td>38mm I500T Aerotech Single use motor</td>
</tr>
<tr>
<td>38mm J425R Aerotech Single use motor</td>
</tr>
<tr>
<td>54mm K400C Aerotech Single use motor</td>
</tr>
<tr>
<td>54mm K535W Aerotech Single use motor</td>
</tr>
</tbody>
</table>

Thrust curves data can be found at: http://www.thrustcurve.org/searchpage.jsp

<table>
<thead>
<tr>
<th>Competition Flight Data Recorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>o This recorder is separate from the team's electronics and will be inserted on the day of launch to record acceleration and altitude.</td>
</tr>
<tr>
<td>o Jolly Logic AltimeterTwo</td>
</tr>
<tr>
<td><a href="https://jollylogic.com/products/altimetertwo/">https://jollylogic.com/products/altimetertwo/</a></td>
</tr>
<tr>
<td>1.90&quot; x 0.7&quot; x 0.57&quot;, ~ 0.35 oz.</td>
</tr>
<tr>
<td>o Powered by built in, rechargeable battery.</td>
</tr>
<tr>
<td>o Mounted within a PVC cylinder 1.13” dia. x 2.50” ~0.8 oz.</td>
</tr>
</tbody>
</table>

Additional Comments:

Interested students with questions about the capabilities of the launch motors or seeking help in getting started are highly encouraged to contact **Frank Nobile** (Maxq3@aol.com) or **Bob Justus** (bob@mhbofini.com) of Tripoli Wisconsin Association (a high-power rocketry association); or a rocket association near them. Students interested in gaining information or experience by observing rocket launches are encouraged to contact these individuals, or to attend one of the regular rocket launches held by Tripoli at Bong Recreational Area. More information and launch schedules can be accessed at [http://www.tripoliwisconsin.org](http://www.tripoliwisconsin.org).

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 as safe as possible, 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 and the National Association of Rocketry.
**Design and Safety Review**

Endeavoring to have all teams perform their flights in a safe and controlled manor, all teams are required to participate in the Design and Safety Review approximately 1 month before the competition flights. The teams must be prepared to discuss the design of their rocket and its systems. In addition the teams must display:

- Rockets must be 90% of ready to fly –
  - **Teams without rockets at this level of construction will not be allowed to continue in competition.**
- Explanation of the avionic system
- Explanation of the dual-deploy recovery system and how it allows motor deployment backup.
- A diagram of the rocket indicating the configuration of its main components
- Analysis of non “pre-qualified” components must accompany the rocket
- Flight simulation showing max altitude and launch guide velocity (min. 50 ft/s at 10 ft. altitude)
- Deployment altimeter user manual
- Preflight Checklist
- Launch Pad and Flight Arming checklist
  - must include the altimeter’s ready/standby tones
- Recovery/Postflight Checklist
  - Must include procedure to “safe” deployment charges and payload

<table>
<thead>
<tr>
<th>Table 2</th>
<th>FAA Model Rocket Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Limitation</strong></td>
<td><strong>Class 1</strong></td>
</tr>
<tr>
<td>Rocket weight</td>
<td>1500 grams (3.3lbs)</td>
</tr>
<tr>
<td>Motor limit</td>
<td>4.4 oz. of fuel (mid-size H motors)</td>
</tr>
<tr>
<td>Altitude limit</td>
<td>None - may be set by local agreement.</td>
</tr>
<tr>
<td>Other</td>
<td>Clear of clouds (all classes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3</th>
<th>NAR/Tripoli Certification Requirements and Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Certification required</strong></td>
<td><strong>Rocket / Motor Limitations</strong></td>
</tr>
<tr>
<td>Total Combined Impulse</td>
<td>None</td>
</tr>
<tr>
<td>(2 G Motors)</td>
<td>320 N-sec</td>
</tr>
<tr>
<td>Combined propellant mass</td>
<td>125 grams (4.4 oz.)</td>
</tr>
<tr>
<td>Single Motor Impulse</td>
<td>160 N-sec</td>
</tr>
<tr>
<td></td>
<td>(G motor)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Single Motor propellant mass</td>
<td>62.5 grams (2.2 oz.)</td>
</tr>
<tr>
<td></td>
<td>No Limit</td>
</tr>
<tr>
<td>Single Motor Average Thrust</td>
<td>80 N</td>
</tr>
<tr>
<td></td>
<td>No Limit</td>
</tr>
<tr>
<td>Sparky Motors</td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td>Allowed</td>
</tr>
<tr>
<td>Total Rocket Mass</td>
<td>1500 grams (3.3 lbs)</td>
</tr>
<tr>
<td></td>
<td>No Limit</td>
</tr>
<tr>
<td>Field distance requirements</td>
<td>Per Model rocket safety code</td>
</tr>
<tr>
<td></td>
<td>Per HPR safety code</td>
</tr>
</tbody>
</table>

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
http://www.tripoli.org/LinkClick.aspx?fileticket=vF%2f34Qq57zg%3d&tabid=185

NAR High Power Rocket Safety Code
National Association of Rocketry
http://www.nar.org/NARhpsc.html

I. All Launches:
   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 LD 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.

Revised 22-SEP-2024
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/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 manufacturer 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 (3m) shall exist between each rocket involved.

<table>
<thead>
<tr>
<th>Installed Total Impulse (Newton-Seconds)</th>
<th>Equivalent High Power Motor Type</th>
<th>Minimum Diameter of Cleared Area (ft.)</th>
<th>Minimum Personnel Distance (ft.)</th>
<th>Minimum Personnel Distance (Complex Rocket) (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 -- 320.00</td>
<td>H or smaller</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>320.01 -- 640.00</td>
<td>I</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>640.01 -- 1,280.00</td>
<td>J</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>1,280.01 -- 2,560.00</td>
<td>K</td>
<td>75</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>2,560.01 -- 5,120.00</td>
<td>L</td>
<td>100</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>5,120.01 -- 10,240.00</td>
<td>M</td>
<td>125</td>
<td>500</td>
<td>1000</td>
</tr>
</tbody>
</table>
Preflight 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’s design and its deployment systems. In addition the teams must display:

- Team’s rocket readied for launch
  - Center of Gravity (CG) and Center of Pressure (CP) must be clearly marked on the rocket’s exterior.
- Preflight Checklist (showing that all steps have been completed up to launch)
- Launch Pad and Flight Arming checklist
  - must include the altimeter’s ready/standby tones
- Recovery/Postflight Checklist
  - Must include procedure to “safe” deployment charges and payload

Postflight Check-in
Following the team’s competition flight the team must follow their Recovery/Postflight Checklist to insure a safe recovery. The team then proceeds to the recovery check-in with:

- The team’s rocket
- Recovery/Postflight Checklist
  - Must show that all steps in the recovery procedure were completed before approaching the check-in station.

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

Design Review Reports Objective
The concept of the design review reports are to evaluate the process and effort that the team put into the design of the rocket and how the engineering meets the intent of the competition. The rocket that illustrates the best use of design to meet the design goals and the best understanding of the design by the team members will score the highest. There are three (3) design reports that must be submitted. The first is the Preliminary Design Review (PDR) report which describes the design goals, constraints, proposed solution idea, preliminary project schedule and proposed budget. The second report is the Critical Design Review (CDR) report that describes how the design was developed, the design of the solution, and predictions for its performance. The third report is the Final Readiness Review (FRR) report which examines how the design was altered following the CDR given the feedback from the Safety Review, as well as any payload performance testing and rocket flight tests.

Report Format
Each report must be single-spaced lines on single-sided pages. They must be in a font not smaller than 12pt. The left margin must be no less than 1 inch and the remaining margins must be no less than 1 inch from the edge of the page. All pages (except for the cover page) must be numbered in the upper right hand 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.

Figure 2 Design Report Page Layout
Preliminary Design Review Report (PDR) – short report, single-sided pages and must include, as a minimum:

- **Cover Page**
  - Team name
  - School
  - Team members
  - Faculty advisor

- **Table of Contents**

- **Design Goals**
  - List the design goals for the design of the rocket and payload
    - How is rocket/payload performance measured by competition?
    - Which will be designed first rocket, payload, or simultaneously?
    - What does the team define as most important

- **Design Constraints**
  - List limits on design
    - Limits imposed by competition
    - Limits team has chosen to include in addition to those required by competition
  - List limits on resources
    - Budget
    - People
    - Skills/tools
    - Time

- **Description of Preliminary Solution Idea**
  - Briefly describe the solution the team has chosen to advance.
  - RockSim model electronic file
  - Sketch of proposed preliminary payload and rocket.

- **Proposed Schedule**
  - Identify competition deliverable dates
  - Identify competition meeting dates
  - Identify school important dates (vacation, final exam days, etc.)
  - Show design, fabrication, documentation/reporting, subsystem and system tests

- **Proposed Budget**
  - All rocket components
  - All payload components
  - Travel expenses
**Critical Design Review Report (CDR)** - no more than twenty five (25) single-sided pages in length and must be included, as a minimum:

- **Cover Page** *(not included in page total)*
- **Table of Contents** *(not included in page total)*
- **Executive Summary**
  - One or two paragraphs describing the rocket, payload and predicted performance
  - Image of the rocket
- **Design Features of Payload**
  - Background Information on possible methods for active control and monitoring of required systems
  - Brief description of each possible method identified
  - Comparison of possible methods including the decision process for evaluation and selection of method employed
  - Design of avionic system and the video recording system
  - Image of the payload
- **Design Features of Rocket**
  - Design compensations made to accommodate the payload and sensors
  - Incorporated downed rocket location aid
- **Design Features of Recovery Systems**
  - Selected altimeter for recovery system deployment and how it is mounted
  - Dual-electronic deployment system (primary)
  - Motor deployment system (required backup)
  - Parachute(s) selected
  - Shock-cord and mountings
- **Accurate Diagram of Rocket** Identifying the dimensioned locations for the:
  - CP (center of pressure) of rocket
  - CG1 (center of mass with the fully loaded rocket motor, payload, batteries, etc.) for rocket
- **Analysis of the Anticipated Performance** – including how each were estimated
  - Liftoff, thrust to weight ratio
  - Estimated launch guide velocity (speed at 10ft altitude)
  - Estimated Maximum Altitude of rocket
  - Estimated Peak Acceleration
  - Plot of Estimated Acceleration of rocket vs. time (from start of flight)
  - Plot of Estimated Altitude vs. time (from start of flight)
- **Construction of Rocket Airframe and Payload** *(include photos)*
- **Conclusion**
- **Photographs of Completed Rocket and Payload** *(not included in page total)*
- **Budget** *(not included in page total)*
**Flight Readiness Review Report (FRR) -** no longer than ten (10) single-sided pages in length and must be included, as a minimum:

- **Cover Page** (*not included in page total*)
- **Table of Contents** (*not included in page total*)
- **Executive Summary**
  - One or two paragraphs summarizing the adjustments made to the rocket, the payload and the predicted performance following the Safety Review, Payload performance tests and Rocket test flights.
  - Image of the rocket and payload
- **Results of Payload System Performance Verifications**
  - Avionic systems testing
  - Rocket mounted video system testing
- **Adjustment to Design of Payload**
  - Document adjustments made to the design of the payload during fabrication and payload performance tests
  - Image of the payload
- **Adjustments to Design of Rocket**
  - Document adjustments made to the design of the rocket during fabrication and flight tests.
  - Image of final rocket
- **Accurate Diagram of Rocket** Identifying the dimensioned locations for the:
  - CP (center of pressure) of rocket
  - CG₁ (center of mass with the fully loaded rocket motor, payload, batteries, etc.) for rocket
- **Adjustment to Anticipated Performance** – including how each were estimated
  - Liftoff, thrust to weight ratio
  - Estimated launch guide velocity (speed at 10ft altitude)
  - Estimated Maximum Altitude of rocket
  - Estimated Peak Acceleration
  - Plot of Estimated Acceleration of rocket vs. time (from start of flight)
  - Plot of Estimated Altitude vs. time (from start of flight)
- **Conclusion**
- **Photographs of Completed Rocket and Payload** (*not included in page total*)
  - With all CP’s and CG’s indicated on exterior of rocket’s airframe

**Evaluation Criteria**
Reports and design will be evaluated on content, organization, clarity, completeness and professionalism of the material. The PDR will be evaluated for completeness, but not scored. Both the CDR and FRR will be scored. The criteria are detailed in Appendix A-1 and A-2.

**Scoring Formula**
The scoring of each required review report (the Critical Design Review Report and the Flight Readiness Review Report) is based on the average of the Design Report Judging forms for the respective report. Then the team’s review report scores will be combined and scaled to meet the required portion the competition total score.
Flight Readiness Review (FRR) Presentation (Oral)

Presentation Format
Team members will deliver the presentation to the judges in front of an audience. All team members who will deliver any part of the presentation, or who will respond to the judges’ questions, must be in the podium area when the presentation starts and must be introduced to the judges. Team members who are part of this “presentation group” may answer the judge’s questions even if they did not speak during the presentation itself.

Presentations are limited to a maximum of seven (7) minutes. The judges will stop any presentation exceeding ten 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. Only team members who are part of the “presentation group” may answer the judges’ questions. If time allows, there may be opportunity to take additional questions from the audience. If questions are taken from the audience, a designated presentation official will determine if the question is appropriate and if so then allow the team to answer.

Evaluation Criteria
Presentations will be evaluated on content, organization, visual aids, delivery and the team’s response to the judges’ questions. Rockets will be evaluated for the quality of their fabrication. The scoring criteria are detailed in Appendix A-1 “Presentation Judging”. The criteria are applied only to the team’s presentation itself. The team that makes the best presentation, regardless of the quality of their rocket, will score highest for the presentations.

Scoring Formula
The scoring of the Presentation is based on the average of the Presentation Judging forms. There is a maximum of 100 points on the Presentation Judging Form that will be scaled to meet the required portion of the competition total score.
Competition Flight

Launch and Flight Format
The launch will take place at a site determined by Tripoli Wisconsin Association. Each rocket must pass a safety inspection before launch and any additional equipment must be cleared by the Range Safety Officer (RSO) before entering the launch area. The official flight data recorder will be installed by the team after receiving it the competition official or designee. The RSO will have discretion over the number of team members that attend to the rocket once it is within the launch area. Each team must assemble a recovery team that will follow the directions of the RSO or designee.

To be considered a safe and successful flight, the rocket must:

- Safe Flight:
  - Launch
  - Fly in a stable, near-vertical trajectory during ascent
  - Rocket’s electronic, dual-deploy recovery system functions successfully (or motor backup deploys successfully)
  - Rocket must be recovered safely and in ready to fly condition

- Successful Flight:
  - Safe Flight
  - Electronic, dual-deploy recovery system functions successfully
  - Apogee is within the acceptable window of 2500 ft to 3500 ft.

Ready to fly condition shall be considered condition that if the team were handed another motor, the rocket would pass RSO inspection and could be put on the pad and flow again safely (without repairs). 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 data on the sheet during and following the flight. Upon completion, a team member must sign their initials of acceptance before a copy will be released to the team.

Evaluation Criteria
Finishing order for of the competition flight will based on:

- 50% Apogee of rocket closest to their predicted altitude (as presented in their FRR Report)
- 30% Apogee of rocket, ordered starting with highest acceptable
- 20% Safe flight and recovery

Scoring Formula
Teams will score points based on the formula:
\[ \text{Score} = 20 \text{ for safe flight} + 30 \left( \frac{\text{team's rocket apogee (ft)}}{\text{maximum rocket apogee (ft)}} \right) \\
+ 50 \left( \frac{\text{minimum rocket alt diff (ft)}}{\text{team's rocket alt diff (ft)}} \right) \]

No less than 20 points will be awarded to rockets that complete a safe flight. There is a maximum of 100 points from the Competition Flight that will be scaled to meet the required portion of the competition total score.
Post-Launch Analysis Review Report

Performance
The performance of the team’s rocket and payload are to be presented in the form of a brief report that will include:

- Cover page
  - Report title
  - WSGC CRL 2024
  - Team Name
  - School
  - Team member’s names
- Assessment of the rocket operation
  - Pre-launch
  - Launch
  - Ascent
  - Deployment
  - Descent
  - Recovery
- Performance of the payload
  - Images of the flight captured from the onboard video system
    - Frames from the video showing launch, separation, and recovery
  - Discussion of the performance of the payload and how it might have been improved
    - Plot of sensor data vs. time for each sensor, with discussion
    - Samples and analysis of any images required
- Actual vs. predicted flight performance
  - a “Flight Performance Reporting Sheet” (see Table 4 sample on next page)
  - Plot: “Acceleration Performance Comparison of Predicted and Actual for Rocket” (Figure 3)
  - Discussion of Results
    - Compare predicted and actual apogees, describe and defend possible reasons for differences
  - Discussion of how flight could have been improved
- Photographic documentation of the flight and team members

Post-Launch Analysis Review Report Format
The performance comparison document should follow the same guidelines as the Design Report, be no more than eight (8) pages in length and must be submitted electronically in .pdf format.

Evaluation Criteria
Reports will be evaluated on how closely the predicted results compare to the actual results, how well the team explains any differences, clarity, completeness and professionalism of the material. The criteria are detailed in Appendix A-3 “Post-Launch Analysis Review Report Judging.”

Scoring Formula
PLAR scoring is based on the average of the PLAR Report Judging forms. There is a maximum of 100 points from the Post-Launch Analysis Review Report Judging Form that will be scaled to meet the required portion of the competition total score.
SAMPLE: POST-LAUNCH ANALYSIS DATA REPORTING SHEET

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>Team</th>
</tr>
</thead>
</table>

1. Operation (determined by RSO or designee)  
   - Launch
   - Stable Ascent
   - Electronic, Dual-Deployment Recovery
     - Drogue deployment
     - Main parachute deployment
   - Recovered
   - Determined to be in flyable condition

<table>
<thead>
<tr>
<th>TIME (s)</th>
<th>ACCELERATION (ft/s²)</th>
<th>PREDICTED (FRR)</th>
<th>ACTUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Maximum Altitude</td>
<td>ft.(m)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Example of Post-Launch Analysis Characteristics Table

![Acceleration Performance Plot](image)

Figure 3: Example of Acceleration Performance Plot

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Project Management

Project Management Performance
The ability of the team to meet the project targets will be assessed during this competition. Targets measured will include:

- Review and discussion of the team’s design at three important phases with their rocketry mentor. Teams are required to submit the reports online by the deadlines posted in the competition calendar:
  - PDR – Preliminary Design Review
    - The PDR demonstrates that the preliminary design all system requirements have been accounted for and that the proposed design approach has sufficient maturity to ensure success of the final design
  - CDR – Critical Design Review
    - The CDR demonstrates that the design is ready for fabrication. Systems are fully accounted for and detailed hardware/software specifications can meet the functional requirements
  - FRR – Flight Readiness Review (Report)
    - The FRR incorporates the adjustments to the design given feedback from the Safety Review as well as any payload performance testing and rocket flight tests.
  - FRR – Flight Readiness Review (presentation)
    - The FRR demonstrates that not only is the system ready to fly, but the procedures have been clearly defined for the pre-flight preparation, the operation and the post-flight safety and data-download.
- Team representation at all meetings either online or in person as required during the competition.
- Completion of online forms to track the team’s progress.
- Completion and quality of team’s documentation in addition to the reports that have been spelled out about. For example:
  - Team member and contact list
  - Project budget
  - Model rocket launch photos/videos

Evaluation Criteria
Timeliness, accuracy, quality and thoroughness will be the basis for the evaluation.

Scoring Formula
Project Management Performance will be documented throughout the competition for each team. The result of the Project Management Performance will be scaled to meet the required portion of the competition total score.
Educational Outreach

Educational Outreach Performance
An “Educational Outreach” element, in which each team shares information pertinent to aerospace with a group. For purposes of the competition, teams will be scored based on the audience reached. Outreach possibilities could include but are not limited to:

- Meet with a K-12 class or student organization to explain how rockets work.
- Make a presentation in the community or to a group on campus to describe the rocket competition and your team’s design.
- Make a presentation to a group on campus describing opportunities at NASA or through the WSGC that are available to students before they graduate.

Evaluation Criteria
At the completion of the outreach event the team will need to have a representative at the event fill out and return to them an EPO (Education/Public Outreach) form that the team must then submit to the WSGC.

Scoring Formula
Teams that successfully complete the Educational Outreach and submit their EPO form will receive the required portion their total score.

Audience scoring:
- K-12 10 pts
- Community, off-campus 9 pts
- University, on-campus university 7 pts
APPENDIX A-1 CDR report

CRITICAL DESIGN REVIEW REPORT EVALUATION

| 0.0 | inadequate or no attempt |
| ¼ Val | attempted but below expectation |
| ½ Val | average or expected |
| ¾ Val | above average but still lacking |
| Max Val | excellent, perfectly meets intent |

AVIONICS SYSTEM (0-25)
- Possible methods identified (15 pts)
  o brief description of each possible method identified
  o Comparison of methods identified
  o Describe the decision process used for the evaluation and selection of top method
  o Comparison of methods identified
  o Justification of method selected
- Design details of system to capture video (5 pts)
- Accommodations to rocket made for avionics system (5 pts)

ROCKET MECHANICAL & ELECTRICAL DESIGN (0-30)
- Accurate diagrams of rocket (5 pts)
  o External appearance with overall dimensions
  o Internal organization identifying components
- Recovery system design specifications (5 pts)
- Recovery deployment altimeter system design specifications (5 pts)
- Planned construction solutions & techniques (5 pts)
- Structural analysis of custom-fabricated parts (5 pts)
- Downed rocket location aid (5 pts)

FLIGHT PERFORMANCE MEASUREMENT PLAN (0-25)
- Rocket parameters – describe how each were estimated (5 pts)
  o Dimensions and weight
  o Motor selection
  o Aerodynamic drag estimates
- Anticipated overall flight analysis (5 pts)
- Modeling of flight profile (5 pts)
- Stability analysis (5 pts)
  o CP’s and CG’s identified
- Environmental conditions analysis (5 pts)

SAFETY (0-10)
- Designed for safe flight & recovery (5 pts)
- Planned pre & post launch procedures and Checklists (5 pts)

MISCELLANEOUS (0-10)
- Followed specifications (3 pts)
- Correct spelling and grammar (3 pts)
- Documented figures and graphs; references and labeling (4 pts)

TOTAL = CDR REPORT POINTS (100 points maximum)
### RESULTS OF SYSTEM PERFORMANCE TESTING (0-25)
- Avionics system, ground tests (10 pts)
- Onboard video system testing (5 pts)
- Downed rocket location system (5 pts)
- Test Flight (5 pts)

### ADJUSTMENTS TO DESIGN (0-30)
- Avionics system (10 pts)
- Rocket (10 pts)
- Onboard video system (5 pts)
- Downed rocket location aid (5 pts)

### FLIGHT PERFORMANCE MEASUREMENT PLAN AFTER MOD (0-25)
- Rocket parameters – describe how each were estimated (5 pts)
  - Dimensions and weight
  - Motor selection
  - Aerodynamic drag estimates
- Anticipated over all flight analysis (5 pts)
- Modeling of flight profile (5 pts)
- Stability analysis (5 pts)
  - CP’s and CG’s identified
- Environmental Conditions Analysis (5 pts)

### SAFETY (0-10)
- Designed for safe flight & recovery (5 pts)
- Planned pre & post launch procedures and Checklists (5 pts)

### MISCELLANEOUS (0-10)
- Followed specifications (3 pts)
- Correct spelling and grammar (3 pts)
- Documented figures and graphs; references and labeling (4 pts)

### TOTAL = FRR REPORT POINTS (100 points maximum)
APPENDIX A-3  FRR presentation

SCHOOL ___________________________ Team ___________________________

FLIGHT READINESS REVIEW ORAL PRESENTATION EVALUATION

ENGINEERING & DESIGN CONTENT: (30 pts)
- Avionics system (15 pts)
  o Selection of sensors and microcontroller
  o Description of how it operates
  o Description of rocket features
  o Description of onboard video system
  o Diagrams/photos showing the above features were implemented in rocket
- Addressed Competition Flight Objectives/Requirements (5 pts)
- Use of Analytical Data (5 pts)
- Description of Construction Techniques (5 pts)

ROCKET APPEARANCE & DETAIL: (15 pts)
- Detail/reality of appearance (5 pts)
- Quality of Visual Appearance (5 pts)
- Quality of Construction (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 (3 pts)
- Use of Supporting Physical Materials (3 pts)

COMMUNICATION SKILLS: (15 pts)
- Articulation, Verbal Projection (5 pts)
- Body Language, Poise/Presence, Eye Contact (5 pts)
- Adherence to Time Constraints (5 pts)

QUESTION & ANSWER: (10 pts)
- Active Listening Skills (4 pts)
- Answer Relevance (3 pts)
- Response Confidence/Persuasiveness (3 pts)

TOTAL = PRESENTATION POINTS (100 points maximum)

COMMENTS:

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APPENDIX A-4 PLAR report

SCHOOL ___________________________ Team ___________________________

POST-LAUNCH ANALYSIS REVIEW REPORT EVALUATION

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

ASSESSMENT OF ROCKET OPERATION (25)
• Flight Anomalies Analysis (10 or 0 pts)
  {If no anomaly then points are distributed across remaining subsections}
• Propulsion System Assessment (3 or 5 pts)
• Flight Path Assessment (3 or 5 pts)
• Recovery System Analysis (3 or 5 pts)
• Rocket Location & Recovery Analysis (3 or 5 pts)
• Pre & Post Launch Procedure Assessment (3 or 5 pts)

PAYLOAD SYSTEM PERFORMANCE (30)
• Avionics system performance (15 pts)
• Still images from onboard video system (5 pts)
• Discussion of overall payload performance and possible improvements (10 pts)

ACTUAL VS PREDICTED PERFORMANCE (20)
• Altitude Comparison (10 pts)
• Acceleration Comparison (10 pts)

PHOTOGRAPHIC DOCUMENTATION OF FLIGHT (15)
• Launch pad and/or liftoff photo(s) (5 pts)
• In-flight photo(s) (5 pts)
• Landed on ground photo before collected (5 pts)
• Recovered rocket showing all intact or damage (5 pts)

REPORT AESTHETICS (10)
• Followed Specifications (3 pts)
• Professionally Written (10 pts)
• Accurate Representation of Events (7 pts)

TOTAL = POST-LAUNCH ANALYSIS REVIEW REPORT POINTS (100 points maximum)

COMMENTS:
APPENDIX A-5 Outreach Form

The Wisconsin Space Grant Consortium (WSGC) and NASA would like to thank you for giving our high-power rocket competition participants a chance to assist your organization. Please take a moment to fill in some information below to verify the students’ participation. A portion of your team’s competition score is based on their outreach activities. Fill out one form for each outreach event you conduct.

The goal of this activity 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.” We are grateful for your involvement in this mission and we encourage you to be a part of additional projects that are taking place through NASA funding. If you have any questions about the competition or our organization, please visit our website at https://spacegrant.carthage.edu/

<table>
<thead>
<tr>
<th>Your Team Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Lead’s Name</td>
</tr>
<tr>
<td>Advisor’s Name</td>
</tr>
<tr>
<td>Academic Institution</td>
</tr>
<tr>
<td>Team Lead Signature</td>
</tr>
<tr>
<td>Advisor’s Signature</td>
</tr>
<tr>
<td>Today’s Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Event</td>
</tr>
<tr>
<td>Approximate # of Attendees</td>
</tr>
<tr>
<td>List Each City, State, &amp; Zip Code Where the Event Took Place</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brief Description of Attendees (Circle all that apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreK: StudentsTeachers</td>
</tr>
<tr>
<td>K-5 Grade: StudentsTeachers</td>
</tr>
<tr>
<td>6-8th Grade: StudentsTeachers</td>
</tr>
<tr>
<td>High School: StudentsTeachers</td>
</tr>
<tr>
<td>University/Campus: UndergradsGraduate</td>
</tr>
<tr>
<td>AdministratorFaculty</td>
</tr>
<tr>
<td>Public at Large</td>
</tr>
<tr>
<td>Informal Education Setting (Museum, etc.)</td>
</tr>
</tbody>
</table>

| List All Organizations Involved With the Event |

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## Brief Description of Activity

<table>
<thead>
<tr>
<th>Is this a new or existing event? (Circle one)</th>
<th>What was the duration of the event? (Circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New    Existing</td>
<td>&lt; 2 days = 2 days &gt; 2 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How many exhibits were supported/developed by this event?</th>
<th>How many student hands-on activities were supported/developed by this event?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How many public at large activities were supported by this event?</th>
<th>If other activities were supported by this event, please explain:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide links to any media coverage (via your institution, local, or regional news outlets) received for this event:

Please provide the title, presenter, and venue for any presentations directly attributed to this activity:

Describe how your team plans to build upon this outreach event:

Please use this space to provide WSGC with any additional information about this outreach event:
Collegiate Rocket Launch Calendar 2024

02-Nov-2023  Kick-Off Meeting @ 6:00 pm
10-Nov-2023  Launch to Learn (L2L) Virtual Training – Build, Fly and Certify Level 1 (Fri and Sat)
13-Nov-2023  Award Acceptance Material Due
04-Dec-2023  PDR Report*, Preliminary Budget*, and Demo Flight* Deadline
             Upload RockSim Model file
             Upload rocket demo flight video on Facebook and/or Twitter and demo flight link to team lead grant management page.
18-Jan-2024  Competition Update with Q&A
12-Feb-2024  CDR Report* Deadline
12-Feb-2024  Final Team Roster* Deadline
12-Feb-2024  TRA/NAR Membership Spreadsheet* Deadline
16-Feb-2024  Deadline to Reserve Hotel Rooms in the WSGC Block for Evening of 26-Apr-2024
22-Feb-2024  CDR Virtual Review 4:30 – 6:00 pm and 7:00 – 8:00 pm, each team by appointment
04-Mar-2024  First Payout Deadline
             Please complete and mail the Travel Summary Expense Form and/or the Team Project Expense Form (found in Tools and Tips) to the WSGC Program Office.
             Include original receipts. Allow 60 days for payment.
23-Mar-2024  Design and Safety Virtual Review Meetings, each team by appointment
             Mandatory meeting with 90% ready-to-fly rocket
01-Apr-2024  FRR Report* Deadline
01-Apr-2024  Education Outreach* Deadline
             Team will share information pertinent to aerospace with a group or audience.
23-Apr-2024  FRR Oral Presentation PowerPoint* Deadline
             Submitted electronically
26-Apr-2024  FRR Oral Presentation at Carthage College
             Present a 6-8 minute PowerPoint presentation discussing team’s rocket
27-Apr-2024  Launch Competition
             Attend the High-Powered Rocket Launch at Richard Bong Recreational Area in Kansasville, WI.
13-May-2024  Post-Flight Performance Review* Report
13-May-2024  Final Payout Deadline
             Please complete and mail the Travel Summary Expense Form and/or the Team Project Expense Form (found in Tools and Tips) to the WSGC Program Office.
             Include original receipts. Allow 60 days for payment.
Aug-2024     Annual Conference
             Teams that place 1st-3rd in the competition, are required to present their results associated with this program at the 34th Annual Wisconsin Space Conference, Univ. of Wisconsin Milwaukee, Milwaukee, WI.
15-Sep-2024  Proceeding Paper**
             Team that place 1st-3rd in the competition, are required to submit a Proceedings Paper for the 34th Annual Wisconsin Space Conference online journal.

Submission of these documents will be uploaded to the *grant management page, and **online journal by the team lead. Submissions received after 11:59 CDT/CST will be considered late.

Revised 22-SEP-2024