2020 Collegiate Rocket Launch

Competition Handbook

Wisconsin Space Grant Consortium
# Table of Contents

Competition Objective .................................................................................................................... 4  
Rocket Design Objectives ........................................................................................................... 4  
Judging Categories ...................................................................................................................... 4  

Competition Engineering Parameters ............................................................................................. 5  
Safety and Construction .................................................................................................................. 8  
  Setting the Tone ......................................................................................................................... 8  
  Design and Safety Review .......................................................................................................... 8  
  Preflight Safety Inspection ....................................................................................................... 13  
  Postflight Check-in .................................................................................................................... 13  

Reports (Written) .......................................................................................................................... 14  
  Design Reports Objective ......................................................................................................... 14  
  Report Format ........................................................................................................................... 14  
  Evaluation Criteria ..................................................................................................................... 17  
  Scoring Formula ......................................................................................................................... 17  

Flight Readiness Review (FRR) Presentation (Oral) ....................................................................... 19  
  Presentation Format .................................................................................................................. 19  
  Evaluation Criteria .................................................................................................................... 19  
  Scoring Formula ......................................................................................................................... 19  

Competition Flight ........................................................................................................................ 20  
  Launch and Flight Format ......................................................................................................... 20  
  Evaluation Criteria ..................................................................................................................... 20  
  Scoring Formula ......................................................................................................................... 20  
  Performance ................................................................................................................................ 22  
  Flight Performance Report Format ............................................................................................ 22  
  Evaluation Criteria ..................................................................................................................... 22  
  Scoring Formula ......................................................................................................................... 22  

Project Management ...................................................................................................................... 23  
  Project Management Performance ............................................................................................ 24  
  Evaluation Criteria ..................................................................................................................... 24  
  Scoring Formula ......................................................................................................................... 24  

Educational Outreach ..................................................................................................................... 26  
  Educational Outreach Performance ........................................................................................... 26  
  Evaluation Criteria ..................................................................................................................... 26  

Rev. 02-OCT-2019
Scoring Formula ............................................................................................................ 26
APPENDIX A-1 CDR report ............................................................................................ 28
APPENDIX A-2 FRR report .......................................................................................... 29
APPENDIX A-3 FRR presentation .................................................................................. 32
APPENDIX A-4 PPR report ......................................................................................... 34
APPENDIX A-5 Outreach ............................................................................................. 36
Collegiate Rocket Launch Calendar 2020 .................................................................... 38
**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 2020 Collegiate Rocket Competition entries can be stated simply as:

Student teams will design and construct a high-power “boosted dart” that will be recovered safely and in flyable condition, predict its flight performance, collect on-board video, and construct a non-commercial on-board data collection package for the dart that will characterize its rotation about the X, Y, and Z axes over time. 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 outreach activity.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Design and Flight Readiness Reports</td>
<td>20</td>
</tr>
<tr>
<td>Flight Readiness Presentation, and Quality of Fabrication</td>
<td>15</td>
</tr>
<tr>
<td>Competition Flight</td>
<td>30</td>
</tr>
<tr>
<td>Performance Post-Flight Performance Evaluation Report</td>
<td>15</td>
</tr>
<tr>
<td>Project Management</td>
<td>10</td>
</tr>
<tr>
<td>Educational Outreach</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Competition Engineering Parameters

Student teams will be required to design, construct and fly a high-power, “boosted dart” (essentially a 2-stage rocket with no motor in the upper stage which drag-separates after motor burn-out) that will be recovered safely and in flyable condition, predict its flight performance, collect down-looking on-board video from the dart and construct a non-commercial on-board data collection package that will characterize dart rotation about the X, Y, and Z axes over time. Additional rocket parameters include the use of a specific motor and dual-deploy, electronic recovery with motor-charge backup. The rocket is required to use motor deployment of the recovery parachute but in addition, teams may also use electronic deployment for more control of the flight. A downed rocket location aid must be included in both the dart and booster. 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 full separation of the dart before apogee and whose dart achieves the highest altitude.

Figure 1  Flight Path of Rocket
<table>
<thead>
<tr>
<th>Table 1 Competition Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flight Mission</strong></td>
</tr>
<tr>
<td><strong>Altitude Required</strong></td>
</tr>
<tr>
<td><strong>Target Altitude</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Video evidence of Dart flight</strong></td>
</tr>
<tr>
<td><strong>Recovery</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Rocket Constraints</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Low-power Rocket Demonstration Flight</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Rocket Design and Safety Reviews</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
- 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
- Recovery systems on both booster and dart must successfully deploy
- Both the booster and the dart must be recovered in flyable condition

**Successful Flight**
- Safe Flight
- Dart must separate for the booster during ascent

In addition to the budget support, the WSGC will provide each team with the following equipment:

**Required Competition Rocket Motor**
- Aerotech Consumer Aerospace:
  - 38mm: I435bt
  - Thrust curves data can be found at: [http://www.thrustcurve.org/searchpage.jsp](http://www.thrustcurve.org/searchpage.jsp)

**Competition Flight Data Recorder**
- 1.80" long x 0.8" wide x 0.55" thick, ~ 0.25 oz.
- Powered by a 9 v battery, ~ 1.6 oz.

  This recorder is separate from the team's electronic deployment system(s) and will be inserted on the day of launch to record acceleration & altitude vs. time.

**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](mailto:Maxq3@aol.com)) or **Bob Justus** ([bob@mhbofni.com](mailto:bob@mhbofni.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 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 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 Booster-Dart separation.
- 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 (speed at 10 ft.)
- 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 2  **FAA Model Rocket Classification**

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

Table 3  **NAR/Tripoli Certification Requirements and Limitations**

<table>
<thead>
<tr>
<th>Certification required</th>
<th>None</th>
<th>Level 1 HPR</th>
<th>Level 2 HPR</th>
<th>Level 3 HPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Combined Impulse</td>
<td>320 N-sec (2 G Motors)</td>
<td>640 N-sec (H,I)</td>
<td>5120 N-sec (J,K,L)</td>
<td>40960 N-sec (M,N,O)</td>
</tr>
<tr>
<td>Combined propellant mass</td>
<td>125 grams (4.4 oz.)</td>
<td>No Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Motor Impulse</td>
<td>160 N-sec (G motor)</td>
<td>No Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Motor propellant mass</td>
<td>62.5 grams (2.2 oz.)</td>
<td>No Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Motor Average Thrust</td>
<td>80 N</td>
<td>No Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparky Motors</td>
<td>Not allowed</td>
<td>Allowed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Rocket Mass</td>
<td>1500 grams (3.3 lbs)</td>
<td>No Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field distance requirements</td>
<td>Per Model rocket safety code</td>
<td>Per HPR safety code</td>
<td></td>
<td></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](http://www.nfpa.org/1127)
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.
      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>
<tr>
<td>10,240.01 -- 20,480.00</td>
<td>N</td>
<td>125</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>20,480.01 -- 40,960.00</td>
<td>O</td>
<td>125</td>
<td>1500</td>
<td>2000</td>
</tr>
</tbody>
</table>

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

*Design Reports Objective*

The concept of the design 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 Report (PDR) which describes the design goals, constraints, proposed solution idea, preliminary project schedule and proposed budget. The second report is the Critical Design Report (CDR) that describes how the design was developed, the design of the solution, and predictions for its performance. The third report is the Final Design Report (FDR) which looks at 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*

The design report can be no longer than twenty five (25) single-sided pages in length. It 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.

![Design Report Page Layout](image)

**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 booster, dart and payload
    - How is rocket/payload performance measured by competition?
    - Which will be designed first booster, dart, 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 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 dart separation, for rotation sensing
  - Brief description of each method identified
  - Comparison of methods including the decision process for evaluation and selection of method employed
  - Design of dart its deployment and operation, and the video recording system
  - Image of the dart and payload
- **Design Features of Rocket**
  - Design compensations made for booster to accommodate the dart
  - Incorporated downed rocket location aid
- **Design Features of Recovery Systems**
  - Altimeter chosen and how it is mounted
  - Booster, motor deployment system
  - Dart, electronic deployment system
  - Parachute(s) selected
  - Shock-cord and mountings
- **Accurate Diagram of Rocket** Identifying the dimensioned locations for the:
  - CP₁ (center of pressure) of booster with dart
  - CP₂ (center of pressure) of dart only
  - CG₁ (center of mass with the fully loaded rocket motor) for booster with dart
  - CG₂ (center of mass) of dart only
- **Analysis of the Anticipated Performance** – including how each were estimated
  - Estimated Maximum Altitude of dart
  - Estimated Peak Acceleration
  - Plot of Estimated Acceleration of dart vs. Time (from start of flight)
- **Construction of Booster, Dart, and Payload** *(include photos)*
- **Conclusion**
- **Photographs of Completed Booster and Dart** *(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 System Performance Verifications**
  - Separation of dart testing
  - Rotation rate sensing system testing
  - Dart mounted video system testing
- **Adjustment to Design of Dart and Payload**
  - Document adjustments made to the design of the dart and payload during fabrication and payload performance tests
  - Image of the dart
- **Adjustments to Design of Booster**
  - Document adjustments made to the design of the booster during fabrication and flight tests.
  - Image of final booster with the dart
- **Accurate Diagram of Rocket** Identifying the dimensioned locations for the:
  - CP₁ (center of pressure) of booster with dart
  - CP₂ (center of pressure) of dart only
  - CG₁ (center of mass with the fully loaded rocket motor) for booster with dart
  - CG₂ (center of mass) of dart only
- **Adjustment to Anticipated Performance** – including how each were estimated
  - Estimated Maximum Altitude
  - Estimated Peak Acceleration
  - Plot of Estimated Acceleration vs. Time (from start of flight)
- **Conclusion**
- **Photographs of Completed Booster and Dart** *(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-2 “Design Judging”.

**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 20% of 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 15% 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 placed in the rocket by the altitude tracking official or designee. The RSO will have discretion over the number of team members that attend the rocket once it is in 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
  - Booster recovery system motor deployed (or electronic with motor backup) successfully
  - Dart recovery system electronically-deployed successfully
  - Booster and dart must be recovered safely and in ready to fly condition

- **Successful Flight:**
  - Safe Flight
  - Dart separation before apogee

Flyable 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 the competition flight will be based on:

- Safe flight and recovery
- Apogee of dart
- Apogee of dart closest to their predicted altitude (as presented in their FRR Report)

**Scoring Formula**

Teams will score points based on the formula:
$Score = 20 \text{ for safe flight} + 60 \left( \frac{\text{team's dart apogee (ft)}}{\text{maximum dart apogee (ft)}} \right) + 20 \left( \frac{\text{minimum dart alt diff (ft)}}{\text{team's dart alt diff (ft)}} \right)$

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 30% of the competition total score.
Post-Flight Performance Report

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

- Cover page
  - Report title
  - WSGC CRL 2020
  - Team Name
  - School
  - Team member’s names
- Assessment of the boosted dart operation
- Performance of the payload
  - Images of the dart’s separation captured from the flight video
    - Frames showing launch, separation, and continued flight of dart
  - Discussion of the performance of the payload and how it might have been improved
    - Plot of rotation speed about each axis with discussion
- 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 Dart” (Figure 4)
  - 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

Flight Performance 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 “Flight Performance Judging.”

Scoring Formula
Flight Performance Report scoring 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 to meet the 15% of the competition total score.
SAMPLE: FLIGHT PERFORMANCE REPORTING SHEET

SCHOOL ___________________________ Team ___________________________

1 Operation (determined by RSO or designee)  ✔
  Launch

  Stable Ascent

  Dart Separation Before Apogee

  Recovery deployment - Booster

  Recovery deployment - Dart

  Recovered - Booster

  Recovered - Dart

  Determined to be in flyable condition

<table>
<thead>
<tr>
<th>Predicted (FDR)</th>
<th>Actual</th>
</tr>
</thead>
</table>

2 Maximum Altitude (ft.)

Table 4 Example of Flight Performance Characteristics Table

Figure 3 Example of Acceleration Performance Plot
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 10% 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 up to 10 points towards their total score.

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

**SCHOOL**

**Team**

---

**CRITICAL DESIGN REVIEW REPORT EVALUATION**

<table>
<thead>
<tr>
<th>Val</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>inadequate or no attempt</td>
</tr>
<tr>
<td>± ¼</td>
<td>attempted but below expectation</td>
</tr>
<tr>
<td>± ½</td>
<td>average or expected</td>
</tr>
<tr>
<td>± ¾</td>
<td>above average but still lacking</td>
</tr>
<tr>
<td>Max Val</td>
<td>excellent, perfectly meets intent</td>
</tr>
</tbody>
</table>

---

**BOOSTED-DART SEPARATION SYSTEM (0-25)**

- Possible methods identified (10 pts)
  - brief description of each possible method identified
  - Comparison of methods identified
  - Describe the decision process used for the evaluation and selection of top method
  - Comparison of methods identified
  - Justification of method selected
- Design details of system to capture video (10 pts)
- Accommodations to rocket made for dart system (5 pts)

---

**BOOSTED-DART MECHANICAL & ELECTRICAL DESIGN (0-30)**

- Accurate diagrams of rocket (5 pts)
  - External appearance with overall dimensions
  - Internal organization identifying components
- Recovery System Design Specifications (5 pts)
- Avionics 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)
  - Dimensions and Weight
  - Motor Selection
  - Aerodynamic Drag estimates
- 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 = CDR REPORT POINTS (100 points maximum)**
APPENDIX A-2  FRR report

SCHOOL __________________________ Team __________________________

FLIGHT READINESS 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

RESULTS OF SYSTEM PERFORMANCE TESTING (0-25)

• Separation system testing (10 pts)
• Rotation rate system testing (5 pts)
• Dart mounted video system testing (5 pts)
• Test Flight (5 pts)

ADJUSTMENTS TO DESIGN (0-30)

• To Dart separation (5 pts)
• To Dart (5 pts)
• To Booster (5 pts)
• To Rotation Rate payload (5 pts)
• To 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)
  o Dimensions and Weight
  o Motor Selection
  o Aerodynamic Drag estimates
• Over all 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 = FFR REPORT POINTS (100 points maximum)
APPENDIX A-3  FRR presentation

SCHOOL ___________________________  Team ___________________________

FLIGHT READINESS REVIEW ORAL PRESENTATION EVALUATION

__________  ENGINEERING & DESIGN CONTENT: (30 pts)

- Boosted Dart System (15 pts)
  - Selection of Booster-Dart interface system
  - Description of how it operates
  - Description of Booster features
  - Description of system video system on Dart
  - 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 realism 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:

Rev. 02-OCT-2019
APPENDIX A-4 PPR report

POST-FLIGHT PERFORMANCE 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 to 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)
- Rotation rate sensing payload (15 pts)
- Still images from 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-FLIGHT PERFORMANCE REVIEW REPORT POINTS (100 points maximum)

COMMENTS:
The Wisconsin Space Grant Consortium (WSGC) and NASA would like to thank you for giving our collegiate 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 their competition score is based on their outreach activities and your willingness to let them assist you in the work you are doing is appreciated.

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.” One of the goals of the WSGC is to promote science, technology, engineering, and math (STEM) fields through educational opportunities in the state of Wisconsin. 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 WSGC funding. If you have any questions about the competition or our organization, please visit our website at [https://spacegrant.carthage.edu/](https://spacegrant.carthage.edu/)

<table>
<thead>
<tr>
<th>Name of Organization</th>
<th>Supervisor Name</th>
<th>Phone or Email</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of Hours</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity Performed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Approx. # of Attendees</th>
<th>Brief Descrip. of Attendees</th>
<th>Brief Descrip. of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Circle one:
K-12 Off-Campus Comm. University

---

<table>
<thead>
<tr>
<th>Name of Organization</th>
<th>Supervisor Name</th>
<th>Phone or Email</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of Hours</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity Performed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Approx. # of Attendees</th>
<th>Brief Descrip. of Attendees</th>
<th>Brief Descrip. of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Circle one:
K-12 Off-Campus Comm. University
Collegiate Rocket Launch Calendar 2020

07-Nov-2019  Kick-Off Meeting @
15-Nov-2019  Award Acceptance Material Due
09-Dec-2019  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.
16-Jan-2020  Design Update Virtual Meeting I
13-Feb-2020  Design Update Virtual Meeting II
18-Feb-2020  CDR Report* Deadline
09-Mar-2020  First Payout Deadline
              Please complete and mail the Travel Summary Expense Form and/or the Team Funded Program Expense Reimbursement Form (found in Tools and Tips) to the WSGC Program Office. Include original receipts. Allow 60 days for payment.
13-Mar-2020  Final Team Roster* Deadline
21-Mar-2020  Design and Safety Review Meeting at EAA Museum
              Mandatory meeting with 90% ready-to-fly rocket
6-Apr-2020   FRR Report* Deadline
6-Apr-2020   Education Outreach* Deadline
              Team will share information pertinent to aerospace with a group or audience.
14-Apr-2020  FRR Oral Presentation PowerPoint* Deadline
17-Apr-2020  FRR Oral Presentation at Carthage College
              Present a 6-8 minute PowerPoint presentation discussing team's rocket
18-Apr-2020  Launch Competition
              Attend the High-Powered Rocket Launch at Richard Bong Recreational Area in Kansansville, WI.
04-May-2020  Post-Flight Performance Review* Report
04-May-2020  Final Payout Deadline
              Please complete and mail the Travel Summary Expense Form and/or the Team Funded Program Expense Reimbursement Form (found in Tools and Tips) to the WSGC Program Office. Include original receipts. Allow 60 days for payment.
Aug-2020     Annual Conference
              If your team places 1st-3rd in the competition, present the results of your studies associated with this program at the 30th Annual Wisconsin Space Conference at Milwaukee School of Engineering, Milwaukee.
15-Sep-2020  Proceeding Paper**
              If your team places 1st-3rd in the competition, submit a Proceedings Paper for the 30th 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.