

Battle of the Rockets TM ***Competition*** ***2017-2018***



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Introduction

The [Battle of the Rockets](#)™ is a program of the [Federation of Galaxy Explorers](#). The program is a series of competitive events focusing on the engineering design cycle. The events within the competition are designed to inspire student's interest in engineering and science with an exciting hands-on competition. The competition provides multiple levels of difficulty of engineering design challenges. These challenges are meant to continuously increase as the competitor's skill level grows. Each year, Galaxy Explorers will introduce new and more complex event challenges for the competition.

Dates

Registration for the competition is due by Oct 30, 2017.
The launch will be held in April 2018 and will be for two days.

The Competition

The competition comprises multiple events. Each event has unique challenges and complexities. The events are judged separately.

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Event 1: Mars Rover Mark III

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This event has returned due to demand. The largest issue with this event is the condition of the terrain. The terrain is a farm field and crops vary from soybean to corn. If corn has been planted, expect the possibility of corn stocks. You need to design your rover to overcome cut corn stocks which can be as tall as a foot. Some changes have been made to the rover requirements to allow some success if maneuvering becomes too difficult.

In the past, all rovers had some failure. Most failures were due to impacting the ground. The most common damage was to the wheels, axles and motor mounts.

Design a rocket and Mars rover to launch to at least 1000 feet and deploy the Mars rover. The Mars rover must be fully contained in the rocket before being deployed. Once deployed, the Mars rover must return to the ground safely. Once landed, the rover will take a picture with a camera. Up to four images will be taken, each image in the forward, left, right, and rear direction. Afterwards, the Mars rover shall release a bright colored marker that can be easily found. The marker must be placed at the point of landing. It cannot be tossed, shot, or projected beyond its landing location. Once released, the rover must then travel 10 feet and release a second marker. The rover then must turn or move 90 degrees in either direction and travel 10 feet. Travel must be completed within ten minutes. Time starts at the time of landing. Method of travel is up to the team.

Rover Requirements

| Req # | Requirement |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Rover cannot weigh more than 2 Kg. |
| 2 | Rover must be contained completely inside the rocket during launch. |
| 3 | Rover must operate autonomously. |
| 4 | Rover cannot be controlled in any way by any remote method. |
| 5 | The rover recovery system must be secured so no part of the rover free falls. |
| 6 | No pyrotechnics are allowed in the Mars rover. |
| 7 | The rover shall take four pictures, one forward, left, right and to the rear of the rover. |
| 8 | Each image must be in color and have a resolution of at least 640x480 |
| 9 | At landing, the rover must release the recovery system. The recovery system can be used as the first marker. |
| 10 | The rover must travel 10 feet or 120 inches then drop a marker. The rover must then travel another 10 feet or 120 inches perpendicular to the first 10 feet. |
| 11 | The rover must travel a minimum of two feet in each segment of travel for the movement to qualify for scoring. |
| 12 | The rover must be able to detect when it has flown and landed. Initiating or providing an external trigger at the launch pad is not allowed. Once the rover is inserted, it must be able to know when it is launched, deployed, and landed. Turning on the rover or arming it when preparing at the launch pad is allowed. |
| 13 | Travel must be completed within 10 minutes of landing |

Rocket requirements

| Req # | Requirement |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Motor clusters are not allowed. |
| 2 | Staging is not allowed. |
| 3 | Total installed impulse shall not exceed 2,560 Newton-seconds or a K motor. |
| 4 | All parts of the rocket must safely return under a recovery system. |
| 5 | The rocket airframe, nose cone, fins, bulk plates, and centering rings cannot be made of any types of metal. Composite materials are allowed. |
| 6 | If the rocket with the rover exceeds 12 pounds, rail buttons for 1515 and extreme rails must be used. |
| 7 | If the rocket is more than 6 inches in diameter, rail buttons for 1515 and extreme rails must be used. |

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| 8 | If the rocket is over 35 pounds or greater than 8 inches in diameter, unistrut rail buttons must be used and will be launched at the away cell. |
| 9 | The rocket must reach at least 1000 feet. |
| 10 | The rocket must use a commercial altimeter for measuring the peak altitude. |
| 11 | The average thrust to weight ratio must be greater than 5:1. |
| 12 | Average thrust is per the motor designation. For example a J240 has an average thrust of 240 newton-seconds. |
| 13 | The rocket must use a motor retainer. Friction fit is not allowed. |

Documentation Requirements:

Teams must submit a preliminary design review document and a critical design review document.

PDRs are due by December 1.

CDRs are due by February 1.

Templates will be provided for both PDR and CDR. Design review will be scheduled after each submission date. Teams will present via teleconference.

Judging and Scoring:

Before launch, teams must secure a judge.

Flight Scoring

Teams will receive a score for each level successfully completed. Certain levels require previous levels and must be completed in order to gain current level points. The scores will be added to the PDR and CDR scores.

| Requirement | Score | Function |
|-------------|-----------|-------------------------------------------------------------------------|
| 1 | 50 | Rover mass does not exceed 2 Kg. |
| 2 | 100 | Rover lands intact. No parts break off. |
| 3 | 25 | Image captured in the forward direction and stored for later retrieval. |
| 4 | 25 | Image captured to the left and stored for later retrieval. |
| 5 | 25 | Image captured to the right and stored for later retrieval. |
| 6 | 25 | Image captured to the rear and stored for later retrieval. |
| 7 | Up to 120 | 120-distance (in) Leg 1 |
| 8 | Up to 120 | 120-distance (in) Leg 2 |
| 9 | Up to 90 | 90-angle. If angle >90 then 90 is subtracted from the angle. |
| 10 | 200 | Rocket reached 1000 feet or greater. |
| 11 | 50 each | Image is transmitted to a ground station. |

Event 2: Sounding Rocket

Event 2: Sounding Rocket

The mission is to launch a sounding rocket to an altitude above 1200 feet and not to exceed 2000 feet. Five seconds after launch, the payload must start taking images of the horizon at no greater than 1 image per second. Once the rocket lands, the payload must stop taking images.

The payload must include sensors and a XBEE radio transmitter to send telemetry. Telemetry must be sent at a 5 Hz rate and include current altitude, current speed, acceleration, spin rate and a count of the images taken. The count increments by one each time an image is taken.

A ground station is required to collect the telemetry and display the data. The telemetry must indicate when a picture is captured.

Payload Requirements

| Req # | Requirement |
|-------|-----------------------------------------------------------------------------------------------------------------------------------|
| 1 | Camera must have a minimum resolution of 640x480 pixels and be in color. No video capture allowed. |
| 2 | Image capture rate shall not exceed once per second. |
| 3 | Images can be stored in the payload for download after recovery. |
| 4 | Telemetry must be transmitted five times per second. |
| 5 | Telemetry must include a timestamp with sufficient resolution, current altitude, speed, acceleration, spin rate and image number. |
| 6 | Each telemetry packet must have a packet count that is incremented for each packet. |

Payload Bonus Objectives

| Bonus | Description |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Real time GPS position is added to the telemetry. Position is updated once per second. |
| 2 | Captured images are downloaded in real time through the telemetry radio link, stored on the ground station and displayed on the ground station. |

Ground Station Requirements

| Req# | Requirement |
|------|-----------------------------------------------------------------------------------------------------|
| 1 | Ground station must display telemetry being received in real time. |
| 2 | The ground station must display the current packet count. |
| 3 | Telemetry data must be plotted in real time, altitude, speed, acceleration, spin rate. |
| 4 | Images must be downloaded from the recovered payload and displayed to the judges. |
| 5 | Ground station must operate on battery power only. |
| 6 | The ground station must be portable so it can be moved to the ground station location on the field. |
| 7 | Ground station antenna must be hand held. |
| 8 | Must provide a table for the ground station. |

Rocket requirements

| Req # | Requirement |
|-------|-------------------------------------------------------------------------------------------------|
| 1 | Total installed impulse shall not exceed 640 Newton-Seconds or an I motor. |
| 2 | The rocket must reach at least 1200 feet and not exceed 2000 feet. |
| 3 | The rocket must use a motor retainer. Friction fit is not allowed. |
| 4 | All common rules must be followed. |
| 5 | The rocket must include an independent commercial altimeter to verify the rocket peak altitude. |

Documentation Requirements:

Teams must submit a preliminary design review document and a critical design review document.

PDRs are due by December 1.

CDRs are due by February 1.

Templates will be provided for both PDR and CDR. Design review will be scheduled after each submission date. Teams will present via teleconference.

Judging and Scoring:

Before launch, teams must secure a judge to be at the ground station. The judge will review the ground station and indicate when ready for launch. The team must also determine when they are ready for launch. One member of the team must be designated the mission control officer and must be positioned at the launch control officer and verify with their team they are ready for launch. The rocket will not be launched until the mission control officer gives word to launch.

After all parts of the rocket has been recovered, the team shall return the payload to the ground station and download the images with a judge present. The images shall be shown to the judge and the count increment correlated to each image along with the telemetry at the count.

Flight Scoring:

The flight scores will be added to the PDR and CDR scores.

| Requirement | Points | Function |
|-------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | 100 | Telemetry is received and displayed on ground station in real time. Telemetry must be transmitted from time of lift off to time of landing or at least drops out of sight due to terrain and ground vegetation. |
| 2 | 100 | Altitude, speed, acceleration and spin rate is plotted in real time on ground station. |
| 3 | 100 | Rocket altitude is greater than 1200 feet and less than 2000 feet. |
| 4 | 25 ea | Image captured and downloaded via telemetry radio showing horizon at altitude greater than 1000 feet. All parts of the rocket must be returned. |
| 5 | 50 | GPS position data included in the telemetry. Position updated once per second. |
| 6 | 5 each | Images are taken five seconds after launch. Images must be shown to the judge. |

Event 3: Target Altitude

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Design and build a rocket to fly on any commercial certified F level rocket motor to an altitude of 1312 feet. The rocket closest to 1312 feet wins. The rocket must safely recover and be in condition to be flown again. The team must perform two successful flights meeting all the requirements out of three attempts. Two attempts must meet the requirements or be disqualified. The altitude difference from 1312 is used as the score. The scores from the two successful attempts are added together. The lowest score wins.

Requirements:

| Item | Requirement |
|------|-----------------------------------------------------------------|
| 1 | Two successful flights must be completed out of three attempts. |
| 2 | Any commercial certified F motor is allowed. |
| 3 | Any commercial altimeter may be used. |

Documentation Requirements:

Teams are required to submit a design document describing the design of the target altitude rocket. A document template will be provided. A telecon will be required to explain the design to judges.

Judging and Scoring

The scoring is the absolute difference between the altimeter reading and 1312 feet. The two best attempt scores will be summed and be the final score. Lowest score wins.

After teams complete a qualification flight attempt, the team must take their rocket with the altimeter to the judges tent to record the altitude. Do not turn off the altimeter until after the altitude has been recorded. The altitude must be recorded at the judge's tent.

Application

Teams must submit an application form and identify each event to be attempted. The application form requires student information and a signed release form. No information will be released or sold. All applications are to be destroyed after the competition. The information requested are for administrative and insurance purposes only. The application fee for the Target Altitude event is \$50 and \$100 for the Sounding Rocket and Rover events. The application fee is nonrefundable. Teams can compete in more than one event.

Team Requirements

Teams shall have at minimum 2 members and no more than 10 members. Teams can consist of university, college, or trade school students currently enrolled in a university, college, community college, high school, or trade school. Each team must have a faculty advisor assigned to the team. The faculty advisor may support multiple teams.

At least one team member must have a membership in Tripoli or NAR to use high power rocket motors of H or greater.

Only team members can work on any aspect of the competition including the design, simulation, construction, repair, and launching. Adults, companies, and any non-team members cannot help.

Safety Review for All Rockets

Teams are to submit a safety document with all sections filled out. The safety document will be provided when teams sign up.

Teams are to complete one test flight and submit a flight document before the competition. Due to the complexity of some of the rockets, test flights must be completed before the competition.

Test flight information can be submitted electronically via email. An email address will be provided.

Common Rules for All Events

| Item | Rule |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | All competitors must follow the Tripoli High Power Safety Code. The code can be found on the Tripoli website. www.tripoli.org |
| 2 | The rocket must have been flown before. No first flight rockets are allowed. |
| 3 | All rockets shall use a single motor: no clusters or staging allowed. |
| 4 | The airframe, fins, nose cone, bulk plates, centering rings, and motor mount cannot be made of any metals. |
| 5 | Metal fasteners and small metal components are allowed. |
| 6 | Composite materials are allowed. |
| 7 | Launch lugs are not allowed. |
| 8 | Competitor can provide their own launch pad and controller. |
| 9 | A positive motor retention is required. Motor retention must pass RSO approval before the flight will be allowed. |
| 10 | Friction fit of motors are not allowed. |
| 11 | No modifications are allowed to any of the currently certified commercial motors. Manufacturers that allow modifications to the delay charge as part of standard assembly is allowed. |
| 12 | Only currently certified NAR/Tripoli commercial motors are allowed. |
| 13 | Average thrust to weight ratio must be at least 5:1. Rockets will not fly below that. |
| 14 | Any of the commercially available altimeters are allowed. |
| 15 | Electronic deployment devices are allowed. |

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| 16 | Electronic deployment devices must be disarmed until the rocket is placed on the launch pad. Giant Leap Rocketry Slimshot and EFC are allowed to be configured as in the directions provided by the manufacturer. |
| 17 | Recovery aids such as radio beacons/trackers and audible beacons are allowed. |
| 18 | Maximum descent rate must not exceed 20 feet/sec. |
| 19 | A recovery system is required so that the rocket lands and is immediately flyable without the need for any repairs or alterations. Rockets not meeting this definition will be disqualified. |
| 20 | Any structural part of the rocket recovery system, or motor that free falls will result in a disqualification. Pop off rail guides are considered part of the ground support equipment. Any components that are supposed to be released or discarded for launch purposes are allowed. The competitor must specify what gets released or discarded for launch purposes before the launch. |
| 21 | The word of the safety committee and range safety officer is final. The safety team and/or RSO are the ultimate judges in determining a safe or unsafe flight. |
| 22 | Rockets are not to exceed 15,000 feet due to waiver limits. |
| 23 | Up to three attempts per competitor per event is allowed. Exceptions are due to malfunctioning launch equipment or faulty rocket motor due to manufacturer defect. Launch attempts stop at 4pm. It is up to the competitor to manage their time. |
| 24 | Rockets may not use any externally-generated signals such as radio or computer control for any purpose, including flight termination, after liftoff. Autonomous on-board control systems can be used. |
| 25 | No guidance systems are allowed. |
| 26 | Boosted darts are not allowed. |
| 27 | Recovery electronics must be turned on before the igniter is inserted. |
| 28 | The igniter is to be installed at the launch pad when the rocket is in the vertical position. |
| 29 | Competitors attempting unsafe recovery from trees or power lines will be disqualified. If a rocket lands in a tree or power line, an official must be notified to make a safe recovery. |
| 30 | The altimeter used for altitude measurement must not be removed from the rocket or turned off until in the presence of a judge. |
| 31 | If a team chooses to use a hybrid rocket motor, the team must provide all ground support equipment. |

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| 32 | No Li-PO batteries allowed. |
| 33 | All electronics power must support up to an hour delay on the launch pad. |
| 34 | No sparky motors or any type of motor that can generate sparks. |
| 35 | If the rocket uses a level 1 or level 2 motor, at least one team member with the appropriate certification level must be present at the launch, handling the rocket and inserting the igniter. |
| 36 | The range safety officer has the right to refuse any rocket deemed not safe. |

Launch Systems

Launch pads will be provided and have six foot long 1 inch (1010) aluminum rails. 8 foot 1.5 inch (1515) aluminum rails will also be provided. The rails are to be vertical. They cannot be angled at all. Teams can substitute with their own launch equipment. Student launch equipment must be inspected before use for safety.

The following table is the rail requirements.

| Rail | Max Motor Size | Rail Buttons | On Pad Max Weight (lb) | Max Rocket Diameter (in) | Rail Length (feet) |
|----------|----------------|---------------|------------------------|--------------------------|--------------------|
| 1010 | J | 1010 | 15 | 6.0 | 6 |
| 1515 | L | 1515 | 25 | 7.5 | 8 |
| Unistrut | O | Unistrut/1515 | 100 | 18 | 20 |

Practice Flights

Teams can perform test flights any time during the year up to the competition. The teams must perform test flights at sanctioned rocket launches supported by NAR or Tripoli. If testing with high power rocket motors, a team member must be certified or the team must find a person at the launch with proper certification to purchase and assemble the rocket motor for the team. Teams must follow all regulations when flying with high power rocket motors.

Weather Issues

The launch provider has the authority to stop the launching of rockets at any time during the competition due to weather conditions causing safety issues. The safety of everyone is the highest priority. The times for the competition are set and cannot be extended.

Disqualifications

A team will be disqualified for any of the following reasons:

1. Recovery system does not deploy and the rocket free falls or comes in ballistic.
2. One or more parts of the rocket free fall from the rest of the rocket.
3. Rocket motor separates from the rocket during any part of flight.
4. Rocket is damaged beyond field repair after flight.
5. Team acts in a dangerous manner.
6. Team misbehaves and or interferes with other team's progress.
7. Team does not launch before the end of flying.
8. Team attempts an unsafe recovery. An unsafe recovery is defined as attempting to remove any part of a rocket out of power lines or trees that require climbing. Rockets can be pulled out of trees or other vegetation if the team member can reach any part while standing on the ground.

Competition Operations

The opportunity to launch begins at 10AM Saturday and ends at 4PM Sunday. All contest entries must be on the launch pad no later than 4pm. The contest ends at 5PM allowing for recovery time after the 4PM end time.

There will be a designated ground station area along the flight line for all teams participating in events that require a ground station. This will allow the judges to stay in one area and score the teams more efficiently. Teams need to bring a small table to support their ground station.

For the planetary lander and sounding rocket events, teams must locate a judge for their ground station to be scored. A field judge will verify lander has uprighted.

For the target altitude event, the altimeter must be returned to the judge's team for the judge to record the altitude. Do not turn the altimeter off before the judge has recorded the altitude.