Battle of the Rockets^{TM} Competition 2018-2019

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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, 2018.
The launch will be held in April 2019 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.

Contact Information

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Competition Operation

The competition starts when the competition guide is posted online in August. Teams can start designing before registration. Registration starts when the competition guide is posted and ends October 31.

All teams are required to submit rocket safety documents by end of Jan 15. Documents will be reviewed and teams will receive comments about their designs. The purpose is to identify any potential safety or operation issues so teams will have a better chance of success. There will be a safety document template made available. Teams must include an email address for comments in the document and use the file name format as follows:

Safety_xxxx.pdf where xxxx is the team number.

Sounding rocket event and rover event teams are required to submit PDR documents in December and have a review with judges. The PDR documents are scored. Teams will get score results after PDR.

February 1, sounding rocket event and rover event teams submit CDR documents and have a review with judges. The CDR documents are scored. Teams will get score results after CDR.

PDR and CDR schedules are created by having volunteer judges sign up for time slots over a one week period indicating their availability for reviews. Time slots are in one hour increments from 7am until 8pm eastern. When two or three judges sign up for the same time slot, it becomes available for teams to select. At least one week before reviews start, the calendar of available time slots will be sent to the teams for selection. Each team is to submit 3 time slots and will be given the first available selected time slot. Reviews are to last a half hour.

In April, the competition launch will take place on Saturday and Sunday. This allows dealing with weather issues and gives teams time to perform up to 3 qualifying launches and any test launches. There is no launch schedule for the two days. It is up to the teams to manage their time and get enough qualifying launches completed. The competition launch periods starts 9am Saturday, ends 5pm Saturday, restarts 9am Sunday and ends 4pm Sunday. Awards are given by 5pm Sunday. Teams do not need to be present. If not present, the award will be mailed to the team.

Weather can affect launching. NAR and Tripoli rules do not allow for launching into clouds or with winds over 20 mph. If the cloud ceiling is too low or the weather is affecting the performance of the rockets in any adverse way, the range will be shut down until the weather improves. The competition must follow all safety rules. It is possible the weather can affect the whole weekend. If rover and sounding rocket teams are not allowed to launch the whole weekend, awards will be given based on PDR and CDR scores. Target altitude teams will not be able to fly and will not receive any awards. Target altitude competition requirements will be kept the same for the next year.

Launch Procedures

All teams are to prepare their rockets and payloads in the team area. Teams must follow all safety procedures for handling rocket motors and ejection charges. When teams are ready to launch, they must bring their rocket to the Range Safety Officer (RSO) table. If performing a test flight, a club flight card needs to be filled out. For high power motors, a member of the team or mentor or any person over 18 and certified by NAR or Tripoli at the correct level must fill out the flight card. The RSO will check the rocket for flight worthiness and verify the rocket motor meets the 5:1 thrust to weight ratio.

Once approved by the RSO, the team with the certified motor handler will move on to the Launch Control Officer (LCO) at the flight line and hand off the flight card. The LCO will assign a launch pad and the team with the certified motor handler can proceed to load the rocket on the launch pad.

At the launch pad, the team can load the rocket and prepare the payload if the rocket has a payload. When it is time to arm the altimeter and insert the igniter, the non-certified team members must back away from the rocket. Only the minimal number of people should be near the rocket during the arming process and igniter insertion. All team members must return to the flight line after the rocket is ready for launch.

After all rockets have been launched, the LCO will announce the range is safe and at that time, teams can go into the field to recover their rockets and payloads.

Specific instructions for each event for recovery and judging are in each event section.

Awards

Each event will have a set of awards. The top three teams will receive a plaque reflecting their ranking. If teams are not present during the award ceremony at the end of Sunday, the teams will be contacted and awards shipped.

All team members will receive certificates of participation. Teams must be present at the launch to receive the certificates.

Team List Management

Each team must fill out an application which comprises of a spreadsheet that includes a list of team members. After submission and payment, the team members will receive their spreadsheet with team numbers for each event the team is participating in. The teams must maintain the list of team members and will submit the spreadsheet once more three weeks before the weekend launch with the final list of team members. The final list will be used for generating certificates and verifying submission of release forms.

Event 1: Mars Rover Mark III

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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. 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.

This mission simulates a rover being sent to Mars and to be used as a tool by an astronaut who arrives later to the same location as the rover.

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 shall disconnect or remove itself from any recovery device and travel 3 feet from the recovery device which will be used as a marker indicating the starting position. At the three foot mark, the rover shall stop and wait for a command. When commanded, the rover shall collect at least 5 grams of soil and place it in a detachable container. A maximum of 25 grams can be collected. The rover will have 5 minutes to collect the soil. A second command shall be used to have the rover take a picture of the area where the soil was collected. The commands for each action must be a single command that triggers the required operation.

The source of the commands shall be a small hand held wireless controller. The controller shall be capable of sending the two commands. As a bonus the image captured shall be received and displayed on the hand held controller. Since this mission simulates an astronaut operating the rover in close proximity, the hand controller must be designed or configured to be operated by an astronaut in a space suit. This means the hand controller must be operated with a gloved hand. At this time, astronaut gloves are bulky. A good simulation would be a pair of welding gloves. The surface of the gloves can be modified with additional materials but cannot be structurally modified. Inexpensive welding gloves can be found at Harbor Freight and local hardware stores for $12 or less.

Rover Requirements

Req #	Requirement
1	Rover cannot weigh more than 2 Kg.
2	Rover must be contained completely inside the rocket during launch.
3	The rover recovery system must be secured so no part of the rover free falls.
4	No pyrotechnics are allowed in the Mars rover.
5	The rover shall take a picture of the site where the soil was collected.
6	Each image must be in color and have a resolution of at least 640x480
7	At landing, the rover must release the recovery system. The recovery system can be used as the first marker.
8	Rover shall meet all operational requirements described.
9	The rover must travel 3 feet within 10 minutes autonomously.
10	Mission must be completed in 5 minutes after commanding.
11	No flying rovers.

Controller Requirements

Req#	Requirement
1	Controller must be hand held.
2	Controller must communicate with the rover via radio signals. WiFi, bluetooth or XBEE radio are allowed. XBEE radios must have their PAN/NET ID set to team number.
3	Controller must send a single command for each action required.
4	Laptop cannot be used.

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.
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.
14	All common rules must be followed.

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.
Documentation should be submitted via email to battleoftherockets@gmail.com.
Templates will be provided for both PDR and CDR. Design review will be scheduled after each submission date. Teams will present via teleconference.

All documents must be in PDF format.
PDR file name format shall be rover_xxxx_pdr.pdf where xxxx is the team number.

CDR file name format shall be rover_xxxx_cdr.pdf where xxxx is the team number.
The file name formats must be followed.

Judging and Scoring

Before launch, teams must secure a judge. The judge must go out with the team during recovery to review the rover. No team member is allowed to touch the rover until the judge says it is OK or if the team decides the rover is nonfunctional. Any team member touching the rover forfeits all points toward the rover.

The judge must be at the site of the rover and monitor when the rover is commanded to collect a soil sample. The container must be removable so the judge can carry the sample back to the judging area and weigh the soil sample.

The team must bring the rocket to the judge with the altimeter so the judge can get the altitude reading for scoring. The altimeter must not be turned off before the judge gets the reading. Once the judge has completed scoring, the team may recover all parts of the rocket and payload.

Flight Scoring

Teams will be 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	50	Rover lands intact. No parts break off.
3	Up to 36	Rover travels 36 inches measured from closest piece of recovery system to back end of rover.
4	100	5 grams of soil collected
5	10 each	Additional 5 grams up to 25 grams total collected
6	50	Image of soil collection site taken

7	50	Image transmitted to hand held controller
8	100	Rocket reached 1000 feet or greater.
9	200	Locomotion method does not use wheels, things that are similar to wheels in shape or function or tracks (rover must move at least 3 feet to get the points)
10	50	Hand controller functional with gloved hand

Event 2: Sounding Rocket

Event 2: Sounding Rocket

The mission is to launch a sounding rocket to an altitude above 1100 feet and not to exceed 1800 feet using a commercial certified G rocket motor. The closer to 1800 feet without exceeding 1800 feet will add more points.

The payload must include sensors and a XBEE radio transmitter to send telemetry. Telemetry must be sent at a 1 Hz rate and include current altitude, current speed based on accelerometer and current speed based on a pitot tube.

A ground station is required to collect the telemetry and display the data. The XBEE radio NET/PAN ID must be set to the team number.

Payload Requirements

Req #	Requirement
1	Telemetry must be transmitted once per second.
2	A pitot tube must be included to measure speed using air pressure.
3	Sensors must be included to measure current altitude.
4	Accelerometer must be included to measure speed and acceleration.
5	Telemetry must include a timestamp with sufficient resolution, current altitude, accelerometer derived speed and acceleration, pitot tube derived speed and acceleration.
6	Each telemetry packet must have a packet count that is incremented for each packet.
7	XBEE radio can operate at 900 MHz or 2.4 GHz.
8	NET/PAN ID must be set to the team number.

Payload Bonus Objectives

Bonus	Description
1	Real time GPS position is added to the telemetry. Position is updated once per second.
2	Video of flight from the rocket shall be captured. The video shall begin at the detection of launch and stop at the detection of landing. Video camera must be in color, have a resolution of at least 640x480 pixels and capture at least 30 frames a second. Any video camera can be used. Camera can be modified to support the start and stop control of the recording.

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.
4	Speed data based on pitot tube and accelerometer must be plotted.
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.

Rocket requirements

Req #	Requirement
1	Total installed impulse shall not exceed 160 Newton-Seconds or a G motor.
2	The rocket must reach at least 1100 feet and not exceed 1800 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.
Documentation should be submitted via email to battleoftherockets@gmail.com.
Templates will be provided for both PDR and CDR. Design review will be scheduled after each submission date. Teams will present via teleconference.

All documents must be in PDF format.
PDR file name format shall be sr_XXXX_pdr.pdf where xxxx is the team number.
CDR file name format shall be sr_XXX_cdr.pdf where xxxx is the team number.
The file name formats must be followed.

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 video with a judge present. The video must show that it

starts at launch and ends at landing. Video showing the rocket sitting on the launch pad or laying in the field for more than 5 seconds will disqualify the bonus points.

For altitude verification, the team must return the rocket with the altimeter still on. Do not turn off the altimeter before the judge records the altitude.

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	25	Altitude, acceleration are plotted in real time.
3	25	Speed from accelerometer is plotted in real time.
4	25	Speed from pitot tube is plotted in real time.
5	30	Speed of accelerometer and pitot tube are within 10% of each other.
6	100	Rocket altitude is greater than 1100 feet and less than 1800 feet.
7	50	GPS position data included in the telemetry. Position updated once per second.
8	75	Video is captured and starts at detection launch and stops at detection of landing.
9	1	Per foot above 1100 feet not exceeding 1800 feet. No points if exceeded 1800 feet. Payload must be minimally functional which means transmitting telemetry.

Event 3: Target Altitude

Event 3: Target Altitude

Design and build a rocket to fly on any commercial certified F level rocket motor to an altitude of 1001 feet. The rocket closest to 1001 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 1001 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.

Documentation should be submitted via email to battleoftherockets@gmail.com.

Judging and Scoring

The scoring is the absolute difference between the altimeter reading and 1001 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 $75 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 per event. Teams can consist of university, college, or trade school students currently enrolled in a university, college, community college, high school, non-profit organization such as boy scouts, girl scouts, 4-H club, etc or trade school. Each team must have a faculty advisor assigned to the team. The faculty advisor may support multiple teams.

At least one Rover team member must have a membership in Tripoli or NAR and be certified 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.

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.

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.

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 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.
9. Team argues with contest director.

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.