ROBO-OPS COMPETITION BASICS

FY16

Contents

2016 ROBO-OPS COMPETITION

Overview

RASC-AL Exploration Robo-Ops Competition (i.e., Robo-Ops) is an engineering competition sponsored by NASA and managed by the National Institute of Aerospace. In this exciting competition, undergraduate and graduate students are invited to create a multi-disciplinary team to build a planetary rover prototype and demonstrate its capabilities to perform a series of competitive tasks in field tests at the NASA Johnson Space Center's (JSC's) Rock Yard in May 2016. Allowable rover systems can include a single rover, multiple independently controlled rovers, or a parent rover with supplementary/scouting micro-rovers, all of which combined together are required to meet packaging and mass constraints.

Based on Project Plans submitted by October 3rd, 2015, up to 8 teams will be selected to participate in the challenge. The Robo-Ops Steering Committee will review each team's project plan and announce the qualifying teams by October 17, 2015.

Up to 8 qualifying teams will be selected to receive a $10,000 award to facilitate full participation in the Robo-Ops competition, including expenses for rover development, materials, testing equipment, hardware and software. At the 2016 RASC-AL Robo-Ops Competition in Houston, TX, the rovers will compete on a planetary analog environment under the supervision of NASA judges. Up to three members of the team (plus the faculty advisor) will travel to JSC for the on-site testing. The remaining team members will stay behind at the local university to conduct "mission control" tasks. The prototype rovers will be tele-operated by the university team and must negotiate a series of obstacles while accomplishing a variety of tasks. Sample tasks include: negotiating specified upslopes and downslopes, traversing sand and gravel pits, picking up specific rock samples and placing them on the rover for the remainder of the course, driving over rocks of specified diameter, and the option of performing an unplanned contingency task that will be revealed during the competition.

Each rover will be required to be controlled from the home university campus via a commercial broadband wireless uplink. The only information available to the rover controller to perform the required tasks will be information transmitted through on-board rover video camera(s), microphones, or other on-board sensors. Cameras will allow the transmission of the competition back to the home universities as well as the general public.

NASA seeks to engage the public in its missions and research. Supporting that goal, Robo-Ops teams will be encouraged to conduct outreach efforts for the purpose of sustaining stakeholder support and public engagement. It is incumbent on the team to find compelling means to engage the public and their stakeholders, and to consider partnering with other organizations to help build awareness for RASC-AL Robo-ops, their team and rover.

Teams participating in the competition will be required to submit a written final report, build an actual rover, and demonstrate the rover's capabilities during the 2016 RASC-AL Robo-Ops Competition. Scoring is based on the ability to perform the tasks, along with adherence to requirements and time.

Winning teams will receive cash prizes.

2016 Planetary Rover Design Constraints and Requirements

1. The rover system (and everything used on the rover during the competition) must be no larger than 1m x 1m x 0.5m in a stowed configuration
    a. Camera masts must fit within the stowed configuration limits. Collapsible/foldable masts may be used, but will need the capability of deploying themselves - without human intervention - from the stowed configuration.
    b. Note: "Stowed Configuration" is NOT the same as "Out of the Crate." Stowed configuration shall be the same as the "as landed" configuration. You will have time to unpack your rover and make necessary adjustments prior to being measured. However, at measurement, ALL items used on the rover system must fit within the stowed configuration constraints, including camera masts.
    c. Time penalties will be incurred for every cm over the established size limit. (See penalty section below)
2. The rover system (and everything used on the rover) must have a mass less than or equal to 45kg.
    a. After the weigh-in at the beginning of the competition, no additional mass can be added to the rover.
    b. Time penalties will be incurred for every kg over the established size limit and for any mass increase after the initial weigh-in. (See penalty section below)
3. The rover(s) must have one or more on-board cameras capable of transmitting visual data back to their home university Mission Control.
    a. Teams are required to provide NIA with their Live Stream of their on-board camera feed (i.e., we want to see what Mission Control sees during the competition).
4. The rover(s) must have an on-board microphone capable of transmitting audio data back to their home university Mission Control.
    a. Teams are required to have audio streaming, along with their visual Live Stream, up and running for the public to hear during their competition run.
5. The rover(s) should be able to traverse over obstacles up to 10cm in height.
6. The rover(s) should be able to negotiate upslopes and downslopes of 33% grades.
7. The rover(s) should be capable of selectively picking up irregularly shaped rocks with diameters ranging from 2 to 8 cm and masses ranging from 20 to 150 gm. The rover(s) must be capable of storing the rocks on the rover(s) and transporting them throughout the course. The rover must also be capable of determining the color (red, purple, blue, green, yellow, or orange) of each of the rocks.

Figure 1: Rock Colors

8. The rover(s) should be capable of traversing sand for a distance of at least 20 feet on slopes between 5 and 15 degrees.
9. Each team will have at most an hour to complete the course and required tasks.
    a. The rover(s) cannot be charged, nor can the batteries be swapped out during this time. The total amount of operational time (within that hour) will vary depending on the strategy used by each team.
10. The rover(s) cannot be powered by an internal combustion engine.
11. The rover(s) should be able to operate in light rain, but the competition will be halted at the judges' discretion due to heavier rain.
12. The rover(s) will be controlled remotely based solely on data, including video, gathered from the rover itself.
    a. The rover(s) will be controlled from the home campus of the university, with the video from the rover capable of being streamed through a web site.
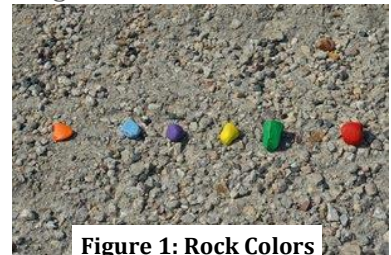
13. A robust communications architecture should be incorporated. Communications with the rover system could be through use of a wireless broadband card, mobile hotspots, or USB broadband devices. Typical data rates at the site are ~0.6Mb/s download and ~0.4Mb/s upload, and latency of 150-300ms.
    a. Teams are invited to use a broadband card/mobile hotspot/USB broadband device from any wireless carrier they desire.
    b. Teams may incorporate more than one communications technology option onto their robot(s).
14. The rover(s) should be able to navigate the Rock Field, Lunar Craters, Sand Dunes, and the Mars Hill (see picture below).
    a. The Gravel Pit, as depicted below, will NOT be used in the Robo-Ops Competition.
    b. The Sand Dunes will be weeded and comprised solely of sand.

Figure 2: Rock Yard Field

Competition Tasks, Rules, and Regulations

COURSE DURATION

Each team will have one hour to complete the course.

COURSE TERRAIN

A minimum of 30 colored rock samples (of the size, mass, and color described in the Requirements document) will be placed throughout the Rock Field, Lunar Craters, Sand Dunes, and the Mars Hill shown in Planetary Analog Test Site (PATS) User's Guide. **Note:** the Gravel Pit will *NOT* be used in the competition. Rocks are restored to their original placement after each team's run.

ROCK POINT VALUES

Different colored rocks will be assigned different point values. In 2016, the higher value targets will be biased heavily in the Mars yard. **NEW THIS YEAR**: Point values have changed for certain colors.

- Purple = 6 points
- Green = 5 points
- Blue = 4 points

- Red = 3 points
- Orange = 2 points
- Yellow = 1 point

Each Team's score for the roving portion of the competition will be determined by how many points worth of rocks are collected and stored by the rover at the end of the competition, as well as any bonus points received. Bonus points will be awarded for:

- successfully completing an unplanned contingency task

- returning with the rocks to the starting point on top of Mars Hill; making contact with the lander platform
- collecting at least one rock from each of the four terrains
- acquiring an "alien life-form"

Total Rock Yard points will be tallied, and the team with the highest number of actual points will receive a score of 60 points for the roving portion of the competition. All other teams will receive their score based on a linear scale proportional to their Rock Yard points.

Special bonus notes for rover systems that contain two or more rovers

For teams that have multiple rovers, samples from each rover will be eligible to receive bonus points. For example, if a team has 2 rover, and one rover collects a rock from the Rock Field and the Sand Dunes, while the other rover collects a rock from the Hill/Mt. Kosmo and the Lunar Crater terrain, they will be awarded with the bonus for collecting a rock in each of the four terrains. Similarly, any rover within a multiple rover system that goes down off the hill and makes it back up to the designated starting platform at the end of the course run will be eligible to receive the bonus points (up to a maximum of 15 points per team). Only one rover within the rover system has to complete the unplanned contingency task or acquire an "alien life-form" to receive those bonus points.

COURSE RUN

Teams will begin at the top of Mars Hill, which is approximately 3 meters in elevation above the Rock Field. Prior to the start of the one hour run, teams will place the rover on top of a raised lander platform (similar to the current Mars return architecture), from which the rover will deploy down a ramp of approximately 3 feet. The slope of the ramp will fall within the stated guidelines of up/down slopes that the rovers may be asked to negotiate. From this altitude the rovers have the opportunity to survey the sites using on-board cameras to see where the samples of most interest are, allowing for more efficient collection. The rovers will then descend to the bottom of the hill looking for rocks along the way. At the bottom of the Hill, the team members controlling the rover from the home campus will have to decide which of the other areas (Rock Field, Lunar Craters, or Sand Dunes) they wish to go to next.

COMMUNICATION

Once the competition commences, on-site team members are not allowed to communicate any information about the course or the other teams' performance to their off-site team members. Teams are allowed to talk with mission control during the 15 minute set-up period at the top of Mars Hill, however, conversation will be limited to robot prep and trouble-shooting. Under no circumstances will course layout or rock placement be discussed during this time. Teams will be allowed to have one photographer (usually the advisor) to take pictures during their competition run, but he/she must remain behind the rover at all times. No other cameras, cell phones, or electronic devices will be allowed on the course, with the exception of the one cell phone being used by the official NASA relay. However, teams going later in the day can watch the camera feed from the other team's rovers.

COMPETITION TIME SLOT SELECTION PROCESS

NASA and NIA have developed a method for teams to compete for time slots they desire – based on the weight of the rovers. A 45-kg mass limit has been established for each rover. Because NASA has an interest in reducing mass wherever possible, we will allow the lightest rover to select the time slot of their choice. The second

lightest will have second choice, and so forth. Teams going later in the competition are afforded an advantage, as they can watch the camera feed from the other team's rovers.

MULLIGAN

If a rover needs to be repaired after initial operation begins, judges will allow one human intervention lasting up to ten (10) minutes. This is the only time a rover can be touched during the one-hour competition. The ten minutes will be considered part of the overall time limit. In order to save time, teams are encouraged to bring a "doctor bag" of any needed tools with them to the rover's starting point. Mulligans cannot be pro-rated – they are a one-time deal. A mulligan will not be permitted to extract a robot that has become stuck by the terrain (e.g. stuck in sand, overturned, etc.). Although the mulligan cannot generally be used to reposition the rover, it can be used in the event of lost communications, to move the rover back to the last spot where communication was transmitted. This will count as the team's only mulligan and a subsequent mulligan for repairs, should the need arise, will not be allowed.

If a team needs to use the mulligan, they are not required to utilize the entire 10 minutes and will be allowed to resume competition tasks as soon as they are able (as long as it is within the 10 minute window). Although teams will not be penalized for using the 10 minute mulligan, its use may become the deciding factor in the event of a tie (i.e., the team who chose NOT to use the mulligan will emerge as the winner). The same is true for the length of time the mulligan was used (i.e., a team utilizing only 3 minutes of their mulligan will emerge as the winner against a team utilizing 5 minutes of their mulligan).

Special mulligan notes for rover systems that contain two or more rovers

Several important mulligan rules apply for teams with a multiple rover system:

- Teams implementing multiple roving systems will have only one mulligan during their one-hour mission.
    - Even if only one rover is repaired during this time, the other vehicle(s) will not have an opportunity to utilize an additional mulligan later in the mission.
- During the mulligan ALL portions of the rover system must come to a stop, until the end of the mulligan is called.
- All vehicles within the rover system can be worked on during the 10 minute mulligan, but there will only be one cell phone link between mission ops and the field site.
- If one rover is unable to continue at the end of the mulligan, the other functioning rover(s) can still continue its run.
- If one rover dies, the team can choose to continue operating the other rover **without** taking a mulligan.
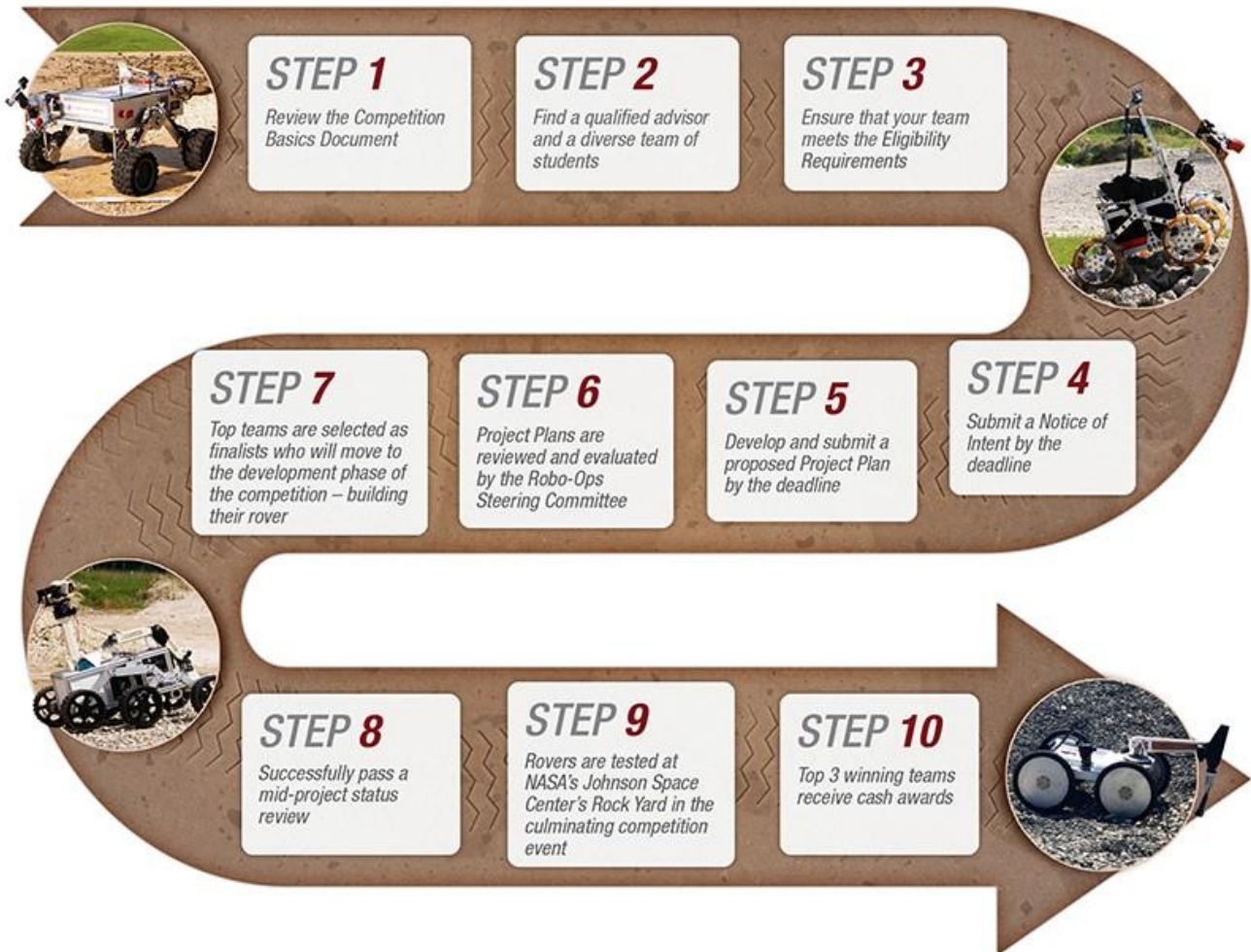
CELLULAR WIFI USAGE BY NON-COMPETITORS

When a team is actively competing on the course, the remaining teams will be required to limit their cellular WiFi usage to reduce unnecessary complications in communication for the competing team.

How to Compete in Robo-Ops

HOW TO COMPETE IN **ROBO-OPS**

STEP 1
Review the Competition Basics Document

STEP 2
Find a qualified advisor and a diverse team of students

STEP 3
Ensure that your team meets the Eligibility Requirements

STEP 7
Top teams are selected as finalists who will move to the development phase of the competition – building their rover

STEP 6
Project Plans are reviewed and evaluated by the Robo-Ops Steering Committee

STEP 5
Develop and submit a proposed Project Plan by the deadline

STEP 4
Submit a Notice of Intent by the deadline

STEP 8
Successfully pass a mid-project status review

STEP 9
Rovers are tested at NASA's Johnson Space Center's Rock Yard in the culminating competition event

STEP 10
Top 3 winning teams receive cash awards

Eligibility

The RASC-AL Robo-Ops Competition is open to full-time undergraduate and graduate students majoring in science, technology, engineering, or mathematics and related disciplines at an accredited U.S.-based university. Teams may include senior capstone courses, robotics clubs, multi-university teams, multi-disciplinary teams, etc. Undergraduate and graduate students may work in collaboration together on the same team.

2016 ROBO-OPS COMPETITION

UNIVERSITY DESIGN TEAMS MUST INCLUDE:

- Team sizes vary widely, but must contain, at a minimum, one faculty or industry advisor with a university affiliation at a U.S.-based institution, and 2 students from a U.S.-based university. There is no limit to the number of participants on each team, however, a maximum of 3 students and 1 faculty advisor may attend the onsite portion of the 2016 Robo-Ops Competition in Houston, TX.
- One faculty advisor is *required* to attend the onsite portion of the competition with each team, and is a condition for acceptance into the Robo-ops Competition.
  - Teams who do not have a faculty advisor present at the 2016 Robo-Ops Competition will be disqualified from competing and travel stipends will be subject to return to NIA.

FOREIGN STUDENTS/UNIVERSITIES

Foreign students or universities can participate *only* as team-members/collaborators with a U.S.-led Team.

Special Note Concerning the Onsite Competition in Houston, TX

Due to increased security measures at NASA, the individuals attending the onsite Robo-Ops Competition in Houston MUST BE US CITIZENS or foreign nationals who carry current green cards. Teams should carefully consider this important restriction when establishing teams.

Dates and Deadlines

2016 RASC-AL FORUM DATES AND DEADLINES

DATE	DESCRIPTION
September 23, 2015	Notifications of Intent (NOI) deadline
October 3, 2015	Deadline for project plan submission
October 17, 2015	Qualifying teams announced
November 7, 2015	Development stipend #1 sent to universities
February 12 , 2016	Deadline to submit Mid-project review
February 22, 2016	Development stipend #2 sent to universities
April 1, 2016	Registration opens for onsite portion of competition
April 21, 2016	Online registration and payment deadline for onsite competition
May 2, 2016	Hotel reservation deadline to receive group rate
May 7, 2016	Deadline to submit audio and video streaming embed code
May 9, 2016	Deadline to submit technical report
May 24 - 26, 2016	2016 Robo-Ops Competition in Houston, TX

Notice of Intent

Notice of Intent deadline: September 23, 2015

Interested teams are encouraged to submit a Notice of Intent (NOI) to compete by the deadline in order to ensure an adequate number of reviewers. Please visit the *Requirements & Forms page* on the Robo-Ops website to complete the brief online NOI submission form.

Project Plan

Project Plan submission deadline: October 3, 2015

GENERAL PROJECT PLAN FORMATTING INSTRUCTIONS

You are responsible for the formatting and appearance of your project plan. Figures and tables must be in digital format. We recommend that you use image file formats that provide acceptable resolution without being huge (for example, please don't use a 1-MB TIFF file when a 250-K GIF file will do).

File size cannot exceed 1.5 MB.

- 8 pages maximum (including figures, tables, and references)
    - A Cover Page is not required, but if your team chooses to use a Cover Page, it will not count toward the 5 page limit
    - A table of contents is unnecessary
- Project plans should be single spaced
- Please use fonts common to Macintosh and PC platforms, i.e., Times, Times New Roman, Helvetica, or Arial for text; Symbol for mathematical symbols and Greek letters.
- Font size should be between 11 and12
- Project plans should be submitted in PDF Format

PROJECT PLAN FILES MUST INCLUDE:
- Title
- Full names of all team members
- University name
- Faculty/industry advisor's full name(s)

TEAMS MUST SUBMIT A DETAILED PROJECT PLAN OUTLINING:

- The following systems requirements:
    - mechanical
    - electrical
    - programming
    - communications
- A detailed timeline including development and testing of all required systems

- The relevant past experience and capabilities of the team's systems leads and facilities available for development the rover
- The physical characteristics and functional capabilities of your proposed planetary rover or rover system
- A 3-D view drawing or solid model representation and dimensions
- A description of how your proposed rover(s) will accomplish the tasks outlined in the Planetary Rover Design Constraints and Requirements section (above) at the JSC Rock Yard.
- A communications plan detailing how your team will engage the public and/or stakeholders
- **RETURNING TEAMS ONLY:** Teams who are re-competing may use any of their previous design concepts, but must demonstrate (and document) some improvement to the overall design of previously used rovers.
    - These teams must include a 'Lessons Learned' section in their Project Plan proposals that provides careful detailing of any improvements, upgrades, enhancements, approaches, and modifications being made to previous rover designs.

SUBMITTING THE PROJECT PLAN

To upload your project plan (.pdf file), please visit the *Requirements & Forms page* on the Robo-Ops website to complete the online project plan submission form. Teams are encouraged to review the Planetary Rover Design Constraints and Requirements section to better understand what your planetary rover must accomplish as a part of the competition.

No revisions can be accepted, so please proof your project plan file very carefully before submitting. If there are any technical problems with the content of your project plan (for example, your file was corrupted), we will try to contact you immediately, so it is very important that you provide us with up-to-date contact information on the submission form.

PROJECT PLAN EVALUATION CRITERIA

- Adherence to project plan guidelines (Max – 10 points)
- Description of how rover will accomplish required tasks (Max – 25 points)
- Appropriateness of project plan (Max – 25 points)
- Project plan capability – degree to which team can accomplish tasks (Max – 40 points)

Deliverables

TEAMS SELECTED TO PARTICIPATION IN THE 2016 ROBO-OPS COMPETITION WILL BE RESPONSIBLE FOR THE FOLLOWING PROJECT DELIVERABLES:

- Mid-Project Status Review - due February 12, 2016
    - Submit a 3-5 page mid-project status review paper demonstrating rover's ability
    - Submit a short video demonstration of rover's ability
- Public/Stakeholder Engagement
    - Development of a team Facebook Page or Blog (kept up-to-date from January – May)
    - Submit embedding code for public viewing of rover's camera and microphone feeds during the competition – due May 7, 2016
- Technical Report - due May 9, 2016

- A 10-15 page technical paper to be judged by Steering Committee
- Poster – Due upon arrival to competition – May 24, 2016
    - to be presented at the Robo-Ops Competition
- Fully Functioning Rover System that meets the Planetary Rover Design Requirements

GENERAL SUBMISSION GUIDELINES

All teams are encouraged to review the Robo-Ops Evaluation Form on the Robo-Ops *Requirements & Forms webpage* to better understand how the Steering Committee will be judging this competition.

Teams are also encouraged to review the Resources section of the Robo-Ops website, under the Competition Basics tab, which provides resources to assist in the development of your report and poster.

Mid-Project Review Guidelines

Mid-project review submission deadline: February 12, 2016

Prior to receiving the second stipend installment, each Robo-Ops team must successfully pass a mid-project status review that demonstrates where they are in the development process. The purpose of the review is to provide the Robo-Ops Steering Committee with evidence that your team is on-target to compete at the Robo-Ops Challenge in Houston, Texas with a fully functioning rover that is capable of completing the tasks outlined in the Planetary Rover Design Constraints and Requirements section.

The Mid-Project Review will initially consist of two parts that demonstrate rover functionality:

1. Submission of a video
    - The video needs to demonstrate the rover's:
        - Drive system
        - Sample acquisition
        - Communications system (or prototype of the communications system)

    Note: The video is not expected to be a "finished" product, nor to be lengthy. It just simply needs to demonstrate the 3 systems identified above.

2. A 3-5 page written document
    - The written document should provide a narrative of where you are in the development process, and whether or not you feel confident that you will have a functioning rover at the 2016 Robo-Ops Competition. It should also outline your:
        - Drive system
        - Sample acquisition strategy
        - Communications system
        - Mission Control Center operational/tactical plan (i.e., decision strategy, MCC staffing, and plan for contingencies/redundancies)
        - Updated schedule/timeline of tasks and deliverables
    - The judges want to know if teams have encountered any problems (or anticipate any problems) and how teams plan to address them.

If there are any concerns regarding a team's rover or scheduled timeline, that team may be asked to conduct a follow-up "face-to-face" meeting with the Steering Committee via Skype or a webinar. At that point, the Steering Committee may request that some changes be made prior to clearing the rover for the next portion of the competition.

SUBMITTING THE MID-PROJECT REVIEW

To upload your team's mid-project review files, please visit the *Requirements & Forms Page* on the Robo-Ops website to complete the mid-project review submission form.

Special Note

- You will first need to upload your video to YouTube and include that URL in the submission form
- The written document should be in PDF Format

Public/Stakeholder Engagement

Public/Stakeholder Engagement deadline: May 7, 2016

One of NASA's objectives in this competition is to engage as many people as possible in space exploration missions. To support this objective, each team must include a public engagement effort to "bring the public along" with each team as they work on the concept, design and finally the competition. NASA and NIA will be looking for teams to partner with organizations (i.e., marketing and communication departments at their school) who can achieve the goals for this portion of the competition by increasing the exposure of their project. Metrics are required.

Key elements that the Robo-Ops Public and Stakeholder Engagement deliverables will be evaluated on include:

- Team Blog or Social Media Page

  Each Team will create a robust blog or social media page for the competition that will document the project for the general public (kept up-to-date from January through the end of the competition in May).

- Live Stream of On-Board Camera and Microphone Feeds & Mission Control

  Teams are required to provide NIA with the live stream of their on-board camera feed. The rover(s) must also have an on-board microphone capable of transmitting audio data back to their home university Mission Control. Teams are required to have audio streaming, along with their visual live stream, up and running for the public to hear during their competition run.

  This will provide NIA with the ability to live stream – that is, broadcast in real time – the viewpoint of each team's rover as they make their way through the NASA JSC Rock Yard. In essence, the viewer should be able to **see and hear** what your Mission Control sees and hears during the competition, via the on-board camera and microphone.

NEW THIS YEAR: Teams will be required to display split screens on their Live Stream: one that shows their Mission Control Operation throughout their run, and the other to show the camera feed from the rover(s).

NIA will compile each team's live stream feeds and house them on a single webpage within the Robo-Ops website. This live stream will be made available to the public during the competition, and teams are required to share the webpage via their networks as well (i.e., blog or social media page), etc. In the past, teams have even reserved auditoriums at their colleges, inviting classmates to view the live stream as a group.

Teams should be prepared to conduct a brief test of their audio and live stream capabilities on the first day of the Robo-Ops Competition (test day). Teams are required to **RECORD** the livestream and provide the recorded footage to NIA for future use. Recordings must be emailed to rascal@nianet.org, shortly after their competition run.

Live Stream Embed Code Requirements

Teams may use livestreaming software or one of the following websites to host their livestream:

- Youtube
- UStream

Teams should provide NIA with one of the following types of code for NIA to embed on a dedicated livestream page:

- Iframe
- Object
- Java

Please **DO NOT** send the following types of files or use the following websites:

- Applets
- Twitch.tv
- Windows Media
- Jar Files

Sample Script

The following is an example of one kind of appropriate script that a team may submit. The value name bolded below should be unique to each team.

```
<iframe width="560" height="315" src="https://www.youtube.com/embed/4mWN3L2KP0c" frameborder="0" allowfullscreen></iframe>
```

SUBMITTING THE PUBLIC/STAKEHOLDER ENGAGEMENT DELIVERABLES

To upload your team's Public/Stakeholder Engagement files, please visit the *Requirements & Forms Page* on the Robo-Ops website to complete the public engagement submission form.

Special Note

Be prepared to submit your blog or Facebook URL, as well as your team's livestream embed code.

2016 ROBO-OPS COMPETITION

Technical Paper Guidelines

TECHNICAL PAPER GUIDELINES:
- Papers should be single spaced
- 10 pages minimum; 15 pages maximum;
    - Cover page, references and appendices are ***excluded*** as a part of your 15 page total limit. They do not count toward the minimum or the maximum page limitations.
    - The appendices are not included in the page limitation, however, it is important to note that the Steering Committee is not obligated to consider lengthy appendices in the evaluation process. Teams are encouraged to use the appendix section wisely.
- Please use fonts common to Macintosh and PC platforms, i.e., Times, Times New Roman, Helvetica, or Arial for text; Symbol for mathematical symbols and Greek letters.
- Font size should be between 11 and12

COVER PAGE MUST INCLUDE:
- Title of presentation
- Photo of the rover
- Full names of all team members
- University name
- Faculty/industry advisor's full name(s)

BODY OF REPORT SHOULD INCLUDE

- **Introduction**
- **System Description**
    - **Chassis Design and Drive System**
        - Brief description of the rover's capabilities
        - For the following, please provide visual (i.e., photos/drawings) and written descriptions, as well as explanations behind your design decisions.
            - <u>Wheels:</u> # of wheels, materials, tread pattern, speed capabilities, steering type, suspension
            - <u>Chassis:</u> dimensions, mass, materials
            - <u>Camera specifics:</u> # of cameras and placement, max height of the camera mast, camera capabilities such as pan, tilt, zoom, resolution, etc.
            - Microphone specifics: type used, placement, strategy for gaining as much audio feedback as possible
            - <u>Manipulator System:</u> # DOF and degrees of rotation for each DOF, dimensions
            - <u>Control and Communication System:</u> sensor gathering (e.g. fusion, integration with GUI), # and purpose of the servers, 3G/4G Network information, # of modems, connection speed
                - Video/audio compression and effects on bandwidth

- ▪ Latency information
    - o **Technical Specifications**: rated payload, max speed, max obstacle size, operating time, drive power, battery, on board computer system, communications interface, software
- **Testing Strategy**: Include the testing results from each of the different terrains
- **Overall Strategy for the Competition:** Reasoning for choice in chassis/wheel/manipulator type
- **Mission Control Center Operational Plan**: A description of your concept of operations for mission control efforts; your tactical plan for that one hour of competition run
    - o Staffing
    - o Practicing
    - o Decision making strategy
    - o Plan for Contingencies/redundancies
- **Budget:** Recognize all sponsors and/or grants, and possibly show the distribution of funds during the building process of the rover
- **Public/Stakeholder Engagement**: A description of your public/stakeholder engagement efforts
- **References Cited**

SUBMITTING THE TECHNICAL PAPER

To upload your team's Technical Paper (.pdf file), please visit the *Requirements & Forms Page* on the Robo-Ops website to complete the online technical paper submission form. This online submission tool will be activated on or about April 1, 2016.

No revisions can be accepted, so please proof your Technical Paper file very carefully before submitting it. If there are any technical problems with the content of your paper (for example, your file was corrupted), we will try to contact you immediately, so it is very important that you provide us with up-to-date contact information on the submission form.

Poster Presentation Guidelines

Each team is required to present a poster describing their rover and operational strategy. Each team will be given one 6' table. Posters must be free standing and able to fit on this table. One tri-fold foam/cardboard poster board will be made available for each team to use at no charge. Posters should be 48" x 36." Thumbtacks will also be available to secure posters to the tri-fold boards.

The Poster Session provides teams with an opportunity to informally interact with the judges and answer any questions the judges have about the rover, the team's decision-making strategy, etc.

Evaluation/Scoring

ROBO-OPS JUDGES/STEERING COMMITTEE

The Robo-ops Steering Committee is comprised of NASA experts who will evaluate and score the competition between participating teams. Robo-Ops projects will be evaluated and judged based on adherence to the Planetary Rover Design Constraints and Requirements and the criteria below. The 2016 Robo-Ops Evaluation Form provides a detailed explanation of the scoring approach.

Teams are responsible for thoroughly reviewing the Guidelines for Deliverables above to ensure compliance in each area.

Sixty percent of the team's score will be related to rover performance. The remaining forty percent will be related to the technical paper, poster presentation, mission control operations, public/stakeholder engagement and participation.

OVERALL COMPETITION SCORE

The maximum possible points for the overall competition is 100.

The detailed Robo-Ops Evaluation Form can be found on the *Requirements & Forms* page of the Robo-Ops website.

Roving Portion

A maximum of 60 points will be awarded for the roving portion of the competition. (Includes rock point values and bonuses). Actual points will be added up and the team with the most points will receive a roving score of 60. All other teams will receive a score that is scaled linearly.

Technical Paper

A maximum of 15 points will be awarded based on the quality of the Technical Paper.
- Key elements that the Technical Paper will be evaluated on are:
  - Technical quality, feasibility, innovation of rover design and quality of technical description (4 points max)
  - Quality of summary of production and testing approach (4 points max)
  - Adherence to Technical Paper Guidelines (2 points max)
  - Quality of Mission Control Operations - tactical plan, staffing, decision making strategy (5 points)

Poster Presentation

A maximum of 10 points will be awarded based on the quality of the oral Poster Presentation. Teams will be required to bring a poster for their rover(s) (48"x36" or 48"x42") to display during the Poster Presentation Session.
- Key elements that the Poster Presentation will be evaluated on are:
  - Technical content, style, and coherence of poster (5 points max)
  - Engagement with judges and quality of answers to questions (5 points max)

Public and Stakeholder Engagement

A maximum of 10 points will be awarded based on the Public and Stakeholder Engagement activities described below.

Key elements that the Robo-Ops Public and Stakeholder Engagement deliverables will be evaluated on include:

- Team Blog or Social Media Page (5 points max)
  The Team Blog or Social Media Page will be evaluated on the following:
  o Design and functionality
  o Quality and quantity of content and activity
  o Number of hits/fan size
  o Relevance to the audience

- Live Stream of On-Board Camera Feed & Mission Control (5 points max)
  The Live Stream from the On-Board Camera feed will be evaluated on the following:
  o Design and functionality
  o Number of viewers watching the live stream
  o Quality of audio stream
  o Display content
    o This refers to what the public sees in addition to the simple camera view. Points will be awarded for additional displays, including a view of mission control operations (a required feature) and any controls that would be of interest to the viewer. For example, teams have displayed torque/roll/speed controls in the past.
    o Teams MUST have a valid livestream up and running for public viewing/hearing for at least 50% of the competition run, or they will incur a severe penalty (refer to section on penalties below).
      o For teams with multiple rover systems, only one on-board camera view is required to be live streamed at a time. At least one camera view must be streaming for 50% of the time.

Competition Participation

The remaining 5 points will be awarded based on the participation, attendance, and engagement of team members at all competition activities.

BONUSES

During the roving portion of the competition, teams will be awarded bonus points for the following actions:
- **NEW THIS YEAR**: 15 bonus points will be awarded for successfully completing the "Unplanned Contingency Activity" on the rock yard, which your rover must discover, interpret and resolve via its local sensors and capabilities. Hint: will likely require manipulation.
- 10 bonus points will be awarded for collecting one of the "alien life forms" on the field. 2 different "aliens" will be placed on the Rock Yard course, but bonus points are only received for acquiring **one** alien life form.
- 10 bonus points will be awarded for picking up a rock in each of the four sections of the Rock Yard:
  - o Rock Field
  - o Lunar Craters
  - o Sand Dunes
  - o Mars Hill
- 3 bonus points will be awarded for every rock returned to the landing point on top of the hill at the end of the competition run, up to a maximum of 15 points;
  - o Rule is that the rover **must** come off the hill & back up to qualify for these bonus points.
  - o Rovers must make contact with the landing platform to obtain this bonus.
  - o For teams fielding multiple roving systems:
    - Only one rover is required to return to the landing point to earn the bonus, but only rocks stored on rovers that return to the landing pad will count for towards the bonus score. Samples from each rover will be eligible to receive bonus points.

PENALTIES

During the roving portion of the competition, teams can incur penalties in several ways:

- Rovers will have an initial weigh-in at the end of the competition test day, to determine eligibility and competition time slots. Rovers will also be weighed for the second time just prior to their competition time. If mass of rover is increased after initial weigh-in, teams will lose 10 minutes of roving time for every kg of extra weight (i.e., 2 minutes for every 0.2 kg over)
- Teams will also lose 10 minutes of roving time for every 1 cm over the size limit of 1m x 1m x .5 m (stowed configuration).
- Teams must transmit both their audio and visual live stream during their hour competition run. If the live stream does not transmit for at least 50% of the run, teams will lose 50% of their total roving portion point value *before* linear scoring is conducted.
  - For teams fielding multiple roving systems, this requirement can be fulfilled by broadcasting audio and video from mission control and from at least one rover at any given time. If all systems are active, it is expected that all vehicles transmit something, though they do not need to all be displayed at all times.

Note: Although teams will not be penalized for using the 10 minute mulligan, its use may become the deciding factor in the event of a tie (i.e., the team who chose NOT to use the mulligan will emerge as the winner).

Rover Games

Throughout the competition, Robo-Ops will host "Rover Games" – small challenges designed for teams to have some fun with their rover and showcase their rovers' capabilities. While participation in these matches is completely voluntary and they do not count toward the overall score, they do provide rovers with the opportunity to show-off. Certificate awards will be presented for the winner of each match. During the Rover Games, teams will be able to control the rovers directly (i.e., they do NOT have to be tele-operated for these events). Teams my wish to bring tethered/wireless controls for this portion of the competition.

POSSIBLE ROVER GAMES MAY INCLUDE THE FOLLOWING CHALLENGES:

- Best dexterity
- Climbing steepest part of Mount Kosmo/Mars Hill
- Manipulator challenges
- Picking up the most rocks from a pile within a given time frame
- Speed (50 meter relay)
- Traversing large rocks/obstacles

Prizes

Up to $12,000 in prize money is available to the top three winning teams.

- 1st Place: $6,000
- 2nd Place: $4,000
- 3rd Place: $2,000

OTHER RECOGNITION AWARDS MAY INCLUDE:

- Best Technical Paper
- Judges' Innovation Award
- Awards for Rover Games

Participation Awards/Stipends

Qualifying teams will receive a $10,000 award to facilitate full participation in the Robo-Ops Competition, including the cost of rover development, hardware/software, outreach video production, and public engagement activities.

The 1st installment of $5,000 will be offered upon notification that teams qualify for further development and entry in the next stage of the competition (early November, 2015).

The 2nd installment will be available after each team successfully passes a mid-project status review evidencing on-time development, and successful integration. This mid-project review may include a video conference with steering committee.

The development funds will be paid by NIA to the Office of Sponsored Programs at each university, with the request that the university waive any overhead fees so that the full amount of the sponsorship goes to each team. It is the responsibility of the faculty advisor to work with this office on its disbursement policies for the funds.

In addition, teams are invited to raise additional funds from their universities or sponsoring organizations and companies. There is no limit to how much additional funds can be raised or contributed.

2016 ROBO-OPS COMPETITION

Evaluation Form

Team:_____ 1st Weigh-In:_____kgs. 2nd Weigh-In:_____kgs. Competition Position:_____

Mulligan taken? ☐YES ☐NO # of minutes:_____ Penalty? ☐YES ☐ NO Describe:_____

Rock Yard (Max 60 points)	Max Pnts	Points	Comments/Notes
Total of rock-related points	TBD		
Unplanned Contingency Activity	15		
Total of alien life form points (points are only received for acquiring one alien life form)	10		
Bonus points for picking up a rock in each section	10		
Bonus points for ending on Mars Hill and making contact with the landing platform (3 bonus points will be awarded for every rock brought to the landing pad at the top of the hill, up to a max. of 15 points; Rule is that the rover **must** come off the hill & back up to qualify for bonus points.)	15		

Purple = 6 pts;   Green = 5 pts;   Blue = 4 pts;   Red= 3 pts;   Orange = 2 pts;   Yellow = 1 pt.

__ x Purple =____   __ x Green =____   __ x Blue =____   __ x Red =____   __ x Orange =____   __ x Yellow =____

Add up Actual Points. Assign team with highest number of actual points a score of 60. Scale other teams points linearly.

Technical Paper (Max 15 points)	Max Pnts	Points	Comments/Notes
Technical quality, feasibility, innovation of rover design & quality of technical description	4		
Quality of summary of production and testing approach	4		
Adherence to technical paper guidelines	2		
Quality of Mission Control Operations (tactical plan, staffing, decision making strategy)	5		

Poster Presentation (Max 10 points)	Max Pnts	Points	Comments/Notes
Poster (technical content, style, coherence)	5		
Engagement with judges and quality of response to questions	5		

Public and Stakeholder Engagement (Max 10 points)	Max Pnts	Points	Comments/Notes
Team Blog OR Facebook: Design & functionality; # of hits/fans; quality and quantity of content and activity; relevance to audience	5		
Live stream of on-board camera feed & Mission Control: Design/Functionality; Display Content; # of Viewers	5		

Competition Participation (Max 5 points)	Max Pnts	Points	Comments/Notes
Participation, attendance, and engagement at all competition activities	5		

SPECIAL PENALTY NOTES

1. Rovers will be weighed for the second time just prior to their competition time. If mass of rover is increased after initial weigh-in, teams will lose 10 minutes of roving time for every kg of extra weight.
2. Teams will also lose 10 minutes of roving time for every 1 cm over the size limit of 1m x 1m x .5 m (stowed configuration).
3. Teams must transmit both their audio and visual live stream during their hour competition run. If the live stream does not transmit for at least 50% of the run, teams will lose 50% of their total roving portion point value *before* linear scoring is conducted.

Rock Yard Competition (60 pts): _____

Technical Paper (15 pts): _____

Poster Presentation (10 pts): _____

Engagement (10 pts): _____

Participation (5 pts):_____

Total Score:_____

2016 ROBO-OPS COMPETITION

Contact Information

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