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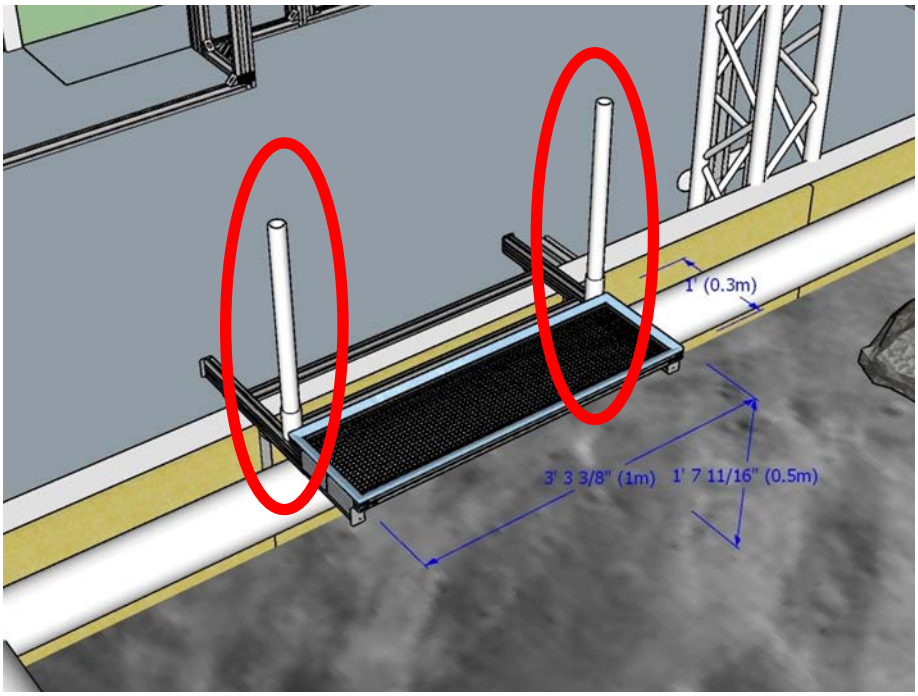
7.0

Q30) Is the faculty advisor required to attend the competition?
A30) Not required, but encouraged.

Q29) So, the picture of the collection bin shows these poles sticking up in the back. I was wondering if we can mount some small things needed for autonomy on these poles. If so, can we get some detailed dimensions, like length and diameter?



A29) These are 1.5" (ID) schedule 40 PVC tubes (vertical uprights) 29" long that are slid into smaller 2" (ID) schedule 40 PVC tubes (base sections) 5" high. The base sections are bolted to the sliding 80/20 sieve frame with 2.5" ID rigid steel pipe straps. The operational concept is for students to fasten navigation targets to the PVC vertical uprights. Students can optionally construct navigation targets ahead of time including their own 1.5" (ID) schedule 40 PVC vertical upright tubes that are ready to slide into the PVC base sections that are attached to the sieve frame. This might save operational setup time.

The vertical up right centerlines are 37" apart. Standard schedule 40 PVC section dimensions are below:

ID	OD
1-1/2"	1.900
2"	2.375

Q28) We are wondering if it would be acceptable to have a small battery onboard that only powers a Raspberry Pi control computer, and whose power does not flow through the main robot kill switch. It seems that there is provision for this in rules and rubrics in Mining Rule 17, but it applies specifically to laptops.

Mining Rule 17 in the rules and rubrics states that:
"[...] The button should disconnect the batteries from all controllers (high current, forklift type button) and it should isolate the batteries from the rest of the active sub-systems as well. Only onboard laptop computers and data-logger(s) may stay powered on if powered by its internal computer battery."

We see this primarily as a safety concern. Our team has a culture of "anyone should hit the robot kill switch at any time if they see the slightest safety hazard". Since the raspberry pi takes a few minutes to boot up, it may make people hesitant to hit the kill switch because they are worried that they would unnecessarily disrupt testing with a false alarm.
A28) We AGREE! Proceed IAW with your process as described.
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6.0

Q27) What data is required for the Supplemental Data?
A27) See below:

Supplemental Data – (due Monday May 11, 2020)

Provide information about the team's off-world mining robot at:
https://docs.google.com/forms/d/e/1FAIpQLSeB3v9iz1LoqPW2y1vLgLNlPGSW9Lt6nSRqU9jE3015Cq3C1A/viewform?usp=sf_link

Here is the information requested. You must respond online at the link provided above.

RMC: Lunabotics - Supplementary Robot Data

The purpose of this form is to collect data about your team's robot. Please be as thorough and accurate as possible. All responses are required using the International System of Units (SI) (ampere, kelvin, second, meter, kilogram, candela, mole). Please fill a separate form out for each of your robots.

Team Registration
School Name:
Space Grant Code:
Number of Robots:
This form is for robot number ___ of ___
If more than one robot, describe specific function of this robot (ex. Mining, hauling, dumping, etc.)

Mobility
Does your robot have:
☐ Wheels

- Tracks
- Combination of both
- Other (please describe)

Wheels

Please describe anything unique or unusual about your (wheel) design.

Number of wheels

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- Other (please describe)

Diameter of wheels (mm)

Width of tread (mm)

Spacing of wheel base, width (side to side) in mm (measure from center of wheel to center of wheel)

Spacing of wheel base length (front to back) in mm (measured from axle to axle)

Grousers?

- Yes
- No

How many grousers per wheel? (If none, answer N/A; note grousers are the short paddles on the wheel tread)

Height of grousers (mm)

Spacing between grousers (mm)

Which shape best describes your grousers

- Straight
- Diagonal
- V-shape
- Other (please describe)

What material is your tread made of?

What material are your grousers made of?

What material are your wheel hubs made of?

How many wheels are driven and which ones are they?

Are the wheels on left and right sides slaved together, or are all wheels driven independently?

- Slaved together
- Independent

Type of gearing to wheels (planetary, etc)?
How many motors on the robots are for driving (ie. If there are 4 wheels and each has its own motor, then put 4)
Motor torque for each motor (at the motor output shaft*) (in-lbs or N-m or other units – please give the units) (*If it is a combined motor/gear system purchased together as a unit, just state what you know about its torque and RPM and tell us if this is the output of the motor or at the output of the assembly after the internal gear reduction. If you know the internal gear reduction in this unit, please state it, too.)
State if this torque was rated at a particular RPM, or for locked rotor, if you know.
What is the gear reduction you used from the motor output shaft going to the wheel(s) or track(s) (ex: 40:1, or 100:1). Include all gear reduction from motor to wheel, including any gearing built-into the motor assembly multiplied by any gear reduction via external chains/sprockets, gear boxes, etc.
Does each motor have a separate motor controller channel? If some wheels are on the same motor controller channel, which ones? (Please describe)

Tracks
If your robot does not have tracks, answer each *required question with N/A and the others can be left blank.
Describe anything unusual or unique about your design if it is different than a 2 track system.
Spacing between tracks (mm)
Length of ground contact for each track (mm)
Width of tread (mm)
Tread material for tracks
Do your robot's tracks have grousers?
- ☐ Yes
- ☐ No

Height of grousers (mm)
Spacing between grousers (mm)
Grouser material
Which shape best describes your grousers?
- ☐ Straight
- ☐ Diagonal
- ☐ V-shape
- ☐ Other (please describe)

Number of driven wheels (per track)
Number of idler wheels (per track)
How many of the idler or driven wheels are tensioners (per track)
Are the tensioners
- ☐ Wheel-driven
- ☐ Idlers

Are the tensioner wheels
- ☐ Ground-contacting

- Raised above the surface
- Other (please describe)

Are the driven wheels
- Ground-contacting
- Raised above the surface
- Other (please describe)

How many idlers are raised above the surface?
How many idlers are in ground contact?
Diameter of the driven wheels (mm)
Diameter of the idler wheels (mm)
Motor torque for the track's driven wheels
Gear ratio from motor to driven wheels
Type of gearing to driven wheels

Traction Control
Please identify and describe any implemented methods or systems designed to maintain tread or wheel traction.

Steering
If your robot has tracks, then tank steering (i.e., skid steering) is normal, but explain if the robot uses tracks with a unique steering method instead
If wheels, check which applies:
- Skid steering/Tank steering
- Ackerman steering
- Front wheels controlled by Ackerman steering
- Back wheels controlled by Ackerman steering
- Both sets of wheels controlled by Ackerman steering
- All wheels independently steered
- Other (Please describe)

Suspension
Is the robots suspension:
- Active
- Passive
- None

Describe suspension (lead springs, rocker bogey, MacPherson strut, etc., or describe)

Chassis
Materials used:
Construction (tube, unibody, etc.)
Welded, bolted, riveted, etc.
Majority ground clearance in cm. (lowest part under the main area under the center of the robot to the ground)

Minimum Ground Clearance in cm (under any motors or brakcets, etc, closer to the sides of the robot that stick down lower than the majority of the ground clearance)

Autonomy

Which autonomous operations will be attempted:

- ☐ Full autonomy
- ☐ Partial autonomy
- ☐ Tele-operated

Describe the navigation systems:

Regolith Mining System

Does your robot have (check all that apply)

- ☐ Auger
- ☐ Bucket ladder (eg. Buckets on chains or belt)
- ☐ Bucket drum
- ☐ Lengthwise bucket wheel
- ☐ Transverse bucket wheel
- ☐ Mining wheels
- ☐ Load/haul/dump bucket
- ☐ Scraper
- ☐ Scoop
- ☐ Rotating brush
- ☐ Other (please describe)

If other, please describe. Additionally, please describe any other strategies or unique features of your robot.

Regolith Transport System

Will your robot (check all that apply):

- ☐ Transport regolith in the mining device itself (in the bucket, scoop, scraper, auger, etc)
- ☐ Transfer it to a hopper for transport (including hoppers that contain conveyors)
- ☐ Place it onto a flat conveyor
- ☐ Other (please describe)

Estimate maximum amount of regolith that can be transported in one mining cycle (kg)

Regolith Unloading System

Does your robot have (check all that apply):

- ☐ Bucket ladder
- ☐ Conveyor belt
- ☐ Tilt dump from hopper, bucket, scraper, etc.
- ☐ Push out with wall or scraper
- ☐ Hatch release (gravity pulls it out)

- ☐ Reverse rotate bucket drum
- ☐ Reverse rotate auger
- ☐ Other (please describe)

Does it use methods to enhance the discharge flow?

- ☐ Yes
- ☐ No

Methods used to enhance the discharge flow:

- ☐ Vibration
- ☐ Tapping
- ☐ Larger-scale jarring
- ☐ Special coatings or slippery surfaces
- ☐ None
- ☐ Other (please describe)

Is special coatings or "other" was checked, please describe

Dust Mitigation Features
Describe any dust mitigation features designed into the robot.

Other Unique Features
Please describe any other unique features that may be helpful to NASA in learning how systems and materials work for space mining

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5.0

Q26) Will there be a livestream of the event? And, if so, where will it be broadcast? While applying for sponsorships, many companies are asking whether or not it will be livestreamed so they can watch the competition.
A26) Check out the NASA Virtual Appearances website at:
http://www.ustream.tv/channel/DUJwdHZRq7b
during the week of May 18-22, 2020 to see the robotic madness" Lunabotics" will bring out in all of us!

Q25) What are the environmental conditions inside the mining area. For instance, is the building air conditioned? What are the temperatures expected to me? Is there any breeze, etc?
A25) The building is air conditioned, the temperature is expected to be in the ~294.3 (K) to ~298.7 (K) range with no breezes expected.

Q24) We had a few questions about the COTS Data Logger, and how it will be used:
According to the rules, we will show the energy consumed by the robot immediately after each competition run. Does this mean the robot will remain powered until this measurement is recorded? If not, is the data logger meant to be independently battery powered? Also, are we allowed to use a data logger that measures the power like this?
A24) The 'immediate' part refers to the judge climbing into the arena, finding the logger and recording the power reading. If the logger is independently powered then the robot can be remotely powered

off after the run. Although this is acceptable, it is not recommended in case the robot needs to be commanded to dump collected regolith that was not deposited into the collection bin to help with cleaning the robot after the run. NASA cannot endorse a particular brand of data.

Q23) What are the specs for the sieve in this year's competition (eg. mesh size, mesh count)?
A23) See FAQ 5 for the sieve specs. The mesh has not been selected at this time, there is no information as to the mesh size/count.

Q22) While filling out the student forms, one of the members on my team voiced a strong objection with the release forms as they are worded, specifically Caterpillar's. The form apparently doesn't limit Caterpillar's rights to just media obtained through the competition but all media for all time. I personally was not alarmed, but others are. Will anyone who does not fill out release forms out of strong moral objections be forbidden from attending the competition?
A22) No one is required to submit a media release, period. Faculty, Staff and/or Students not completing the media release forms will definitely still be able to compete, we'll just have to come up with a system (perhaps a wrist band or sticker on the badge) that identifies those do not wish to have their photos taken. We'll confirm with the Team Leads/Faculty Advisor prior to the competition. Thanks for the heads up!
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4.0

Q21) Autonomy: When the obstacle zone is setup and prepared for a competition run, will there always be at least one path of travel through the obstacle zone that, if chosen correctly by the robot, will allow the robot to navigate through the obstacle zone without hitting any obstacles (assuming the size of the robot fits within the starting dimensions)?
Q21) Obstacle zones are wondrous, with treasures to satiate desires both subtle and gross; but they are not for the timid. So yes. The intent is to construct positive (rocks, berms, etc) and negative (craters) obstacles but in doing so, leave a path that is navigable by the robot based on the new rules regarding the physical size constraints of the robot. The purpose of this regarding autonomy is to drive development a perception system that allows the robot to "see" the world and to be able to determine the navigable path. It is not guaranteed that any two teams will have the same path, only that there will be a navigable path. In regard to the electro-mechanical mobility system, teams can choose to navigate the obstacles or conquer them in any way desired.

Q20) In (Mining) Rule 13, it states that the robot may be allowed to separate. Do the two robots need to be touching initially? Or can the two robots be separate, but fit within the initial size constraints?
A20) The two (or more) robots can be separate, but must fit within the volume and mass constraints.

Q19) We are trying to incorporate deep learning into our robot to allow it to maneuver via vision. We were wondering if we would be allowed to practice before actual competition on a similar test bed to capture data.
A19) Practice makes perfect, so read Registration, Rules and Rubrics, Page 15, Practice Runs for Monday and Tuesday for more information about these runs.

Q18) We were wondering if you had photos from the arena. I understand there was a Lunabotics competition back in 2011 and I was wondering if the composition of the ground was the same as well as its color.

A18) For information on the Lunar Regolith simulant go to Registration, Rules and Rubrics, Page 51, Black Point-1 (BP-1). As to photos, go to YouTube and search for NASA Robotic Mining Competition videos and see the competition arenas and Lunar regolith simulant used through RMC 2018.

Q17) Are the points for one full cycle of full autonomy (300) supposed to be the sum of the pieces of that cycle?
A17) No.

Q16) For example, autonomous travel from starting area to mining area = 150; autonomous excavation = 50; autonomous travel back from mining area to starting area = 0?; autonomous docking/offloading = 50. So, total those up and you get 150 + 50 + 50 = 250, which does not equal 300. Was it supposed to equal 300 or was the additional 50 points the reward for putting all the pieces together?
A16) Yes. Additional points are meant to be for integration of all of the automation features into a complete, autonomous cycle.

Q15) Does travel only count from starting area to mining area?
A15) Yes. The intent was localization near the collection sieves is covered in the Dump automation points. Localization at distance to the mining area is covered in the Travel automation points. Again, integration of all into a complete, autonomous cycle gives the 300 point opportunity.

Q14) Autonomy: Can the beacon protrude forward from the front plane of the bin so that it is more visible from the side (as seen from the mining area). In 2019 at UA, Caterpillar allowed this, but in previous years NASA has not allowed the beacon to extend in front of the front plane of the collection bin (i.e. it was not allowed to extend into the starting zone).
A14) This is a good idea, but we cannot implement it for Lunabotics 2020. However let's get together at competition to further discuss this.

Q13) Our idea is to put the NASA logo on one of the sleeves similar to a mission patch idea. I was unsure what the trademark system was like with NASA and if that would be allowed or if we have to include any paperwork when submitting our shirts.
A13) We love the spirit and enthusiasm, but please read the NASA Media Usage Guidelines on NASA logo usage at https://www.nasa.gov/multimedia/guidelines/index.html
You can get the links and download the Lunabotics 2020 logo on our website.

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3.0

Q12) General Questions:
What is the depth of the BP-1 layer (before you hit the gravel layer)?
~30 cm.

What is the depth of the gravel layer (from the bottom of the BP-1 layer to the bottom of the arena)?
~15 cm.

Combined, how deep is the BP-1 layer + the gravel layer before the robot would hit the bottom of the arena?
We were told, there would be no math today.

What are the dimensions for the starting zone, the obstacle zone, and the mining zone?
See FAQ Q11.

What is the precise location of the collection bin?
The collection bins are being replaced by collection sieves. The sieves will be located inside of the arenas.

What are the precise dimensions (including height above the top of the BP-1 layer) of the collection bin?
See FAQ Q5.

Q11) When will we get the arena layout for the starting, obstacle and mining areas for the new arena?
A11) We are currently working on a complete technical drawing with the new arena layout and dimensions (yeah, proofing is important).

Q10) What are the new arena dimensions for RMC: Lunabotics 2020:
A10) The Mining Arena is located inside The Astronauts Memorial Foundation's (AMF) Center for Space Education (CSE) across the hall from the RoboPits and has the following dimensions:

Arena Dimensions	
Max Length (m)	**~5.4**
Max Width (m)	**~3.6**
BP-1, regolith simulant depth (cm)	**~30.0**
Gravel, icy-regolith simulant depth (cm)	**~15.0**

The mining arena contain ~45 cm of BP-1 (regolith simulant). The mining zone contains ~30 cm of BP-1 over a ~15 cm bed of gravel (icy regolith simulant), with a mean particle size diameter of ~ 2 cm.

Q9) If a student is not registered at our college, but attends a university within our region (Oregon State University) can that student be a part of our team and take part in the competition if they do not attend classes at our College? We have a Lead Software Engineer that is a huge part of our team.
A9) Of course they can be a part of your team. This is a collaboration between two schools: Linn Benton Community College in collaboration with Oregon State University. You have to amend your registration to reflect this status. Your Lead Software Engineer (from OSU) has to comply with the same rules and regulations that applies to the team members from LBCC.

Q8) There is a portion in the Rule 13 that our team is taking issue on. It seems overly restrictive given the requirements that have been used years past. They have no issue regarding restriction of use of sensors to detect walls and avoiding collision with the wall and not allowing use of walls for navigation. There is, however, an issue with non-allowance of using contact sensors for "any other surface" as being too restrictive. Our team was considering using bump sensors to detect contact with rock obstacles and then maneuver around them. Would this be allowed. The intent is the robot will need to track its position in the arena at all times so it does not maneuver into an area that constitutes a border to the allowed area of operation (a.k.a. "the wall"). Please advise if this portion of Rule 13 could be modified or clarified. If bump or contract sensors are not allowed at all then please clarify that as well.

A8) Mining Rule 13 stands as written.

Q7) Rule 17 states that there shall only be one "Kill Switch" on the robot. Rule 13 states that the robot may separate itself as long as both parts are under control. In the interest of Safety, should there be a "Kill Switch" on each part of the robot that is separated?
A7) Great catch and according to one of Bending State University's prominent alumni, all humans should be equipped with one too. Mining Rule 17 has been amended to read as follows:

> 17) The mining robot must be equipped with an easily accessible red emergency stop button or "Kill Switch." Use good engineering practices and principles in placing the "Kill Switch" on your robot(s), failure to do so may result in a safety disqualification. The "Kill Switch" shall have a minimum diameter of 40 mm, it shall be located on the surface of the mining robot and require no additional steps to access it. Only one "Kill Switch" per robot and in the case of multiple robots, each robot will have its own "Kill Switch." It shall be easily accessible and activated in an easy and quick manner. Disabling the "Kill Switch" without authorization from the Competition Staff shall result in a safety disqualification. The emergency stop button must stop the mining robot's motion and disable all power with one push motion on the button. It must be highly reliable and instantaneous. For these reasons an unmodified "Commercial Off-The-Shelf" (COTS) red button is required. A closed control signal to a mechanical relay is allowed as long as it stays open to disable the mining robot. This rule exists in order to have the capability to safe the mining robot in the event of a fire or other mishap. The button should disconnect the batteries from all controllers (high current, forklift type button) and it should isolate the batteries from the rest of the active sub-systems as well. Only onboard laptop computers and data-logger(s) may stay powered on if powered by its internal computer battery.

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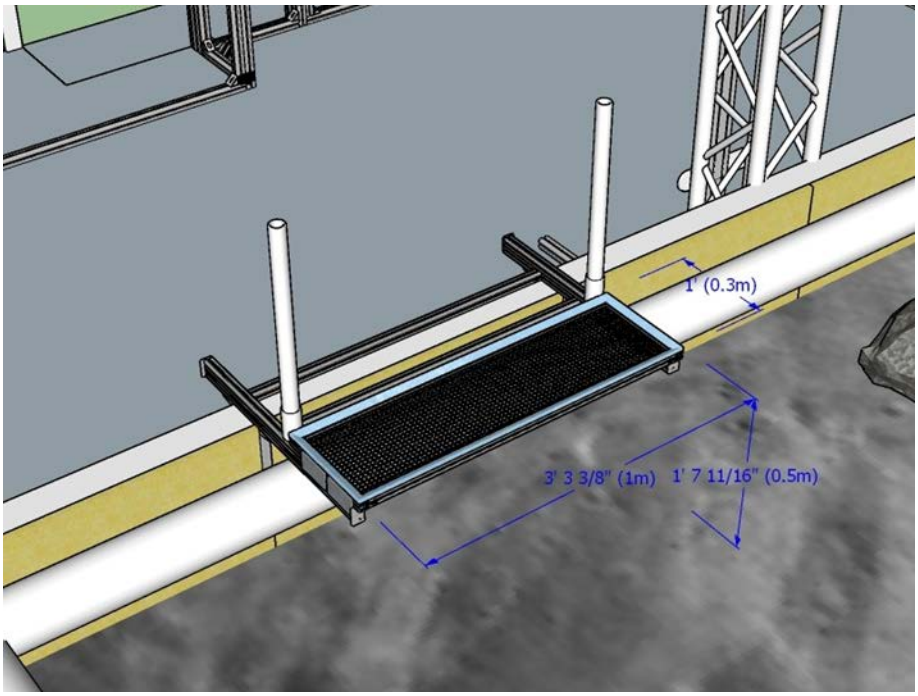
2.0

Q6) Mining zone regolith clarification.
A6) **The mining arena contain ~45 cm of BP-1 (regolith simulant). The mining zone contains ~30 cm of BP-1 over a ~15 cm bed of gravel (icy regolith simulant), with a mean particle size diameter of ~ 2 cm.**

Q5) Collector bin / sieve Information.
A5) The new collector bin / sieve measures 1.0 m X 0.3 m, the top of the sieve is located ~0.5 m above the surface of the mining arena and is located inside the arena. A technical drawing will be released shortly.



Q4) I am the secretary of the robotics club in my college in Mexico, we saw the competition and we would like to participate. Are we able to participate being from Mexico?
A4) We are sorry, but at the current time only schools located in the United States may participate.

Q3) How much of the Team, Advisor, and Student Member forms must be completed before the team will be notified if we have been accepted into the 2020 competition?
A3) Submit the following on the Team Registration Form to receive a registration complete email from RMC: Lunabotics 2020: 1. Email address, 2. Have read the official Rules and Rubrics, 3. School Name, 4. Team Name, 5. Do you have an official collaboration with another school that is competing?, 6. Dean's Letter of Support (PDF Format) - Each team must upload a SIGNED Letter of Support from the lead university's Dean of Engineering, 7. Faculty Advisor's Letter of Support (PDF Format) - Each team must upload a SIGNED Letter of Support from the team's Faculty Advisor.

1.0

Q2) Is a foreign entity allowed to provide funding for the NASA RMC? And if there are any conditions associated with the aforementioned situation.
A2) The question is not too clear so I am going to try to cover all the bases. First, NASA's RMC: Lunabotics 2020 is funded by the Federal government, as such, no funding from outside the Government can be accepted. Second, NASA's relationship is only with the college or university team that is registered for the competition. If some entity wants to help a particular team, then that is a concern between the entity and the school. NASA is not involved in any way whatsoever.

Q1) Is American Citizenship required for participation in the NASA RMC?
A1) Not at all. But to participate, students must meet all of the criteria listed in the Registration, Rules and Rubrics ... and must justify their favorite Doctor!

~ end of FAQ's ~