NASA’s Third Annual Lunabotics Mining Competition

Informational Webcast
September 27, 2011
Kennedy Space Center

Presenters: Dr. Phillip Metzger and Susan Sawyer
Benefits of Competition

• Excavation is a necessary first step in living off the land – In-Situ Resource Utilization (ISRU)
  – Oxygen extraction, launch & landing pad construction, habitat foundation, radiation protection, road construction

• Competition prepares NASA to excavate on lunar and planetary surfaces

• New concepts for excavation technologies

• Prepare students for future workforce
  – NASA Systems Engineering Process
  – Teamwork
Eligibility

- Undergraduate and graduate student teams enrolled in a U.S. or international college or university
- Teams must include:
  - One faculty advisor from a college or university
  - Two or more undergraduate or graduate students
- Teams may be with a senior design course, robotics club, engineering society, etc.
Collaborations

• A group of universities also may work in collaboration on a single team
• Multidisciplinary teams are encouraged (up to 10 extra points toward the Joe Kosmo Award for Excellence)
• Collaborations between majority institutions and U.S. minority serving institutions are encouraged (10 extra points toward the Joe Kosmo Award for Excellence)
What is a Lunabot?

- Robot controlled remotely or autonomously
- Visual and auditory isolation from operator
- Traverses across rough lunar terrain
- Mines Black Point 1 (BP-1) aggregate
- Traverses back across rough lunar terrain
- Deposits BP-1 into LunaBin at .5 m above simulated lunar surface
- Weight limit - 80 kg
- Dimension limits - 1.5 m length x .75 m width x .75 m height
Black Point 1 (BP-1)
Discovered during 2009 Desert RATS in Flagstaff, AZ
LunArena
Competition Categories

- On-site Mining (required)
- Systems Engineering Paper (required)
- Outreach Project (required)
- Slide Presentation (optional)
- Team Spirit (optional)
On-Site Mining Category

• Design, build & compete a remote control or autonomous Lunabot

• Earn LunaPoints for design and operational factors while mining a minimum of 10 kg of BP-1 within 10 minutes in each of 2 competition attempts.

• Win $3000, $2000, $1000 team scholarships and 30, 25, and 20 points for the 3 teams with the highest average number of LunaPoints earned.
LunaPoints

In each of the two official competition attempts, the teams will score cumulative LunaPoints. The teams’ ranking LunaPoints will be the average of their two competition attempts.

A) Each team will be awarded 1000 LunaPoints after passing the safety inspection and communications check.

B) During each competition attempt, the team will earn 2 LunaPoints for each kilogram in excess of 10 kg of BP-1 deposited in the LunaBin. (For example, 110 kg of BP-1 mined will earn 200 points.)

C) During each competition attempt, the team will lose 1 LunaPoint for each 50 Kb/sec of average data used throughout each competition attempt. A minimum of 10 kg of BP-1 must be mined and deposited in the LunaBin during each competition attempt or the team will lose 100 LunaPoints, which is the maximum number of LunaPoints for this rule. (For example, 5000 Kb/sec will lose 100 points.)

D) During each competition attempt, the team will lose 10 LunaPoints for each kilogram of total Lunabot mass. (For example, a Lunabot that weighs 80 kg will lose 800 LunaPoints.)

E) During each competition attempt, the team will earn 100 LunaPoints if the amount of energy consumed by the Lunabot during the competition attempt is reported to the judges after each attempt. The amount of energy consumed will not be used for scoring; a team must only provide a legitimate method of measuring the energy consumed and be able to explain the method to the judges.
LunaPoints

F) During each competition attempt, the judges will award the team 0 to 200 LunaPoints for regolith dust tolerant design features on the Lunabot and regolith dust free operation. If the Lunabot has exposed mechanisms where dust could accumulate during a lunar mission and degrade the performance or lifetime of the mechanisms, then fewer points will be awarded in this category. If the Lunabot raises a substantial amount of airborne dust or projects it due to its operations, then fewer points will be awarded. Ideally, the Lunabot will operate in a clean manner without dust projection, and all mechanisms and moving parts will be protected from dust intrusion. The Lunabot will not be penalized for airborne dust while dumping into the LunaBin. All decisions by the judges regarding dust tolerance and dust projection are final.

G) During each competition attempt, the team will earn 250 LunaPoints if the Lunabot is able to drive autonomously (no teleoperation), through the obstacle area only. The Lunabot may be teleoperated in the mining area and LunaBin/starting area. A minimum of 10 kg of BP-1 must be mined and deposited in the LunaBin during each competition attempt to receive these LunaPoints.

H) During each competition attempt, the team will earn 500 LunaPoints if full autonomy is achieved and a minimum of 10 kg of BP-1 is mined and deposited in the LunaBin. No teleoperation is allowed to achieve full autonomy status.
## LunaPoints Example

<table>
<thead>
<tr>
<th>Mining Category Elements</th>
<th>Specific Points</th>
<th>Actual</th>
<th>Units</th>
<th>LunaPoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass Inspections</td>
<td></td>
<td>110</td>
<td>kg</td>
<td>1000</td>
</tr>
<tr>
<td>Regolith over 10 kg</td>
<td>+2/kg</td>
<td></td>
<td></td>
<td>+200</td>
</tr>
<tr>
<td>Average Bandwidth</td>
<td>-1/50kb/sec</td>
<td>5000</td>
<td>kb/sec</td>
<td>-100</td>
</tr>
<tr>
<td>Lunabot Mass</td>
<td>-10 /kg</td>
<td>80</td>
<td>kg</td>
<td>-800</td>
</tr>
<tr>
<td>Report Energy Consumed</td>
<td>+100</td>
<td>1</td>
<td></td>
<td>+100</td>
</tr>
<tr>
<td>Dust Tolerant Design &amp; Dust Free Operation</td>
<td>0 to +200</td>
<td>150</td>
<td>Judges' Decision</td>
<td>+150</td>
</tr>
<tr>
<td>Autonomy through Obstacles</td>
<td>+250</td>
<td>0</td>
<td>1= Achieved, 0= Not Achieved</td>
<td>0</td>
</tr>
<tr>
<td>Full Autonomy</td>
<td>+500</td>
<td>0</td>
<td>1= Achieved, 0= Not Achieved</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>550</strong></td>
</tr>
</tbody>
</table>
Systems Engineering Paper Category

- Page limit is 20 pages
- No appendices this year
- Win plaque and $500 team scholarships for 1st place and individual certificates for 1st, 2nd, and 3rd place and up to 20 points toward the Joe Kosmo Award for Excellence
- Make sure to address each element in the rubric.
- Higher standards this year
Outreach Project Category

• Page limit is 5 pages

• Win plaque and $500 team scholarship for 1st place and individual certificates for 1st, 2nd, & 3rd place and up to 20 points toward the Joe Kosmo Award for Excellence

• Make sure to address each element in the rubric.

• Higher standards this year
Presentation and Demonstration Category

• Live presentation and demonstration in a more formal setting at the event with a 20 minute limit with 5 additional minutes for questions and answers
• Presentations will be judged prior to and during the competition
• Win plaque and $500 team scholarship for 1\textsuperscript{st} place and individual certificates for 1\textsuperscript{st}, 2\textsuperscript{nd}, & 3\textsuperscript{rd} place and up to 24 points toward the Joe Kosmo Award for Excellence
• Make sure to address each element in the rubric.
• Higher standards this year
Team Spirit Category

• Team Spirit will be judged on teams’ actions all year and during the event.
• Win plaque and $500 team scholarship for 1\textsuperscript{st} place and individual certificates for 1\textsuperscript{st}, 2\textsuperscript{nd}, and 3\textsuperscript{rd} place and up to 15 points toward the Joe Kosmo Award for Excellence
• Higher standards this year
Bonus Points Categories

- Collaboration between a majority school with a designated United States Minority Serving Institution (10 bonus points)
- Multidisciplinary Engineering Teams (up to 10 bonus points)
- Mined and Deposited BP-1 but did not place 1\textsuperscript{st}, 2\textsuperscript{nd}, or 3\textsuperscript{rd}, (up to 10 bonus points)
Category Prizes

• $3000, $2000, $1000 team scholarships for 1\textsuperscript{st}, 2\textsuperscript{nd} & 3\textsuperscript{rd} place respectively for On-site Mining and launch invitations to a future launch
• $500 team scholarship for Systems Engineering Paper
• $500 team scholarship for Outreach Report
• $500 team scholarship for Slide Presentation
• $500 team scholarship for Team Spirit

Team plaques and/or individual certificates will be given for 1\textsuperscript{st}, 2\textsuperscript{nd}, and 3\textsuperscript{rd} place in each category.
Joe Kosmo Award for Excellence

Grand prize awarded to team with highest cumulative score: Trophy, $5000 team scholarship, $1000 in travel expenses for each team member and one faculty advisor to attend a NASA remote test, & invitations to a NASA launch at KSC
Judges’ Innovation Award

Trophy and certificates awarded to team with the most innovative and lunar like design at the discretion of the judges.
Efficient Use of Communications
Power Award

Trophy and certificates awarded to the team using the least amount of average bandwidth during the timed and NASA monitored portion of the competition. Teams must collect the minimum 10 kg of BP-1 to qualify for this award.
## Important Dates

<table>
<thead>
<tr>
<th>Event</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Application</td>
<td>November 30, 2011</td>
</tr>
<tr>
<td>or 60 teams</td>
<td></td>
</tr>
<tr>
<td>Letter of Support from lead university’s Dean of Engineering</td>
<td>November 30, 2011</td>
</tr>
<tr>
<td>Letter of Support from lead university’s Faculty Advisor</td>
<td>November 30, 2011</td>
</tr>
<tr>
<td>MSI Collaboration Notification</td>
<td>November 30, 2011</td>
</tr>
<tr>
<td>Team Roster with MSI students indicated</td>
<td>January 31, 2012</td>
</tr>
<tr>
<td>Student Participant Form</td>
<td>January 31, 2012</td>
</tr>
<tr>
<td>Faculty Form</td>
<td>January 31, 2012</td>
</tr>
<tr>
<td>Transcripts (unofficial copy is acceptable)</td>
<td>January 31, 2012</td>
</tr>
<tr>
<td>Signed Media Release Form</td>
<td>January 31, 2012</td>
</tr>
<tr>
<td>Request for Team Invitation Letter for International Teams</td>
<td>February 24, 2012</td>
</tr>
</tbody>
</table>

**Note:** All times are 12:00 p.m. (noon) eastern time in the United States. Teams that do not submit required items on time will not be allowed to compete on site.
# Important Dates

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Photo including faculty (high resolution .jpg format preferred)</td>
<td>March 30, 2012</td>
</tr>
<tr>
<td>Team Biography (200 words maximum)</td>
<td>March 30, 2012</td>
</tr>
<tr>
<td>Head Count Form</td>
<td>March 30, 2012</td>
</tr>
<tr>
<td>Revised Team Roster (no changes accepted after this date)</td>
<td>March 30, 2012</td>
</tr>
<tr>
<td>Systems Engineering Paper</td>
<td>April 23, 2012</td>
</tr>
<tr>
<td>Outreach Project Report</td>
<td>April 23, 2012</td>
</tr>
<tr>
<td>Presentation File (optional)</td>
<td>April 23, 2012</td>
</tr>
<tr>
<td>Team Spirit (optional)</td>
<td>All year</td>
</tr>
<tr>
<td>Rule 31 documentation</td>
<td>April 30, 2012</td>
</tr>
<tr>
<td>Rule 32 video</td>
<td>April 30, 2012</td>
</tr>
<tr>
<td>Check-In at Lunabotics Tent at Kennedy Space Center Visitor Complex</td>
<td>May 21 &amp; 22 (by noon), 2012</td>
</tr>
<tr>
<td>Practice Days</td>
<td>May 21-23, 2012</td>
</tr>
<tr>
<td>On-Site Mining Competition</td>
<td>May 23-26, 2012</td>
</tr>
</tbody>
</table>

Note: All times are 12:00 p.m. (noon) eastern time in the United States. Teams that do not submit required items on time will not be allowed to compete on site.
Rules, Rubrics & Frequently Asked Questions (FAQs)

- **Official Competition Rules & Rubrics**
  - Rules are available on the competition website at [www.nasa.gov/lunabotics](http://www.nasa.gov/lunabotics) and are subject to change.
  - It is the teams responsibility to ensure they are familiar with the official rules.

- **Questions must be submitted in writing to Susan.G.Sawyer@nasa.gov**
  - Questions and responses will be posted on the competition website [www.nasa.gov/lunabotics](http://www.nasa.gov/lunabotics)
  - FAQs are considered part of the official rules
  - It is the teams responsibility to ensure they are familiar with the FAQs.
International Teams

• International participants are responsible for obtaining their own funding and U.S. visas
• NASA cannot assist international teams with either funding or visa issues
• For more information on applying for a U.S. visa, please visit http://travel.state.gov/visa/temp/types/types_1262.html
• All competition documents must be submitted in English
• Concurrent international competitions are encouraged
Funding Resources

• Teams encouraged to request funds from
  – University
  – Local Space Grant Consortium
  – Engineering Society
  – Private Industry
• Estimate $10,000 - $20,000 for materials, testing, roundtrip shipping and travel
Lessons Learned

- Create a budget and schedule, to include expenses and time for travel & shipping.
- Brainstorm! The more ideas, the better! Don’t turn people’s ideas down right away because they might be the answer you need, with a little modification. Respect all team members’ opinions as equal and don’t let one voice dominate!
- Once you brainstorm, try to narrow your options down. As a team, choose which option seems most successful or most feasible and weigh all the pros and cons. KEEP A BACKUP IDEA ON HAND!!! You will most likely use it!
- Team continuity is very important. When problems arise, communication is key to resolving them. Any problems with team members need to be addressed early. It makes a difference when all team members are willing to lend a helping hand.
- Off-the-shelf components seem to work best. Custom-made parts take a long time to fabricate and reduces testing time. Most of the time, modifications may be made to off-the-shelf parts if needed. Also, in part selection, keep in mind the weight budget and delivery dates. Over-estimate the weight of each component to account for fasteners and brackets.
- Do not make any fixtures permanent early on! There will be time after testing to finalize the design. While assembling, test every subsystem of the design before and after it goes onto the robot. Test, test, and test again!
The properties of the BP-1 were very different than the properties of sand. The angle required to make the simulant slide out of the box was a lot steeper than what was designed for sand.

During testing, failure is an option. It will happen. Even before the test, have an idea of what may fail and the necessary steps to correct the problem.

Pictures and video are very important to document the entire process! Keep those cameras handy!

The transportation of the robot should be considered in the design phase. The team that required no disassembly to move their robot strapped it into a box truck. Many teams spent valuable time reassembling their robots with some teams finding damaged parts. This time could be spent resolving other problems, such as communication issues, instead of rebuilding the robot.

One team had several parts that were spares, including the wheel assemblies with sprockets mounted to the wheels and spare scoops. These were ready to be thrown onto the robot with a maximum of 5 minutes working time should the need arise. Spare parts and tools make repairs very fast and easy.
Lessons Learned

- No modifications that require personal protection equipment may be made in the LunaPits. For example, no grinding, welding, etc.
- Come ready to practice and compete. Don’t count on time to do major work on your Lunabot to get it ready. Given the amount of teams, you will only be given one practice attempt.
- Auditory Isolation in Mission Control Center means that teams need to consider in their design that they will not be able to communicate with other team members outside the MCC once the competition attempt starts. There were a few issues this past year with loud distractions in the MCC.
- Because of the heat, the LunaPits will remain open during the competition days so teams may stay in the air-conditioned tent, work on their robots, and talk with guests.
- Teams need to clean their Lunabots more thoroughly before bringing them back into LunaPits. There will be stronger vacuums available as well.
- Return shipping must be arranged prior to the competition.
Lunabotics Mining Competition Links

- Competition Website:  www.nasa.gov/lunabotics
- Facebook Page:  www.facebook.com/Lunabotics
- YouTube:  http://www.youtube.com/user/lunabotics
- Twitter:  http://twitter.com/#!/lunabotics
- To apply for the competition visit https://www.spacegrant.org/forms/?form=lunabotics
- Teams notified via e-mail when application is approved for registration.
- For more information contact: Susan Sawyer at Susan.G.Sawyer@nasa.gov
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Questions?