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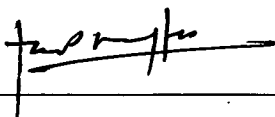
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Residential Internship
Kennedy Space Center
Lunar Regolith Excavation Student Competition Design
Nething, Constance
June 7, 2009 – July 31, 2009

Reviewed by:

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Applied Technology, KT-C-H1



Lunabotics Mining Competition

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Lunabotics Mining Competition
NASA/INSPIRE
Kennedy Space Center
Mentor: Rob Mueller
June 9, 2009 – July 31, 2009

Many people around the world share the dream that we will one day live in space. Transportation is not an issue due to the technology evident in rockets and shuttles, but how do we survive once we get there? It is this question that my department is trying to answer. Led by my mentor, Rob Mueller, the Surface Systems team is working to learn about lunar regolith and how we can use it as a source of air, water, and fuel for spacecrafts. However, excavation of this valuable regolith is difficult because the robot has to conform to many specifications (mass limit, efficiency level, etc.). NASA has therefore decided to include college students and companies in the search to create the best robot by making it into a competition, which was my project for the summer.

Currently, air, water, and fuel are all extremely heavy and therefore expensive and difficult to take up into space. This causes the astronauts to have a very limited time frame for their mission. However, due to tests on lunar regolith, NASA has found that lunar regolith is rich in both oxygen and hydrogen. Therefore, once the regolith is excavated, NASA can extract both of these elements, which would completely solve the aforementioned problems because then they would just be able to create air, water and fuel on the moon instead of bringing it with them.

Unfortunately, the robot itself has many requirements that it must fulfill before it can go to the moon. It must have a certain efficiency level, it must be under a certain mass, and one must be able to completely operate it from Earth. Therefore, NASA Kennedy Space Center decided to hold the Centennial Challenge Regolith Excavation Competition for companies and colleges to make robots that, after meeting the requirements, can excavate the most amount of lunar regolith stimulant. In a mere thirty minutes, robots are expected to excavate at least 150 kg of simulant. Other requirements include that the robot has to have a mass under 80 kg, the operator cannot see the robot (though they can see the robot through a video feed), and the robot has to move across the sandbox at some point in the competition time. The grand prize for this competition is \$500,000, but unfortunately no one has yet won this prize. In the past years, few teams entered (only 5-15 teams on any given year), and many of those robots broke down the day of the competition because they had no practice time beforehand and they were not allowed to repair the robot once the competition began. The robots that did work did not succeed in excavating 150 kg, and were therefore not qualified to win the prize. This disappointing end to a competition with such long preparation time made the competition organizers decide to head in a

new direction for the next years. Though the Centennial Challenge Regolith Excavation Challenge has not been discontinued, as of this year there is an additional competition that is slightly easier and more exciting, the Lunabotics Mining Competition.

The Lunabotics Mining Competition is geared specifically for college students. The intent of the competition is to discover new technology for future excavation robots, interest students in STEM careers, and excite students about a possible future career at NASA. The requirements are also slightly easier than they are for the Centennial Challenge. For example, instead of having a requirement of 150 kg excavated in 30 minutes, the new competition will have two qualifying trials of 15 minutes each in which the team must excavate 10 kg in one of those rounds, and 2 15-minute rounds after that for the Semi-Finals and Finals with no excavation requirements. This way, there will definitely be a winner at the end of the competition (and preferably first, second, and third place winners). Though the grand prize is worth a considerable amount less than the Centennial Challenge (\$5,000 instead of \$500,000), this is worth it when one considers that so far no one has won anything from the Centennial Challenge because no one has been able to meet the requirements. Also, to off-set possible robot failures, teams will be given at least one full practice day in the sandbox beforehand to work out any problems, and they will be able to make minor changes between rounds of the competition itself (in case something goes wrong on the day of). Also, teams are now not only competing for the grand prize, but many non-robot related prizes as well. There are now monetary awards (\$500 each) for team spirit, slide presentations, outreach to informal education or K-12 education, and system engineering papers.

The format of the competition is also extremely different from the original Centennial Challenge. In the original competition, the arena was a basic box and the robot was required to move at some point during the competition, but there was no particular destination. In the new competition, there are three “areas”: the starting area, the obstacle area, and the mining area. There are two robots competing at one time in the same arena, so they have opposite mining and starting areas, but the same obstacle area (which is in the middle). The robot must begin in the starting area, then move across the obstacle area (which has craters and large rocks) until they reach the mining area, which is the only place where they are allowed to excavate lunar regolith simulant. The robot must then go back across the obstacle area to the original start area to deposit the simulant in the hopper on that side. Because two robots are competing at once, another obstacle is avoiding the other robot. However, an offensive strategy (damaging the other robot, stealing its regolith simulant, etc.) is not permitted because not only could it permanently damage a robot, but it is not realistic for the purpose of excavating regolith on the moon. Also, the new competition has a points system. For every 0.1 kg excavated in the qualifying round (in both time trials), each team receives 1 point, with a minimum of 100 points to make it to the next round, the Semi-Finals. In this round, each 0.1 kg excavated is worth 2 points and is added to the number of points received in the qualifying round for a total score. At the end of the Semi-Final Round, those teams with the four highest scores will move on to the Final Round. In this

round, the third and fourth ranked teams will compete at the same time, and then the first and second ranked teams will compete at the same time. Each 0.1 kg excavated is now worth 3 points, and whichever teams earn the three highest amounts of points at the end of the round will receive first, second, and third place prizes respectively. This new points system was devised to make the competition more exciting for participants and viewers, and to give teams more leniency so that if their robot breaks down in one round they still have a chance to win. In this way, the competition encourages, instead of discourages, students to try out new ideas in the world of STEM.

The process of designing the competition was actually quite complicated. Our first major obstacle was the sandbox itself. The sandbox has to be sturdy enough to support 30 tons of regolith simulant, cheap enough to fit well within our \$50,000 total competition budget, quick to assemble/disassemble, and storable for most of the year. We ended up using the company 80/20 to create the frame for the sandbox, and then we will use another material (most likely plywood) for inside the frame. Also, we had to update the rules from the Centennial Challenge. This resulted from many meetings in which we not only discussed the changes to the competition itself, but we also had to learn the diction used in a formal rules document so that there is no confusion for the participants. Additionally, we had to determine resource availability. This includes going to the Astronaut Hall of Fame (the future site for the competition) and measuring the space available so that we know the maximum dimensions for the sandbox, determining the possible dimensions for the robots based on the size of the elevator, and figuring out basic logistics for a DJ, spectators, etc. Furthermore, we worked on the publicity for the competition. First, we worked with the graphics department to create a logo and poster for the competition, complete with the slogan "Design it. Build it. Dig it." Then, Mrs. Gloria Murphy designed a Facebook page and a website dedicated to promoting the competition and answering questions about it.

In the time that I was not working on the competition, I was going through the tutorials of two computer programs, Pro/Engineering and MathCad. Pro/Engineering is a computer program that engineers use to make 3-D images of their designs. While engineering students do not learn how to use Pro/Engineering until their sophomore year of college, Mr. Mueller decided that it would be helpful for us to get acquainted with now. Therefore, Chris Le and I (with the extensive help of Yenny Su, who had experience with a similar program) worked on the tutorial, which involved creating a cell phone by building all of the different parts and then eventually putting them together. Unfortunately, we both got caught up in other projects (mostly the competition) and did not finish building the cell phone. We did, however, gain valuable experience in using the program, and we will be ahead of other students when we go to college. Also, I worked on going through the tutorial for MathCad, which is a computer program that does in-depth calculations. It is much more than a calculator because it can connect different variables and equations to give immediate answers, and it can make 3-D color graphs with

instant response if even a single variable is changed. Working with MathCad was one of the highlights of my summer because I absolutely love math.

Outside of work, I engaged in many INSPIRE activities. We went to the beach and theme parks, visited the Orlando Science Center, planted seeds that went into space, and a variety of other activities. My personal favorite activity was going to the beach, but that is simply because I am from Florida and no summer is perfect without a trip to the beach. Of the educational after-work activities that we did, my favorite would probably be the presentation about Mars because I learned quite a bit.

The experience I had at NASA/INSPIRE this summer was one that I would not trade for the world. Though I was hesitant at first to apply (I thought there was no way I would be accepted), I am thrilled that I was in fact accepted and that I was able to spend my summer here. I have developed a deeper appreciation for NASA and the space program, and I hope to continue this development by coming back next year. Though my mentor was amazing and I had a fun project, I don't feel that mechanical engineering is the right career path for me. However, I still want to pursue something in STEM and I hope to one day work at NASA.

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