Design • Build • Program • Learn • Compete

SERVO MAGAZINE

FOR THE ROBOT INNOVATOR

www.servomagazine.com

August 2012

3rd Annual Lunabotics Competition

Mining For Knowledge

- Wireless Servo Controller
- Touch Sensing
- Virtual Sensors
- Parrot AR Drone 2.0

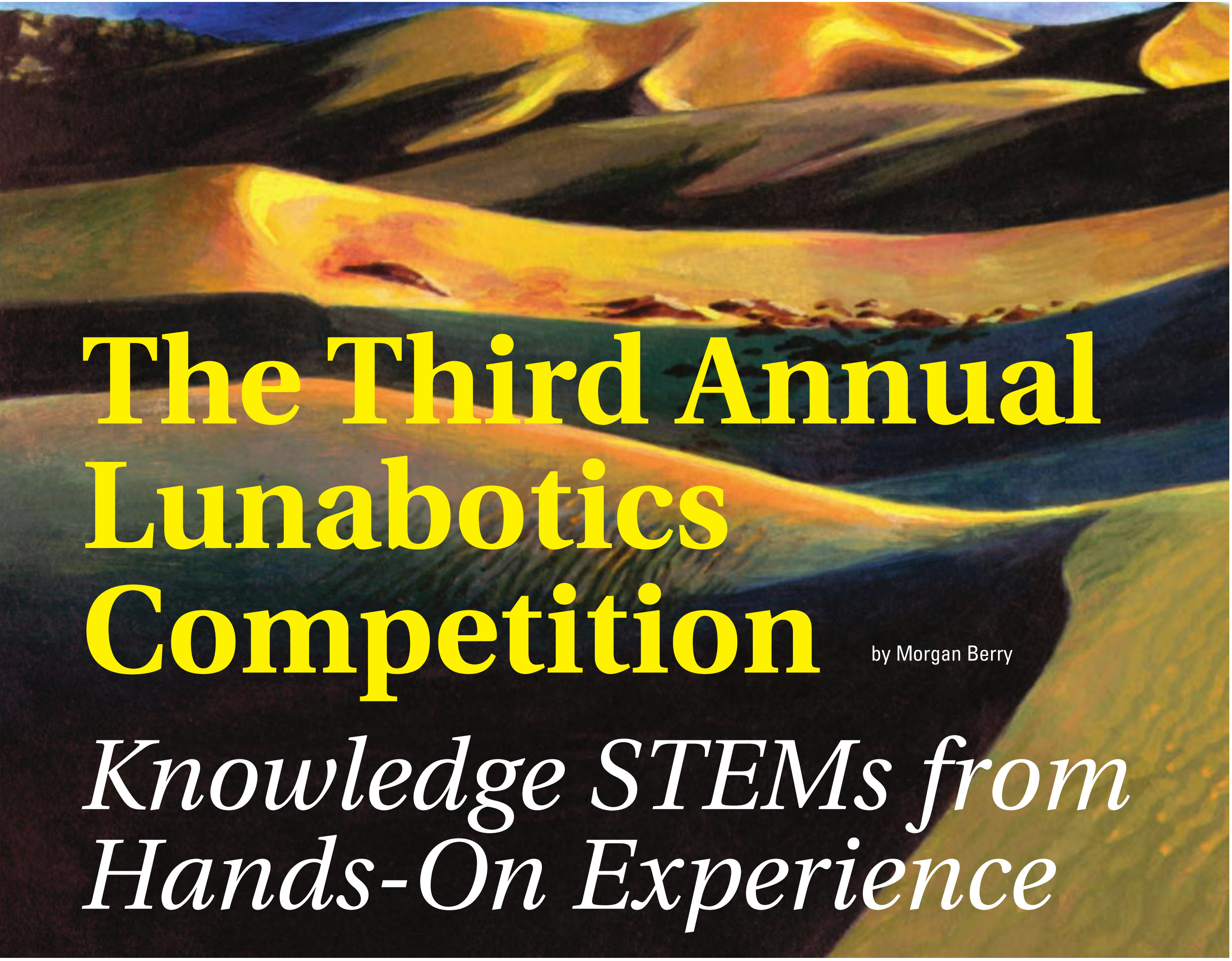
SERVO editor Bryan Bergeron does a complete analysis, teardown, and mod of this popular quadcopter.

U.S. $5.50 CANADA $7.00

08

0 71486 02422 4

Vol. 10 No. 8 SERVO MAGAZINE LUNABOTICS • TOUCH SENSING • WIRELESS SERVO CONTROLLER • PARROT AR DRONE 2.0 August 2012



The Third Annual Lunabotics Competition

by Morgan Berry

Knowledge STEMs from Hands-On Experience

Just this last May, a few hundred college students converged on Cape Canaveral — a town situated on the eastern coast of Florida. They spent the week forming memories with friends, making late night runs to the store, and frequenting the beach. Although this might seem like a typical college student spring break getaway, it was actually far from it. The students didn't go to Florida to party. They came to compete in the third annual Lunabotics competition hosted by NASA at the Kennedy Space Center Visitor's Complex.

The goal of the event is to encourage STEM (Science, Technology, Engineering, and Mathematics) education among college students, while also helping NASA develop an actual lunar rover prototype. The teams design and build a lunar rover that mines a simulated version of the regolith soil found on the moon. All those trips to the beach? They were doing last minute mining tests on their Lunabot. Those late night store runs? They weren't for beer. They were for replacement parts as teams prepared for the competition. These teens are some of the best and brightest in their academic fields, and NASA is taking full advantage of their talents.

Again, the primary goal of Lunabotics is STEM education. The teams learn engineering in a hands-on way by designing and building lunar rover prototypes. At the Lunabotics competition, they put their machines to the test in a pit of simulated regolith, competing with other teams to mine the most soil. In previous years, mining regolith was the only goal.

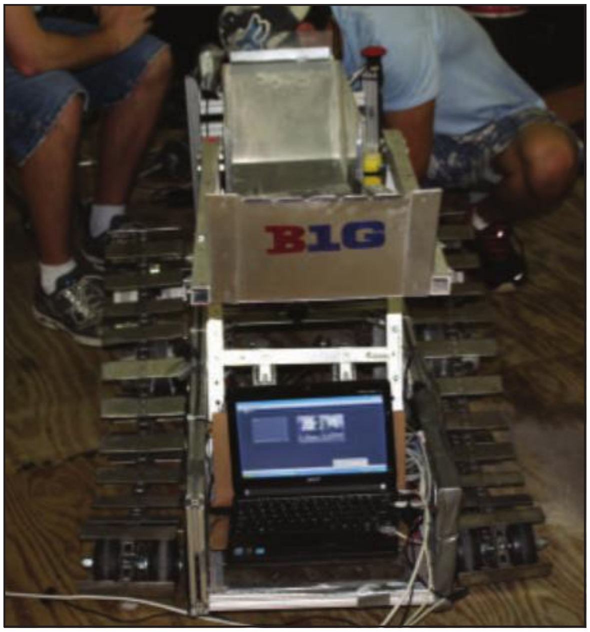
This year, NASA made changes to the competition. Now, in addition to the amount of regolith the Lunabots mine, teams also earn points for making a lighter and more compact bot, dust-proofing their machine, having a multidisciplinary team, and other criteria. For NASA, these changes mean more innovation in the team's entries. Every unique idea that the teams develop brings NASA one step closer to fine-tuning their actual lunar rover.

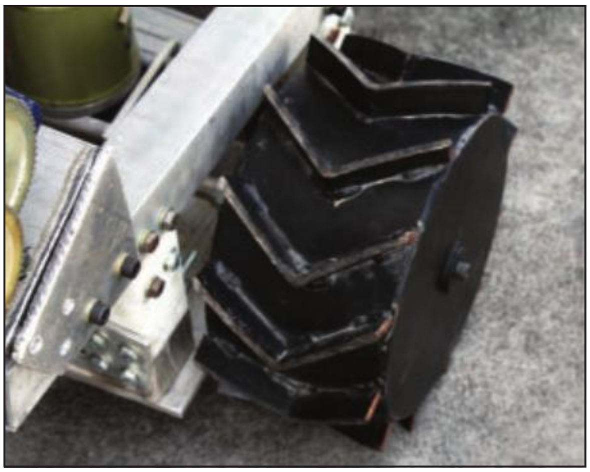
Students learn other skills for their future STEM careers in the competition, as well. The teams are required to write a systems engineering paper. This is basically a roadmap of how the students will design and build their bot. It is a frequent task of engineers in the real world; by learning this skill in Lunabotics, they will have a leg up as they enter into their chosen field. An outreach project — where teams are required to give presentations or demonstrations about Lunabotics in their local community — teaches the students how to educate others about their work. A slide presentation judged by NASA engineers is good practice for similar presentations that the students may do while working in their future careers.

So, what was it like to be a part of the 2012 Lunabotics competition? Check out this collection of photos from the event to find out.

Since NASA scientists won't have the luxury of being in the same room — or even the same planet — as a lunar rover, the same rules apply to the Lunabotics students. They must operate their bot from a command center bus, where they view the LunArena and their Lunabot on small, closed circuit television screens. The bots must operate wirelessly. One change that NASA made to the competition this year was giving the teams added points for making their bots autonomous — just as an actual lunar rover would be.

Team members from Florida State University (FSU) waited — excited and anxious — for their turn in the LunArena. The teams are required to mine a minimum of 10 kg of regolith, and pass through some lunar obstacles during their turn in the regolith pit. The FSU students decorated their suits with the school's logo, as well as with phrases such as "Go 'Noles!" (an abbreviation for the school's mascot, the Seminole), and "Hi mom!" Although wearing the thick white suits in the middle of Central Florida's 90° heat was uncomfortable — to say the least — they are a necessary safety requirement. The simulated regolith could easily get into the student's eyes and throats when they brought their robots into the LunArena.





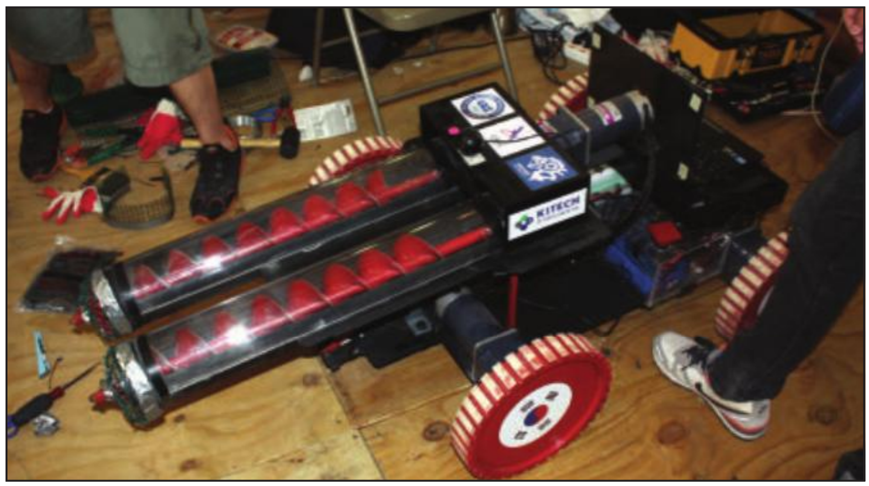
Last year, *SERVO* reported in an article entitled "Dust in the Wheels" (which, yes, was in fact riddled with some shamelessly bad classic rock puns) that one of the most common technical issues faced at last year's Lunabotics competition was traction problems. Many bots became trapped in deep ruts or slipped on top of the fine soil. The teams this year were more prepared for this problem. Every team *SERVO* spoke with had practiced and perfected navigating in the fine soil, making wheel problems a thing of the past.

The pits for all 55 teams — a much needed air conditioned escape from the sweltering heat — were set up in a massive tent near the LunArena. Inside the pits were numerous large screens that showed the team's mining trips in real time. In addition to the chatter between teammates and the buzzing of electrical tools, frequent sounds heard in the pits were the gasps and cheers of members from other teams as they watched their competitors mine regolith. It appeared that the students enjoyed experiencing Lunabotics as a spectator sport as much as participating in the actual event.

After a particularly successful trip, one of the Colombian teams burst in through the entrance to the pits, chanting and dancing as they wheeled their Lunabot back in. At that moment, the atmosphere of the pits changed from a workshop into something more like the stands at an exciting sporting event. The change was tangible, and the other teams joined in the fun as well, dancing and clapping along with their competitors.

It wasn't all fun and games in the pits, though. As anyone who has ever attended a robotics event knows, some of the most frantic and difficult moments happen inside this small area. Teams make last minute adjustments, charge up their batteries, and mentally prepare for the competition. The difference between the teams who have already competed and the teams on deck is quite noticeable. Just a few stations over from the celebrating Colombian team was a team preparing for their impending round. They shifted nervously as they tested their robot just one last time before going off to face the LunArena.

The amount of time and energy the teams put into the competition is astounding. The teams spend months preparing for Lunabotics, and travel thousands of miles to compete. It takes a physical toll on the students. If you look closely at this picture of students from South Korea's Hanyang University, you can see one of the other members of the team asleep on the plywood floor in the background. No one said it would be easy, but for the students at Hanyang University competing at Lunabotics was well worth a little sleep deprivation.



The students from Hanyang University traveled about 7,500 miles across the Pacific Ocean and the Continental United States to make it to Cape Canaveral. They first learned about Lunabotics from a professor, who read about the competition on the Internet through his interest in NASA and space exploration. The team decided to participate in Lunabotics for their senior design project which — according to team member Min Yong Lee — they expect to earn a very good grade on. The team chose an auger design for their bot. They clearly focused on the bot's appearance as well as function, painting the auger, wheels, and other hardware a sleek red.

Buckets, and Augers, and Conveyors, Oh My!

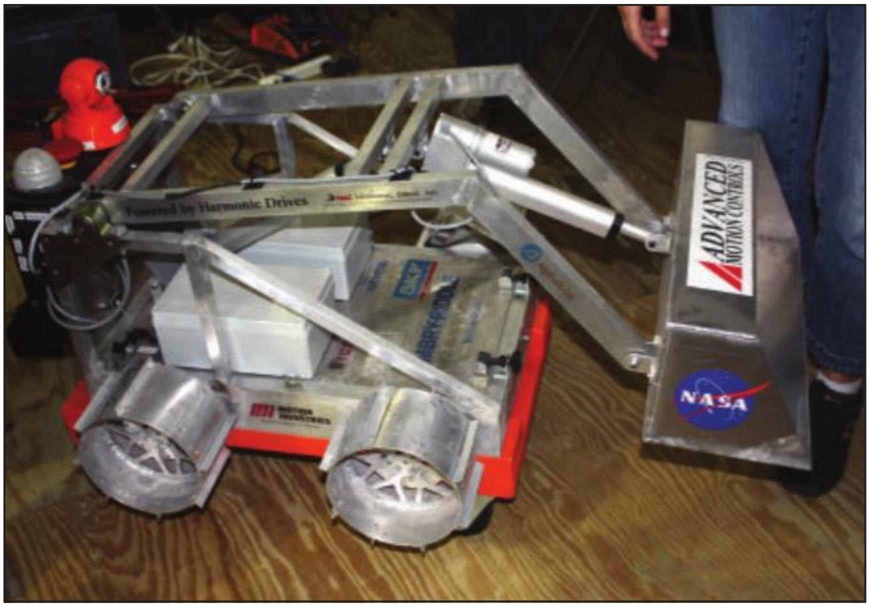
Three main robot designs have emerged out of the Lunabotics competitions. The bucket design works like a bull dozer, using a large scoop to collect the simulated regolith. The auger uses a screw design to pull the lunar soil up into a collection area. The conveyor transports lunar soil up onto a moving belt.

All three of these designs are inspired from real world applications. The advantages of the bucket are clear. This is a commonly used design for moving sediment on construction sites. It is a simple design which means less room for mechanical failures. However, this design requires constant trips to the deposit area.

By using an onboard storage area, conveyors and augers eliminate this problem. They also tend to look a lot more impressive than the simplistic bucket designs. As a result, however, they are more often plagued by technical problems than their scooping counterparts.

Augers have a tendency to become clogged with regolith. They do tend to stir up less dust than either the conveyor or the bucket design, though. This is important at Lunabotics because stirring up the fine lunar regolith can cause problems for bots, as well as cause point deductions.

As you can see, choosing a design style is a tricky business, with teams often starting and then scrapping designs as they wade through the many options. The winners of the mining competition have so far been conveyor designs but, of course, there's a lot more to winning than simply choosing a design. It takes a good design, skilled driving, practice, and a little luck to take home the first place prize.



Students from Embry Riddle Aeronautical University in nearby Daytona Beach used a bucket style design for their Lunabot. Their machine used Jaguar controllers and A123 batteries from DeWalt packs.

What set this bot apart from many of the other Lunabots was that all of the hardware for the bot was sealed inside the chassis using a gasket. This was in line with NASA's desire for the Lunabots to be designed in a dust-proof manner. Regolith is extremely fine and can easily cause problems for astronauts and lunar equipment alike; Apollo 17 astronaut Harrison Schmitt reportedly suffered from an allergic reaction after breathing in lunar regolith on the moon. The Apollo astronauts also had problems with the dust corroding and scratching equipment. The Lunabots designed with exposed parts would not last very long on an extended trip to the moon. By addressing this issue, Embry Riddle earned some extra design points.

Another positive design aspect for the team's Lunabot was its size. At 45 kg, this bot was about half the weight of some of the other competitor's entries.

Practice Makes Perfect

Since lunar regolith is so different from any soil on Earth, it can be difficult for teams to prepare for the unique qualities of the BP-1 regolith simulant. So, to practice for the event, teams have come up with some unique solutions to this difficulty.

Teams living in a coastal region have an automatic advantage over the landlocked teams. They have free, unlimited access to beach sand. Although sand is a lot different from regolith, it is cheap and abundant. It was very common for teams from Florida — as well as the coast of India and other countries — to practice in this manner. And, since the competition was held on the coast of Florida, many teams practiced at local Playalinda or Cocoa Beach the night before the event.

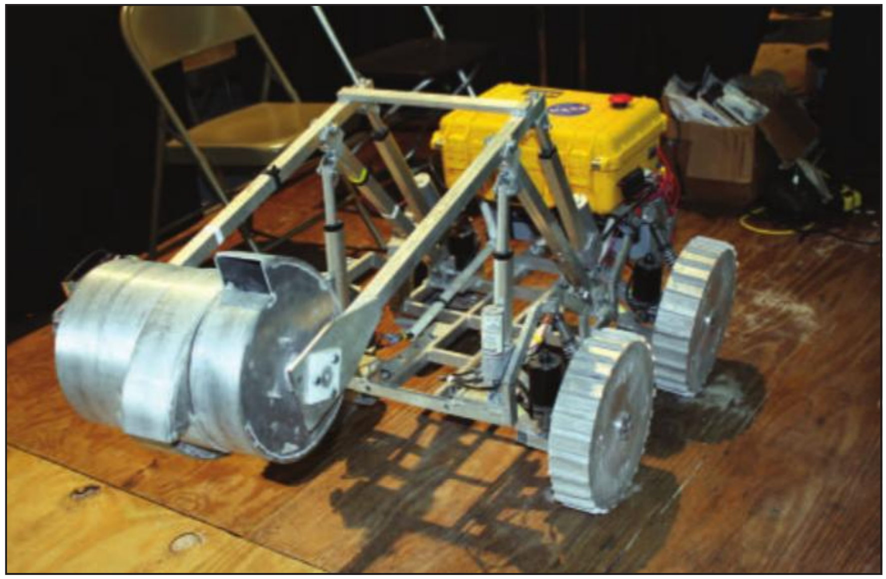
Another variation on this was the volleyball court method. Teams not near a beach often use the school's volleyball pit. For many schools, this is the only sand available to them. The Hanyang University team from Seoul, Korea practiced in a playground.

This is as far as most of the schools go to practice for the competition. Others go to some greater lengths to prepare.

Iowa State created their own mix to mimic the BP-1 regolith simulant. They used a mix of five parts Portland cement, three parts fly ash, and one part sand. They collected the fly ash from Iowa State's own coal burning power plant. Since the plant burns a different mix of materials every day, the team had to get all they needed on one day, so there wouldn't be inconsistencies in the material.

Last year, Laurentian University was sponsored by EVC Ltd., a company that produces simulant. They provided the team with regolith simulant to practice with. This year, Laurentian tested their bot with crusher dust — a fine dust that is the byproduct of some mining operations.

The team from Iowa State University considered a number of different designs before deciding on a conveyor belt. They thought about using a bucket, but decided to challenge themselves with a more sophisticated design. They also made plans for a bucket-wheel excavator — where a machine collects regolith by scooping it with buckets attached to a spinning wheel — but calculated that they could mine more soil by using a conveyor design. Whatever the motive for choosing the design, it certainly paid off; the Iowa State team came in first place in the mining category.



Not all teams stuck to one of the three most common design archetypes. This Lunabot from Montana State University chose a different approach. They designed a version of a bucket-wheel excavator, collecting the lunar regolith in a hollow drum. This kind of innovative design approach is exactly what NASA is trying to encourage with the Lunabotics competition. Montana State took home a first place prize for the systems engineering paper category and placed second in the outreach project category.

A major sponsor of the event this year was heavy machinery producer Caterpillar, Inc. This seems fitting, because Caterpillar products — like the pictured Cat® 287C semi-autonomous multi terrain loader — are basically designed with the same goals in mind as the Lunabots: to collect a large amount of soil. In fact, many of the Lunabotics teams modeled their bots after this type of machine, citing the effectiveness of Caterpillar machines in the real world at construction sites as evidence that the "scoop" design is effective.

"Caterpillar has a long history of supporting educational opportunities that promote the STEM areas. We need to encourage technology, innovation, and ingenuity to students of all ages. The development of autonomous systems will ultimately help our global customers boost safety, efficiency, and increase profitability," said Eric Reiners, a manager at Caterpillar, Inc., and one of this year's judges at Lunabotics. **SV**

The 2012 Lunabotics Winners

Joe Kosmo Award for Excellence (Grand Prize)
First Place — The University of Alabama in collaboration with Shelton State Community College
Second Place — Iowa State University in collaboration with Wartburg College
Third Place — West Virginia University

On-Site Mining Award
First Place — Iowa State University in collaboration with Wartburg College
Second Place — The University of Alabama in collaboration with Shelton State Community College
Third Place — Milwaukee School of Engineering

Judges Innovation Award
Polytechnic Institute of New York University

Efficient Use of Communications Power Award
Iowa State University in collaboration with Wartburg College

Best Use of Social Media
Universidad de Los Andes of Colombia

Slide Presentation and Demonstration Award
First Place — The University of Alabama in collaboration with Shelton State Community College
Second Place — West Virginia University
Third Place — Universidad de Los Andes of Colombia

Outreach Project Report Award
First Place — Iowa State University in collaboration with Wartburg College
Second Place — Montana State University — Bozeman
Third Place — John Brown University

Systems Engineering Paper Award
First Place — Montana State University — Bozeman
Second Place — John Brown University
Third Place — University of Illinois at Urbana — Champaign

Team Spirit Award
First Place — The University of Alabama in collaboration with Shelton State Community College
Second Place — Instituto de Astrobiologia Colombia IAC
Third Place — Polytechnic Institute of New York University