Ideal Engineering

Anti-personnel devices in non-combat areas maim or kill someone—often a child—every 22 minutes somewhere in the world. For the MineSweeper team, designing a landmine detection robot is not just a competition; it's a humanitarian mission.

By Dan Tuohy

It was a boxy hunk of shiny aluminum, multi-colored wires and circuits, and knobby, little tires. But even a race car would look naked stripped to the chassis.

This vehicle, the Cornell MineSweeper, was in the capable hands of a student pit crew in May as Abraham Cantwell '10 ECE leaned over and deliberately tested the power source and checked each component against his laptop.

"It's a lot of work. But it's really great to see the whole thing come together," he says. "I like that we're doing something to really affect something. No disrespect to any of the teams here. I do like this because it did have an ideal, a goal."

The student engineering team has labored 20 hours a week for most of the first six months of this year to bring the Cornell MineSweeper blueprint to life. The initial goal was to build a vehicle for a contest. But team leader Hamzah Sikander '09 ECE says the competition immediately became just a waypoint on a journey to a higher ideal.

Like the DARPA challenge teams, Cornell MineSweeper is dedicated to constructing an autonomous vehicle, but one that can detect and remove landmines. Its intended use is for non-combat areas, targeting anti-personnel devices that maim or kill someone every 22 minutes somewhere in the world.

"I feel like we have a real mission," Sikander says as he oversees Cantwell building part of the team's solution. "This is not about a competition."

As a rookie team starting everything from scratch—and the latest team on the engineering scene at Cornell—the Cornell MineSweeper audited this year's Intelligent Ground Vehicle Competition held May 30 to June 2 at Oakland University in Rochester, Mich. The experience inspired the student engineers.

"We are going to be the big thing very soon. And we are very much in the path of our success," Sikander says. "The idealism of it is very important."

Engineering to Save Lives

The mission of this student-initiated project is to design and fabricate a landmine detection robot that is low-cost as well as autonomous. Doing so requires a diverse skill set, including understanding of machine vision, artificial intelligence, mechanical design, and landmine detection. Such a robot would become central to de-mining operations, benefitting military, commercial, government, and community interests. But Sikander underscores that Cornell MineSweeper is, first and last, a humanitarian endeavor. He became team leader earlier this year, succeeding colleague and friend Vikas Reddy '08 ME.

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Their mission reflects time-honored principles of the profession. The first value statement for the National Society of Professional Engineers is: "Protection of the public welfare above all other considerations." Another touts the importance of "teamwork, unity, and fellowship of all professional engineers across all disciplines."

The project's cross-disciplinary challenges appealed to Cantwell. He was inspired to sign up after seeing a flier for the new team late last year.

Launched in 2007, Cornell MineSweeper has already swept in a few accolades. Based on his work on the project, Reddy was selected as a Cornell Presidential Merrill Scholar in May. In March, the Cornell Engineering Alumni Association named Cornell MineSweeper the Project Team of the Year. The team won $1,000 and was honored at the association's annual banquet.

Also in March, Nobel Peace Prize co-laureate Rae McGrath delivered a lecture at Goldwin Smith Hall on his work to rid the world of landmines and cluster bombs. A co-founder of the International Campaign to Ban Landmines, McGrath met with Cornell MineSweeper and applauded the team's vision and its research before launching development. McGrath said Cornell MineSweeper was valuable in its flexibility and he promised to stay in touch as a resource.

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Rae McGrath, 1997 Nobel Peace Prize co-laureate, speaks on landmines and cluster munitions in Goldwin Smith Hall in March while showing on screen a photo of a cluster munition explosion on a concrete street in Iraq.

Associate professors Ephrahim Garcia, of the Sibley School of Mechanical and Aerospace Engineering, and William Philpot, of the School of Civil and Environmental Engineering, serve as faculty advisers.

"In this project, no one discipline can solve all the problems so the students learn to work together and rely on one another," says Garcia. "The real world is unforgiving. It is important for students to get to the crux of the problem as quickly as possible. There is nothing better than real machines and devices in order to learn these lessons."

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The Problem

Researching current landmine detection and removal technology brought home to the team just how pernicious the problem is. Since their deployment in mass numbers during World War II, landmines have killed and maimed hundreds of thousands of people. Whether from a conflict that has simmered for decades or a war long since over, leftover antipersonnel mines kill indiscriminately in regions around the world. The International Campaign to Ban Landmines estimated that by the end of the 1990s there were between 15,000 and 20,000 new casualties each year.

"I was more shocked at just how bad we are at finding them and getting them out of the ground," says Cantwell. "Pretty much the most effective way of doing it now is to go out there with a metal detector."

Some of the most mine-contaminated places are Afghanistan, Angola, Burundi, Bosnia and Herzegovina, Cambodia, Columbia, Iraq, Nepal, and Sri Lanka, according to the campaign. Peace has come to many of these one-time hotspots, but like a bad memory, the landmines linger on. They do not distinguish between the footfall of a soldier or a child. In Afghanistan in 2006, 59 percent of an estimated 796 total casualties were children, according to the group.

Committed to an international ban on the use, production, stockpiling, sale, transfer, or export of antipersonnel landmines, the campaign led to the 1997 Mine Ban Treaty that now has 156 member states. But for various political and military reasons, as of April of this year, 37 countries have not signed the treaty, including India, Israel, Pakistan, Russia, Vietnam, and the United States. Still, the treaty is making a difference, McGrath has noted, though the organization is continuing its work and concentrating on a variation of the killer: cluster munitions.

Sikander, who is from Pakistan, says some team members have met some family members of mine victims in the course of their work. "For some of us, from our own countries," he says.

Some team members have met some family members of mine victims in the course of their work, in some cases, from their own countries.

The interaction, so emotional and inspirational, cast their work in a new light. "Everyone should pay attention to it," he says.

The Challenge

The Intelligent Ground Vehicle Competition is designed to advance and promote intelligent mobility for civilian and military ground vehicles. Such driver aids will make possible the automated highways and intelligent transportation systems of the future, according to event organizers.

Bill Agnew, co-chairman of the 16th Annual Intelligent Ground Vehicle Competition and a judge in this year's design category, says faculty advisers praise the event as an excellent multi-disciplinary design experience for student teams. A number of schools also give credit for student participation.

"In the auto industry there is already movement to introduce lane-detection technology in cars, and inter-communication between vehicles and between the vehicle and the infrastructure is coming soon. Rangefinders to predict collisions and aid in parking are already in use. Industry will benefit greatly from having available engineers with experience in these kinds of technologies," says Agnew, former head of Research and Development at General Motors and a Society of Automotive Engineers Fellow, in an e-mail. "It may also benefit from some of the unique innovations created by IGVC teams. Also, the automobile and many other types of machines and mechanism are now controlled by electronics and computers, as are our IGVC vehicles; there is high demand for engineers knowledgeable in these areas of control."

Agnew says student benefits include the hands-on and real-world intensive engineering experience, including practical mechanical, electrical, and computer science work. "It is highly dependent on systems engineering, a subject where industry leads most engineering schools by a large margin," Agnew says.

And the team work is increasingly important in today's workforce, Agnew adds. He reports finding more women on

Standing row (from left):
Prof. Ephrahim Garcia (faculty adviser), Greg Meess, Sarah Leung, Karim Hamdoun, Hamzah Sikander, Michael Hsu, Saran Baskaran, Vaishal Patel, Evan Levine, Steve Gilson, Naveen Dasa, Felix Pageau
Top seated row (from left): Tanya Gupta, Harsh Chamria, Hung Dang, Jawwad Asghar, Steven Liu
Bottom seated row (from left): Jay Dev Mahadevan, Yong Sheng Khoo, Andres Mack

Vikas Reddy

University Photo

the teams than ever before and non-engineering majors, including business and liberal arts students.

Sikander says his 35-member team features a mix of majors, including students majoring in Spanish and economics.

The IGVC competition is judged on several categories, including design, autonomous function, and navigation.

Specifications for the small all-terrain vehicle mandate that it must be between 3 feet and 7 feet long, and between 2 feet and 5 feet wide. It cannot exceed 6 feet in height. Maximum vehicle speed is 5 mph. Each vehicle is required to carry a 20-pound payload, typically a cinder block. A team must demonstrate that its vehicle can detect and follow lanes, and avoid obstacles on an outdoor course. Vehicles cannot be remotely controlled by a human operator during competition. All computational power, sensing, and control equipment must be carried on board the vehicle.

University Photo

David Heller '81 ME presents CEAA's Al George Award for best project team to Cornell MineSweeper members Vikas Reddy '08 ME, Hamzah Sikander '09 ECE, Andres Mack '09 (independent major), and Steven Liu '11 ME.

Progress: A Game of Inches

Cornell MineSweeper is so new that it operated from vacant classrooms for several months before landing lab space at the start of this year in the basement of Upson Hall. Team members constructing the vehicle in May methodically worked on the project under tight deadlines. Without its aesthetic covering applied, the base of the vehicle looked like a heavy duty vacuum cleaner, though one designed to sustain a rough landscape.

Cornell MineSweeper is approximately 4 feet tall. It has a camera mount to add future sensors, and the vehicle system is waterproof. It is powered by a lithium battery.

"This thing is designed to be very solid," Sikander says. "We've given it a lot of punishment. If you strip off the expensive sensors, this thing can probably be made again for $5,000."

But the team upgraded its motors, so a rebuild would cost around $8,000. "The total price tag of this thing at this moment, if you were to rebuild the exact same thing with all the sensors would be around $50,000."

MineSweeper is not designed to last through a direct explosion. To test its durability, teammates dropped the vehicle randomly and from different heights.

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"In this project, no one discipline can solve all the problems so the students learn to work together and rely on one another,"

—Ephrahim Garcia, Sibley School of Mechanical and Aerospace Engineering

"We like to call this a modular design because we can take things apart pretty easily," he says.

Landmine activist McGrath, upon conferring with Cornell MineSweeper, spoke of the value of removing mines, not just detecting them, according to Sikander.

McGrath discussed functionality, such as the addition of clearing and cutting tools. As a result, the team intends to review the potential for a robotic arm with the Cornell Snake Arm team.

"It's basically whatever you want to do with it," Sikander says. The goal is to develop a method that is 100 percent accurate or, if less perfect, to achieve detection and removal without human consequence.

In constructing the vehicle, the team kept an eye on sustainable practices, as much as they could. The aluminum can be reused. And there are very few parts that cannot be recycled. In addition to the vehicle function, Cornell MineSweeper had to create the software to operate the vehicle and sensors.

"It's making 10 decisions every second," Sikander says.

Sikander says money was the team's biggest challenge because motors and sensors are so expensive. Also, as a new team, it was required to buy tools and supplies. Cornell MineSweeper has a $13,000 budget, without gifts, from different departments and schools in the university.

The team runs like a business, with a chain of command for work on various parts of the vehicle production and operation. Sikander estimates team members have logged 8,000 hours, working according to task. The first semester, there were two team leaders, sub team leaders, and members, with much communication and file sharing online. MineSweeper also focused on interacting with other competitive teams to build relationships.

"We understand we are the new kid on the block," Sikander says.

At some point, the team plans to share its research, design, and development on the Web, embracing the open-source concept to advance its mission. "Here's everything," Sikander says. "Use it, upgrade it, whatever you like."