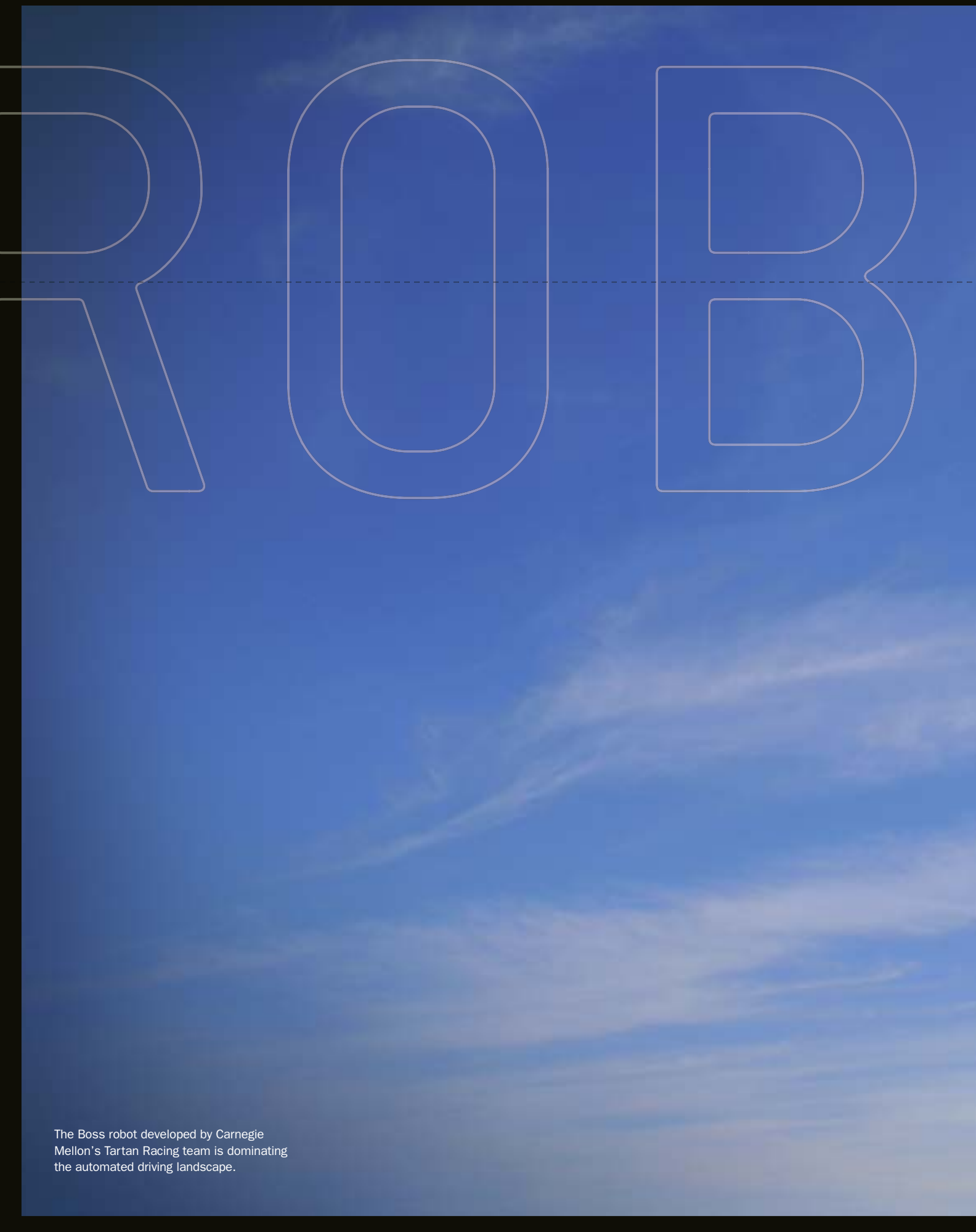

The Boss robot developed by Carnegie Mellon's Tartan Racing team is dominating the automated driving landscape.

ECONOMICS

CARNEGIE MELLON UNIVERSITY TOOK THE TOP PRIZE IN LAST FALL'S DRIVERLESS ROBOT COMPETITION; NOW NATIONAL CORPORATIONS AND LOCAL FOUNDATIONS WANT TO APPLY THE NEW TECHNOLOGY IN WAYS THAT WILL MAKE DRIVING AND OTHER TASKS SAFER WHILE EXPANDING ECONOMIC OPPORTUNITIES IN THE PITTSBURGH REGION.

BY CARMEN J. LEE AND C. D. JOHNSON PHOTOS BY TARTAN RACING

In Pittsburgh's South Side, there's an old locomotive roundhouse — a hodgepodge of brick, wood and sheetmetal that's weathered and discolored with age — where two SUVs sit loaded with enough technology to catapult the evolution of the car to levels only dreamed of not too long ago.

The 2007 Chevy Tahoes — each dubbed "Boss" — look like racing contenders with large sponsor logos emblazoned on their two-toned, black-and-blue exteriors. But the real action takes place in the elaborate network of software and hardware that stretches from a bank of computers in the rear of the vehicles to control monitors at the front and in the high-tech sensors strategically attached to various places on the bodies.

Using lasers, radar and global positioning systems, the two SUVs drive themselves with such precision that the Carnegie Mellon University team responsible for transforming them into driverless robots won the $2 million first prize at the Urban Challenge Robotics Competition in November. The race across a 52.8-mile cityscape course in Victorville, Calif., was sponsored by the Pentagon's Defense Advanced Research Project Agency, or DARPA.

Yet winning the money — and a large trophy in the form of a bald eagle that looks ready to swoop on its prey — was just the first step of the challenge. Next is taking the technology from the roundhouse-turned–robotics lab to the mainstream of 21st century American life. "Maybe 30 to 40 years from now, it will be considered quaint to have a steering wheel in a car," says Chris Urmson, director of technology for Carnegie Mellon's "Tartan Racing" program.

From increasing mobility independence for the elderly and disabled to replacing the need for human workers on "dull, dirty or dangerous" jobs to making land travel safer and more convenient for the average person, the applications of robotics technology are numerous.

"If there was a push to get a good [research and development] program running and with solid funding available, the commercialization of some of this technology would be only about a decade off," Urmson notes.

Several Pittsburgh-area philanthropies, including The Heinz Endowments and the Richard King Mellon, Hillman and Benedum foundations, joined corporate sponsors in supporting work to move closer to that goal and to unleash the technology's enormous potential to be a catalyst for economic growth in the city and western Pennsylvania.

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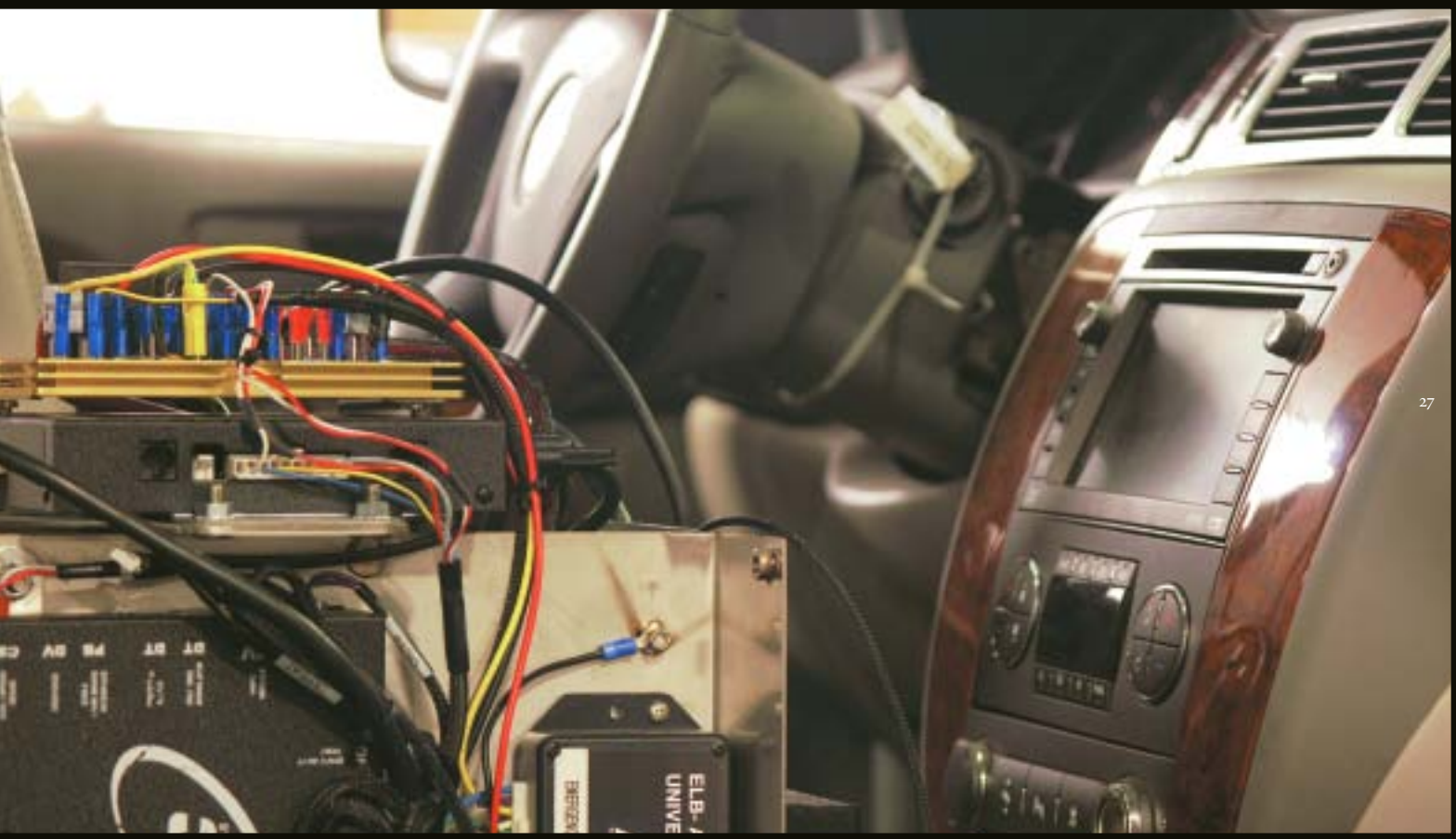

Photo: Vincent Zeng

Above: When the cover of the central console in the Boss robot is removed, the intricacies of its wiring and components are exposed. The console is between the front seats and includes controls and readouts that human drivers can use to monitor and "communicate" with Boss during testing.

Below left: Members of Carnegie Mellon University's Tartan Racing team work on one of the Boss robots inside the roundhouse garage in Pittsburgh.

Below: Tartan Racing members talk with Allison Heinrichs, a reporter for the Pittsburgh Tribune-Review, while standing next to a Boss SUV on display during a site visit by the Pentagon's Defense Advanced Research Project Agency.

Photo: Vincent Zeng

Two years ago, the Endowments gave Carnegie Mellon $200,000 toward the development of "Robot City," which occupies a corner of former steel mill property that includes the old train roundhouse. The foundation, three other philanthropies — Benedum, McCune and Richard King Mellon — and the nonprofit Regional Industrial Development Corp. are members of the Almono Partnership, which purchased the 178-acre former steel mill and coke works from LTV Corp. in 2002 for brownfield development. In recent years, the site has been the center of robotic development activity for Carnegie Mellon students and researchers, commercial company sponsors, employees of spinoff companies and regional development organizations.

Last year, the Endowments awarded the university $650,000 to help support the commercialization of the technology developed through the creation of the Boss robots and others. Foundation staff also hopes to see startup companies and new technical jobs created in the Pittsburgh region, as well as innovative programs developed in city public schools that will help prepare students for employment in the robotics field.

"This world-class research is creating a whole new range of exciting commercial opportunities for robotics and advanced automation," says Christina Gabriel, the foundation's director of Innovation Economy. "Our support is designed to provide the best possible environment here in southwestern Pennsylvania to take advantage of this. With smooth connections between researchers and the region's growing cluster of robotics companies, innovations will move quickly into the new products that can stimulate job growth and lead to broadly shared prosperity."

William "Red" Whittaker, founder of the Field Robotics Center that developed the Boss robots, is personally committed to encouraging high school students and other young people to have an interest in robotics, which increases the possibility of future school programs based on the new technology, adds Bomani Howze, the Endowments' Innovation Economy program officer.

"There are great engineers all over the world who will tell you how they were first inspired by the teamwork they learned as part of Red Whittaker's robotics challenges," says Howze. "Now middle-school students like those in Pittsburgh Lincoln's pre-engineering program can have the opportunity to get connected to this work and the career paths that are being created by these industry collaborations in our region."

Because of ongoing advances in technology, ideas once considered so far-fetched they appeared doomed to the outer limits of science fiction are now a part of life in this millennium. Space exploration, computers and wireless phones have become so integral to our everyday lives that they now seem commonplace. Engineering and innovation have married to create microwave ovens, cyber pets and robotic vacuum cleaners.

Some of this existing computer and sensor technology — along with some sturdy nuts and bolts — served as the foundation for developing the Boss robots. For example, the Tahoe was chosen as the robot platform because it was roomy enough to rig up a central power strip that allowed several researchers

OPTIONAL EQUIPMENT

The Boss robot's exterior accouterments are as elaborate as the technical wiring inside. Shown above are:

1. Long- and short-range radars attached to the SUV's grate
2. Pan heads, mounted with radars and laser radars, known as lidars; the pan heads can move to check clearance for left or right turns
3. A Velodyne lidar, on the front of the roof; the spinning sensor provides a 360-degree view around the robot
4. GPS antennas
5. Lidars for sensing curbs and lane markings
6. Bumper-mounted lidars

and engineers to sit inside with their laptops and work on the software, explains Bob Bittner, head of robot testing for Tartan Racing. By placing bulky roof racks atop the SUVs, team members could easily move, add or remove some sensors, depending on which combinations were the best in guiding the vehicle.

Thanks to Carnegie Mellon's Robotics Institute—more specifically the institute's Field Robotics Center—Pittsburgh is on the cusp of becoming an epicenter of leading-edge technology for robotics. Whittaker is a multi-award–winning educator/scientist whose research has earned him 16 patents along with the admiration and respect of colleagues, corporations and students. He confidently asserts that, because of the center's work, "Pittsburgh is known as a robotics city."

Carnegie Mellon officials established the Robotics Institute in 1979 with the notion of designing machines to perform tasks that may be time-consuming and exacting, or even hazardous for humans, such as exploration and research in toxic environments. Think automated land rovers to explore the lunar surface, Mars and other planets. Through the work of the Field Robotics Center, the university's students and faculty transform such technology into everyday, mostly outdoor, applications—like a car that drives itself.

The Boss vehicles got their cool, muscular name from Charles F. "Boss" Kettering, co-founder of major automotive supplier Delco and a legendary inventor and innovator whose accomplishments include developing the automotive electric starter and the neonatal incubator. The robots were programmed with more than 100,000 lines of software code. The 27 sensors, the global positioning systems, and more than a dozen lasers, cameras and radars enabled the vehicles to have a 360-degree view of their environment.

Two SUVs were beefed up with the extensive technology so that development and refining of the robotics could continue without interruption, says Bittner. When adjustments were

Left: One of the Boss robots sits in a warehouse at General Motors' Desert Proving Grounds in Mesa, Ariz. The robots were originally black and tan, but that changed after they arrived in Mesa, where they received a new black-and-blue paint job and sponsor decals. Shown at near left is one of the Boss robots in full rally regalia.

being made in one, the other was up and running. And on race day at the former George Air Force Base in Victorville, the vehicle that didn't compete was available for spare parts, if needed.

After more than 70 other teams failed to make the qualifying rounds or finals, Boss bested the 10 remaining competitors by autonomously navigating the cityscape course, which contained intersections and two-way traffic created by the other robots and 50 stunt car drivers. The vehicles had to obey traffic laws while safely merging into moving traffic, navigating traffic circles, negotiating busy intersections and avoiding obstacles. Boss completed the course in the fastest time of four hours, 10 minutes and 20 seconds, nearly 20 minutes ahead of the Stanford robot, its closest competitor.

For example, as part of its sponsorship, Caterpillar provided advanced technologies such as drive-by-wire steering, sensing and software. The company's electronics system generated the electrical power and air conditioning for the on-board navigation, control and guidance systems. Additionally, Caterpillar had an embedded engineer working full-time with the Tartan Racing team.

"Team Caterpillar is tremendously proud to be involved as a sponsor of Carnegie Mellon's Tartan Racing team. This victory represents what can happen when business and academia combine forces and work toward a shared goal of advancing technology," says Tana Utley, vice president of Caterpillar's Technology & Solutions Division and chief technology officer.

"NOW MIDDLE-SCHOOL STUDENTS LIKE THOSE IN PITTSBURGH LINCOLN'S PRE-ENGINEERING PROGRAM CAN HAVE THE OPPORTUNITY TO GET CONNECTED TO THIS WORK AND THE CAREER PATHS THAT ARE BEING CREATED BY THESE INDUSTRY COLLABORATIONS IN OUR REGION."

Bomani Howze, Innovation Economy program officer, The Heinz Endowments

Beyond fulfilling a sci-fi fantasy, Tartan Racing's victory meant that the $2 million prize as the world's most accomplished robotic vehicle could be invested in the Robotics Institute to support research. The win also solidified relations with the team's 18 corporate sponsors, which included Caterpillar, Continental, GM, Google, Hewlett-Packard and Intel. Several of the companies are committed to the extent that some of them have established a presence in Pittsburgh to be able to continue to work closely with the project.

Caterpillar's involvement in the competition also has led company officials to open a Pittsburgh office as part of their commitment to pursuing development of automated off-road equipment for use in areas such as mining and construction.

GM is focused on using automation technology to reinvent the automobile in ways that enhance driving safety and reduce traffic congestion, energy consumption and emissions. The company had two engineers who worked on the Boss project.

"This competition has significantly advanced our

Right: A Boss robot sits at a four-way stop during the Nov. 3 Urban Challenge race in Victorville, Calif. The robot can't "see" the stop sign, but an electronic map of the cityscape course in its computers tells it that the sign is there. Boss has to correctly determine which vehicle has the right-of-way to enter the intersection.

Tartan Racing team members, some wearing white T-shirts and others wearing red ones, applaud in the grandstand during the Nov. 4 Urban Challenge awards ceremony.

William "Red" Whittaker, Tartan Racing team leader and founder of Carnegie Mellon's Field Robotics Center where the Boss robots were developed, proudly displays a bald eagle trophy after his team wins the Urban Challenge competition in Victorville, Calif., in November. Not on display is the $2 million that also was part of the top prize.

understanding of what is needed to make driverless vehicles a reality," says Larry Burns, GM vice president of Research, Development and Strategic Planning. "Imagine being virtually chauffeured safely in your car while doing your e-mail, eating breakfast and watching the news. The technology in Boss is a stepping stone toward delivering this type of convenience…We look forward to integrating the technology we used in this race into our cars and trucks, and to ensuring that future personal transportation is sustainable."

Other "real-time" applications of the technology include using robotics to guide tanks and other combat systems into high-risk battle zones without endangering soldiers as well as to aid in the recovery of miners in conditions that could be harmful to rescuers.

Back at Robot City, a row of robots that look like large riding lawn mowers offers a glimpse of the technology's more routine work potential. With various tools and equipment attached to their frames, the robots help with the site development, including such activities as surveying, leveling the land, preparing the ground, removing old walls and structures, shoveling snow, landscaping and mowing.

Leaders in robotics research believe that having a single location for research activities is critical to rapidly transferring technology into commercial application. Applying field robotics to operations and enterprises such as "urban challenges" inspires students and attracts attention to Pittsburgh as an exciting place to develop and commercialize visionary technology.

Already, small companies are starting to crop up in the region to develop new applications for this latest robotics technology. They include RedTeam Inc., which evolved out of the lessons learned from robots built for the 2006 Grand Challenge, a precursor to last year's Urban Challenge. The company uses automated driving technology to perform environmental surveys.

Whittaker also points to Astrobotic Technology Inc., which opened recently to use robotics technology to pursue space enterprises that include working with him on his next project: trying to capture the $25 million Lunar X Prize sponsored by Google and the X Prize Foundation. That competition will require building a robotic rover and devising a way to land it on the moon, where it must be able to travel at least 5 kilometers and beam photographs back to Earth. The deadline for completing the task is the end of 2012, with a smaller prize awarded if the first successful rover lands on the moon before the end of 2014.

With more earthbound priorities, the technology used in the Boss vehicles is being shared through a "world tour" of various conferences—"Today Show" television personality Al Roker even hitched a ride in the robot at one event—and through journal papers.

Carnegie Mellon and corporate researchers also are continuing to investigate more applications of the technology, bolstered by new possibilities to move abstract, far-flung notions from concept to reality. *h*