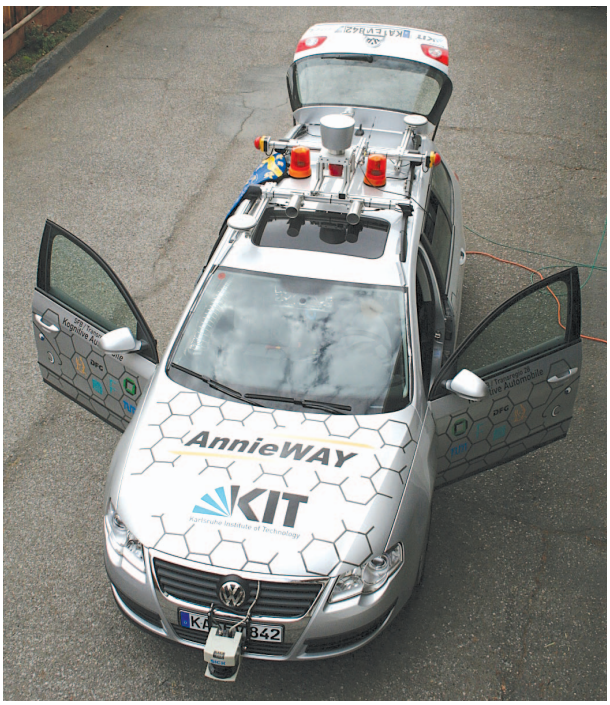
BY HEATHER WAX

Autonomous Vehicle Development: No Accident

MARY ELLEN RANDALL AND ANNIE LIEN USE LIDAR, PROXIMITY SENSORS, ACCELEROMETERS, AND RADAR—NOT TO MENTION COMPUTERS—TO BUILD CARS THAT DRIVE THEMSELVES

In the fall of 2006, the Insight Racing team in Cary, North Carolina, began turning a bright-blue Lotus Elise into a driverless vehicle that could compete in a robotic car race. Working with a truck would have been a lot simpler. With an SUV, say, the team could stuff the back with big computers. With the Elise, they couldn't. The Elise is a small car with its engine in the rear, next to the trunk. The computers that would drive it had to be small enough to fit—without overheating—but still able to store and process the vast, rapid flow of information coming from the car's sensors. Cooling became a huge issue. But Lotus was willing to sponsor the team and give it the car, and it was an offer Insight Racing couldn't refuse.

"A sports car created a lot of unique challenges we had to address," says Mary Ellen Randall, former chair of the IEEE Women in Engineering Committee and the only female member of Insight Racing. "But getting a small solution is



The AnnieWay robotic car made it to the finals of the Urban Challenge where it competed for US$3.5 million in cash prizes.

PHOTO COURTESY OF ANNIE LIEN

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very valuable. In order to make this work on a sports car, we solved engineering problems that no one else had to grapple with. So we felt like we came a long way toward miniaturization of the whole autonomous vehicle problem."

Moving Light-Years Ahead

Randall's husband Grayson, the team's leader, founded Insight Racing five years ago, and last October, its little car competed in DARPA's "Grand Challenge." The mission of DARPA, the Defense Advanced Research Projects Agency, part of the U.S. Department of Defense, is to develop technology with military applications. When, in 2001, Congress mandated that at least a third of all military vehicles be autonomous by 2015, the agency responded with a series of races, all with million-dollar prizes and open to anyone who could build a driverless robotic car. "They needed to move autonomous vehicle development ahead faster than it was going," says Mary Ellen Randall. "Since anybody could sign up and work on this problem, there was a lot of development in a short period of time by a lot of different creative minds, and the whole technology moved light-years ahead very quickly."

In the first Grand Challenge, held in the Mojave Desert in 2004, no vehicle made it more than eight miles past the start. Back then, Insight Racing was using a 1987 Chevy Suburban that members of the team had chipped in to buy, and while it was invited to compete in the national qualifying event, "because we didn't have enough funding, a business decision was made not to go," Randall says. "We could have tried to raise the money to go out to the race, but there was only a one-year development cycle, and we didn't feel that was adequate for someone to be able to win it.... So instead of spending money on the trip, the team said we're going to focus on further development of the car."

The decision paid off. In 2005, the Suburban's scores placed it 12th out of 196 cars in a second desert challenge; five vehicles finished the 132-mile race.

PHOTO COURTESY OF ANNIE LIEN

Team members expose the inner workings of the AnnieWay robotic car.

An Urban Challenge

DARPA then moved the competition to the site of the former George Air Force Base in Victorville, California, in 2007, and raised the stakes. It created an "Urban Challenge" that required entrants to build cars that could obey traffic laws, navigate obstacles, park themselves, and avoid other moving vehicles successfully—and as quickly as possible. (See box "A Robotic Chauffeur in the City") Insight Racing's Lotus, the smallest car in the competition, was a semifinalist.

It was an impressive finish for the all-volunteer Insight Racing team, made up of industry engineers, members of the North Carolina State University community, and a number of engineering students. "I got involved to work with students, to give them a real-world project to work on. It has a large scope and it's long term, and it gives them something they can't get in the classroom.... There are so many life lessons you get out of a project like this-not to mention the technical things that you learn," says Randall.

DARPA responded to a Congressional madate for autonomous military vehicles by holding driverless robotic car races for million-dollar prizes.

Friendly Competition

"When you're at the competition, what's really nice is that's where you have a chance to kind of collaborate, to go and view what everybody else did with their car. Because we're all housed together in a pit area, it's easy to walk from one team to the next to the next, and although you can't get into what they did software-wise, you can see where they mounted sensors, what kinds of sensors they used, and you get to talk to all kinds of people who are like-minded, who have a common interest. So it's a really high-energy event. I think the students were surprised

about how intense it was and how much they could learn just being there."

It was at the Urban Challenge that Randall came to know Annie Lien. Lien, a contract worker at Volkswagen's Electronic Research Laboratory in Palo Alto, California, was the only woman to lead a racing team. Like Insight Racing's Lotus, Team AnnieWAY's car, a silver VW Passat, was equipped with lidar (light detection and ranging) sensors that can find obstacles around the car, look for curbs and depressions in the road, and detect whether the vehicle is going uphill or downhill. They also both used radar technology that could detect cars driving ahead and those in oncoming traffic, as well as a GPS navigation system and a "drive-by-wire" system, which allows computers to control the gas, steering, and brakes. But unlike the standard-production Lotus, which Insight Racing had to convert to a drive-by-wire vehicle, the AnnieWAY's Passat was custom made so that it could switch between manual and autonomous driving.

When you're in any kind of engineering-related field, you have to use creativity, and creativity is also the edge in the entrepreneurial world.

"I had to understand the technical things on a basic level," says Lien, a specialist in human-computer interaction with no engineering or robotics background. "When I was asked to be the team leader, at first I was surprised…. But they were basically going by, 'Who do we know that we trust?' Gender was not an issue."

A Few Days of Paperwork

It was back in 2006 that Lien met German researchers Sören Kammel and Ben Pitzer at the Robert Bosch Research and Technology Center in Palo Alto. Kammel and Pitzer wanted to start a team for the robotic car race, and they had the backing of a number of German institutes and universities working together at the Collaborative Research Center on Cognitive Automobiles, but the official rules of the race required that teams be based in the United States and be led by a U.S. citizen. So they turned to Lien, assuring her the job would entail only a few days of paperwork. Before long, however, she was spending nights and

A ROBOTIC CHAUFFEUR IN THE CITY

The third DARPA Grand Challenge—the "Urban Challenge"—was a far cry from the agency's first two robotic car races. The wide-open desert courses of the previous contests were traded for a 60-mile course in a city environment, simulated on a former Air Force base in California. In the desert races, cars simply had to stay on course and within the road boundaries. Now, they had to complete a series of missions that included parking, turning, and getting from one specific point to another. And they had to do it all while following state traffic laws. It was a much trickier feat.

ROBOTS ARE PART OF THE TRAFFIC

Out of 35 semifinalists, 16 cars were disqualified and only 11 were selected for the final race on November 3, 2007. "The [National Qualification Event] tested the vehicles' capability to merge into traffic, navigate four-way intersections, respond to blocked roads, pass oncoming cars on narrow roads, and keep up with traffic on two- and four-lane roads," DARPA Director Tony Tether said in a written statement after six days of trial runs. "In fact, the only major difference between the NQE and the final event is that other robotic vehicles will be part of the traffic in the final event."

Exactly what the courses looked like is kept secret, but by all assessments, they were complicated, replicating the kind of terrain that many military missions encounter. "The courses were hidden from our view, so you don't know exactly what your car did when it was on the courses, and there was no scoring that was shared," says Mary Ellen Randall of the Insight Racing team, whose car was neither disqualified nor chosen for the final race. "We were allowed to put a camera on board that would record for analysis afterward, but there's no communication with the car during the race whatsoever, other than from the DARPA officials who could turn them off if they felt it was dangerous. That was the only remote interaction with the car—an emergency stopping capability. Even in the final race, you could see only bits of the course because it was a long road."

NO MOVING VIOLATIONS

A time limit of six hours was set for the final race, and with none of the top three finishers losing any points for traffic violations, it came down to which car finished fastest. The top prize of US$2 million went to Carnegie Mellon's Tartan Racing team and its 2007 Chevy Tahoe. The Stanford Racing Team, which won the 2005 challenge, took home second place and US$1 million with its Volkswagen Passat wagon, while Virginia Tech's Victor Tango team came in third with a hybrid Ford Escape, earning US$500,000. Tether said in a press conference that the average speed of Carnegie Mellon's car was about 14 miles per hour, while Stanford's car averaged about 13, and Virginia Tech's car was slightly slower, making for about a 20-minute time difference from one team to the next. Three other cars completed the course, though only one of them, MIT's Land Rover, within the time limit.

"Since teams successfully completed this race, I don't think they'll be another city race unless [DARPA's] looking for something very specific," says Randall. "Their role, I think, is pretty much done unless they come up with some other kind of gimmick. The cars can drive in the city and they can drive in the country; the technology has proven that it's viable. Now it goes into normal kinds of commercialization and development."

—Heather Wax

PHOTO COURTESY OF ANNIE LIEN

Annie Lien, a specialist in human-computer interaction, takes a moment with the AnnieWAY vehicle, while the Osh Kosh robot looms in the background.

weekends on the project, and she was hooked. Even though the team, a small group of engineers and students, received little financial support, AnnieWAY made the finals of the Urban Challenge, competing for US$3.5 million in cash prizes.

"I had a great time making the car work. I really found myself enjoying it.... But I never sought out to do this. I just do whatever I love and what moves me and motivates me. Women should do what they love, what really sparks excitement, and then go for it," says Lien, not only the sole woman on Team AnnieWAY but also one of the few women to compete at the race at all. "I always appreciated the engineering aspect, what engineers do, but I think now, maybe because I understand a bit more, I really feel their excitement."

DARPA has no further robotic races planned. Lien says she's looking for another engineering-type project to get involved with, while Randall is focusing on her company, Ascot Technologies, which develops software for cell phones that connects mobile people with large corporate inventories and databases—like the Multiple Listing Service.

Creativity Is the Edge

"When you're in any kind of engineering-related field, you have to use creativity, and creativity is also the edge in the entrepreneurial world. If you're trying to solve a problem—a technical problem or a business problem—it takes thinking outside the box, thinking about the problem on a bigger scale, looking at it from another angle," says Randall, who discovered that many of the skills needed to make a business run—risk taking, marketing, public relations, and funding—are also needed to make an autonomous car run and compete. "It's really important for young people starting out to realize that life is a whole learning process and just because you're out of school doesn't mean that you're done. You've got to keep your skills current and on the leading edge. It's really, really important, especially in this field, where things move so fast."

—Heather Wax is a freelance writer living in Brookline, Massachusetts.

PHOTO COURTESY OF ANNIE LIEN

Team AnnieWAY members proudly display their finalist medals, which were presented during the closing ceremony at the Urban Challenge.