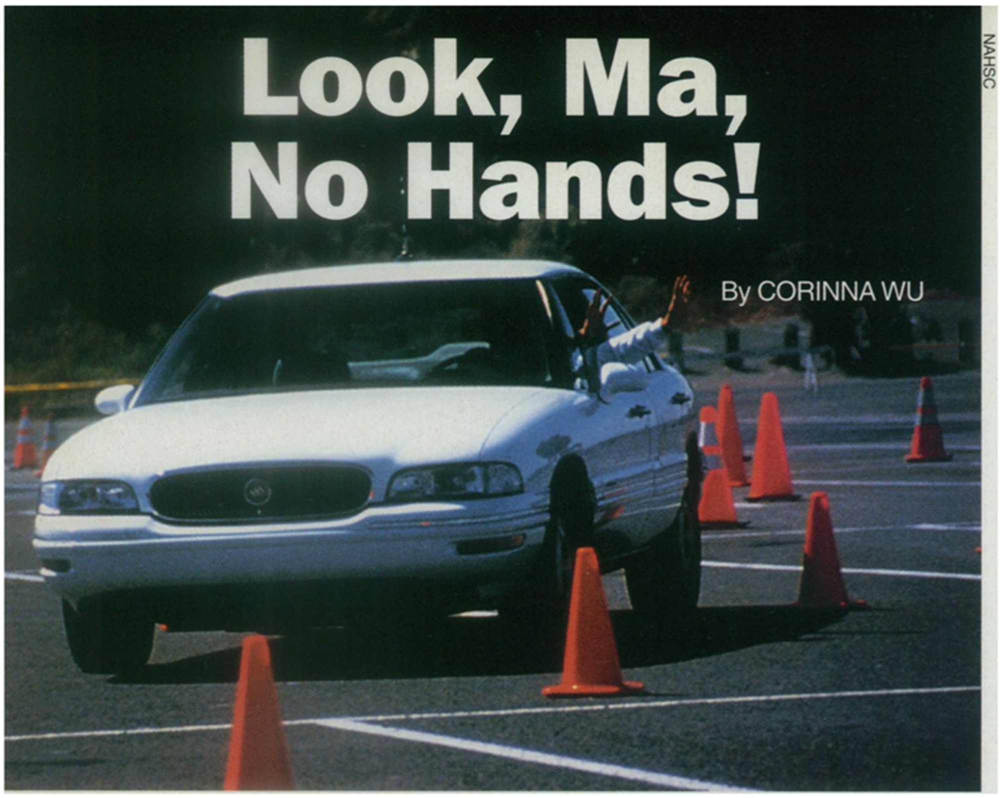

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An automated car navigates around traffic cones on a test course while its driver waves his hands out of the window.

Look, Ma, No Hands!

Automated cars take their drivers for a ride

By CORINNA WU

As the comedian George Carlin has wryly observed, anyone who drives slower than you is an idiot and anyone who drives faster than you is a maniac. Everyone believes that he or she drives perfectly; traffic jams and accidents would disappear if all of the other people on the road could just see the errors of their ways.

Now, by helping cars move in concert with one another, new technology promises to bring people closer to true driving perfection. A consortium of researchers from universities, government, and industry is developing an automated highway system in which cars drive themselves, communicating with the road and with each other. An automated highway system of this sort promises to reduce accidents, cut travel times, and reduce fuel consumption and pollution.

Since safety officials attribute 90 percent of accidents to human error, they reason that taking the human out of the loop should reduce the potential for mistakes. Moreover, a self-driving car won't rubberneck or brake unpredictably, causing traffic congestion.

From Aug. 7 to 10, the consortium demonstrated its new technologies on a specially modified, 7.6-mile stretch of Highway I-15 near San Diego. A total of 1,350 passengers took test rides in automated cars. Some waved their arms out of the windows, roller coaster style, to show off their handsfree driving.

In 1991, an omnibus transportation law called the Intermodal Surface Transportation Efficiency Act, or ISTEA (pronounced "ice tea"), authorized a research effort into automated highways and mandated a demonstration of feasible technologies by 1997. The National Automated Highway System Consortium (NAHSC) won a bid to run the program and must deliver a completed system by 2002, says Terry Quinlan, test and demonstration manager for the NAHSC in Sacramento, Calif. No one knows the details of the final system, although broad outlines have been drawn.

This month, Congress is expected to consider the reauthorization of ISTEA, which expires on Sept. 30. The new bill, the National Economic Crossroads Transportation Efficiency Act (NEXTEA), updates the provisions for the research program.

Dick Bishop, program manager for vehicle highway automation at the Federal Highway Administration in McLean, Va., believes that automated cars and roads are "inevitable." Auto makers will continue to improve cars to the point at which they drive themselves, he says, so the program is merely "bringing the roads and cars together to get greater performance." This will require the cooperation of many government agencies and car makers.

In the end, the real hurdle to building automated highways may not be in the technology but in convincing lawmakers and the public that it will work reliably and safely.

Although they seem futuristic, cars that drive themselves may just be the logical result of a trend toward automation. Power steering, automatic transmission, cruise control, and antilock brakes are already unremarkable features in many cars. Autos have come a long way from the days when starting the ignition meant turning a hand crank at the front of the car.

In San Diego, consortium members demonstrated several different technologies that might become part of the finished system.

Researchers from the University of California, Berkeley unveiled a concept called platooning, which has cars traveling close together in a pack, tailgating each other at a distance determined by computers. The cars communicate through radio signals, keeping track of each other's speeds. The car at the head of the pack acts as the leader, watching for what lies ahead and informing the rest.

The idea behind platooning is that cars equipped with sensors react faster and more reliably than a human can and thus are able to drive closer together to increase traffic flow. Human drivers have long been taught to leave enough distance between traditional cars to allow for a 3-second delay in a person's response. An automated car, on the other hand, can react to a problem in milliseconds.

For the demonstration, researchers at Berkeley's Partners for Advanced Transit and Highways program (PATH), cooperating with General Motors, extensively modified eight 1997 Buick LeSabres as well as the stretch of Highway I-15's high occupancy vehicle lane.

Embedded in the road are cylindrical ceramic magnets—"like refrigerator magnets, but larger," says PATH's Wei-Bin Zhang—spaced a few feet apart. Magnet sensors installed on the underside of the cars detect these markers and keep the cars centered in the lane. Because the north-south polarity of each installed magnet can point either up or down, the set of magnets can encode information about the roadway in binary format. A laser sensor mounted under the front bumper of each vehicle acts as an electronic eye to keep tabs on other cars and any obstacles.

The various sensors offer drivers "more pairs of eyes," Zhang says.

The cost of automating an existing highway should be only a fraction of the cost of building new roads, Bishop says, which currently averages about $50 million per mile per lane. Adding magnets or other passive reference markers would only amount to about $10,000 per mile per lane. The lipstick-size magnets cost 80¢ apiece plus $5 to install each one, Zhang says. As for the cars, the on-board computers are the same as those sold at any computer store.

Platooning could potentially double or triple lane capacity, using existing roads more efficiently. "In a lot of places like Los Angeles or San Francisco, there's no place to build new highways," Zhang says.

Eliminating stop-and-go traffic also translates into fuel savings, he adds.

What's more, if the cars travel close enough to each other to take advantage of drafting, the pressure reduction created behind a vehicle, all the cars except the leader would get even better gas mileage. In wind tunnel tests, a half-car-length spacing translates into a 20 to 30 percent fuel savings. Such a short following distance is likely to be nerve-racking for drivers, however. For the demonstration, the cars maintained an arbitrary distance of 6.5 meters while moving at highway velocity, but they were instructed to increase the distance to 15 meters as soon as they encountered a problem.

Magnetic guidance systems could be used for a wide variety of vehicles, such as snowplows, Zhang says, since the technology seems to work fine in inclement weather.

An automated highway system that requires modifications to infrastructure suffers from the "chicken or the egg" dilemma, says Quinlan. Without enough automated cars, converted highways would go to waste, but without converted highways, automated cars wouldn't take full advantage of their features.

In any case, it would be impractical to modify all highways, especially those in little-traveled rural areas. The danger of quiet, lonely, country roads lies mainly in people falling asleep behind the wheel—a danger that automated systems could mitigate even on unmodified roads.

With the various issues in mind, members of the consortium have developed what they call multiplatform, free-agent technology. Working with Houston Metro—the city's local transit authority—Carnegie Mellon University in Pittsburgh outfitted two buses and three passenger vehicles with a system that navigates by monitoring existing lane markers on the road.

A postage-stamp-size camera mounted on the windshield behind the rearview mirror takes images of the road many times per second. An on-board computer analyzes them and instructs the vehicle to center itself in the lane and avoid obstacles such as oil spots and ruts. The camera controls only the steering, says Todd M. Jochem, a systems scientist in Carnegie Mellon's robotics department, while a radar mounted in the front controls acceleration.

Because of the vehicle sizes, Jochem says, "we thought there was going to be a difference between the bus and the car [in the software needed], but there wasn't." The biggest challenge for the group was integrating the camera and radar systems, especially for executing maneuvers such as changing lanes.

In July 1995, the group drove one of its automated cars from Washington, D.C., to San Diego. Except for about 50 miles, it had no problem navigating. Ten of those 50 miles had just been paved, so there were insufficient lane markings, Jochem explains.

Only by doing lots of on-the-road testing can the researchers improve their software's recognition capabilities. "You can't sit down and enumerate every situation," Jochem says. Good drivers are able to analyze thousands of different road conditions and react appropriately.

NAHSC

Self-guided cars allow their drivers to concentrate on other tasks, such as typing on a portable computer. A camera mounted on the windshield watches lane markings and controls the steering.

People may adjust their driving styles easily to fit whatever road they're on, but automated cars need a little more help. In San Diego, Honda engineers demonstrated how a car could integrate both platooning and free-agent technologies, switching from one to the other depending on the road. Car makers don't want to limit their products to work exclusively in urban or rural settings, says Damon Delorenzis, an engineer at Honda Research and Development in Torrance, Calif.

On two 1996 Accords, Honda researchers modified the actuators—the systems that steer, brake, and accelerate the vehicle—while U.C. Berkeley scientists took care of the control and sensor systems. The cars combine many of the individual components tried earlier: magnet sensors for platooning, a camera-based vision system, and a laser sensor for detecting obstacles.

"The technology is not as 'Star Wars' as people might think," says Delorenzis. The NSX, one of Honda's top-of-the-line sports cars, for example, already comes with actuators that can respond to computerized commands.

In future passenger cars, a computer might be connected to the power steering, he says, which is used now only as assistance, not as control.

The consortium members expect that advanced technologies will be introduced into new cars slowly. At first, new features would probably only assist drivers, as in lane-departure warnings, says Delorenzis. Later, the computer might copilot without taking complete control. Finally, cars might offer full automation.

The researchers are working with the idea of modifying the standard car models that come out 10 years from now, not the autos of today. Many of the needed systems will already be there, the consortium members say, so it won't be too large a leap to a fully automated car.

Toyota is exploring evolutionary scenarios, planning how new features could be gradually integrated into cars as steps toward full automation. Adaptive cruise control, for instance, could sense when a car is getting too close to the vehicle in front and adjust speed accordingly. Laser sensors or cameras could warn drivers of obstacles in the road or if the car is drifting out of the lane. These innovations could come within 5 years, Jochem says, while fully automated cars probably will require another 25 years to take hold.

Japan is also actively pursuing automated highway research, striving to have a section of automated highway in use by 2005.

The San Diego demonstration marked completion of the U. S. program's first goal by showing that an automated highway system is technically feasible. However, the most challenging aspect may not be developing the technology but working out the complex policy issues. While the consortium is developing the blueprints for a final system, it is also confronting the issues of safety, liability, environmental impact, and how people might interact with the technology.

About 125 organizations, such as local transportation agencies and car companies, have signed on as associates of the consortium, Quinlan says. "We need to have a national consensus on this, so that we're not just laying the system on the nation."

Will the public accept automated cars and highways? Bishop believes that the demonstration convinced many folks to give them a try. The public has already put its trust in airplane flight, which is highly automated, he says.

"People are technically savvy enough to accept it," says Quinlan. The choice of whether to use the automated features in a car will likely remain with the driver, so motorists can opt for the traditional way of driving whenever they want.

Although automated highways sound like the stuff of science fiction novels, the primary purpose remains the same as for any transportation system—to get people where they're going safely, cheaply, and quickly.

"Driving is intuitive," says Delorenzis. "The goal is to make it easier, not more complicated." □