INTELLIGENCE in Motion

Smart-vehicle technology prompts new intelligence in transportation infrastructure and opportunities for engineers

By Samuel Greengard

INSET: C.J. BURTON; CHINAFACE/GETTY IMAGES

The automobile is undergoing a radical transformation. Advancements in technology, along with growing pressure to reduce congestion, trim carbon emissions and improve safety, are fueling the concept of connected cars and smart transportation systems.

Already, automated braking, lane-departure alerts, collision warning and adaptive cruise control systems are available in many vehicles. Meanwhile, Google's Self-Driving Car project has tallied more than 1 million miles without causing a collision. >>

Nissan's self-driving car makes a turn at an intersection.

THE ASAHI SHIMBUN/GETTY IMAGES

How these technological advances will impact America's roadways is a new challenge facing engineering firms. There's growing demand to develop smart infrastructure systems that do things such as alter traffic flow dynamically. Motorists are using apps, such as Google Maps and Apple Maps, to bypass congestion and incidents, but far more advanced vehicle-to-vehicle (V2V) communication and vehicle-to-infrastructure (V2X) systems lie ahead.

"There is a lot of research and development focused on automated and autonomous vehicles," says Matthew Schiemer, vice president of intelligent transportation systems at Gannett Fleming. "Although much of this technology is still well out into the future, there is no question that vehicles and driving will change over the coming years."

Industry leaders expect that change to provide significant business opportunities for engineers, according to the latest (3rd quarter/2015) *ACEC Engineering Business Index (EBI)*. Results show that "Smart Infrastructure/Smart Cities" was ranked No. 1 by Member Firm leaders (21 percent) among emerging markets they believe show the most potential for growth in the coming years, followed closely by "Renewable Energy Production, Transmission, Storage" (19 percent) and "Climate Change/Resiliency" (15 percent).

"When you change or eliminate reaction times, steering within lanes and other human factors, you can reengineer roadways to add capacity."

JOHN MOELLER
JOHNSON, MIRMIRAN & THOMPSON

Rolling Forward

It's no secret that the nation's highways are in need of technological advancements. According to an August 2015 study conducted by the Texas A&M Transportation Institute, U.S. drivers spent a collective 6.9 billion hours stuck in traffic in 2014. That equates to about 42 hours per year per commuter and collectively wastes $160 billion in time—approximately $960 per motorist. In addition, distracted drivers are a serious problem. Human error is responsible for 70 percent to 80 percent of all vehicle collisions, according to the U.S. Department of Transportation.

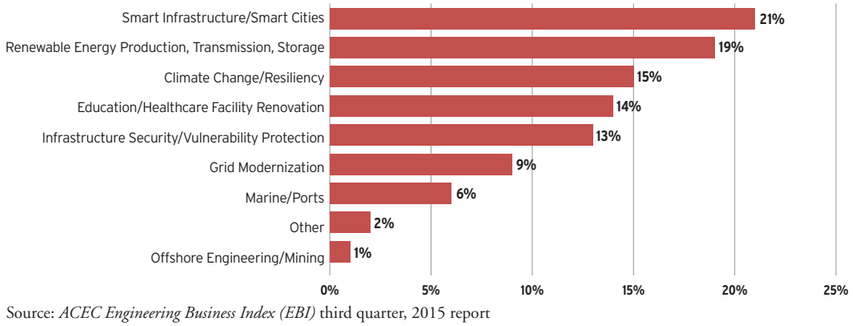
"It's very clear that we need to make infrastructure safer and more efficient," says Theodore Zoli, national chief bridge engineer at HNTB Corporation. "We need to make investments in smarter vehicles and transportation networks in order to maintain a functional transportation infrastructure and the desired quality of life."

Automakers are leading the way. They're moving forward with systems that reduce human input, and the technology is rapidly evolving. Many high-end cars now use sensors to brake automatically if a driver approaches a vehicle too quickly or does not begin to slow at a stop sign. Other vehicles issue alarms and warnings if a driver veers out of a lane without using a turn signal.

General Motors is introducing Super Cruise in the 2017 Cadillac. It takes control of highway steering, acceleration and braking at speeds of up to 70 mph through the use of radar, ultrasonic sensors, onboard cameras and GPS. Mercedes-Benz has already demonstrated a fully autonomous concept car, while Volkswagen, Audi, BMW, Nissan and other manufacturers plan to introduce vehicles that, under good weather conditions, operate without driver input on rural roads and interstate highways. These systems will also apply the brakes or take control of the steering wheel when they detect danger.

The endgame is smarter infrastructure. Today's informatics systems, including emerging products such as Apple CarPlay and Android Auto, offer basic input about traffic and can suggest alternate routes based on current traffic flow and congestion. "This introduces a level of connectivity that hasn't previously existed,"

Which of the following emerging engineering markets do you believe shows the most potential for growth?



Source: *ACEC Engineering Business Index (EBI)* third quarter, 2015 report

The Jane Addams Memorial Tollway (I-90) contains smart features designed by Alfred Benesch & Company that foretell the future of highways.

Automated cars will allow highway designers to narrow roadways and add more lanes.

ILLINOIS TOLLWAY

says Laura McGovern, senior vice president at engineering firm Alfred Benesch & Company.

As a result, highway designers will need to integrate signals, roads and other infrastructure to create V2V and V2X networks. As McGovern puts it, "Bigger gains are possible when most or all cars on the road are connected and communicating with one another."

For now, the framework is largely under development, and the federal government is establishing rules, standards and protocols for V2V and V2X systems. These mesh networks will use dedicated short-range communications to communicate with vehicles at a range of 1,000 feet or about 10 seconds at highway speeds. Ultimately, motorists will receive information and warning messages via a visual display or audible alert. In addition to providing alerts when it isn't safe to enter an intersection or when a vehicle several cars ahead begins braking, these systems would deliver warnings at rail crossings or when black ice appears on roadways. Sensors in roadways or data from other vehicles could alert motorists before they reach an icy patch or a flooded intersection.

"It's very clear that we need to make infrastructure safer and more efficient."

THEODORE ZOLI
HNTB CORPORATION

What's more, data from these sensors and vehicles would stream into Traffic Management Centers (TMCs) that monitor and manage conditions and events in real time. This would allow a TMC to adjust traffic signals or lower or raise speed limits, for example. It could also help officials dispatch maintenance crews or snow plows faster and exactly where they're needed.

Highways of the Future

An Internet of cars would revolutionize how engineers design highways. "When you introduce connected and autonomous vehicles, it's possible to have cars drive at optimal speeds and distances and nearly eliminate collisions," says Dennis Motiani, executive director of the National Operations Center of Excellence. "A smarter transportation network is possible." This could mean developing urban transportation grids that function in a real-time, optimized way by adjusting for changes in traffic flow dynamically.

Immediate possibilities include greater use of reverse lanes, express toll lanes and dynamic lines that adjust to capacity. Interactive lighting could provide speed or weather guidance, while dynamic paint adjusts to weather and lighting conditions.

Further out, as more smart cars begin to eliminate human operation, cars will travel closer together, allowing engineers to add additional lanes to roadways by narrowing their width. John Moeller, president of Johnson, Mirmiran & Thompson, an engineering firm that specializes in transportation projects, says, "When you change or eliminate reaction times, steering within lanes and other human factors, you can reengineer roadways to add capacity."

V2X systems will also pull data, such as traffic volume and speed, from connected traffic signals, bridges and tunnels, and adjust the speed or route of other vehicles. These systems could also reduce vehicles' carbon footprint and improve safety.

The Illinois Tollway's 15-year, $12 billion program, "Move Illinois: The Illinois Tollway Driving the Future," will improve mobility, relieve congestion, reduce pollution, and link economies across the Midwest region.

ILLINOIS TOLLWAY

For instance, they might detect a boulder or mudslide and issue a real-time alert. Connected infrastructure and vehicles would also allow buses and trains to optimize schedules and even wait a few minutes longer during a traffic delay. They could also hold signals longer for older or disabled individuals.

At some point, when fully automated and autonomous vehicles roll onto roadways, highways may no longer need signs, signals and other physical information delivery systems. "The display in the automobile becomes the alert system," Moeller explains.

In fact, the future is beginning to take shape. For example, the Jane Addams Memorial Tollway (I-90) in Illinois contains a smart corridor designed by Alfred Benesch & Company that provides information about traffic, collisions and road conditions at half-mile intervals. The system uses road sensors and cameras to collect data and feeds the data to signs that can direct traffic. "If the system detects a crowded off-ramp, it may suggest an alternate exit," McGovern says. "The system will communicate with drivers and let them know when a bus is using an inside lane."

In Singapore, officials have tested a system that relies on induction loops in roadways to monitor traffic. The next phase of the system will add data from video cameras and taxi GPS systems to provide more precise data about traffic conditions. The same technology is now being used in Lyon and Montpellier, France. The traffic control algorithm relies on a number of key factors, including road category, density of traffic on the road, speed limits, and traffic and incident data to adjust stoplights.

"The system will communicate with drivers and let them know when a bus is using an inside lane."

LAURA McGOVERN
ALFRED BENESCH & COMPANY

Challenges Ahead

The biggest obstacles, for now, are establishing design and engineering standards to support connected vehicles and obtaining funding to build connected infrastructure. McGovern says that without clear and workable standards that span 50 states and even other countries, "the entire system starts to break down. National standards must exist for both auto manufacturers and motorists."

Funding is another challenge. Motiani says, "With infrastructure and transportation funding dwindling, tax revenues falling due to fuel-efficient and electric vehicles, and virtually no political will to change the current environment, there are still many more questions than answers."

In the end, transportation experts take a cautious but optimistic view. "We are seeing the technology advance and vehicles becoming more sophisticated, but the idea of widespread self-driving cars is still decades away," Schiemer says. "There are still too many technology concerns, infrastructure issues, policy and legal matters, and social issues to sort out."

Nevertheless, Moeller believes it's important for engineers to view connected transportation as an opportunity. "The reality is that vehicles and highway design have changed considerably over the last few decades. This is simply a continuation of the trend. At some point, connected vehicles and infrastructure will take shape." ■

Samuel Greengard is a technology writer based in West Linn, Ore.