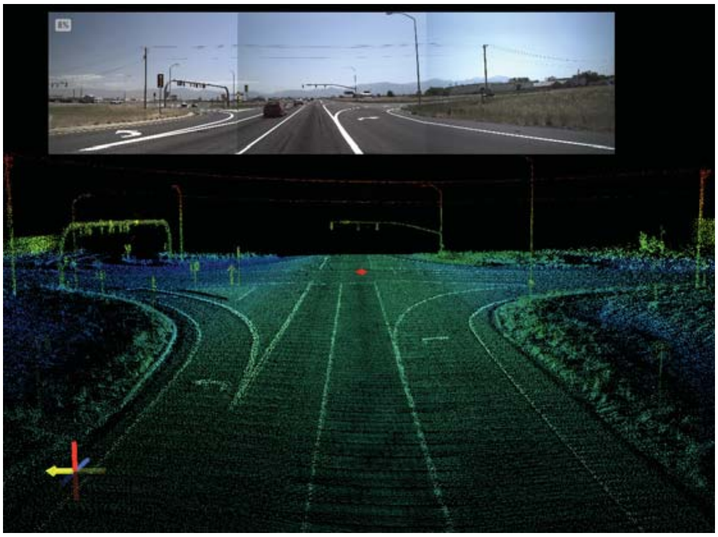
# Increased interaction

## Automation quickly becoming integral part of road safety



**By Robert Dingess**
Contributing Author

Next year marks the 100th anniversary of the first stop-sign installation.

Not surprisingly, this innovation was developed and installed in Detroit. It was a rather simple device—the word STOP written in black on a white metal background. Over the next century a system of uniform rules, road-design criteria, signs, markings and signals evolved to accommodate the human behind the wheel and keep them on the road. Roadside-safety devices also were developed and installed along U.S. highways so that when vehicles leave the road, the deaths, injuries and damages are minimized. As components of connected and automated vehicles enter the market, the interaction between the vehicle and the traffic-control devices and roadside-safety devices is expected to undergo a transformational change. This prompts the question: What is the future of traffic-control devices and roadway-safety devices in a world with an increasingly connected and automated vehicle fleet?

### Man vs. machine

Just like the legendary John Henry beat the steam-powered drill in the famed 1870 contest of man vs. machine, human drivers are nowhere near being replaced by automated drivers. Google's pronouncements and advancements notwithstanding, today's fully automated vehicle technology is still under development and has only been partially demonstrated, mostly on tightly controlled closed courses. Negotiating the more complex aspects that come with typical point-to-point commutes, such as home to work, have yet to be proven in a reliable manner. While feats such as driving legally blind Steve Mahan to the grocery store and through a Taco Bell drive-through—and more recent video of the Google car "reading" road signs in an urban setting—demonstrates improvement, our infrastructure is no more prepared to support full automation today than our road network was prepared for nationwide motor-carrier traffic prior to the interstate highway construction boom of the 1950s and '60s.

Reducing human input has the potential to allow for the reduction in the margins of safety commonly integrated into highway-design criteria, such as perception-reaction times, gap-acceptance times and element limits by human sight-distance restrictions such as vertical curvature rates.

According to ABI Research, the assisted-driving-system market reached $10 billion in 2011 and the number could go as high as $130 billion by 2016. A recent IHS Automotive industry study estimated that there will be 230,000 "self-driving" cars by 2025 and 11.8 million globally by 2035. They go on to predict that nearly all vehicles in use after 2050 will be self-driving. Companies that find themselves too far outside the technology curve fear that in-vehicle entertainment technologies combined with automated driving will result in strong market demand. In short, manufacturers need to keep up—or be left behind.

### Safety vs. productivity

In 2012, the FHWA estimated that vehicle-to-infrastructure communications could reduce 73% of single-vehicle crashes categorized as loss-of-control, roadway-departure and pedestrian-related—equating to annual costs of $164 billion. For multivehicle crashes, the estimated crash benefit is even higher at $175 billion. Clearly advanced vehicle technologies will improve safety. Safety, however, is not likely to drive adoption by consumers. Why? Most people think that other people are unsafe and are unwilling to pay a premium to let someone else drive them home.

If not safety, what will motivate the move from human to automated drivers? In all likelihood consumers will seek in-vehicle entertainment, conveniences and the increased productivity that full automation can provide. Policy makers, on the other hand, will be driven by the potential to reduce crash-related costs and improve mobility through reduced congestion.

Potential safety and efficiency benefits will be sought. Fully automated freight carriers, for example, can operate in a tight platoon formation, saving fuel. An automated tractor trailer can travel at a safe speed and will not be subject to hours-of-service regulations—it drives until it needs fuel, refills and continues to drive until it reaches the destination. A commuter in a fully automated vehicle can watch a DVD, work on the computer, shop on the way to the store, talk, text, search the Internet or continue working while on the way to her daughter's school event without worrying about the behavior resulting in a crash. These vehicles will be in as much demand as cell phones are today compared with when they burst on the scene in the 1980s.

Transportation agencies and policy makers will have strong incentives to get humans out from behind the wheel as soon as possible. Why? The cost of a road network designed to keep us alive is expensive and not terribly effective. The economic cost alone of motor vehicle crashes is estimated to be somewhere north of $200 billion annually. This, combined with our slow reaction and processing capacity, inability to think systemically and wide array of competency limitations, results in our underutilization of the current road network.

### FACT FINDER

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## Digitally enhanced

While these technologies are in limited use by transportation agencies today, the ability to improve asset inventory management and planning is changing the way agencies manage their systems. Fully automated vehicles tend to have a few core systems worth mentioning from a management perspective. These include: lidar, GPS and 5.9-GHz dedicated short-range communication connectivity.

Light detection and range (lidar) is a laser-based scanning technology. If you have checked out Google Earth, you have experienced lidar. Through lidar, the infrastructure is digitized to create a digital base map that provides virtual guide rails for vehicles, giving them information such as what lane they are in and the characteristics of upcoming horizontal curves. While lidar is used by data collectors to create base maps, automated vehicles also incorporate lidar to sense the roadway environment. Specialized GPS systems provide precise vehicle location information and in-vehicle communication devices send and receive signals to each other (V2V) and to pre-positioned corridor control systems (V2I) on a 5.9-GHz FCC band.

A number of states are beginning to utilize these same technologies to digitally capture their network. Every roadway feature is extracted to improve asset inventory management. Specialized pavement evaluation and sign-visibility technologies are used to provide detailed assessments of condition and performance. Utah DOT has digitally mapped its entire network twice using the same sensor technologies found on a number of high-end automated research vehicles. New management practices are already beginning to pay off in tremendous productivity gains and better planning, maintenance, safety and environmental tools are in development.

## In earnest by 2030

While it is impossible to fully know how technologies and societies will develop over the next 100 years, knowing what we know about today we can make an educated guess about the future role of road-safety devices in an age of connected and fully automated vehicles.

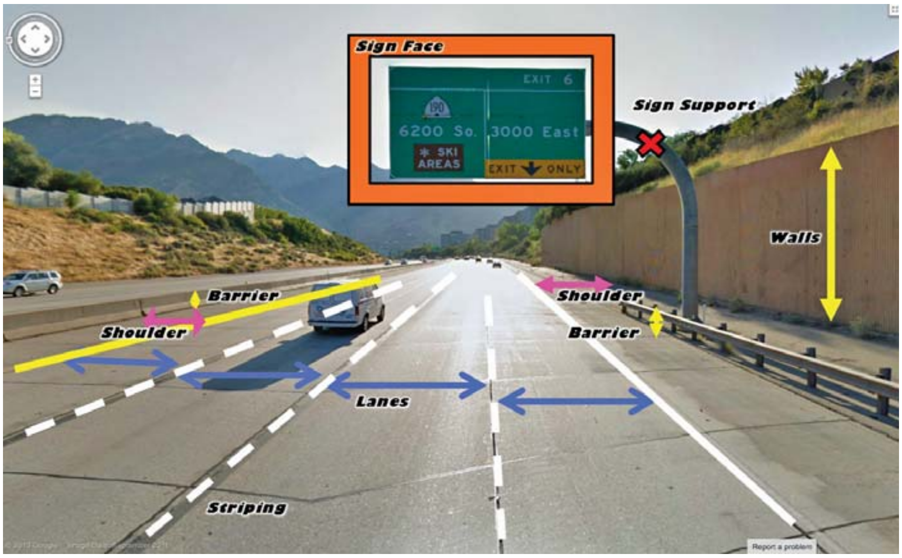
In the short term (five to 10 years), there will be very little change in the role of roadway-safety devices as the first generation of fully automated vehicles slowly makes its way into the commercial market. Beginning in 2025, however, full automation will gain greater niche market acceptance, and demonstrations of the technology for freight and transit purposes will begin in earnest by 2030. At this point serious discussions begin on when to incorporate these technologies into public and private transit and rental fleets. This will be a game-changer for transit as the possibility of creating "smart," integrated transit systems supplants more expensive passenger rail. Expect the first fully automated public-transit vehicle to be operating somewhere in the U.S. no later than 2035. If the IHS Automotive research study is correct that the entire fleet will contain full automation capabilities by 2050, this would be the result of a rapid market shift in the 20 years between 2030-2050.

How does this increased automation impact our current roadway-safety infrastructure? Over the next 20 years, roadway-safety devices such as traffic signals, signs and pavement markings will likely grow in importance and complexity. Traffic signals will likely be the first TCD to adapt to the benefits of connected and automated vehicles. Research is already under way to improve flow-through signalized intersections by having approaching vehicles communicate their arrival and having the traffic signals optimize timing to improve flow and reduce delay. Other TCDs are not far behind. As GM's Mike Robinson recently explained to Congress, automakers need "clearly marked lanes and shoulders. This will enhance the capabilities of the technologies we are already using to 'sense' the road." Markings that are currently designed exclusively for human vision will eventually give way to markings designed to be highly visible to both humans and machines. Markings may provide additional information to vehicles through embedded technologies or may be seen by vehicles even when they are not visible to drivers (think snow-covered roadways).

Regulatory sign meanings and locations may be embedded in lidar-captured digital base maps, or sign-sheeting technologies may be developed to enhance the ease of scanning by vehicle sensors. Devices such as guardrails are likely to remain a key safety component until fleet automation has reached significant market penetration (2040-2050). There will come a tipping point, however, at which time transportation agencies will begin to incorporate the various levels of automation into calculations regarding how and whether to install or replace guardrails and other signs such as guide signs.

Our nation's roadway construction and maintenance work zones need to become smarter. Traffic incidents and work zones add complexity to the connected- and automated-vehicle environment. You cannot capture short-term work zones in a fixed base map—but traffic-control plans can be layered onto previously captured digital maps with lane changes communicated via the 5.9-GHz band to connected vehicles operating within the region. Agencies and organizations like the National Committee on Uniform Traffic Control Devices should begin discussing how to safely communicate device meaning and location in a connected-vehicle environment.

One of the great benefits of a fully automated vehicle will be its ability to store and process more information about the system than its human counterparts. The capture of increasingly sophisticated base maps that incorporate friction, pavement condition, cross-slope, road curvature, width and other potential fixed hazards provides automated vehicles with the capability to more effectively match speed to road conditions. Algorithmic adjustments will be constantly altering speed and vehicle lane location to maximize safety and movement while connectivity provides data on other potential V2V threats. In the short term, agencies will use increased understanding of the network to make roadways safer for human drivers. Having automated vehicles capable of adapting to road conditions and other vehicles should dramatically reduce system improvement costs and allow for greater investments in long-term rehabilitation of the current network.



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## Preparing for an age of automation

State transportation agencies are already beginning the process of evaluating automated-vehicle technologies and seeking to understand their potential benefits and challenges. Michigan DOT and Caltrans have well-developed programs and Utah DOT hosted a meeting with automakers May 7 to discuss UDOT's network lidar digital base map. UDOT is offering to establish five connected and automated vehicle test decks using the network data to select appropriate testing sites. The same vendor that collected Utah's digital network is collecting auto manufacturers' vehicle research test tracks. The plan is for the auto industry to work with Utah DOT in selecting connected-vehicle technology suites for further evaluation on Utah roadways as early as 2015. Expanding the use of 3-D digital base maps for asset management and to accelerate the move to automation will be discussed during the upcoming U.S. DOT/GTMA Data Palooza meetings in June. In July, at the Transportation Research Board's Automated Vehicles Symposium, there will be a two-day breakout session titled Highway Infrastructure: Needs for Automated Vehicles. The session will include presentations and further discussions on the benefits of digital infrastructure and needs of traffic-control devices to support automated vehicles.

It is hard to imagine a future in which safety devices completely disappear from our nation's roadways. At some point, however, agencies may begin to ask if all the commonly used retroreflective signs and pavement markings will continue to be necessary. With vehicles that adapt to road conditions and provide dramatically expanded capacity, massive construction of new roadways may be significantly diminished as well. Almost 100 years ago, the first stop sign was installed. Today, that stop sign is essentially the same. What will the stop sign look like 100 years from today? Will there even be stop signs on our road network? This is an exciting time for the transportation industry. We are likely to see transformational changes in the next few decades unlike any seen since the contruction of the interstate highway. **ST**

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Dingess is president and chief executive officer of the Geospatial Transportation Mapping Association, Washington, D.C.