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# New connections

**David W Smith** speaks to state DOTs in the USA about the challenges of deploying connected-vehicle infrastructure, and finds out about the solutions that are being worked on now, and planned for the future

Blaine Leonard, Utah Department of Transportation's (UDOT) technology and innovation engineer, is fond of using the 'chicken and egg' analogy to explain a new dilemma facing transport planners. "The chicken and egg question is this: Will vehicle manufacturers build applications on cars if there is no infrastructure for the vehicles to talk to, and how can we justify spending public money to build infrastructure when there are no cars to talk to? Who steps into the water first?"

Fortunately, Leonard is not alone in worrying about the chicken and egg problem. At a Vehicle to Infrastructure Deployment Coalition (V2I DC) meeting, he and his colleagues discussed the issue and may have found a possible solution. The V2I DC is a collaboration between the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), and the Intelligent Transportation Society of America (ITS America). Having considered the dilemma, representatives of the various groups came up with the 'SPaT challenge' (signal phase and timing) to inspire DOTs to be proactive.

"We challenged states to notify vehicle manufacturers that they are building roadside infrastructure for automated and connected vehicles," says Leonard. "We decided that a straightforward approach would be for each DOT to find a corridor of around 20 intersections, to implement DSRC (dedicated short-range communications) infrastructure, and to broadcast SPaT and map data.

"Signalized intersections already have poles, power, communications and other equipment in place," he continues. "So it's relatively easy to connect DSRC to the signal controller, grab the data describing the signal phasing and timing, and broadcast it."

Four states have SPaT systems up and running, a further 10 are at the planning stage and many others are considering it. The divergent responses reflect a pattern in the USA, where some states are willing to spend money to test advanced technologies – even if they are unsure of their ultimate relevance – whereas other states adopt a 'wait and see' approach.

"It's an exciting time because some level of automation will happen and the changes will be as radical as going from horse to horsepower," says Leonard. "But it's also frustrating for planners allocating resources to be used 20 years from now. We could do preliminary design work and then might not build something for 15 years, by which time it's redundant. We have a lot of information and modeling, but our predictions are, ultimately, guesswork."

A potential tipping point would be a decision by the federal government to mandate DSRC for vehicle-to-vehicle (V2V) communications. The rule was proposed by the Obama administration, but is opposed by groups such as the Israeli start-up company, Nexar, which operates an app-based V2V network in New York City. Nexar believes that mandating DSRC would place it at a commercial disadvantage. Leonard admits that this is a controversial area. Right now, DSRC is much faster, but cellular works well for less time-sensitive data, and the cell industry is promising faster 5G soon.

It's worth remembering, too, that around 70% of cars already have cellular connections.

The strong possibility that DSRC will play an important role, however, has encouraged Leonard and his Utah colleagues to experiment with a permanent deployment on a fleet of buses traveling along the Redwood Road corridor in Salt Lake City. The system broadcasts SPaT and map data, facilitating communication

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Above: An aerial view of Redwood Road, Salt Lake City, where UDOT has deployed connected vehicle technology on signals to help keep buses (opposite) running on time


between bus and roadside. Buses behind schedule can be allocated additional green light time.

The main aim is to learn how to deploy DSRC technology, but Utah is also carrying out a traffic engineering study of its effectiveness and the potential impact on cars. Afterwards, there is potential to expand across the state. Even further ahead, the corridor will allow Utah and its partners to start looking at applications in cars, such as red light running software, or eco-driving applications.

One topic that results in universal agreement in the V2I DC group is the value of fiber-optic cables. Leonard says Utah's ITS network has benefited enormously from putting in high-speed fiber statewide. "It forms an important backbone," he says.

## A future for VMS?

More difficult to predict is whether future roads will require expensive overhead variable message signs (VMS). If vehicles are connected, then information can come directly into the car, says Blaine. A crucial question, he says, is how much penetration of new technology is required before DOTs decide not to invest in VMS. "If 70% of cars are connected, or even 90%, we may still need VMS. But we believe when we have 100% penetration of connected and automated technologies we won't need them," he says.

Such discussions foster more head-scratching about long-term asset management plans. It may make sense to install VMS for the next five to 10 years, because there won't be enough connected cars for another 15 or 20 years. But after that, DOTs might think about an 'end of life strategy' for existing VMS and stop replacing them, Leonard says.

However, it is fiendishly difficult to predict when there will be enough market penetration to justify such decisions. If the federal mandate goes ahead, it might clarify the situation. Cars would begin requiring DSRC in 2021. Leonard says the average turnover of cars is 12 years, meaning that by 2033 a significant number would be equipped. Older models could be retrofitted and the process accelerated.

Further debates center on the potential for 'platooning' lines of automated vehicles moving at the same speed, 20ft apart. "With platooning, we could dedicate a lane for these vehicles, and ultimately, when all vehicles are autonomous, put five narrower lanes on a highway instead of four wider ones. So, transport planners are discussing whether between now and 2040, we should be adding more width to roads," he says.

But making such decisions is hard when DOTs do not know whether there will be an increase, or decrease in vehicles on roads. "That's the biggest debate of all. Will people be happier to commute further as they are watching TV and not driving? If cars are driving themselves, how many will be empty as they travel between dropping someone off and picking someone up? Does that facilitate shared ownership models?"

## Autonomous vehicle race

One of the most proactive states is Virginia, where Governor Terry McAuliffe wants to "bury those other 49 states" in the race to become the autonomous vehicle capital. Virginia DOT (VDOT) already runs the third-largest network of state-maintained roads, with 60,000 miles, ranging from plains to mountains, and in Virginia Tech Transport Institute (VTTI) it has found an ideal research partner.

VDOT is experimenting with connected and automated corridors. In 2014, VDOT and VTTI jointly introduced the Virginia Connected Corridors (VCC) initiative along one of the most congested US corridors, the I-66, and two parallel roads, the US-50 and US-29. Roadside equipment units broadcast DSRC signal and timing data. For vehicles not equipped with DSRC, an app allows smartphones to receive signal data. In addition to live roadways, VDOT has already equipped signalized intersections along the two-mile Virginia Smart Road, in Blacksburg, with the same hardware.

One aim is to understand the feasibility of eliminating certain high-dollar infrastructure through connected-vehicle applications. VDOT says overhead guide signs cost US$100,000 apiece, while changeable message signs and traffic signals cost US$200,000 and US$250,000, respectively. Savings could run into hundreds of millions of dollars. "We're making investments to reduce investment in other areas," says Catherine McGhee, director of the

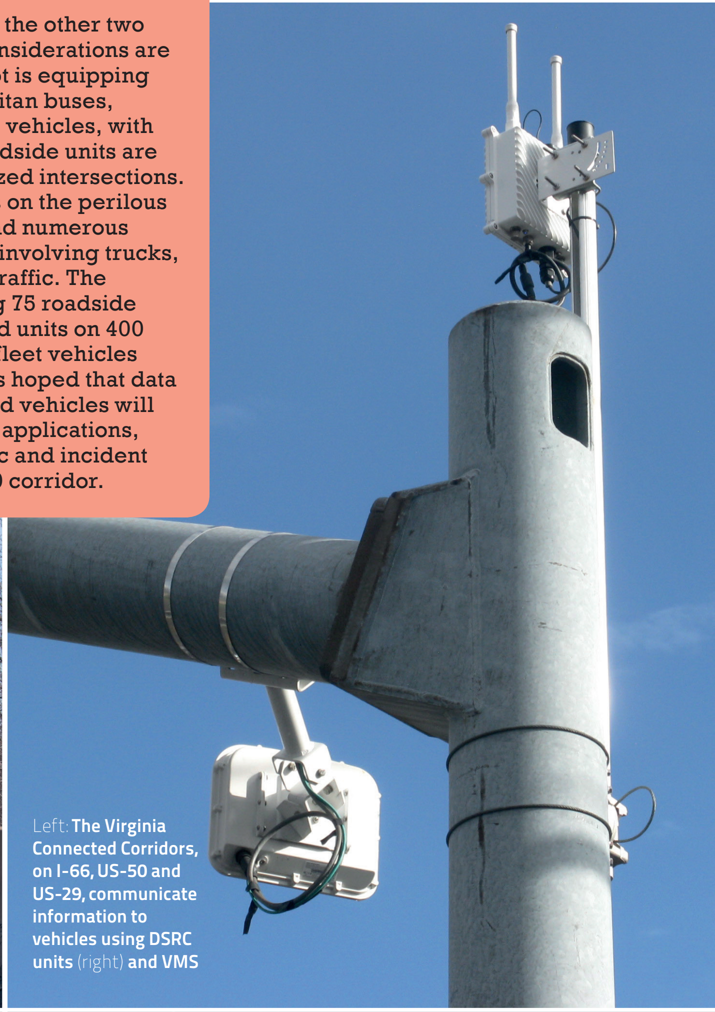
## USDOT connected vehicle pilots

**USDOT has awarded cooperative agreements, together worth more than US$45m, to three regional connected vehicle pilot schemes**

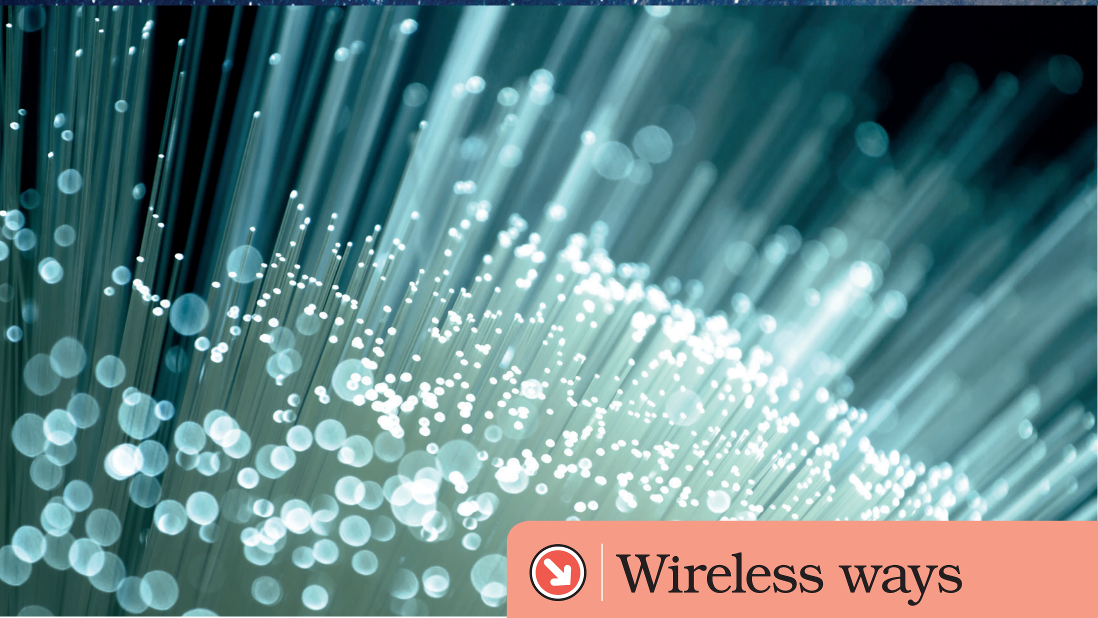
At peak times in downtown Tampa, Florida, there are frequent delays and rear-end crashes, and conflicts between car drivers, bus drivers and pedestrians are commonplace. The Tampa Connected Vehicle Pilot is equipping 10 buses, 10 streetcars, and 1,600 privately owned vehicles with connected vehicle technology, enabling them to communicate vital information with each other as well as with transportation infrastructure. At least 500 pedestrians are also participating by using a smartphone app. The expectation is that drivers, transit riders, and pedestrians in the connected vehicle environment will enjoy a range of safety and mobility benefits, including crash prevention, enhanced traffic flow, and greenhouse gas reductions.

The focus is different for the other two sites although the safety considerations are similar. The Manhattan pilot is equipping 5,850 taxis, 1,250 metropolitan buses, and hundreds of other fleet vehicles, with connected technology. Roadside units are being placed at 310 signalized intersections.

In Wyoming, the focus is on the perilous 402-mile I-80, which has had numerous high-profile crashes, often involving trucks, which make up 30-55% of traffic. The Wyoming Pilot is deploying 75 roadside units and installing onboard units on 400 vehicles, a combination of fleet vehicles and commercial trucks. It is hoped that data collected from the equipped vehicles will not only support in-vehicle applications, but will enable better traffic and incident management along the I-80 corridor.

Left: **The Virginia Connected Corridors, on I-66, US-50 and US-29, communicate information to vehicles using DSRC units** (right) **and VMS**



Left: Fiber-optic lines are an essential communication 'backbone' to enable V2X technology

Below left: Virginia's purpose-built Smart Road is putting the state at the forefront of autonomous and connected vehicle testing

## Wireless ways

**Ohio is investing in fiber-optic cable to enhance its Smart Mobility Corridor**

Ohio is another proactive US state that wants to build a reputation as a world leader in smart mobility, and in autonomous and connected vehicle research. This year, it is investing US$15m to install advanced fiber-optic technology along the Smart Mobility Corridor, a four-lane 35-mile stretch of US Route 33 located in central Ohio, running between Dublin and East Liberty, northwest of Columbus. State Governor John R Kasich says that his state's partnership with leading automotive research centers and local governments is now all set to create "an ideal proving ground to safely test innovative technologies that will change the way people and products are transported in Ohio and across the world."

The high-capacity fiber-optic cable along the Smart Mobility Corridor will enable analysis of data from embedded and wireless sensors along the roadway. These links will allow the automotive testing, research and manufacturing facilities to test smart transportation technologies on a highway that carries up to 50,000 vehicles a day through rural and urban settings in a full range of weather conditions. This data will also provide more frequent and accurate traffic counts, weather and surface condition monitoring, and incident management improvements.

Virginia Transportation Research Council. "For a relatively small sum of a few million dollars, out of a US$5bn annual budget, we're positioning ourselves for every eventuality. It could have large pay-offs down the road."

Following 2015 legislation, the Virginia Automated Corridors project opened up 70 miles of interstates and arterial roads to automated vehicle developers. The corridors allow connected vehicle capabilities enabled by dedicated DSRC and cellular technology. The VTTI is leading the automated corridor project. VDOT hopes to encourage OEMs to use the facility and enter into PPP initiatives.

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> **Catherine McGhee, director, Virginia Transportation Research Council**

VDOT's embrace of new technology includes two other projects. The state has installed variable speed limit signs on a mountainous section of I-77 that drops for miles into North Carolina and has seen horrendous crashes in bad weather. Full color matrix displays adapt speeds to conditions. Though not connected yet, such technologies could certainly be equipped to talk to cars one day.

Secondly, VDOT has installed an active traffic management system on I-66 in Northern Virginia. A variable speed limit app can warn drivers of queues ahead and signs inform drivers when lanes are closed off. Most beneficially, dynamic shoulder running allows the breakdown lane to be temporarily opened in heavy traffic. Again, VDOT is studying different ways to bring information into cars, including dynamic message signs and smartphone apps. "We want to be out there where the decisions are being made rather than reacting afterward," says Rob Cary, district engineer in Richmond, Virginia.