traffic
TECHNOLOGY INTERNATIONAL

February/March 2015

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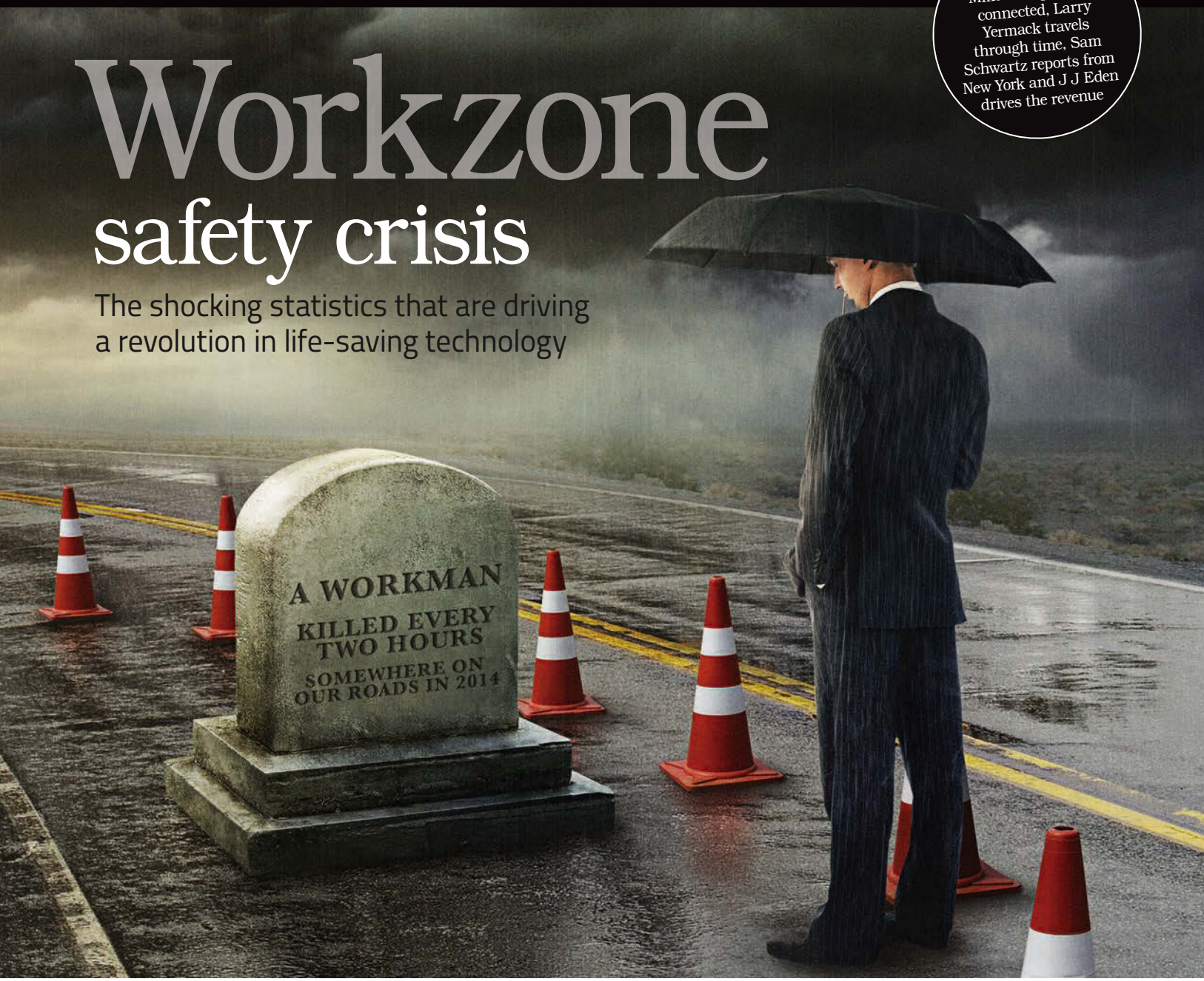
Road stud revolution
Get ready to dig up highways and embed intelligent lighting

Hot new models
The road simulation techniques that can outsmart congestion

Opinion
Mike Schagrin gets connected, Larry Yermack travels through time, Sam Schwartz reports from New York and J J Eden drives the revenue

Workzone safety crisis

The shocking statistics that are driving a revolution in life-saving technology



PLUS

Maintenance costs halved
The smarter asset management techniques that are helping DOTs slash their spending

Traffex 2015 uncovered
We get the inside story from the UK's biggest traffic show, in a chat with event director Bill Butler

Truck parking solved
How ensuring that truckers always have a place to stop and rest will save the US economy billions of dollars

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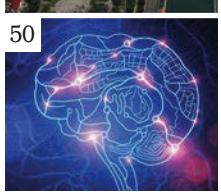
Cover story

40 Highway to the danger zone

Fixing our roads is the most dangerous job in construction

Timothy Compston finds out how technology is being used to improve safety in workzones



Technology Profiles

Editor's letter

On December 22, 2014, a garbage truck lost control on a busy Glasgow street and plowed across a packed sidewalk, killing six people out doing their last-minute Christmas shopping. The driver apparently lost consciousness at the wheel and appears to have been suffering from an undiagnosed heart defect. The investigation into the incident is ongoing as we go to press.

In years gone by, such a tragedy might have been viewed as just 'one of those things' – the chilling price society must sometimes pay for automotive convenience. Now, however, there is a brighter, safer future coming into focus. A prototype vehicle that could soon prevent this type of tragedy ever happening again is already being tested. In our feature, beginning on page 40, you'll find out about the autonomous attenuator truck that is being developed by the Southwest Research Institute to protect highway workforces. One of its key features is that it can be controlled using hand gestures by a worker walking in front of it. It's not a massive leap of imagination to envisage such trucks being used to collect garbage on our city streets, equipped with 360° sensors that will mean they will never even scrape a bollard, let alone knock over a pedestrian (for more of the latest autonomous vehicle research, don't miss the breaking news on page 4).

It's just one of the many pieces of technology that are being developed to tackle the problem of workzone safety. As our cover depicts, a road construction worker dies every two hours somewhere in the world. This is an estimate based on around 130 worker deaths per year in the USA, representing 0.4% of US road deaths. As many countries do not record specific accident data, we extrapolated this out and took 0.4% of the 1.24 million road deaths annually to be of road construction workers – giving a total of 4,960 (or 13 per day). This excludes the drivers who die crashing into workzones (if we added them, the figure would be at least four times as many).

It's a rough estimate, but a conservative one, given that the USA has a good safety record compared with many other nations. Indeed, as the World Health Organization figures show, it is in developing countries that the road safety crisis is really unfolding. Left unchecked, road deaths are predicted to top 2 million worldwide by 2020, becoming the fifth most likely way to die by 2030 – overtaking any single type of cancer. It is now up to leaders in road safety to show the rest of the world the way forward.

And nowhere is action needed more than in workzones. Just as no one with a desk job expects to be smashed into oblivion at a moment's notice, while designing a spreadsheet, the men and women maintaining our infrastructure shouldn't be subjected to this kind of risk every day they do their jobs – especially as we enter an era where the technology exists to make such risks a thing of the past. As you'll discover in our feature, the UK is already Aiming for Zero in workzones; the rest of the world should follow suit.

Tom Stone
Editor

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Traffic Technology International USPS 012-893 is published bi-monthly – in February, March, April, June, August, and October by UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK. Annual subscription price is US$131. Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, New York 11434. Periodicals postage paid at Jamaica, New York 11431.

US Postmaster: send address changes to *Traffic Technology International*, c/o Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, New York 11434. Subscription records are maintained at UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK.

Air Business is acting as our mailing agent.

published by UKIP

Member of the Audit Bureau of Circulations

Average net circulation per issue for the period January 1-December 31, 2014 was 17,408
Annual subscription US$131/£73
USPS Periodicals Registered Number **012-893**

ISSN 1356-9252
Traffic Technology International

Printed by William Gibbons, Willenhall, West Midlands, WV13 3XT, UK

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SEEING IS BELIEVING

Future proof

This summer, some of the greatest minds in autonomous vehicle research, testing, validation and development will be united to impart knowledge and share experiences. **Lauren Ansell** gets exclusive news from behind the scenes as we prepare for our first-ever Autonomous Vehicle Test & Development Symposium

From June 16-18, *Traffic Technology International* is proud to be co-hosting the first-ever Autonomous Vehicle Test & Development Symposium, in Stuttgart, Germany. With excitement building around rapid advances in technology that are bringing us ever closer to the commercial realization of driverless cars, we can exclusively reveal some of the detail of this unique event, which will encourage interest and collaboration as a fundamental part of the development process.

"There are currently no set standards for the testing and validation of autonomous vehicles," says event director Mike Robinson. "The current challenges facing the adoption of autonomous vehicle technology can only be overcome through increased testing and advanced

Autonomous Vehicle
TEST & DEVELOPMENT
Symposium 2015

www Read our full interview with Frederick Diederichs at trafficTechnologyToday.com/frederick

Better together

Key attendee says networking and discovery are the secrets to growth in this sector

According to Frederik Diederichs, senior researcher at Fraunhofer IAO (who will be giving a presentation on the third day of the conference), testing and validation at this stage of autonomous vehicle development is essential if we are to find the best solutions. "It also has a social importance," he says. "Since automated driving must promise enhanced safety, validation of this promise is the key to social acceptance."

Diederichs is excited about what he will discover at the Autonomous Vehicle Test & Development Symposium. "There will be great networking opportunities and I expect to see a mix of disciplines there who share a common goal," he says. "The industry has to face a technology and business model that has the potential to be a game-changer. The search for the best among numerous ideas, roadmaps and applications will bring companies to the frontline of innovation, enhancing their chance of survival in this fast-changing business."

The Autonomous Vehicle Test & Development Symposium will unite industry partners, researchers, legal experts – and also competitors. "The risk that 'someone else copies my idea' could also be seen as a chance to set a trend – to be the first and best in an emerging field," says Diederichs.

"My presentation will focus on the human factors of automated driving, the changing role of drivers, and new challenges for the human-machine interface," he continues. "Level 3 automation, which allows drivers to be out of the loop for a certain amount of time, incorporates great challenges for the control interface. I will talk about testing methods for transition strategies into manual driving mode, as well as the design and potential control of permitted non-driving-related activities. I will also present our ongoing work to set up a simulator dedicated to testing automated driving."

development techniques, technologies and changes to legislation. The aim of the Autonomous Vehicle Test & Development Symposium is to bring together all of the different communities involved in autonomous vehicle research and development to discuss how these challenges can be overcome."

The three-day conference program will feature more than 65 presentations by some of the most innovative and influential figures in the autonomous vehicle sector. Particular highlights include: Lutz Lorenz, project manager for HMI automated driving at BMW Research and Technology; Jean-Baptiste Haué, head of the project engineering department at Renault; Dr Nick Reed, academy director of the UK's Transport Research Laboratory; Matthew Avery, research director at Thatcham Research, UK; Stefan Wolter, specialist in vehicle interior technologies at Ford Research and Advanced Engineering Europe; Professor Frank Flemisch, head of system ergonomics at Fraunhofer FKIE, Germany; and Chris Reeves, commercial manager of intelligent mobility and future transport technologies at MIRA, UK.

"It's a must-attend show for anyone involved in the development of autonomous vehicles and advanced driver assistance systems [ADAS]," says Robinson. "There is no other conference in the world that is dedicated to the testing and development of autonomous vehicle technology."

Asking the right questions

The conference will address several important topics

- Public road testing
- Virtual testing
- Simulation
- Traffic scenario testing
- Embedded software testing
- Reliability testing of software and hardware systems
- Safety and crash testing
- Fail-safe testing
- Cyber-threat testing
- Validation and verification
- Autonomy software
- VeHIL
- V2V and V2X testing
- Robotics
- Testing legislation
- Safety standards and legislation
- Human factors and HMI testing
- Case studies
- Possibilities
- Best practices

Book your delegate pass now at **autonomousvehiclesymposium.com**

A 2014 IHS report forecasts **54 million** driverless cars on the road by 2035

The symposium will be held at the Automotive Testing Expo 2015 Europe

> "The search for the best among numerous ideas, roadmaps and applications will bring companies to the frontline of innovation
>
> *Frederik Diederichs, senior researcher, Fraunhofer IAO, Germany*

Autonomous Vehicle TEST & DEVELOPMENT Symposium 2016

31 MAY - 2 JUNE 2016 STUTTGART, GERMANY

The world's only conference dedicated to the **testing** of autonomous vehicles and advanced driver assistance systems

The Autonomous Vehicle Test & Development Symposium 2016 will bring together the world's leading engineers in the field of autonomous vehicle research, testing, validation and development. The conference will be held in Stuttgart alongside Automotive Testing Expo 2016, the world's largest exhibition dedicated to new vehicle development and testing, and in conjunction with *Traffic Technology International* magazine, the world's leading magazine for advanced highway and traffic management technologies.

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Topics under discussion:

- Public road testing
- Virtual testing
- Simulation
- Traffic scenario testing
- Embedded software testing
- Safety and crash testing
- Fail-safe testing
- Cyber threat testing
- Validation and verification
- Autonomy software
- VeHIL
- V2V and V2X testing
- Robotics
- Testing legislation
- Safety standards and legislation
- Case studies
- Possibilities
- Best practices
- Reliability testing of software and hardware systems

For more information about the Autonomous Vehicle Test & Development Symposium 2015, **please contact Mike Robinson,** conference director: mike.robinson@ukipme.com
Tel: +44 1306 743744 | www.autonomousvehiclesymposium.com

Powerful investments

Lloyd Fuller looks at how expected growth in the electric vehicle (EV) sector will impact road infrastructure

Electric potential

EU program supports infrastructure growth

The European Union's Trans-European Transport Networks (TEN-T) program has committed almost €5m (US$5.8m) to the study and pilot installation of 200 EV charging points along France's main motorways. The three-phase project aims to contribute to the growth of connected charging infrastructure and enable a wider use of electric transport in Europe. The project will work on a set of technological, environmental and end-user requirements to enable an interoperable fast-charging network and foster rapid EV deployment in France.

Support network

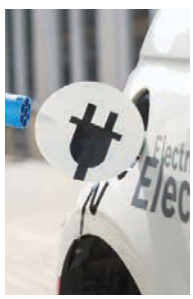
EV infrastructure continues to expand in the UK

The adoption of EVs in the UK has received a boost with two recent announcements. Chargemaster installed its 10,000th public and commercial charging point at the end of 2014 and has now reported that it has just completed its one millionth vehicle recharge. The company records all charging events through its Chargevision back office system, and while it took nearly two years to rack up 500,000 charges, from the first one in September 2012 to July 2014, it took just six months to reach the one million mark. The rapid growth in EV charging on the company's nationwide network is supported by figures from the SMMT, which show that the number of plug-in cars registered in the UK quadrupled from 2013 to 2014.

Tesla, meanwhile, has opened a new 'Supercharger' DC fast-charging station in Maidstone, Kent, which is part of a rapid expansion of its network that will soon allow UK Model S owners to drive anywhere in the country and on the continent.

Fast forward

Bosch chairman foresees a boost in EV adoption



The chairman of Robert Bosch has said that he anticipates a rapid acceleration in the electrification of vehicles in the next 10 years. Speaking at the January 2015 Car Symposium in Bochum, Germany, Dr Volkmar Denner revealed he expects roughly 15% of all new cars built worldwide to have at least a hybrid powertrain by 2025. He feels that advances in battery technology are the key to lower vehicle prices. Denner believes that by 2020, batteries will deliver twice as much energy density, for half the present cost. The European Union has set strict fleet CO_2 emissions targets for 2021, and for this reason alone Bosch expects hybrid powertrains to become the standard for SUVs, as they make traditional engines more efficient.

American express

Partnership to increase EV fast chargers in the USA

Volkswagen and BMW, together with ChargePoint, have announced an initiative to create express-charging corridors along heavily traveled routes on the east and west coasts of the USA. The initiative will help meet the large and growing demand for convenient, publicly available EV fast chargers, including direct current (DC) units, and support the adoption of EVs. In the initial phase, the aim is to install nearly 100 DC fast chargers across both coasts, with plans to expand the program across the country. The newly installed DC fast-charging stations will be added to the ChargePoint network of more than 20,000 charging spots in North America, which make it the largest in the world.

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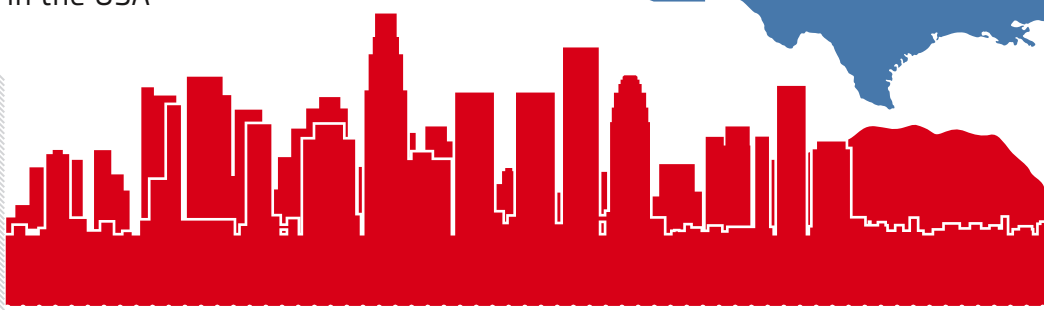
Lights, cameras, congestion

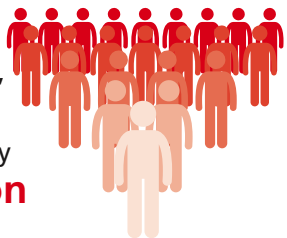
Los Angeles is renowned for traffic jams – and for good reason: the city topped a 2014 global traffic report that confirmed it as the most congested in the USA

Infographics: Louise Adams



The 7,500 miles of roads that make up the Los Angeles city road network are managed and operated by the Los Angeles Department of Transportation (LADOT), in collaboration with Caltrans

According to the most recent census, Los Angeles is home to approximately **3.9 million** people

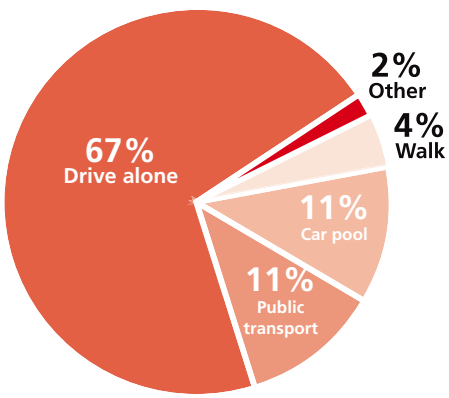


Traffic congestion in LA increased by

8.5%

between 2012 and 2013

Commuting in Los Angeles



The city of Los Angeles has

38,011

on-street parking meters

THE ROADS IN LA ARE MOST CONGESTED ON **TUESDAY MORNINGS** AND **THURSDAY EVENINGS**

(2014 TOMTOM TRAVEL INDEX)

DID YOU KNOW?

Los Angeles' full name is 'El Pueblo de Nuestra Senora Reina de los Angeles sobre el Rio Porciuncula' (The town of our lady queen of the angels on the Porciuncula River)

The Los Angeles road network has approximately

40,000 intersections

4,398 traffic signals

22,000 marked crosswalks

75.2 MILLION

miles are driven in the city of Los Angeles each day

(53% of which are on freeways)

LA drivers spent an average of 64 hours in gridlock in 2013 – five more hours than in 2012

Congestion cost the city of Los Angeles an estimated

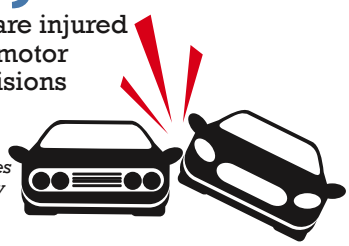
US$23.3bn

in 2013 – more than 10 times the estimated value of the LA Clippers

Source: Inrix

36,000

Angelenos are injured or killed in motor vehicle collisions each year



Source: Los Angeles Department of City Planning

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Seeing the bigger picture

A good overview of the condition of critical infrastructure requires either a godlike all-seeing eye, or the latest data-analysis techniques and software. **David W Smith** speaks to the experts who are able to map and predict the life expectancy of essential assets, thereby reducing delays *and* saving money

Photographs: Khakimullin Aleksandr

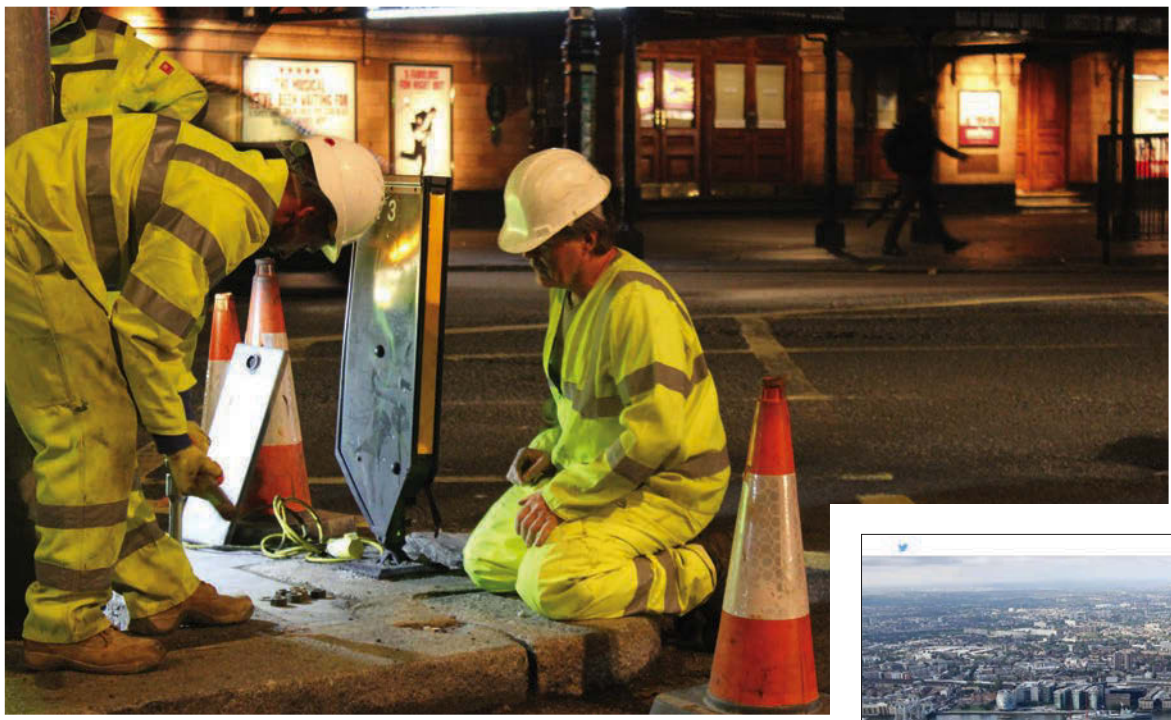
The scale of traffic infrastructure in London means that when assets fail, the disruption affects large numbers of people. An infamous example came at the end of 2011 when severe structural faults were found in the Hammersmith flyover in West London. For 18 days, about 90,000 cars a day had to be diverted while emergency repairs were made. Further disruptions continued for another four months, as only a single lane remained open.

Transport for London (TfL) – which manages all aspects of London's Strategic Road Network – was heavily criticized for not taking care of such an important asset. TfL's new director of road space management Alan Bristow says, "The Hammersmith flyover showed that you can't have major assets failing because they've not been maintained for many years. So a lot of our effort at the moment is in making sure our assets are fit for purpose. You need assets functioning as they should to have the flows going over them that you need, before you can start playing with traffic lights and managing those flows."

Investment in London's road network will double from £2bn to £4bn (US$3bn to US$6bn) over the next decade and the new Traffic Control Management Services (TCMS2) contract will see 6,000 traffic signals upgraded to the latest and greenest standards, as well as new crossings for pedestrians and cyclists. A large proportion of the new TfL budget will be spent on managing these and all other surface transport assets.

Improving the data

To make this gargantuan task easier, TfL has placed the responsibility for all the assets with one directorate. "My team now sits alongside the departments dealing with highways, tunnels and structures, and bus infrastructure," says Iain Blackmore, TfL's head of traffic infrastructure. "The kit is different, but we all look at lifetime costs and best practice for investment. Bringing it under one roof allows us to coordinate work. If we're digging up a stretch of road, we can do the street signals, lighting and bus stops at the same time."



(Above) **Smart asset management in London means fewer components must be replaced, minimizing disruption to the public** (Right) **Transport for London's Twitter account is a useful tool for enabling the public to report faults**

TfL has gradually improved its asset management since the 1980s when it first began to collect a lot of data. Blackmore says the key is greater 'granularity', meaning higher levels of detail. TfL used to record so few details about a site that it was easy to make the false assumption that all components had been installed at the same time.

"One important development with the new contracts is that we are recording the age of each element and how it deteriorates over time," says Brendan Sleight, TfL's chief engineer. "Before we used to say, 'Right, it's an 18-year-old junction so let's replace all electronics, poles and lighting.' Recording the age of each element enables us to change some bits and keep others going. We know that electronics rarely last beyond 18 years, but civil duct work under the road, or the poles, can last 20 to 30 years."

Modern technology has made it easier to keep tabs on the equipment. Sleight says that two contracts ago, TfL's site engineers were not equipped with iPads, but now they all carry tablet computers. All engineers and contractors have access to a database detailing the condition and age of all assets. Sleight says it has become cheap for TfL's engineers to take photos on-site, tag them and upload the details to the database. The next engineer to inspect the site can easily see what the previous engineer has done, saving time and money. "The ultimate goal is for all the components to self-report faults, which we hope to achieve within the next few years," says Blackmore.

Tweets on the streets

Social media technology is another great tool for reporting faults to TfL, he says. Passers-by who spot something awry can send information to TfL via Twitter. This effectively increases the pairs of eyes watching over London's transport networks. Twitter allows pictures to be geo-coded, so TfL analysts can pinpoint the faults to precise locations. A further line of defense comes from trusting relationships with suppliers who are in close contact with the assets. These suppliers recommend 10% of TfL's signal modernizations per year. They are the signals that are the most difficult to maintain, or the hardest to access.

Advances in technology have also encouraged TfL to be much less prescriptive when sourcing components from suppliers. Instead of telling them what needs to be installed, TfL now trusts them to choose the equipment. "This has several benefits for our assets," says Blackmore. "It drives prices down by encouraging competition and it prevents the 'ghetto effect' of one supplier dominating the whole of London. As a result, we hope for better interfacing and compatibility. We're aiming for a situation where we can buy a brand X signal, which fits with a brand Y controller and brand Z ducting. We want plug and play."

> The ultimate goal is for all the components to self-report faults, which we hope to achieve within the next few years
>
> **Iain Blackmore, head of traffic infrastructure, Transport for London, UK**

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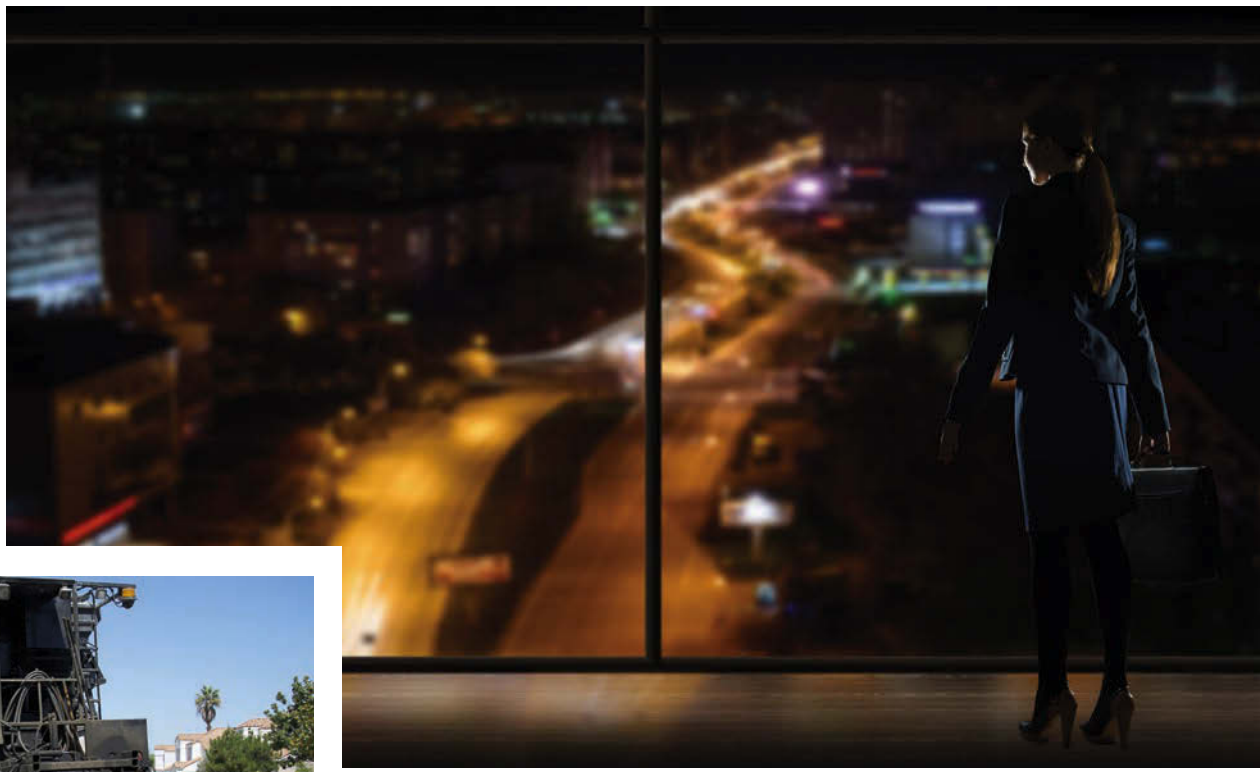


(Left) **Application of chip seals helps to extend pavement life**

Spreading the word stateside

Meanwhile, in the USA, the MAP-21 legislation has forced DOTs to develop asset management plans, including descriptions of the condition of assets, lifetime costs, risk management analysis and 10-year financial plans. Many DOTs are unfamiliar with the asset management process and seek advice from outside agencies such as Applied Pavement Technology (APTech), a pavement engineering consulting firm.

APTech's president, Katie Zimmerman, is a major figure in the US world of asset management. She chairs the Transportation Research Board (TRB) Committee on Transportation Asset Management and her company has advised the Federal Highway Administration (FHWA) on asset management. Zimmerman says that DOTs are often surprised by how much more efficient asset management can make them.

"For one DOT, we used its data to show the value of its Transportation Asset Management Plans (TAMP). Over a long period, the pavement preservation strategy, which included preventive maintenance, cost less than half the previous strategy, which was to rehabilitate pavements once they were in poor condition. That's often referred to as a 'worst first strategy'," she says.

APTech also demonstrated to the same DOT that for every dollar invested in expanding their network, it was making a commitment of US$1.50 to US$3 in future maintenance costs. "In the USA, most agencies ignore future maintenance costs when they invest in new roads, whereas in Australia local agencies have to account for future maintenance requirements in financial plans. As a result, they are more focused on ensuring that future funding covers both capital and maintenance costs," she says.

APTech showed a second DOT that if it increased the use of chip seals on its low-volume road network, it could substantially reduce lifetime costs. For bridges, the same study found that applying an annual preservation treatment on 5% of the network saw similar savings.

> "Pavement preservation strategy, which includes preventative maintenance, can cost less than half that of simply rehabilitating pavements once they are in poor condition"
>
> **Katie Zimmerman, president, APTech, USA**

The key to effective Transportation Asset Management Plans, Zimmerman says, is to ensure they are integrated in an agency's budgeting processes, long-range plans and transportation improvement programs, right from the start. "TAMP should be more than just a report that sits on a shelf," she says. "It's also about fostering closer coordination between maintenance forces and asset management staff as agencies put more emphasis on long-term preservation of assets. The hardest people to convince are often the

Software that beats winter

The right analysis can make preventing damage more cost-effective than repairing it

Failure to protect assets during cold winters can prove costly. There was an estimated £1bn (US$1.5bn) of road damage due to freezing conditions in the UK during the winter of 2013. The problem has prompted the Department for Transport (DfT) to allocate extra funding to local authorities in England and Wales.

Visualized asset management software can help authorities to target vulnerable assets, and so is particularly useful during the winter. Introduced in 2012 and recently launched in the USA, Yotta's Horizons program is used by many local authorities across the UK.

Yotta's Simon Topp says that a preventive approach can save money: "We tend to think immediately of the problem of surface damage and potholes following water ingress and subsequent freezing," he says. "But is too heavy an emphasis placed on reactive maintenance?"

Horizons enables teams to analyze the overall impact of winter weather on networks and choose the most cost-effective treatments. It can also be useful to review road surface treatments to help build resilience ahead of winter. For example, it can map winter gritting routes and salt bin locations. "Gritting treatment can run to several million pounds a year for a council. They need to grit where it will be most beneficial. Horizons can bring together all the data into a centralized view," says Topp.

The UK's Highways Agency has also recently strengthened its partnership with asset management software provider Bentley Systems. Since 2012, Bentley's AssetWise software has delivered a shared platform for the Highways Agency and its supply chain.

The Highways Agency will now run an AssetWise Academy alongside Bentley. "The Academy will play a key role in helping us propagate best practices to take full advantage of AssetWise IAM IS capabilities as they grow," says Robert Greaves, head of IT at the Highways Agency. The software is already being used to monitor a large number of major assets. "Development next year will include network events and then structures, followed by drainage and geotechnics implementation in 2016," Greaves adds.

executives, but they usually come on board once they realize the huge savings that can be had from implementing such practices."

Turning detailed data into quality information

Matt Haubrich, the asset manager in the performance and technology division at Iowa DOT, agrees with Zimmerman that there has to be an awareness of TAMP throughout the agency and all key stakeholder groups. "I was once asked by a colleague from another agency how many people it takes to implement TAMP. My answer was 'all of them'. An integral component of Iowa's TAMP is our communication plan, which includes face-to-face meetings, blogs, videos and social media. Making everyone aware of their part is a big job, but it's arguably the most important aspect of TAMP development."

Haubrich says that the DOTs most successful in incorporating TAMP view it as a 'change initiative'. "My goal is to eventually work myself out a job as TAMP principles become ingrained in the way our agency does business. In Iowa, we've created a whole division to focus on helping the agency change and adapt. Communication is critical to change, and therefore critical to TAMP."

Another vital element, Haubrich says, is getting quality information. He says the words 'information' and 'data' are often used interchangeably, but he sees a sharp distinction. High-quality data is next to useless without analysis to turn it into information. Iowa DOT's recent TAMP initiatives have put a strong focus on improving the data analysis function.

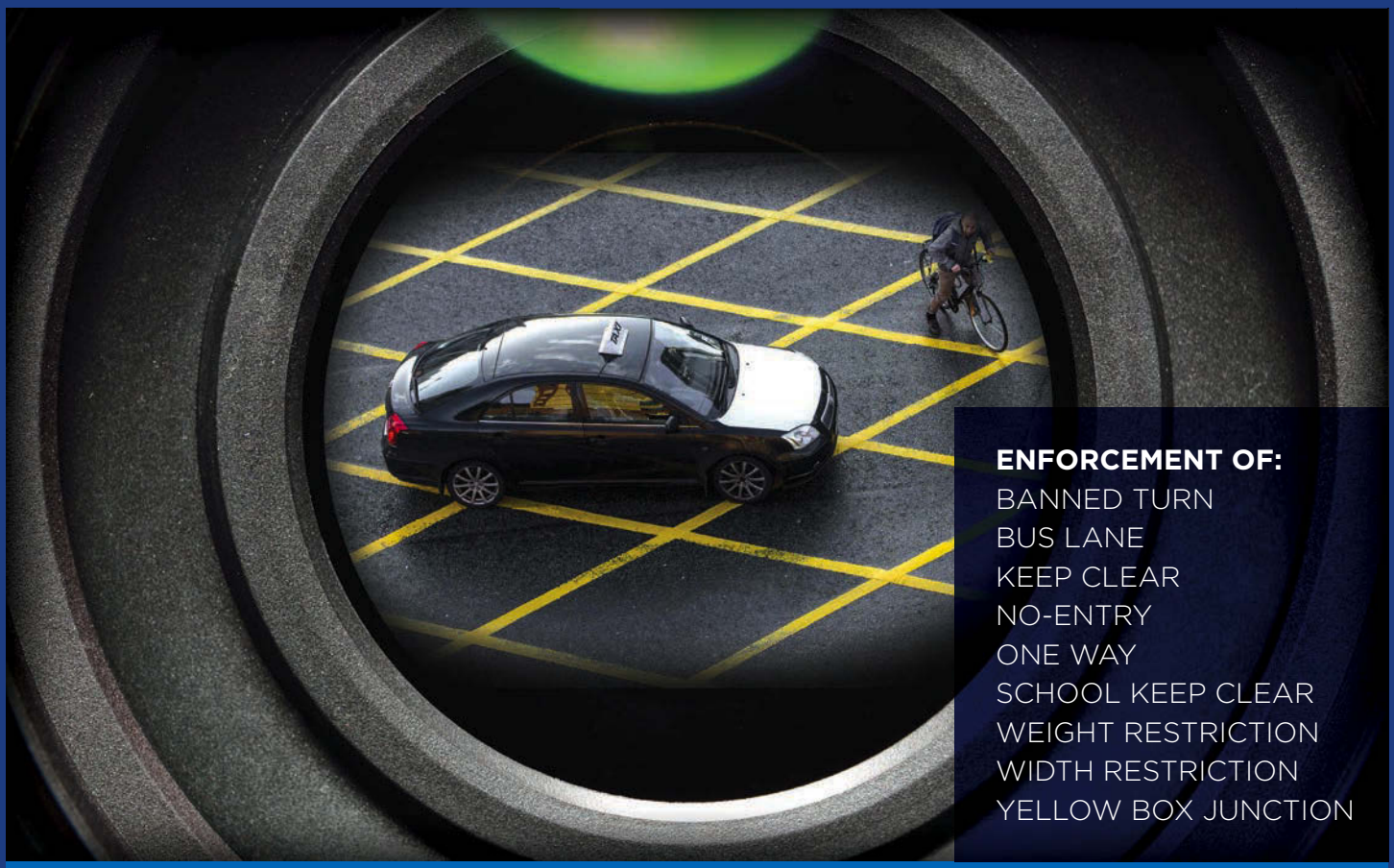
One of the important investments has been in a unified linear referencing system (LRS), which provides a common road network across Iowa's management systems and allows analysts to view many attributes at the same time. For example, Iowa recently used the LRS, along with pavement, bridge and traffic data to create a unified infrastructure index. Using its investment in GIS tools and analysis, Iowa was able to visualize this index value on a map.

> Building a unified linear referencing system for Iowa was not a small job… but the investments we've made have taught us important lessons
>
> **Matt Haubrich, asset manager, performance and technology division, Iowa DOT, USA**

"Building a unified LRS for Iowa was not a small job – it took us years and maintenance is also a major commitment. But the investments we've made have enabled all kinds of new ways of learning about how our infrastructure is performing and insights into where and how we should be investing," he says.

Iowa has tried to make the systems database-centric and software-neutral. Most of the infrastructure data is housed in Oracle spatial databases. "This enables us to use whatever GIS or analytics tools we find valuable to conduct our analysis. We have some ESRI products and we also use products from Bentley, Intergraph, Deighton and many others to analyze and maintain data stored in our spatial databases," Haubrich says.

In this, the Iowa DOT approach is indicative of an important trend in asset management – such systems are at their most useful when they can be accessed and used by as many different people, using as many different types of analysis as possible.



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The Space race

Solving the everyday problem of parking trucks safely in Michigan has led to smart solutions that break new ground. **Tom Stone** reports on the USA's first fully operational smart truck parking system

Michigan's I-94 had a problem – a big problem that is of growing concern across the USA. Trucks in excess of 50 tons seemingly had nowhere to park. They ended up on rest area entrance and exit ramps, on freeway entrance and exit ramps, and even on the shoulder of the highway itself. It wasn't the kind of situation you want on any road, let alone a major international trade corridor, carrying heavy industrial traffic between the Toronto area of Canada and America's Midwest.

"We had a lot of issues with truckers making unsafe parking decisions," admits Michigan DOT's connected vehicle technical manager Collin Castle. "We felt that it wasn't that there weren't enough parking spaces – it's that the drivers didn't have enough real-time information. There are five rest areas and there are a number of private truck stops on our section of the I-94. The rest areas only have about 160 spaces, but the private truck stops have over 1,000, so we needed to give better information to truck drivers."

Castle and his team were prepared for the technical challenges of amalgamating parking information from multiple locations and delivering it effectively to drivers: And it is testament to their abilities that they now have the USA's first fully operational and scalable smart truck parking system. However, the development of the system wasn't always plain sailing. What they had not anticipated was difficulty in getting private truck stop operators involved in the scheme. This

Prior to the new smart parking system, truckers on Michigan's I-94 couldn't be certain of safe parking

> It's not that there aren't enough parking spaces; it's that the drivers didn't have enough real-time information… we needed to get better information to truck drivers

Collin Castle, connected vehicle technical manager, Michigan DOT, USA

(Top left) **Michigan DOT's attempt to discourage parking on the freeway, but before smart parking, the signs could be confusing** (Top centre) **Private truck stops are now monitored using a video detection system** (Top right) **I-94 rest areas have magnetometers installed in the pavement to monitor usage**

required new thinking and an innovative new business plan, which is now forming the blueprint for similar schemes to be rolled out across the country.

Winning support

Seeing the need for smarter parking management, the FHWA issued a grant to build the information management system. The plan was to deploy detection technologies in both public rest areas and private truck stops, and then to provide real-time information to truckers on parking availability. "We ended up doing five rest areas and were able to get 10 private truck stops to enter into the project," says Castle. "Originally we were shooting for 15, but there were some limitations with budget, as well as with people not wanting to participate. It's an interesting relationship with a government-funded project trying to deploy infrastructure on private truck stops."

The 'interesting' part turned out to be a degree of suspicion and distrust surrounding MDOT's motives. "What we found when we met with truck-stop operators was that if the state government was involved in any way, shape or form, they would shut down," recalls Castle. "They weren't candid about the way they responded regarding their interests. They had other concerns: 'Why is a project funded by the state government monitoring our lots?' It was just one of those things that they weren't really interested in. The project wouldn't have happened if we hadn't changed things."

So MDOT decided to modify their contract with system designers Truck Smart Parking Services (TSPS) and HNTB to create a 'buffer' between the state and the private truck stop owners. "They were originally just charged with designing the system," says Castle, "but then we modified our contract and we are now paying for a service. We pay a monthly fee for the data feed. They are responsible for deployment of the infrastructure, and operating and maintaining the infrastructure at the private sites. Ultimately it makes more sense to let private industry run with it as opposed to a public agency trying to deploy infrastructure in a private facility. Plus, with the state government contracts we have, it would be very difficult to enter into one with each of these private entities and keep them up-to-date. The only contractual relationship we have now is simply for the data feed."

Collecting the data

Although MDOT delegated the duty of directly collecting data from private truck stops, it still had to deploy hardware in its own, state-owned rest areas. The different business, contractual and physical realities of the two types of parking facility on I-94 led to different technical solutions. "For the rest areas, we use Sensys Networks magnetometers, which you epoxy into the pavement," says Castle. "These work well in the rest areas because there are very well-defined entry and exit points." The sensor can detect whether a truck, or another type of vehicle, is driving over it, based on how long the object is, so a tally can be kept of the number of truck spaces available. It then wirelessly communicates the information to an

> [At private truck stops] video detection is used, as opposed to magnetometers, because it's less intrusive in terms of installation and gives flexibility to tailor the system to the driveway
>
> **Collin Castle, connected vehicle technical manager, Michigan DOT, USA**

access point, which sends it over a cellular connection to the back office.

However, such a solution was not found to be suitable for private truck stops. "In those locations video detection – manufactured by Citilog – is used, as opposed to magnetometers," says Castle. "Firstly, because it's less intrusive in terms of installation, and secondly the geometry of these truck stops can be really weird. Sometimes you have wide dirt driveways and multiple entrances and exits. Things can change in terms of where they come in, depending on plowing after snow. So the video detection system gives the flexibility to tailor the system to the driveway depending on changing conditions. Plus it's more cost-effective when you have multiple driveways."

Distributing the data

Once all the data has been collected and aggregated to create a complete parking picture, it needs to be distributed to the truck drivers who need it. This is where some of the latest traffic management systems are brought into play. "The rest area information goes to our statewide ATMS software," says Castle, "which is what we use for controlling roadside signs and monitoring cameras. And all the private truck-stop information goes to Truck Smart Parking Services. "The systems interface and share information with one another, and then disseminate it via multiple methods."

This is where MDOT's role becomes all-important. The state transportation department has the necessary permissions and infrastructure to reach the maximum possible number of truck drivers through roadside signs. Meanwhile Truck Smart Parking Service coordinates some of the more technical side of communicating with truckers. There are no fewer than five ways in which truck drivers can access the parking information that is being compiled for them…

Saving time in the city

Central London is a proving ground for a new smart parking system

At the end of October 2014, more than 3,000 parking sensors were switched on in central London, marking the beginning of Westminster City Council's first-ever smart parking scheme. Phase 1, which is currently undergoing live assessment, stretches across the West End from south Marylebone through Mayfair and Soho, down to St James's and across Covent Garden to the Strand. The £889,395 (US$1.35m) contract with Smart Parking is funded solely from revenue raised through paid-for parking.

The sensors installed in every parking space communicate availability information to Smart Parking, which can then be accessed via the ParkRight app. Using this, drivers can access a virtually real-time map (updated every minute) showing where they are most likely to find a parking space.

"We'll spend some time reviewing the impact the sensors have on parking habits and curbside space before rolling out further," says Heather Acton, Westminster City Council Cabinet Member for Sustainability and Parking. "The ParkRight app went fully live in November and has received some excellent reviews from drivers trying to find a parking space."

Simon Morgan, parking change officer for Westminster City Council, who was project manager for the roll-out, takes up the story: "If the first phase is deemed a success (evidenced by improved customer experience and a rebalancing of occupancy in surrounding streets) we'll then need to then go through internal sign-off for Phase 2 (7,000 bays).

"The app has received some good reviews of late and we have responded to customer feedback on how the functionality can be improved by rolling out iterative developments."

Westminster Council is hoping that other software developers will soon release their own apps, so that drivers have a choice of interfaces: "We've set up a web portal for third-party developers to access real-time data via an API (https://api.parkright.io). For us, there are clear benefits for the data to be shared and made available to motorists through other channels, especially as cars become more connected. All this should make it easier to find parking and take the pressure off the curbside."

1) Roadside signs

Dynamic truck parking signs (DTPS) – a form of VMS – are the longest-established way to disseminate live parking information. The I-94 corridor has five signs along the 130-mile stretch as part of the truck parking scheme. Each sign constantly updates the spaces available at three nearby destinations. In each case one of the locations shown is an Michigan DOT rest area and two are alternative private truck-stop exits where parking is available.

2) The DOT website

Michigan DOT's custom-built Mi Drive website (michigan.gov/drive) displays a host of real-time information about the state's road network – from traffic incidents and current or planned construction, to weather information and average road speeds. It's a useful resource for all drivers, and this site now also includes the live information about truck parking.

3) A private website

As well as providing parking information Truck Smart Parking Services are giving additional information to truckers, such as fuel pricing, amenities and showers through their website TruckSmartParkingServices.com. "That's really not our interest," says Castle. "But it is important to truckers. Also you'll notice that on their website they have pictures. The state DOT made a decision early on that we weren't going to post any pictures to our website because there may be some sort of perception of this 'Big Brother' thing – of surveillance of facilities. That's now part of a business-to-business relationship between Truck Smart Parking Services, and the truck-stop owner. So if they decide they want their images posted to the web, it's additional information and validation for the trucker." Research shows this visual back-up is valued by truckers.

(Right) **Michigan DOT's Mi Drive website is constantly updated with truck parking availability on I-94**
(Below) **Information is also displayed on roadside DTPS**

4) Smartphone apps

A further data delivery method is through a smartphone app for iPhone or Android. This helps to get information directly into truckers' cabs and is designed to be as simple and easy-to-use as possible so as not to distract drivers.

5) Connected vehicle technology

The final and most cutting-edge delivery system is supplied by Kapsch. It involves five road-side units (RSUs) equipped with dedicated short range communication (DSRC) technology at critical decision points along the highway. They communicate with a pilot number of trucks equipped with unit in their cabs that automatically display real-time parking information as the vehicle passes.

The future of V2I

The smart truck parking system in Michigan represents an early real-world application for V2I technology, and

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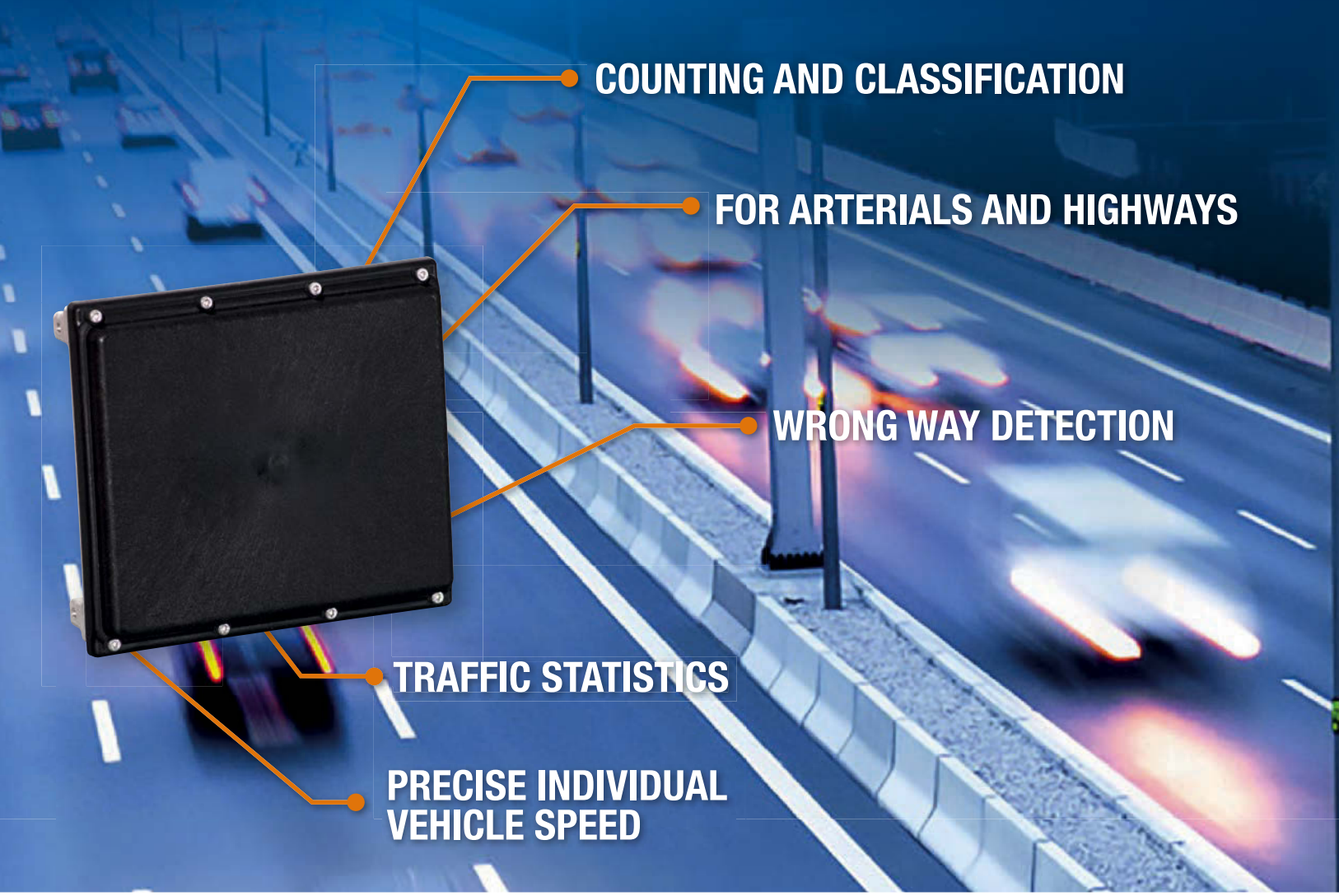

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The busy I-94 route has equally busy private truck stops and state-owned rest areas

as far as Castle is concerned this is just the beginning. "There can be a lot more value in those RSUs in the future," says Castle. "For example, we could receive information off those vehicles about the operational characteristics of the freeway or weather characteristics. We could then take that information and maybe process it and return it back to motorists to tell them about current situations. We're looking at it from a two-way perspective. We can receive information off the vehicles that can give us a better understanding of how the roadway is operating from a mobility/weather/incident perspective. But in turn we can provide that information back out to the motorist."

Michigan is home to the largest V2X testbed in the world in Ann Arbor, and I-94 links directly to it. This city already has over 3,000 vehicles equipped with the technology, growing toward a target of 9,000 – representing roughly 10% of the city's driving population. Of course, Castle and his team can't help but be affected by such a massive project happening on their doorstep. "We've been able to access a lot of the data coming off those vehicles, to determine how we could use it for our various agency applications," says Castle. "So we're looking at how to monitor our roadways for congestion, queues and incidents. How vehicles are interacting with signalized intersections, for example. At certain intersections we can determine the signal phase and timing information being broadcast. We've definitely been able to leverage the testbeds the USDOT has funded in Michigan to allow us to do some research and determine how we move forward with a more real-world, sustainable deployment, which we are actually in the process of starting to plan for right now."

So, from very specific beginnings in transmitting the number of parking spaces available for trucks in set locations, the RSUs on I-94 look likely to one day disseminate every kind of safety and infrastructure information imaginable, surpassing websites, smartphones, DTPS and VMS in the accuracy and breadth of data they are able to provide. In case you hadn't heard, the future is connected.

Parking from the air

Intelligent parking drone prototype to enter development stage

Drones could one day be used to help drivers find parking spaces more quickly – if a prototype currently being planned by Siemens proves a success.

The idea came from the winner of the tech giant's first-ever Mobility IDEA (Improving Design and Engineering for All) Contest. University of Massachusetts Dartmouth student Amir Ehsani Zonouz came up with the plan to use quadcopters to find parking spaces and direct drivers to them via the shortest route, either using a mobile app or directly through the car's navigation system. The technology will also have the ability to use infrared and thermal cameras to fly at night.

"This contest brought in a wealth of interesting and forward-thinking ideas to help solve traffic challenges. But with 30% of downtown traffic created by people looking for parking spaces, the judges found Zonouz's idea to use drones to monitor and identify parking spots the most innovative and potentially impactful idea in the contest," says Ben Collar, head of US research and development for Siemens Road and City Mobility.

Siemens will now bring together its top research and development experts to hold an innovation workshop to produce a fully developed prototype of the parking drone technology.

"Since the drones would be operating in public, ensuring safety is the highest priority," says Collar. "If a drone flies too low or somehow loses control, it could damage a vehicle or injure someone.

The drone's own controls as well as the overarching system must address safety and dependability explicitly and should consider unlikely failures. An additional challenge relates to GPS; in general GPS is not accurate down to the width of a regular parking space. Finally, it'll be interesting to coordinate the activity of multiple independent drones."

Looking to the future, Collar sees this system being attractive for a host of potential buyers. "One of the major advantages is cost," he says. "With the drones, there is no need to periodically tear up the road surface to replace the sensor batteries." Accordingly it's the kind of innovative business opportunity Siemens will be carefully evaluating.

"At first the main customers would be large parking lot operators. Larger lots may not be electrified – this can be quite a high cost – and thus require video systems or embedded sensors. These large lots are particularly suitable for the drone system. I suspect the first deployments would be in the USA and Europe.

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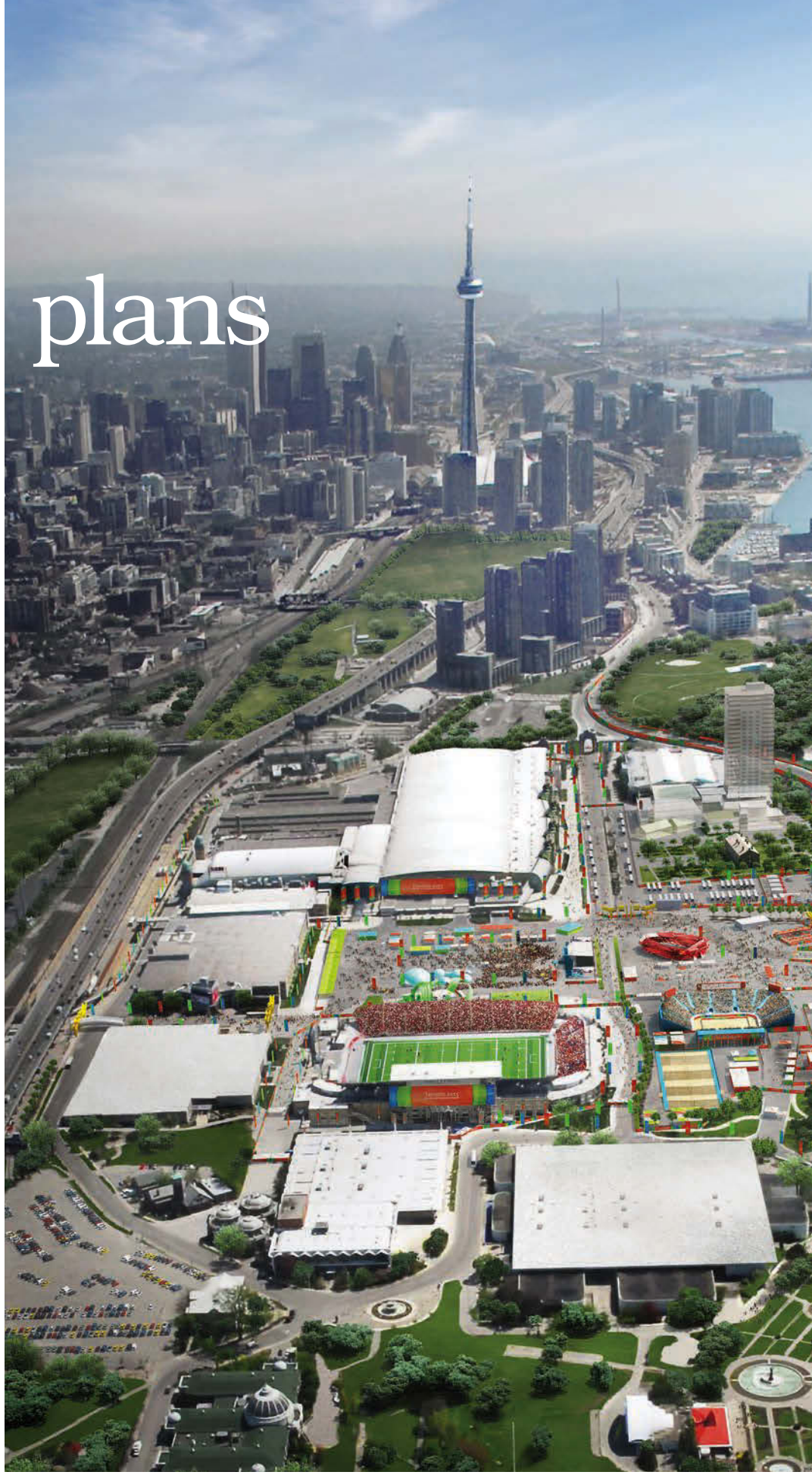
Action plans



Changes to traffic management strategies can be complex and costly. **Lauren Ansell** speaks to experts in the field of microsimulation to find out how data and complex algorithms can be used to make road traffic planning more detailed, accurate and cost-effective

Image: Toronto 2015 Pan Am & Parapan Am Games

Road traffic simulation has been around for more than 50 years, but it is only in the past two decades that such models have been considered intelligent enough to be a viable alternative to more traditional modeling approaches. This is not only attributed to advances in technology, but also to a realization by the industry that more detail and accuracy was needed in the evaluation of traffic scenarios.

"In the past, crude assumptions were made in developing several models that dealt with more general aspects of traffic, rather than looking at a specific issue," explains Saad Yousif, program leader of transport engineering and planning at Salford University, UK. Today's advanced microsimulation models, however, are able to determine the movements of individual vehicles traveling around road networks by using car-following, lane-changing and gap-acceptance rules. The models are now so realistic that traffic planners are relying on them to assist with overcoming challenges. For example, microsimulation will play an essential role in region-wide transportation plans surrounding the summer 2015 Pan Am and Parapan Am Games.

> These models are considered to be powerful tools and are being used to help designers, planners and road authorities make informed decisions
>
> **Saad Yousif, Salford University, UK**

(Left) **The 2015 Pan Am and Parapan Am Games will have a major impact on the Toronto landscape this summer**

"The most advanced models offer more flexibility in making proposed changes to road layouts, or monitoring variations in traffic conditions and traffic behavior, than empirical models," says Yousif. One simply alters the programming code in the software.

"These models are considered to be powerful tools and are being used to help designers, planners and road authorities make informed decisions about the

impact and effectiveness of changes to road layouts, signals and junctions," Yousif adds. "Traffic performance measures can include journey speeds, delays and queue predictions for certain areas."

Most models currently used by the industry also provide a visual depiction of traffic movements. "This means they can easily and clearly illustrate places where bottlenecks occur in response to certain changes," says Yousif. "Therefore suggestions for alleviating such bottlenecks and hotspot areas can be made by altering certain parameters within the model. This may involve making changes to the geometric design, altering the information given to drivers, introducing different controls such as changes to speed limits, providing enforced measures or prohibiting certain movements. The proposed changes can be tested in the model without the need to physically implement them on-site. The impacts of these changes can then be evaluated and assessed."

Yousif's research confirms that, if implemented correctly, microsimulation models can be used to successfully evaluate the impact of introducing new roadway infrastructure, such as ramp metering on motorway slip roads. "In this instance, the model uses values for certain parameters to trigger the traffic signals at the ramp," he explains. "Such parameters include traffic flow rates on both the ramp and the mainline motorway lanes, speed reductions on the mainline motorway lanes, changes in occupancy in certain lanes and queue lengths on the ramp. This information is then used to optimize the operation, by triggering the traffic signal controls and determining the length of the cycle time."

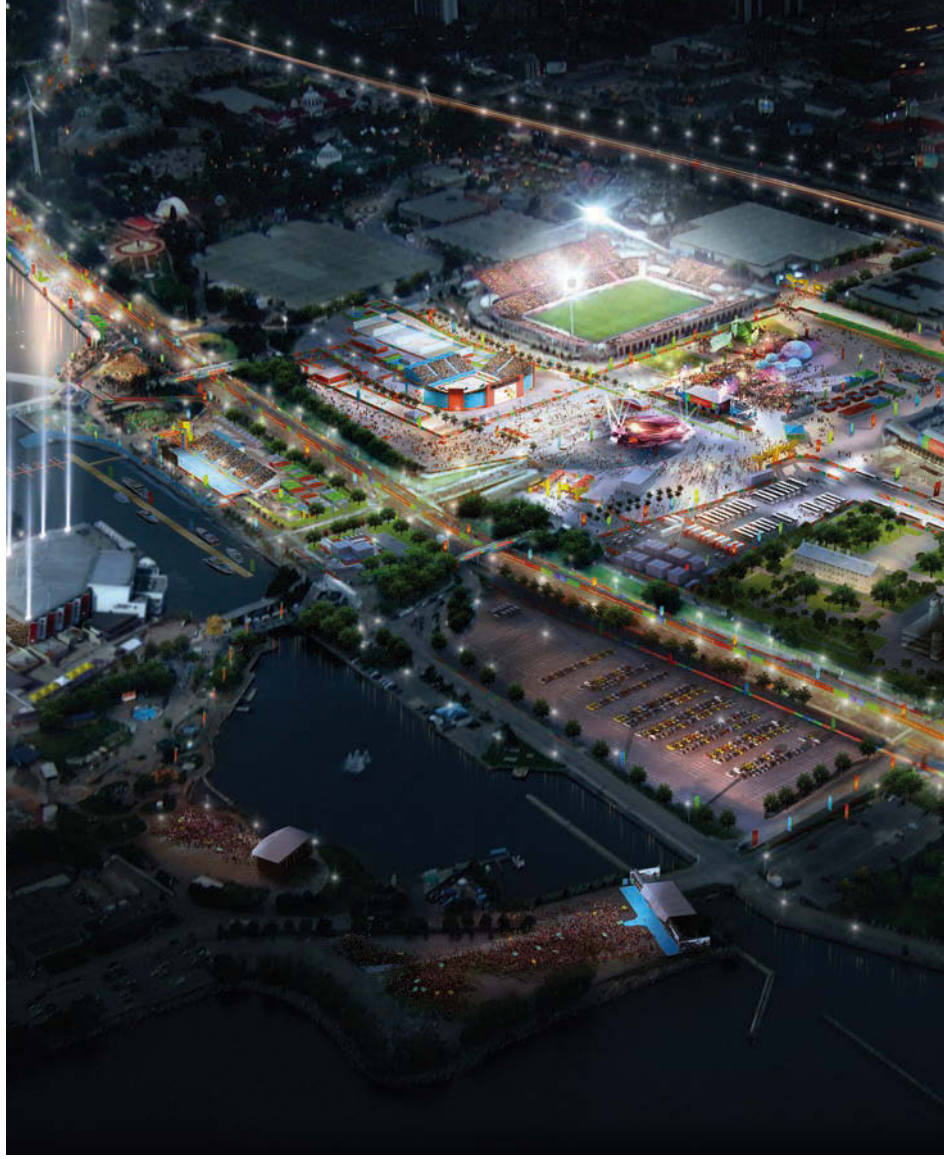
Microsimulation models have also proved to be an effective tool in considering the impacts of changes to road markings and signage, particularly surrounding temporary workzones and in the case of major sports or music events in urban areas.

Ahead of the game

The 2015 Pan Am and Parapan Am Games are expected to draw more than 7,000 athletes and 1.4 million spectators to Toronto and Canada's Greater Golden Horseshoe region. With congestion already a problem in the area, it has been essential for organizers to find a way to better manage travel throughout the region during the Games, and ensure optimized transportation for athletes and officials.

To this end, the Pan Am/Parapan Am Transportation Team (PATT) has been working on a C$60m (US$51m) transportation plan, which includes a Games Route Network designed to provide safe and reliable travel for the Games Family. The plan includes the introduction of traffic management measures such as a temporary priority lane network (PLN), parking restrictions, prohibited turns, public transit adjustments and road closures.

To evaluate the implications of creating a PLN for Games Family transport, the PATT decided to use the Aimsun hybrid simulation package from Transport Simulation Systems (TSS) to model the region's highways, with priority lanes added for high occupancy vehicles (HOV). This is not the first time the region's authorities have made use of such simulation techniques. The Ministry of Transportation, Ontario (MTO), has used traffic simulation modeling for highway planning and design, construction, operational reviews and traffic management strategies for several years (see *Traffic Technology International* April/May 2012). However, it is the first time MTO has used this method to anticipate a special event of this size. With competitions taking place in 30 venues over a 2,046 square mile (5,300km^2) area, the combined Games are set to be one of the largest events of the kind ever to take place in Canada.



(Above) **Regional authorities are using microsimulation models to make informed decisions about traffic management during the Games**

"Our experience has shown that mesosimulation and microsimulation, in conjunction with macro-level demand modeling, is the most effective methodology for evaluating the traffic operational implications of changes to the highway system," explains Goran Nikolic, head of traffic planning at MTO. "This is particularly true with respect to a congested highway system where time dynamics plays an important role. Microsimulation also enables us to evaluate the

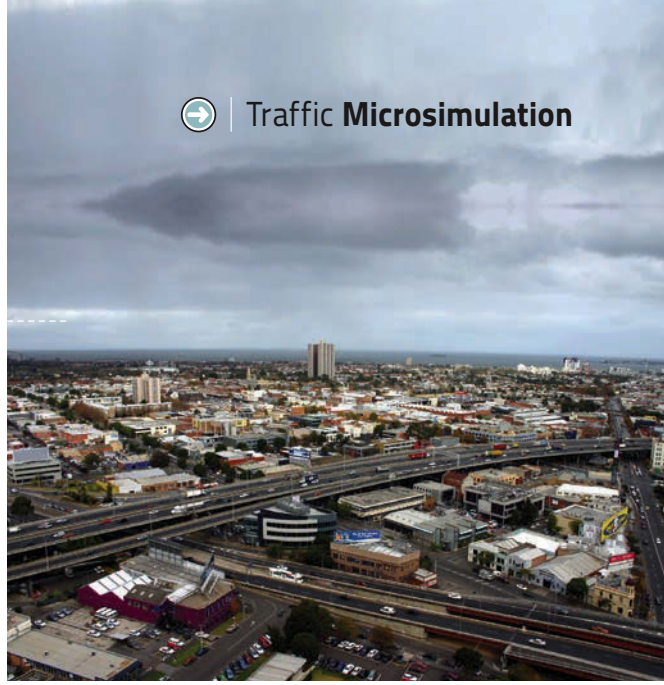
> The proposed changes can be tested in the model without the need to physically implement them on-site
>
> **Saad Yousif, Salford University, UK**

implications of overlapping and interacting highway features that could only be considered in isolation using analytical techniques."

The Aimsun simulation model, which was created using detailed information from the Land Information Ontario GIS system, comprises three levels of detail: macroscopic, mesoscopic and microscopic. As such, it delivers the fast computational benefits of mesoscopic modeling while enabling the organizers to zoom in on more congested or troublesome areas without having to change over to a different software package.

"The software has enabled us to evaluate the potential consequences of implementing traffic management solutions during the Games," says Nikolic. "We have been able to consider both the level of service provided to athletes and Games officials, as well as the impact on the traveling public. We have evaluated various eligibility options for the PLN and have considered how the public might adapt and respond to proposed traffic management measures."

The results from the model suggest that implementation of the PLN will have a positive impact on Games Family transport, while simultaneously benefiting the greater highway system. "It's useful to have this kind of technical support when making key policy and planning decisions," says Nikolic. "The simulation results are playing a key role in decisions currently being made."



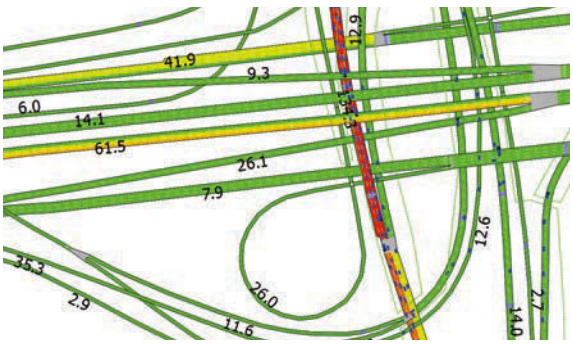
Quality matters

Verification, calibration and validation are essential parts of the modeling process

While microsimulation can be extremely useful, Salford University's Yousif warns that inaccurate data will result in a false representation of reality. "Rubbish in will lead to rubbish out," he says. Furthermore the unpredictable nature of road traffic makes management changes extremely complex. "Driver behavior and choice of location within the road space is much more difficult to predict and model than, for example, a train on a railway track," says Yousif.

While it is impossible to clearly identify and quantify all the factors that influence driver and vehicle behavior, most current microsimulation models contain user-adjustable parameters that control factors such as driver aggressiveness, car-following sensitivity and threshold speeds. This enables operators to replicate local conditions as accurately as possible.

"To ensure that a microsimulation model is developed properly, a series of verification, calibration and validation processes must be conducted," says Yousif. "Knowledge of the local conditions will reduce the chances of making improper assumptions, or accepting biased output results from the model."



(Left) **The Aimsun traffic model for the Pan Am games area comprises a larger mesoscopic-level area with some pockets of microscopic modeling**

While Nikolic recognizes that there is always a possibility that the real-world consequences of new traffic management strategies could differ from those predicted by the model, he believes that accuracy can be optimized by using common sense and engineering judgment gained from experience with the local highway system and traffic conditions. He understands that the success of this type of simulation analysis is dependant on the quality of the inputs available, including forecast travel demand and existing traffic volume and speed data.

"We would recommend this approach, provided that the required input data is available at a suitable quality level and provided that sufficient lead time is provided to avoid the need to rush the modeling process," he says, adding that detailed evaluation can be a resource- and time-intensive process. "We have a reasonable level of confidence in the results but there is no practical way to assess this level of confidence," he admits. "However, our level of confidence using any other methodology would be much lower. The amount and quality of the information obtained from the simulation model would simply not be possible using other methods."

> "The amount and quality of the information obtained from the simulation model would simply not be possible using other methods"
>
> **Goran Nikolic, Ministry of Transportation, Ontario**

Modeling mobility

The high level of detail provided by microsimulation models has also made them useful to researchers in Australia evaluating the viability and effectiveness of on-demand urban mobility. The iMoD (Intelligent Mobility on Demand) project was launched in 2011 by a team of academics from the University of Melbourne and Monash University to investigate how demand-responsive transportation (DRT) could increase mobility and access in growing cities, in a sustainable way. The development of highly detailed computer simulation models has been integral to their research.

"Traditional strategic approaches tend to be too high level to model DRT in reasonable detail," says Nicole Ronald, the research fellow in collaborative transportation for the Department of Infrastructure Engineering at Melbourne University and one of the iMoD initiative's key researchers. "Traffic microsimulation, however, where the precise movement of vehicles is modeled down to acceleration and deceleration, is ideal for small areas and for scenarios where demand-responsive vehicles could frequently stop, have their own lanes, or receive priority at traffic signals.

"Microsimulation enables us to explore the effects of individual choices and behavior, particularly the

Extra signals improve traffic flow by 15%

A microsimulation model proves that road authorities don't need to make huge investments in infrastructure to combat congestion at intersections

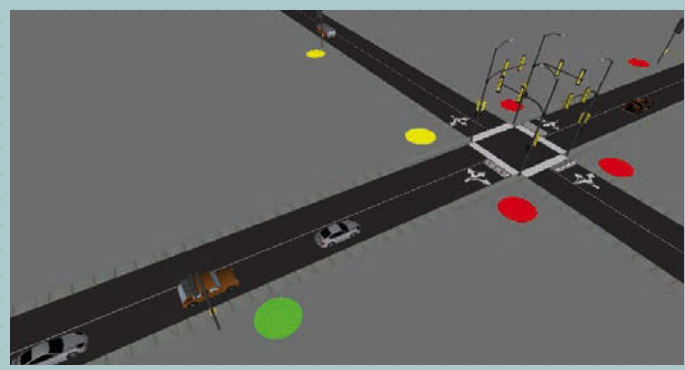
With the aim of finding a simple, cost-effective solution for overcrowded intersections, a research team from the University of Minho, in Portugal used microsimulation to evaluate how the implementation of pre-signals on intersection approaches could improve traffic flow and reduce waiting times.

"Our theory was that pre-signals would improve the efficiency of intersections," explains Luís Dias, assistant professor at the university. "So we used microsimulation to create models that make a realistic comparison between intersections with and without pre-signals." The input data was based on field observations as well as research and experience.

The researchers used a tool called Simio, which uses an object-oriented paradigm. "The tool enabled us to include variables such as vehicle acceleration and driver reaction times," says Dias. "That meant we could make the models as realistic as possible." The model also provided the flexibility to change the type of intersection (with or without pre-signals), the distance between a pre-signal and the main lights at each approach, the traffic light green time and the traffic intensity.

The model showed that the cars using the intersection with pre-signals waited one minute less than the cars using the standard intersection. Furthermore queues were shortened by 60m and traffic flow increased by 15%.

"We found that in heavy traffic a distance of 40m between the pre-signal and the traffic light was ideal and in light traffic the distance doesn't influence the performance of the intersection," says António Vieira, a researcher at the university who worked with Dias on this project.



The model has been verified and the team is confident that the results could be replicated in the real world. "We are now working on a model that compares the performance of an intersection with pre-signals with the performance of a roundabout," says Vieira. "We're also looking at emissions and fuel consumption."

Videos of the model can be found at trafficTechnologytoday.com/micro

interactions between vehicles and people," Ronald continues. "For example, it can take into account individual driving behaviors and explore the effects on other vehicles, or look at how changing working hours will impact rush-hour traffic." This is particularly useful for DRT, as the routes of vehicles are determined by passenger requests.

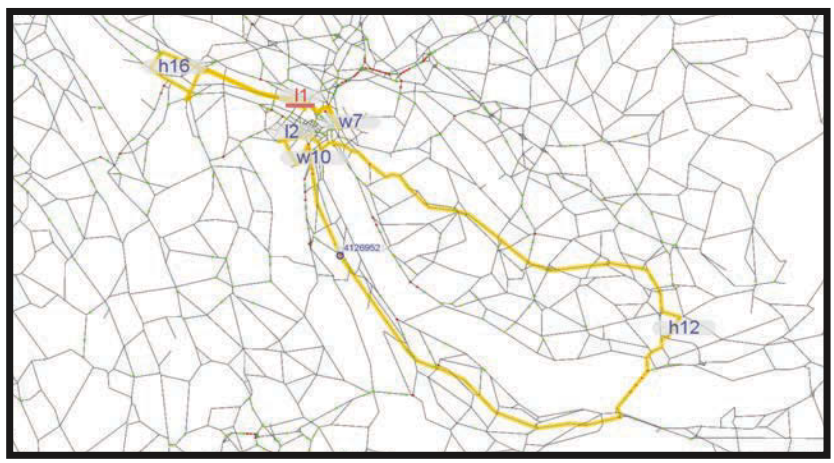
An integrated approach

The iMoD researchers have looked at three types of model so far. "We started by creating our own DRT-only software from scratch, which enabled us to explore some of the effects of changing the number of vehicles, vehicle sizes, and demand patterns," Ronald explains. "However, this did not incorporate other traffic, which could affect the performance of the system. As a result, we have developed a prototype of DRT simulation on top of traffic microsimulation and found it was more useful for exploring detailed operations."

Ronald's team has also been using an agent-based microsimulation software package called MATSim, developed by TU Berlin and ETH Zurich, which has been previously used to model vehicular traffic and public transport for large areas, such as Zurich and Singapore. "Up to now we have been simulating DRT alone," says Ronald. "Our next step is to integrate the DRT model with other modes. This will enable us to evaluate multimodal systems and quantify costs and benefits for our project partners."

One current iMoD project is using microsimulation to explore how different types of DRT schemes could work in two neighboring towns in regional Victoria. Here, fixed route buses were replaced with a demand-responsive service in late 2013. At set times during the day, a vehicle starts from the center of one town and picks up and drops off passengers as requested. If there are no requests, the vehicle does not travel.

"We created a model of this as our base, alongside an altered scheme without the time constraints – so the vehicle runs the whole day," describes Ronald. "We can now develop demand estimations and costings for these schemes. Using data from the real-world service enables us to ground the model, and will lead to use for other towns in Victoria."



(Above) **An agent-based microsimulation model of an area in Zurich, using MATSim software**

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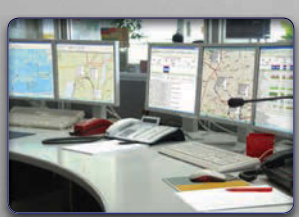

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Social network

In anticipation of Traffex 2015, taking place April 21-23, in Birmingham, *Traffic Technology International* gets the inside story on the UK's largest and most successful traffic industry event, from event director Bill Butler

Traffex has been uniting different sectors of the traffic industry for more than 30 years. "People love to come and network," says event director Bill Butler. "There's a great spirit that runs through this industry in particular." And that networking is growing in its diversity: while the show's roots are in road infrastructure and physical engineering solutions, over the years it has evolved alongside the industry to become increasingly technology focused. "Local authorities and contractors are becoming more and more aware of the intelligent transportation systems that are out there," says Butler. "People are not necessarily building new roads now – it's more about utilization of the existing network capacity. There is a recognition that we can't just build our way out of our road shortage. Greater use of technology and an understanding of the journeys being made will help us make better use of existing transport networks."

It takes two years for the Traffex team to organize the Birmingham show that brings together more than 400 exhibitors and 10,000 international visitors. "The challenge for us each time is to keep it fresh and interesting, and to continue uniting the public and private sectors," says Butler. "So we're always introducing new features, zones and aspects into the show – making sure we keep the content right. In 2013 we introduced a feature area called Lighting The Way, which looked at illumination. This year we're creating a live highway area, which highlights some of the products and services available to assist vulnerable road users. We'll be giving visitors the opportunity to get on a bike, put on a safety helmet, and have a spin through urban daylight night-time environments."

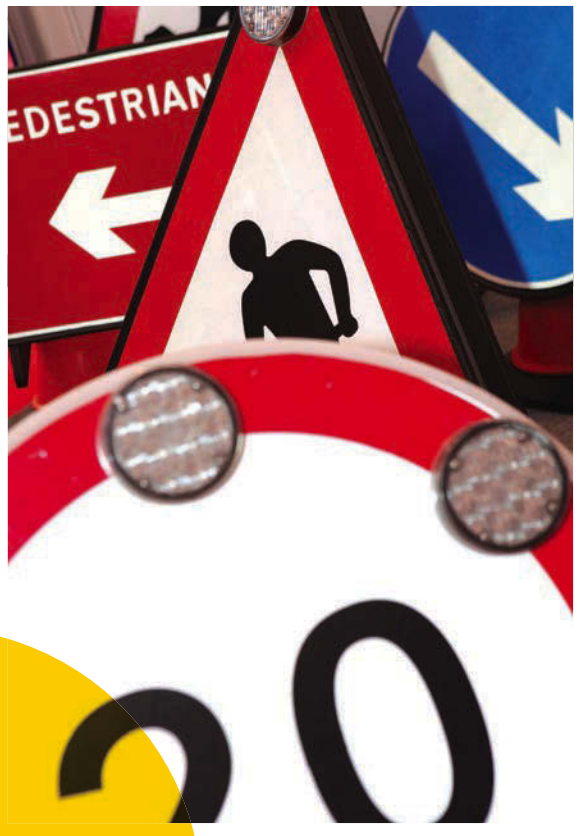
Visitors will also be able to experience an urban traffic environment, which covers some 43,000ft^2

Traffex
21-23 April 2015
The NEC, Birmingham, UK

(4,000m²) of the exhibition hall, from a pedestrian point of view. "You'll be able to explore on foot or cycle around what is effectively a public highway," says Butler. "We'll also have cars, trucks and buses as part of the feature layout. There'll be a working traffic signal-controlled junction, pedestrian and cycle crossings, and some live roadworks going on.

"This is all about promoting debate," Butler continues. "It's very much for a technical audience – engineers will be able to see things from a risk-assessment point of view. There will be a particular focus on road worker safety. The UK government has made a big commitment to reduce casualties in that sector [see p40 for more on workzone safety]. In the last quarter of last year there were at least five road worker fatalities on the road network. We'll have a highway taper to show some of the products and services that are currently being used to help protect the workers who are out trying to keep the network open."

(Above) **More than 400 specialist suppliers will be showcasing thousands of products and services at Traffex 2015** (Left) **The NEC in Birmingham is the largest exhibition center in the UK** (Right) **Workzone safety is an important part of the event**



Business class

In addition to the notoriously busy exhibition, Traffex 2015 will also include three days of speaker seminars. "I'm particularly looking forward to seeing Graham Dalton, the [outgoing] chief executive of the newly formed Highways England," says Butler. "He's going to be echoing the theme of this year's show, which is Smarter, Leaner, Stronger, Together. He is the keynote speaker on the first day. Then we've got Keith Manston, head of product management for traffic solutions at Siemens, looking at the UK's Traffic Signs Regulations and General Directions (TSRDG) updates and the new Traffic Open Products and Standards (TOPAS) for traffic signs, which will be interesting. We also have Sue Stevens, director of education and membership at CIHT (the Chartered Institution of Highways and Transportation), who will be talking about developing skills through professional qualifications."

Cycling will be a recurring theme at Traffex this year. Rob Gallagher, an independent transport planning consultant, and John Parkin, professor of transport engineering at the University of the West of England, will be speaking about new developments in cycle planning and design. Matt Sweeting, head of network development at Highways England will also be talking about planning for cyclists. "It's a hugely topical area where there's much work to be done," says Butler. "Given that about 55% of car journeys are under five miles long, there are clearly many journeys being made that do not require a car."

Other seminar highlights include: Matthew Lugg from HMEP (the Highways Maintenance Efficiency Programme), who will be providing an update on the organization's annual plan; a lunchtime debate hosted by ITS UK looking at the in-car and driverless car technologies that are emerging; and a session hosted by David Stones, head of network performance at Highways England, who'll be looking at the role of expressways. "It's already an incredibly big topic in the USA," says Butler. "I think we'll start to see that term referred to more in the UK in the coming years."

Global reach

According to Butler, although the biggest group of visitors to Traffex are from the UK's public transportation sector (about 40% of attendees), private business interest is growing. "An increasing number of our highways are being managed in partnership with the private sector and Traffex is also an opportunity for those in the public sector to discover what new products and services are available," says Butler. "The efficient movement of people and goods is an incredibly huge area and it's important for the whole economy.

"The industry has a fondness for Traffex," Butler continues. "People have grown up with the show. Those who are now at the top of their tree have been coming here since they were studying for their qualifications or starting their careers. It's one of the shows that the industry loves and knows, and, thankfully, continues to support. Companies will time the launch of their new software or product to tie in specifically with the April show."

Approximately 18% of Traffex visitors come from overseas – mostly from Europe, but also from the Americas, sub-Saharan Africa, the Middle East and from new EU countries. "The UK is still regarded as an innovator," says Butler. "We've had big buying groups come here from all over the world."

The show's exhibitors are becoming increasingly international, too. "We get exhibitors from Europe, the Americas, Australia and Asia who are looking to do business in the UK," Butler explains. "They come to Traffex to meet a partner or to test the market, or to find out about the legislation and discover what opportunities exist. There's a lot of inter-business between the companies that take part in the exhibition, which is unusual at trade shows. I always joke that you could almost take every visitor out of the hall at Traffex and there would still be an enormous amount of business done! It's just one of those industries."

> Greater use of technology and an understanding of the journeys being made will help us make better use of existing transport networks
>
> **Bill Butler, event director, Traffex**

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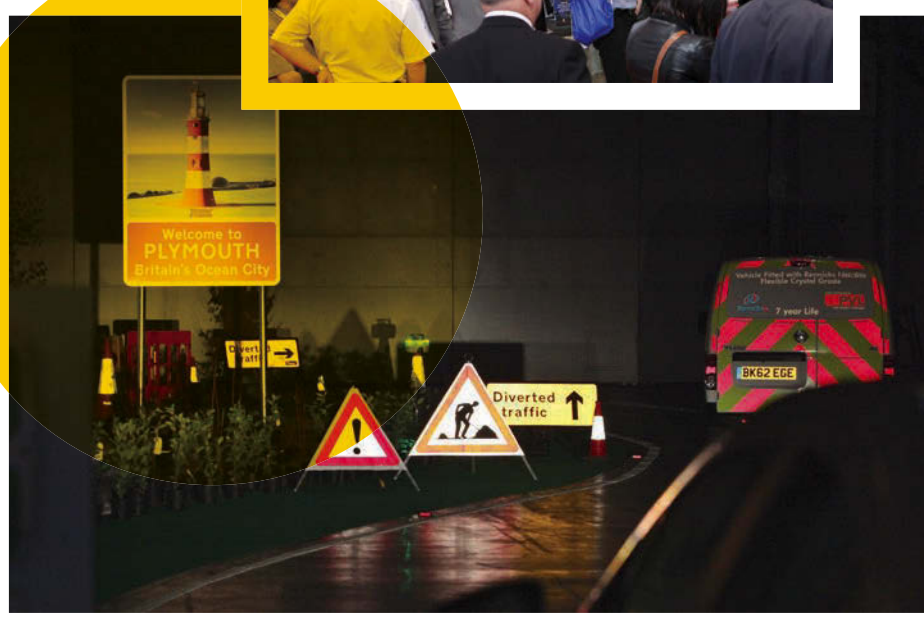
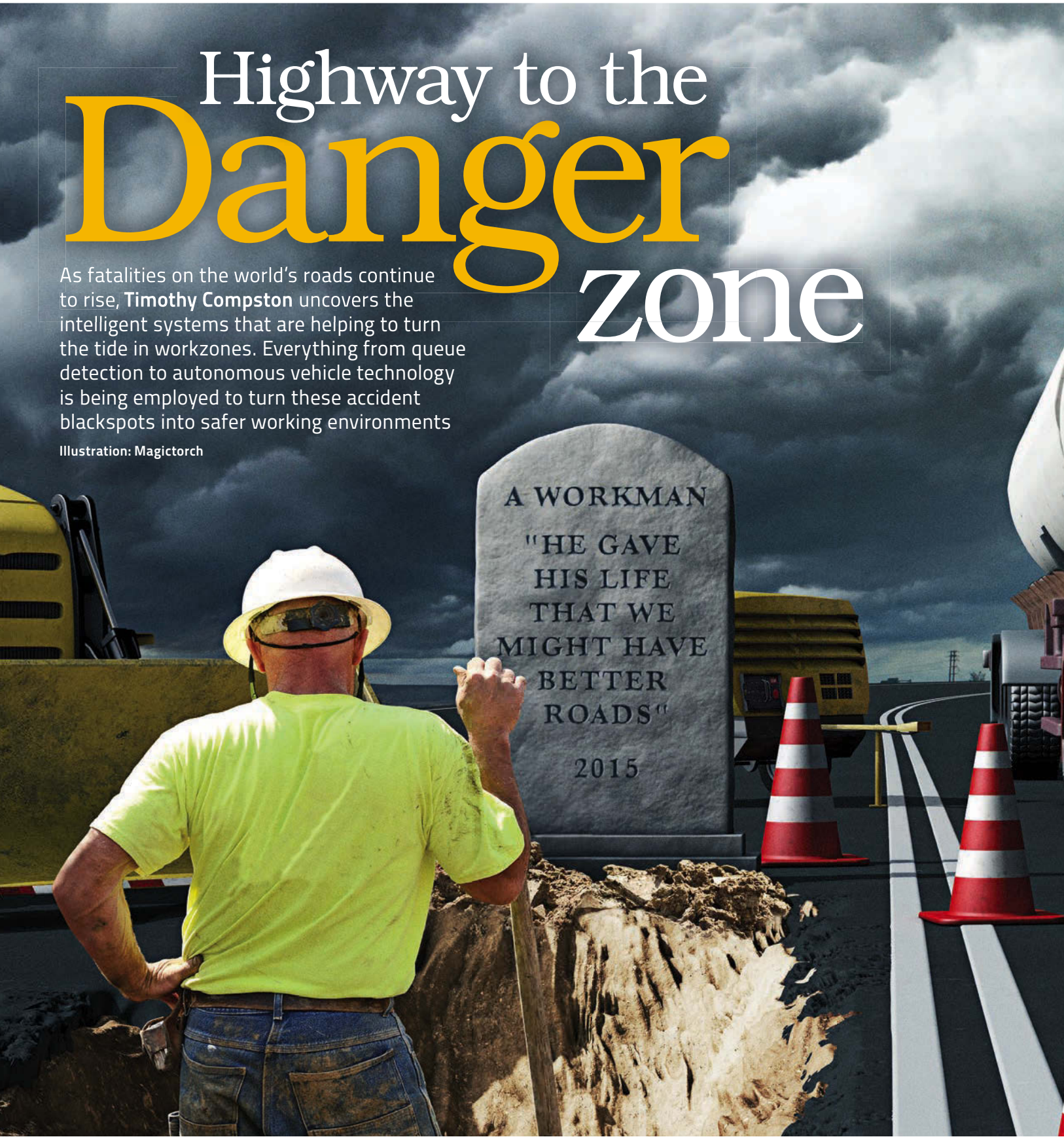


(Above) **Bill Butler, Traffex exhibition director** (Right) **The show provides numerous networking opportunities** (Below) **The Lighting the Way exhibit in 2013 provided the inspiration to create a full live highway area for Traffex 2015**

Highway to the Danger zone

As fatalities on the world's roads continue to rise, **Timothy Compston** uncovers the intelligent systems that are helping to turn the tide in workzones. Everything from queue detection to autonomous vehicle technology is being employed to turn these accident blackspots into safer working environments

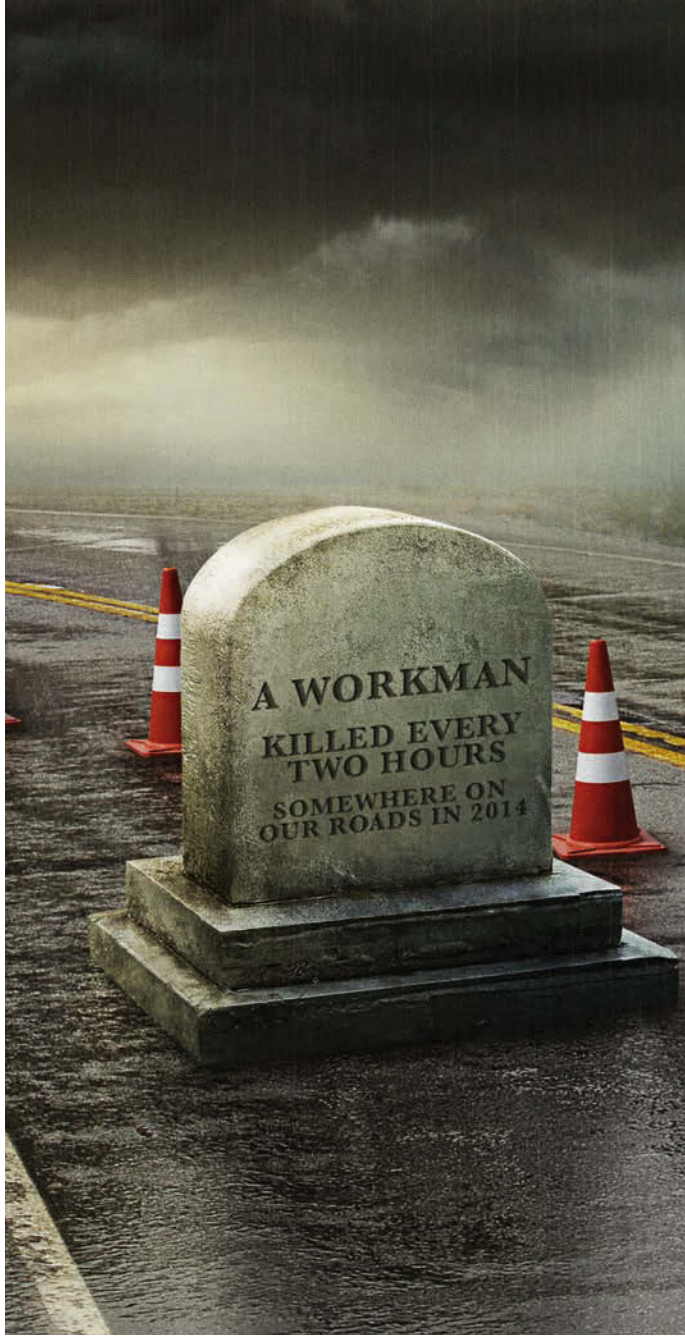
Illustration: Magictorch



There is little doubt that workzones throw up a host of safety challenges, with hundreds of fatalities every year in the USA alone, and thousands more worldwide. Talking to researchers, and those out in the field, there is a series of issues that they are keen to spotlight, such as the need to be able to warn drivers not only of the presence of workzones, but to provide real-time information as queues build. Furthermore, as workzones are, by their nature, static (or slow-moving) and have distinct boundaries, with fewer variables than the open road, they could soon become the first places to routinely utilize autonomous vehicles to help improve safety.

Heroes for zeroes

Working to maintain roads is the most dangerous job in construction, accounting for around 5,000 deaths worldwide every year. While this is only a tiny fraction of all road deaths (which are now in excess of 1.2 million), it is significant in that the workers involved are exposed to these risks every day. Most of us accept some degree of risk and responsibility when we get into a car; however, most of us do not have to endure such risks every hour at work. Accordingly, making workzones safer is a high priority for road authorities around the world, and some, such as the UK's Highways Agency (HA), see it as an area where, through clever use of the latest technology, Vision Zero could be achieved before anywhere else: Its workzone-dedicated health and safety initiative is known as Aiming for Zero.



(Above) **The wreck of an attenuator truck that was hit as it protected a road workforce in the UK**

Although the UK is among the safer countries in which to dig up roads, casualties are still unacceptably high – a fact underscored last year when the HA released footage of a truck ignoring a large 'X' on an overhead gantry and crashing through traffic cones protecting workers (**trafficktechnologytoday.com/workzone**). Data provided by the HA shows that road workers on or near highways suffered the highest number of serious injuries for six years during 2013. It's not surprising, then, that the HA has been ramping up efforts to put the brakes on these accidents.

Risky business

Top of the agenda are 'live' lane crossings, which make work crews vulnerable to inattentive drivers. The man with the inside track on this is Ian Smith, the HA's program manager for Aiming for Zero. Smith explains that the Agency is driving forward with a wholesale rethink: "Live lane crossings are carried out by workers, usually in the dark, with no warning signs as they are actually carrying the signs from the shoulder to the central reservation [center divide]."

The HA has been looking at ways to reduce these lane crossings through cutting the amount of signs required. "We carried out on-road trials, in night-time conditions, to test if you can manage with near-side signs," says Smith. "So, for overnight works we halved the number of signs at the approach to roadworks. The result was that, in one stroke, lane crossings reduced by 40%." To eliminate lane crossings completely, however, smart solutions, particularly in warning motorists about workzones ahead, are also being employed.

> "For overnight works we halved the number of signs at the approach to roadworks. The result was that, in one stroke, lane crossings reduced by 40%
>
> **Ian Smith, program manager for Aiming for Zero, Highways Agency, UK**

Sign of the times

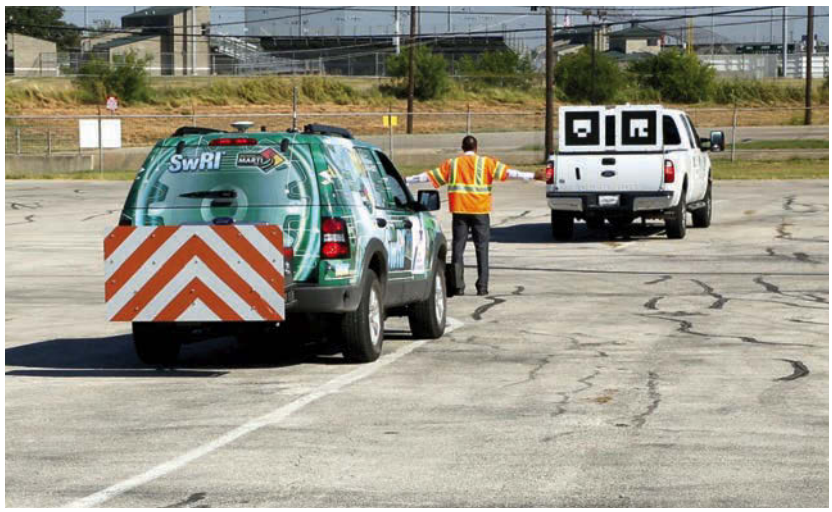
Connect Plus, which maintains, operates and upgrades the M25 around London on behalf of the HA, has played an important role in managing traffic approaching workzones. Trials carried out by the firm – with the backing of the Road Workers' Safety Forum, the HA and the Transport Research Laboratory – indicate that improved overhead and nearside signage removes the need for temporary signage at the center divide. Already the method has been implemented on over 620 miles (1,000km) of the network, saving an estimated one million road worker crossings.

Philip Ross, senior health, safety and environmental manager for Connect Plus on the M25, explains that it is possible to use smart signs to forewarn motorists more effectively. "We are able to use the overhead gantries on the all-lane-running sections and the intermediate gantries hanging over the hard shoulder to indicate to drivers that there are lanes closed ahead, or that they need to keep left or right," he explains.

Ross feels that the red 'X' symbol – meaning a lane is closed at that point – is a great supplement to physical emergency traffic management measures, like cones and high-impact protection vehicles, especially

when LED overhead signs and other signage are automated and work on remote SIM cards with GSM technology. With 25 years' experience in the field, Ross is well acquainted with workzone safety challenges and is keen to flag up the necessity of managing the so-called 'plant and people interface' through worker education. A case in point, he says, is zone training, which is now beginning to use smart technology.

"This is about educating and interacting with the workforce in an environment they are comfortable with, and involves setting up a number of machines in a warehouse." The 'traditional' way to educate workers about safety around these machines is with zones physically painted on the floor (red, amber and safe zones). Cardboard cutouts can then be placed and machines moved to demonstrate the visibility of workers to the drivers. It's helpful as every machine has a slightly different safe zone and unsafe zone. Now technology is beginning to make this training much more effective. Ross reveals that trials have been underway with a number of systems that are proximity devices: "Basically this is where a machine has a receptor and each road worker has a transponder. If the transponder and receptor come within a set distance, then it will buzz with an alarm."



(Above) **The prototype attenuator truck, developed by San Antonio's Southwest Research Institute, is completely driverless**

Beyond this, new machine vision technology can now recognize human shapes around plants and give safety recommendations accordingly. Such systems are set for use around the Dartford Crossing on London's M25, Ross says. Here, they will help workers to spot if a person enters a zone where they shouldn't be. A machine isolation switch or 'kill switch' can then be applied to any motorized equipment so the machine is kept in a static position until that person exits the work area. As a parting shot, Ross reiterates the point that while technology can enhance safety procedures in workzones, it doesn't completely replace them: "In my view, safety still relies on very good machine and person exclusion zones."

Automatic for the people

Another glimpse of the future, where workzones are concerned, comes in the form of a prototype automated attenuator vehicle developed by San Antonio-based Southwest Research Institute (SwRI), which wowed the crowds with its gesture-based control and autonomous operation during a series of demo sessions at the ITS World Congress in Detroit last September.

In the world of workzones, an attenuator is essentially a buffer that absorbs energy to mitigate the effects of a vehicle collision. These are generally mounted on the back of a truck that runs slowly behind a moving workforce to protect them. The truck is normally also emblazoned with a giant flashing arrow as a last-ditch attempt to warn oncoming vehicles to move over. We've all seen them… and a surprising number of people treat themselves to an impromptu close-up inspection. Steven Dellenback, executive director of the intelligent systems department in the automation and data systems division at SwRI, puts the scale of the safety issue into perspective: "In Texas, about twice every week an attenuator truck gets hit." It comes as little surprise, then, that Texas DOT is worried about the safety of its workers. Up to 100 hits per year is pretty extensive in terms of personal injury and medical lawsuits.

Smart wheels

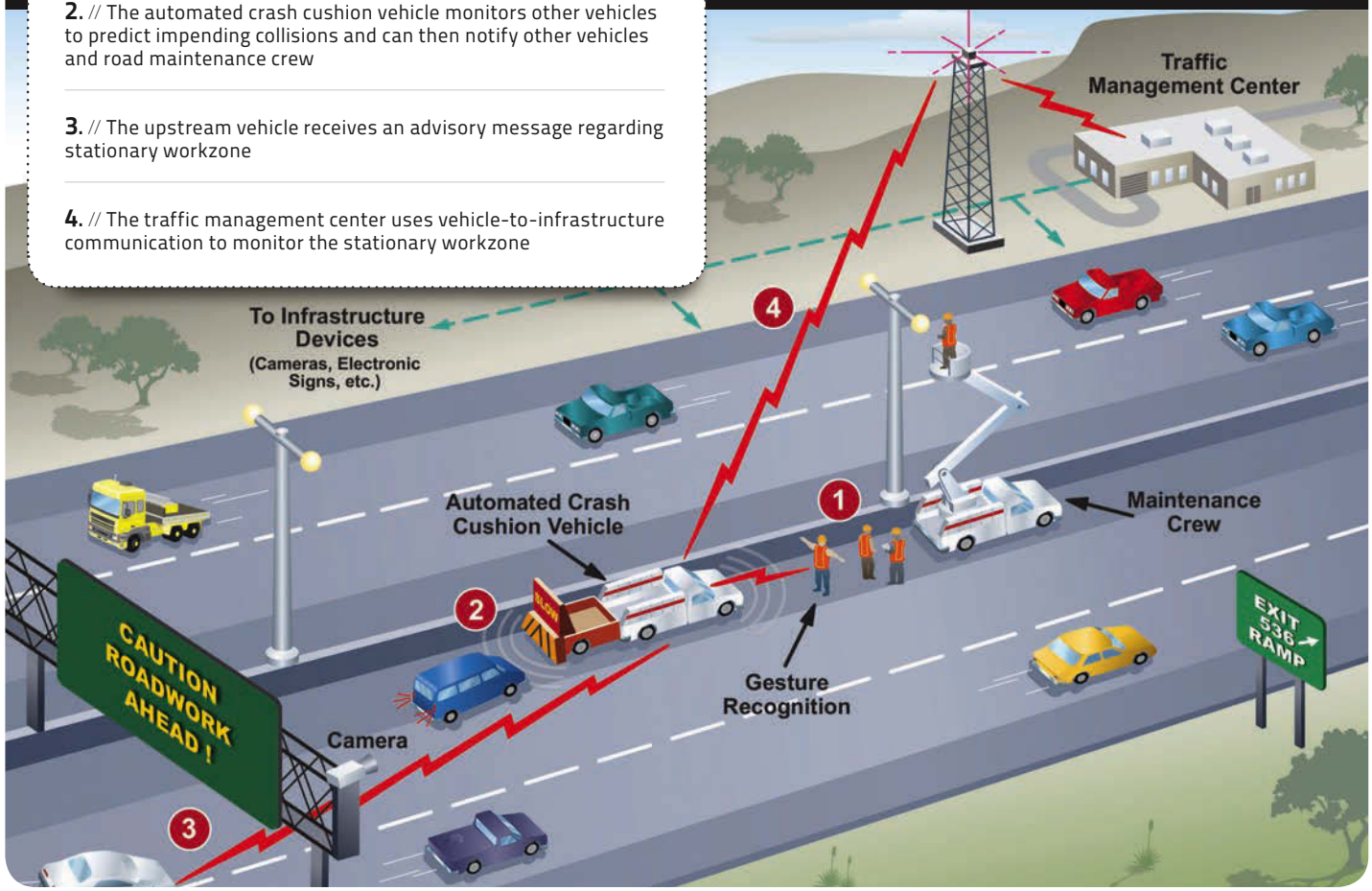
How the autonomous attenuator truck works

1. // Maintenance crew can control an automated crash cushion using tablets or gesture recognition

2. // The automated crash cushion vehicle monitors other vehicles to predict impending collisions and can then notify other vehicles and road maintenance crew

3. // The upstream vehicle receives an advisory message regarding stationary workzone

4. // The traffic management center uses vehicle-to-infrastructure communication to monitor the stationary workzone



Dynamic workzones typically have two trucks protecting them: the lead truck, which heads up the convoy; and the following attenuator truck, which has the much more dangerous job of protecting the workers' backs. In the gap between, maintenance is carried out. One of the most dangerous jobs in this setup is driving the attenuator truck – or walking up the lane to jump into the cab after a period of static work. It's the removal of these tasks that mean an automated attenuator truck could have a massive impact on workzone safety.

Building the future

The first move toward making the automated attenuator vehicle concept a reality was to fit out SwRI's existing state-of-the-art MARTI-1 (Mobile Autonomous Robotics Technology Initiative) SUV to show what might be possible. Dellenback takes up the story of the vehicle's development: "Our Ford Explorer [MARTI-1] already had laser and camera sensors and we added a connected vehicle capability to communicate positional information. We have used fiducials [machine-read symbols] on the back of the lead vehicle, which the vision system tracks to make sure it is keeping to the right distance and alignment."

> Implementing hand signals enables a person to move the attenuator truck forward, left or right, instead of them having to walk back or go to a computer interface
>
> **Steven Dellenback, executive director, Intelligent Systems Department, SwRI, USA**

There are two main ways of adjusting the programming of the automated vehicle. The lead truck can employ a tablet interface to vary the following distance – which can be between 25m and 100m – and, if necessary, tell it to offset: "You may want it to follow 5m off to the left to protect the lead truck rather than directly behind, making the traffic go around," says

Assessing success

Research in Illinois reveals just how much of a success workzone ITS can be

Ted Nemsky, who is a construction engineer for Illinois Department of Transportation (IDOT), has had recent experience in applying ITS to develop smart and safe workzones and has also assessed how successful his projects have been.

It was an incident in IDOT's Carbondale District that brought smart workzones back into the picture. "On July 16, 2010 we had an awful seven-vehicle accident on I-57 involving trucks hauling asphalt to our job," recalls Nemsky. As a remedial measure, a message board was run on a truck against the queue to alert people that traffic was backing up. More practical options were then investigated, such as iCone's system for queue detection with Doppler radar detectors and an algorithm to send messages back to boards on the roadside.

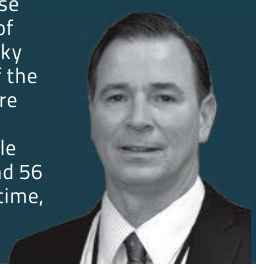
In late 2010 IDOT undertook a huge building project in a rural section of Interstate, this time running between St Louis and Springfield or Chicago. "It was going to disrupt traffic because we were taking out one lane of a two-lane Interstate." Nemsky says that, in the aftermath of the I-57 pile-up, there was a desire to roll-out queue detection: "We ended up with 73 portable chargeable message signs and 56 Doppler radar sensors." This time, the radar sensors were from Ver-Mac. With other projects in the pipeline to the south, Nemsky says that it made sense to extend the reach of the smart workzones to the wider corridor rather than concentrating everything on a solitary stretch: "We covered the whole project, there was 30 miles [48km] of construction on I-55 and I-55/70."

(Left) **Nighttime workzones are dangerous places** (Below) **Illinois DOT has shown that queue and speed detection systems improve safety**

In an effort to prove tangible results, Nemsky undertook before and after analysis on I-55, taking as his benchmark the level of rear-end collisions. Gerald Ullman, senior research engineer at Texas A&M Transportation Institute, concurs that often workzone issues stem from slowdowns that are unexpected, leading to rear-end crashes: "These are by far the biggest category of workzone crashes." Collecting data is also a challenge. "If you have several miles of back-up at the upstream end, a lot of times these crashes don't get recorded as workzone-influenced," says Ullman.

Nemsky believes he has found a way around this problem: "You have the same corridor, one year without any of these systems, and the next year with them." He sifted through the accident data for the two years and threw out all of the accidents except rear-end collisions. He put this into context by calculating lane closure days: "I counted a lane closure day any time we had a lane closure within the corridor because experience shows that is where your back-up occurs and you have accidents."

The next stage was to calculate 'total vehicle exposure', taking the average daily traffic times and the number of lane closure days to see how many cars drove by the lane closures – about 13 million in 2010 and 16.3 million a year later. The stats that stand out are a 14.6% reduction in property damage accidents, an 11% fall in accidents causing injury, and a 14% drop in queuing accidents, following the implementation of the Ver-Mac system.



> "[I looked at] any time we had a lane closure within the corridor because experience shows that is where your back-up occurs and you have accidents"
>
> **Ted Nemsky, construction engineer, Illinois Department of Transportation, USA**

Dellenback. An autonomous attenuator vehicle is easier to implement than a self-driving car because it is working in a more constrained environment. "You are not worried about traffic signals because the lead truck is setting the pace for the attenuator vehicle," says Dellenback. "Also, as we are primarily looking forward, we don't have to put in the highest-resolution cameras."

The truck can also be controlled using hand signals, which could help to minimize risks in workzone situations like patching-up potholes or fixing a piece of guardrail, where you only need to move up a road in small increments – 10 or 20m at a time. "Walking back to the attenuator vehicle is a dangerous operation when the attenuator driver is also part of the work crew," says Dellenback. "Implementing hand signals enables a person to move the attenuator truck forward, left or right, instead of having to walk back or go to a computer interface."

The truck is not quite at the stage where a DOT could actually deploy it into workzones for day-to-day operations, but it is a taste of things to come. "The current vehicle is very much a proof-of-concept," says Dellenback. "We are now talking about creating a prototype based around a real attenuator truck that we can then automate and use to enhance our algorithms and to do some in-the-field testing for the first time."

Right here, right now

Returning to the current state-of-play regarding workzone safety in the USA, Jawad Paracha, Federal Highway Administration (FHWA) workzone program manager, flags up that in 2012 there were 609 workzone fatalities, of which 133 were worker-related. After dropping towards the end of the 20th century, for the last 10 years worker fatalities have remained static around this number. Indeed, Paracha feels that the headline issues today are much the same as they were

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(Above and above right) **Real-time queue warning VMS systems at workzones in Texas**

a decade ago and still center around inadequate warning of workzones, especially lane closures coupled with excessive speed, sudden lane changes and distracted driving. More recently, the extension of night-time working has started to factor into the equation, which demands effective project coordination.

ITS has had a huge impact on reducing the dangers associated with workzones. Paracha has seen an increase in end-of-queue warning system deployment. Alongside this, he signals that the next wave of the FHWA's Everyday Counts program – EDC3 – which started in early 2015, is bringing smart workzone systems firmly into the frame. "EDC continues to highlight proven ITS technology that should be standard practice," he explains.[1]

Paracha reports that the proportion of workzone fatalities associated with trucks is disproportionately high. He says that plans are in place to hold a national symposium to debate this issue, bringing together key stakeholders such as the Federal Motor Carrier Safety Administration, law enforcement, researchers, workzone practitioners and safety specialists.

Heavy trucking

Gerald Ullman, senior research engineer at Texas A&M Transportation Institute, echoes the FHWA's concerns about large trucks being over-represented in fatal crashes, pointing to FARS (Fatality Analysis Reporting System) data, which shows 23.6% of fatal crashes in workzones in 2012 involved at least one large truck.

Reflecting on specific solutions, Ullman explains that queue-end warning is one aspect of workzone ITS that is heavily promoted: "We are doing it very extensively in Texas. It is simple to deploy and has good credibility with the traveling public as they are recognized as 'real-time' and not just a 'watch out there may be a queue here'." Ullman feels this has the potential to improve safety and says Texas A&M Transportation Institute is trying to further quantify the effects on I-235 in central Texas.

Queue-warning systems aren't the only way in which intelligent systems can improve safety in workzones. Ullman is a firm advocate of other ITS solutions. He assisted on the Federal Highway Administration's *Workzone ITS Implementation Guide*.[2] It lists real-time traveler information, dynamic lane merging, incident management, variable speed limits, automated enforcement, entering/exiting vehicle notification and performance measurement as current applications for ITS in workzones, with potential for wider deployment. It also gives detailed recommendations on how to assess the suitability of locations for the application of these types of technology. "We have had good feedback on this," Ullman says.

Highway to the safety zone

It is clear that the way workzone safety is being handled has moved on considerably in recent years, whether it is an appreciation of where the real dangers are, or what ITS measures should be deployed. For the future it will be interesting to see not just whether there is a decline in overall accidents and fatalities across workzones, but also what impact – through analysis like that undertaken by Illinois DOT – specific schemes are having.

> Queue-warning systems are simple to deploy and have good credibility with the traveling public as they are recognized as 'real time'
>
> **Gerald Ullman, senior research engineer, Texas A&M Transportation Institute, USA**

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Q FREE

LEADING THE WAY

Bright ideas

The road of the future will light up to warn drivers of everything from pedestrians about to cross and vehicles pulling out, to whether they are driving the wrong way. **Max Glaskin** gets the latest from several large-scale, intelligent road-stud projects that are nearing completion

Illustration: Solarseven

In the age of in-car information, keeping drivers' eyes on the road isn't always easy – so what if the road itself could provide helpful information? That's the aim of researchers who are currently developing new ways to add intelligence to asphalt.

Wolfgang Birk at Luleå University of Technology in Sweden has been leading a study on intelligent road studs since 2008. The goal throughout has been to make units that can detect the position of an approaching vehicle, its direction and speed, and even the type.

"We have now achieved what are essentially close-to-production prototypes," says Birk. "They've been tested in real-life conditions and there are demonstrator installations on the road. The project has been undertaken with the support of Geveko and a number of smaller enterprises interested in the development and analysis of the tests."

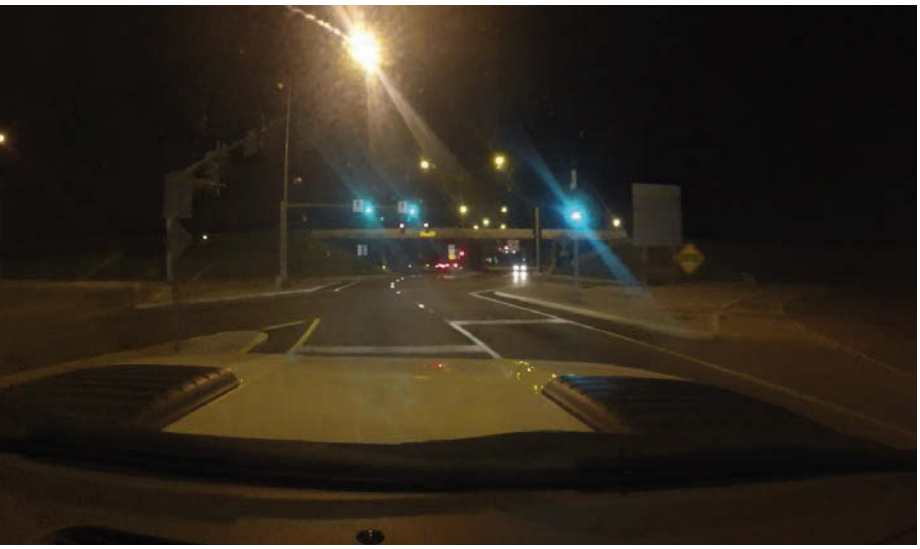
Specializing in the mathematics of estimation, Birk assessed what could be reliably inferred from the data captured by different sensors in an intelligent stud. The input of collaborators has resulted in stable algorithms and hardware that does the job. "We have four sensors integrated into a single stud: a magnetometer, an accelerometer, a temperature sensor and a light-intensity sensor," Birk explains. "These sensors provide

> We have four sensors integrated into a single stud: a magnetometer, an accelerometer, a temperature sensor and a light-intensity sensor
>
> **Wolfgang Birk, Luleå University of Technology, Sweden**

information on vehicle classification, speeds, flow and wrong-way driving."

Some of the information processing is performed in the studs but it is then transferred to the cloud for further processing. "This is useful when you want to combine information from several nodes, to derive extra information," says Birk, "For example, the quality of vehicle speed and position information is enhanced when you combine data from more than one node."

Four studs were put on long-term trials on a two-lane urban road carrying a medium volume of light vehicles. Data from 20,000 vehicle movements was



(Below) **Missouri DOT has installed 16 lightweight, solar-powered road studs to delineate the 'skip lines' on a diverging diamond interchange**

assessed by the Swedish Traffic Administration (Trafikverket), which is working with other Scandinavian countries to define the kind of traffic analysis they all need and the methods they should adopt. "We have now started a project that transfers the knowledge from the research into a product," says Birk. "It's the last step for us and we'll finish in June."

Safety and sustainability

In the UK another noteworthy project is also almost complete. The final demonstration from the INROADS (INtelligent Renewable Optical Advisory System) project is taking place in early 2015. It's the culmination of over three years of research to develop intelligent LED studs with sensors and communications capabilities, with at least part of their energy harvested through renewable technologies: they could be self-contained units.

Potential applications identified early in the project included detecting and reacting to pedestrians and vehicles at pedestrian crossings: the studs light up when safety is critical and power down when not needed. By communicating with each other, they might switch on to delineate curves on unlit roads beyond the range of headlights and they could react similarly to warn drivers of vehicles emerging from side roads.

"Trials have shown that sufficient energy is generated from piezoelectric devices beneath the studs when vehicles pass over the units," says Martin Lamb at Transport Research Laboratory (TRL), who coordinates INROADS. "This means they could work in the wheel path of vehicles approaching pedestrian crossings. The faster and heavier the vehicle, the more power you get from the device."

Vehicles can be detected by magnetic sensors, and there is hope that the length and intensity of the pulse created as vehicles pass may even reveal the category of vehicle. "Theoretically there is also potential for the average speed of a vehicle to be obtained by calculation from the time a vehicle takes to pass separate units," says Lamb.

> Trials have shown that sufficient energy is generated from piezoelectric devices beneath the studs when vehicles pass over the units
>
> **Martin Lamb, Transport Research Laboratory (TRL), UK**

Virtual versions of the studs were shown to volunteers on a driving simulator to make sure they could be seen. At their dimmest, they were visible to 95% of the subjects, and at their brightest they were uncomfortable and distracting. Videos of different colored studs and various flashing sequences have helped to assess which is the most effective at alerting drivers approaching a smart pedestrian crossing.

Integrating the sensor, communications unit and LED board has raised problems of interference that are still to be resolved completely. If this can be done, there is hope that the studs could be cost-effective alternatives

Weather factors

How can road markings be optimized for maximum visibility in wet and dark driving conditions?

The RAINVISION project, run by the European Road Federation (ERF), with funding support from the EU, has been studying how drivers of different ages react to various types of road markings in a range of night-time weather conditions.

Studies on simulators from Aximum and Colas, France, suggest that drivers are better able to keep their vehicles well positioned within a lane if they are able to see road markings 2.5 seconds in advance of any direction changes. If they get the visual information only 1.5 seconds in advance, they are less likely to be able to fully adjust their vehicle's position before the lane direction changes.

Ironically, real-world tests at the Wachauring circuit in Austria were hampered by poor weather and by race cars that irreparably damaged some of the markings.

The tests showed, however, that driver comfort increased when road markings were more visible. This comfort resulted in faster speeds, though the researchers emphasize that the speed increase was small and claim that the benefits of improved markings outweigh the disadvantages of faster traffic.

Markings optimized for wet conditions, using ceramic glass beads and corundum anti-skid particles, seemed to be most effective in making driving less stressful.

As we go to press, RAINVISION is nearing its conclusion and the final report will be presented at a conference in Brussels on March 9 by the project's coordinator, Konstandinos Diamandouros.

to street lighting in guiding drivers safely, with lower installation and running costs, and reduced carbon emissions. The INROADS project has cost €3.8m (US$4.3m), of which the EU has funded €2.5m (US$2.8m), with the balance coming from business partners.

Solar guidance

Some intelligent road stud technology has recently gone beyond the research stage to public installation. In November 2014, Missouri DOT installed 16 lightweight, solar-powered road studs in Springfield. The studs delineate the 'skip lines' on a diverging diamond interchange (DDI) – where two directions of traffic on the non-freeway road cross to the opposite side on both sides of the bridge at the freeway. There were three such interchanges built in France in the 1970s but there were no others built until 2009, when MoDOT built one in Springfield. There are now 44 DDIs across the USA, five of which are in Springfield.

"We implement diverging diamond interchanges where there is a high level of left-turning traffic," says Joseph Rickman, district traffic engineer for MoDOT. "They fit well into the footprint of the conventional diamond interchange. They eliminate the need for left-turn storage [lines of waiting traffic] on the ramps and arterials, and they improve safety by reducing the incidence of conflicts.

"The studs are in a clear plastic housing that's light and thin, and we don't have to do a whole lot of cutting in the road to fix them," continues Rickman. "They're installed with epoxy and go in quickly and easily."

Although DDIs have proved to provide better traffic flow and management at left-turn lane intersections for expressways, some drivers may not be familiar with the configuration, particularly with regard to merging maneuvers along the left side of the roadway or the crossover flow of traffic. MoDOT has installed the studs in an effort to clarify lane positioning for drivers. They have sensors to detect ambient light, so they can change their illumination levels to maximize visibility.

"Most people love the DDIs, but some people complain about the ability to see the skip lanes in wet conditions, poor light or snow," says Rickman. "So that's why we're trialling the new pavement markers." There are DDIs elsewhere in the USA with studs that alter their illumination in sync with the traffic signals, but they have to be wired to communicate with the control system. The MoDOT trial is typical of the current generation of intelligent studs – they are standalone and have individual sensors.

Challenges and considerations

However, the introduction of intelligent studs on public highways is often blocked by legislation. Ten temperature-sensitive studs, which flash when there is a danger of ice on the road, are being tested at Northern General Hospital in Sheffield, UK. But current laws mean they would not be permitted on UK highways, because they operate outside specified color and illumination levels. Intelligent studs are also restricted to some degree by what drivers are used to. In Sweden, signs, road markings and delineator posts

Sophisticated detection

Roadside solar-powered sensors can warn drivers of adverse road conditions and vulnerable road users

The iMilePost research project, supported by the Latvian National Research Program, didn't have to deal with some of the difficulties presented by road studs because its units are designed to be placed at the edge of the road. Each solar-powered unit detects vehicles in low visibility, senses icy conditions, and can tell when pedestrians and animals are present at night. It then illuminates an appropriate LED hazard sign and has the potential to communicate wirelessly with other units by using a low-power transceiver.

Tests have shown it can reliably detect vehicles at least 83% of the time and sense pedestrians up to 16m away.

"It's possible to expand the range of meteorological sensors, measuring atmospheric pressure and so on, and therefore try to detect potentially dangerous road-surface conditions in a more sophisticated way," says project leader Artis Mednis. "Additionally, one of our past projects was related to the detection and classification of passing vehicle types using wireless sensor networks equipped with magnetic and passive infrared sensors. It is possible that both these topics could be merged into one common solution."

are conventionally used to help guide drivers around curves safely. The idea of using active LED studs as well has been studied by Jonas Ihlström for VTI (the Swedish National Road and Transport Research Institute). He concluded that adding studs to the mix could risk overloading drivers with too much visual information and, overall, given that road markings, delineator posts and signs are in use, wouldn't be helpful.

It's different in the UK, where delineator posts are rare. A study by TRL used a simulator of a typical British rural road to test the impact of active studs on driving behavior. Author Dr Nick Reed, recently appointed director of the TRL Academy, says the studs probably helped to give drivers better information about controlling their vehicles around bends. Also, more visible road-edge studs seemed to prompt drivers to keep a safer distance from the center line round bends. "Active studs offer a notable safety advantage over standard passive retro-reflective studs since they appear to improve lane guidance in right-hand curves, without causing drivers to proceed at higher speeds," says Reed.

A result of better lane positioning on curves was also found during simulator studies published last year by the French Institute of Sciences and Technology for Transport, Development and Networks (IFSTTAR). The project threw up an interesting problem – the need for software that could create a display of studs that were realistic enough to convince test subjects so that they remained immersed in the virtual environment. It's tough making studs work in the real world, but virtual studs can be equally as challenging.

One serious real-world challenge is preventing wrong-way driving. In November 2014 the Danish Road Directorate (Vejdirekoratet) released the results of a five-year test using active road studs to warn drivers going in the wrong direction. The illumination of the studs, placed at seven test sites, is triggered by inductive loops and coordinated so that the driver sees a wave of light coming toward them. "They registered 38 wrong-way drivers, 29 of whom turned their cars around," says Rene Juhl Hollen, engineer at the Vejdirekoratet. They're more effective than the in-road spiked 'hedgehogs' that have been used until now, and will be assessed again in two years.

Embedded intelligence

Illumination is always the main application of road studs, but they could also have communication roles assigned to them, act as nodes, or even help vulnerable road users. To this end, researchers in Japan have tested center-line road studs that include an antenna. When they receive location data via UHF signals transmitted by RFID tags fitted to bicycles, the patterns of their LED arrays change to warn drivers that cyclists are nearby. They say the studs could also forward the signal to an in-car receiver. Work is ongoing to expand the signal's range.

The ability to use wireless technologies to control intelligent studs will help in places where the studs are solar powered. On the whole they have no wiring, which poses the problem of how to relay instructions to, and receive data from them. Jan-Hielke le Roux has a solution – a low-rate personal area wireless network, similar to that specified for the ZigBee communications protocol, which transmits by line of sight over a distance of less than 100m. He built a working demonstrator at Stellenbosch University in South Africa, proving that it's technically feasible to control solar studs wirelessly. He has since moved on to different projects, so it's up to others to pick up on his work with this technology.

This research along with advances in energy harvesting, power storage, sensors, LEDs, communications and data processing means that, inevitably, studs will soon be shining examples of the best in traffic technology.

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According to **Hermann Meyer**, CEO of ERTICO-ITS Europe, integration will be fundamental to future mobility

Interviewed by Silvia Curbelo

> ITS will develop along information and automation lines; mobility services that best integrate these will win

This year could potentially be one of the biggest in the history of ERTICO-ITS Europe, as it prepares to host the 22nd ITS World Congress in Bordeaux. The event, which grows in size and stature every year it is held, is returning to France 21 years after it began in Paris back in 1994. ERTICO's mission, however, remains unchanged: to save lives, protect the environment and boost sustainable mobility through cost-effective intelligent transport systems.

ERTICO (European Road Transport Telematics Implementation Coordination Organization) was founded in 1991 as a platform for cooperation between all stakeholders involved in ITS development, deployment and promotion. Since then it has grown to become a public-private partnership comprising of more than 100 companies and public authorities. We caught up with the man currently at the helm, CEO Hermann Meyer, who was in an enthusiastic mood about the opportunities ITS creates to tackle the challenges that are currently facing transportation, not only in Europe, but around the world.

Meyer feels that transportation is in an important phase of transition – moving from a mode-centric approach to providing multimodal mobility as a service. "End-to-end customer mobility services for people and goods will become the ultimate target for competition," he says. "This will, in turn, lead to further improvements in safety, comfort, efficiency and reliability. Given that current and upcoming ITS services will develop along information and automation lines, the mobility services that best integrate these two dimensions will win. For this to become a reality, private companies will need to reshape their business models, and be sustained by adequate policy frameworks.

"Many of the current challenges are a result of increasing urbanization and mobility demand, combined with increasingly scarce resources and space limitations," he adds. "This means there is also a need to reduce road accidents and fatalities, while simultaneously driving mobility toward a more sustainable model that reduces environmental impact."

While most ITS applications and services are already mature, moving forward will require public and private stakeholders to achieve quick and effective deployment so that ITS becomes even more relevant for businesses. "There is a need to integrate

smart freight transport, smart infrastructure, smart traffic management and smart logistics operations in the context of data collection, exchange and processing," Meyer explains. "When this happens, then we will be able to speak about genuine smart mobility.

"To achieve effective deployment, we must avoid thinking in silos and instead focus on user needs and affordability, realizing that data sharing and processing will be key," Meyer continues. "After all, deployment of ITS is, and will be, the cheapest and most effective way to sustain mobility, save lives and protect the environment."

> Deployment of ITS is the cheapest and most effective way to sustain mobility, save lives and protect the environment

Growth and development

As mobility needs continue to evolve, Meyer hopes that 2015 will bring in the winds of change necessary to better respond to present challenges.

"The ERTICO Partnership is currently immersed in the process of developing strategic programs, establishing our priority areas in ITS," Meyer explains. "These programs will define milestones for multisector cooperation to achieve successful development and deployment. They will also provide us with additional direction, by putting existing activities into a broader and more meaningful context."

French connections

This year, Meyer is particularly excited about the World Congress, taking place October 5-9, in Bordeaux. The event is organized by ERTICO-ITS Europe in partnership with the European Commission, ITS America and ITS Asia-Pacific. The Congress is co-hosted by TOPOS Aquitaine on behalf of the City of Bordeaux, Bordeaux Metropolis, the Departmental Council of the Gironde, and the Aquitaine Region, and with the strong support of the French Ministry of Transport, ITS France, CEREMA and IFSTTAR.

"We are expecting more than 10,000 attendees from all over the world," the CEO enthuses. "Our experience from previous congresses suggests that it will be an ideal breeding ground for new forms of international and cross-sectoral cooperation in ITS."

With the theme 'Toward Intelligent Mobility – Better Use of Space', the Bordeaux Congress will explore the opportunities brought by the new satellite constellations for geo-localization, earth observation and communications, as well as the likely impact of smart mobility in cities.

"The 2015 ITS Congress will weave a net of sessions, expositions and demonstrations discussing hot topics such as localized emergency call (e-Call), communications between vehicles and infrastructure, the future of connectivity (4G and 5G), driving assistance, and highly automated driving vehicles," Meyer explains. "We are looking forward to experiencing the latest developments and welcoming the ITS community at what we believe will be the highlight ITS event of the year."

Strength in experience

Prior to joining ERTICO-ITS Europe in 2008, Meyer represented the interests of the Volkswagen Group in the EU institutions in Brussels as head of the Government Relations Office. He joined Volkswagen in 1995, serving as manager in the sustainability strategy department and as head of the technology and science department in the Government Relations Offices in Bonn and Berlin.

In 1996/1997 Meyer was seconded to the principal policy department in the German Federal Ministry of Transport and from 2003 to 2006 to the European Automobile Manufacturers' Association (ACEA) as director of environmental policies.

Between 2001 and 2003, he headed the vehicle technologies working group of the Mobility 2030 initiative at the World Business Council for Sustainable Development.

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High-resolution imaging: better performance at lower system costs

Almost all modern ITS uses imaging as the primary sensor technology to automatically detect, classify and identify vehicles and drivers, or recognize stopped and wrong-way traffic or hazardous objects on the road.

Due to the fundamental and often safety-critical role played by imaging and the increasing need for automatic image analysis, the use of industrial-grade equipment is absolutely essential. Machine vision (MV) cameras and advances in image sensor and camera interface technologies provide much greater resolution, speed, sensitivity and dynamic range. This gives better system performance with fewer manual process steps, in addition to higher revenues due to increased accuracy in automatic license plate recognition (ALPR). It also reduces system complexity and cost, as multiple lanes can be monitored with fewer cameras.

The role of imaging in ITS

The benefits of imaging are best seen in surveillance, enforcement and tolling applications, where systems rely on automatic image or video analyses via specialized software algorithms. The capabilities and accuracy of these recognition algorithms benefit from detailed images.

Tolling and enforcement applications identify vehicles from their license plates using ALPR algorithms. They localize license plates in the image, and recognize the numbers and characters for documentation and retrieval purposes. A higher automatic recognition rate means less manual work for law enforcement institutions and greater revenue for tolling agencies.

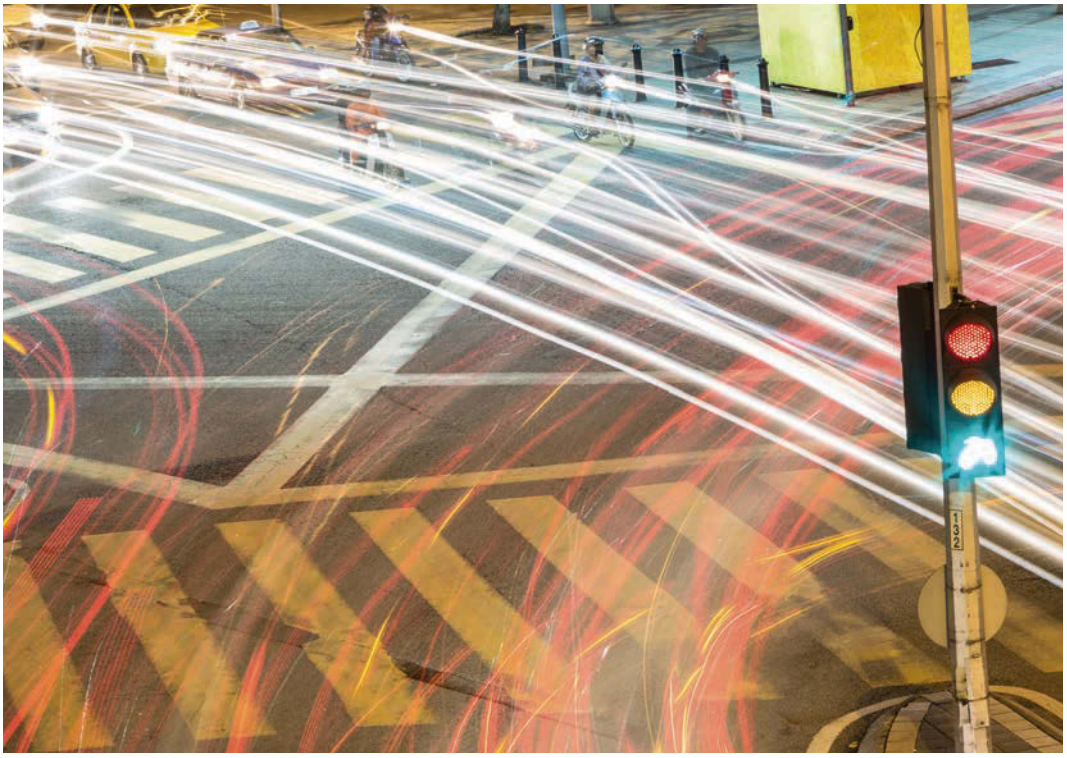
To achieve an ALPR recognition rate of at least 98%, North American license plates should be captured with a minimum horizontal pixel density of 1,620 pixels per lane or no fewer than 135 pixels per foot for a color camera. Using a monochrome camera offers even higher precision. The legal regulations of many countries, especially in Europe, also require the capture of the driver's face, which again highlights the importance of a camera with high resolution, sensitivity and a high dynamic range.

Measurement sensors, such as radar sensors or induction loops under the road surface, trigger image capture for speed or red light enforcement; however, these applications need to be continuously monitored by a dedicated camera. The same is true for modern tolling systems and applications where it is necessary to recognize car type, for example by means of vehicle length or axles, based on a highly detailed video of traffic flow.

ITS challenges

Traffic applications present a challenging set of requirements for cameras and automated image analysis. Rain, fog, snow and dust reduce visibility. Even more challenging, however, are lighting conditions – from direct sunlight and glaring reflections off windshields to complete darkness with bright headlights at night. To accommodate these conditions, cameras must be able to simultaneously capture a bright, reflective license plate and a driver's face inside a dark vehicle.

The capture of video data in high resolution generates large amounts of data. This is demanding on the bandwidth of the camera interface, the image processing computers and the data storage. Furthermore, the cameras for most ITS applications are installed at remote and elevated positions above the roads, which can lead to costly maintenance. Consequently, all equipment must be able to handle continuous operation, and must provide reliability and longevity. This can be achieved by using industrial grade components that don't have any moving parts.



(Above left) **Advanced imaging technology is able to capture reflective license plates as well as drivers' faces inside dark vehicles**
(Above) **High-resolution image sensors are ideal for traffic light enforcement applications**

Need to know

Developments in image sensor and camera technologies provide for more efficient ITS

- Modern CCDs with high resolution and improved frame rates generate a large amount of data, and classic interfaces such as 10/100 Base-T Ethernet or 1000 Base-T Gigabit Ethernet are often not sufficient for data transfer
- Using an industry-adopted interface such as 5Gbps USB 3.0, modern cameras use chipsets and drivers that can offer reliable operation and data transfer with Microsoft Windows and Linux platforms

Technical advances

Given the important role of imaging technology in traffic applications and the challenges provided by ITS, it is crucial that the key components, especially the camera, are selected carefully.

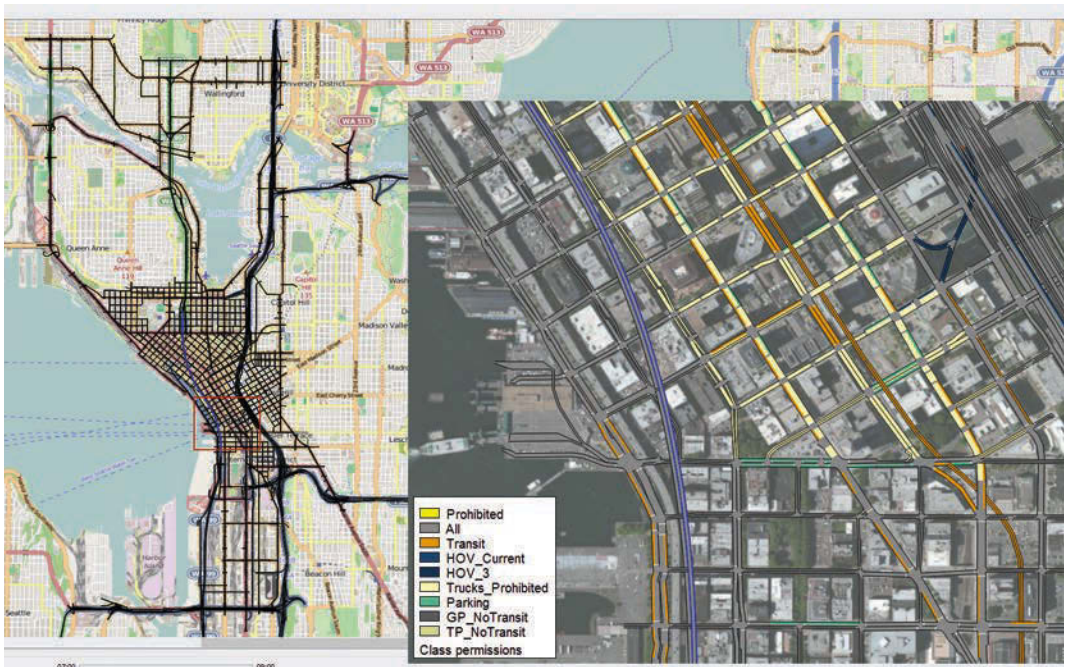
Several professional MV cameras, however, fulfill ITS requirements with industrial grade image sensors, as well as control interfaces for image capture parameters and integrated lens control. The latest generation of CCD (charge-coupled device) image sensors, with their novel pixel architecture and read-out electronics, excel in sensitivity and dynamic range, and are ideal for traffic applications.

With higher resolution sensors, such as 5MP for single lane monitoring, these cameras provide higher recognition rates for license plates, and details of a vehicle and its driver. The high sensitivity of modern CCD cameras enables shorter exposure times (<1ms), so they can capture fast moving cars with very little smear. When it comes to toll collection and safety surveillance systems on highways, the high number of lanes and the large road area to be covered could lead to complex and costly systems.

As a result of advances in sensor technology, high-resolution sensors up to 29MP are now available. ITS integrators have the option to use a single 5MP camera per lane or optimize multilane imaging using a single 11, 16 or 29MP camera, depending on the situation. Using fewer high-resolution cameras reduces system overhead, as overlapping areas are reduced.

Manufacturers and integrators of ITS can seize new technological opportunities to build better, more cost-effective solutions. These opportunities are created by image sensors with the high resolution, sensitivity and dynamic range found in MV cameras, with modern interfaces for high-speed video transfer.

Innovative toll forecasting optimizes tunnel investment project



(Above left) **INRO's Dynameq software in action** (Above) **Seattle's congested roads at rush hour**

In Seattle, construction is underway on a US$3.1bn tunnel to replace the double-decked six-lane Alaskan Way Viaduct, which suffered structural damage during the 2001 Nisqually earthquake. In 2013, the Washington State Department of Transportation (WSDOT) was directed to raise US$200m from tolls to help fund the tunnel project, and the Advisory Committee on Tolling and Traffic Management needed to identify a tolling scheme that would meet funding goals while minimizing the impact of traffic diversions to arterials and the parallel Interstate 5 (I-5), both of which are highly congested.

"We identified the need for a model platform to provide better estimates of travel times on local streets and consider queuing, especially on off-ramps, and also peak-hour variation and downtown transit routes," says Andrew Natzel, transportation engineer and planner at Parsons Brinckerhoff, the lead general engineering consultant for the project. "The Viaduct cuts through downtown, which is surrounded by congested arterials. The nearby I-5 is easily the most congested highway in the region."

Need to know

Sophisticated simulation software provides an accurate representation of reality

- The model includes 466 signalized intersections
- It simulates more than 4,000 buses and 880,000 vehicle trips during the 6:00-9:00am and 1:00-6:00pm periods for six vehicle categories, each of which may have distinct toll costs and values-of-time that vary according to time of day
- The road network includes truck prohibitions, car pool lanes, transit lanes and parking restrictions

A model of reality

A key goal was to reduce the risk of overestimating congestion and diversion that can come from limiting the study area. INRO's Dynameq wide-area traffic simulation software was selected because of its unique combination of detailed vehicle-by-vehicle, lane-based traffic simulation and equilibrium dynamic traffic assignment (DTA) that enables the accurate prediction of drivers' routes through the changing traffic congestion during a typical day.

"The model considers the time-dependence of traffic congestion and the complexity of a signalized, multi-modal street network," says Natzel.

The study area was explicitly designed to include all possible diversion routes, covering a five-mile stretch of the SR 99- a nd I-5-corridor up to three miles wide, including all arterials and downtown streets.

"With a generalized cost equilibrium DTA, Dynameq predicts drivers' route choices as they anticipate traffic conditions, and weigh the toll cost and their willingness to pay against the travel time savings offered by the tunnel," says Michael Mahut, VP of traffic simulation at INRO.

The study considered single-point and multiple-point tolls, time-of-day tolls to charge different rates during peak, off-peak, nights and weekends,

and class-based tolls to charge trucks and cars differently. The Advisory Committee report evaluates seven toll schemes and their predicted diversions. The recommended tolling scheme, presented to WSDOT, achieves the funding obligations and minimizes the impacts of the predicted trips diverted from the new tunnel, mostly to the Alaskan Way and other north-south arterials west of I-5.

The Seattle DTA model has also been used on a separate study, north of downtown Seattle. It will be further improved for an investment-grade study of the tunnel, which will include transit and bicycle priority improvements.

by **JJ Eden**

Making conferences lead to good business

This is the time of year when conference plans are being finalized, agendas locked in and speakers contacted. This year seems to be busier than ever. As I was wading through the emails, texts, phone calls and notes that I have accumulated on my desk, I began to see why there is an increase. As I have touched on in past articles, we are speeding toward solutions. Most of these solutions have a problem that they are aiming to solve. However, few bridge to other solutions or address multiple problems. For example, at the 2015 Las Vegas International Consumer Electronics Show, several automobile manufacturers are unveiling new technologies including autonomous vehicles, and new and improved in-vehicle systems. These innovations may satisfy consumer demand for the latest, greatest technological innovation, but how will they interface with mobile payment systems, connected cities, or even other autonomous vehicles?

Just a few years back, we had high-level conferences on broad topics. Tolling, ITS, and transit all had their conferences, as well as state DOTs, DMVs, county and state government. Today, in addition to these conferences we also have specialty conferences, with topics that have been broken out into more detailed sessions to provide solutions to today's pressing problems. Some examples are: all-electronic tolling, tolling enforcement, reciprocity, managed lanes, highway financing, mileage-based user fees, connected vehicle, connected cities, in-vehicle technology, mobile commerce and mobile payment systems. So, why are there so many specialty conferences? Most are driven by technology and business rules. Is the new technology too complex to discuss at a higher level? Are the business rules that we have all used independently for so many years too complex to work across multiple states? Maybe we are still missing some other conferences. How are the new technologies going to evolve? A transportation system or even a vehicle will need an upgrade path. Currently, even cell phone connectors and Bluetooth versions are outdating our still drivable vehicles. Federal money and grants are usually available to build and install the infrastructure, but we lack funding for maintenance, operation and upgrades.

Specialty conferences still need to happen; however, we need to bring these discussions and solutions back to the bigger picture without being so disruptive that we start over. When do we get the key players together for the overall solution? I hear this sentence a lot: "When we deploy our solution, everyone will have to use it." Is this wishful thinking, or is this truly how our transportation systems will progress? If you look, commercially most providers have reluctantly learned to get along. Cell phones work between providers, your credit card works on Amazon and Apple Pay. How did they get there? How are they sharing data and financial networks? How did they resolve the hundreds of issues unique to each industry? Maybe we need another conference to get the players together to talk about the vision for 2020 and 2025, and explore real solutions for combining efforts and resources toward a common end game. Between our industries we have the financial and technical capabilities to not only solve today's transportation needs, but to set in place a sustainable blueprint for the future.

"We need speciality conferences, but we also need the bigger picture"

JJ Eden, is the director of tolling at Aecom, ***james.eden@aecom.com***

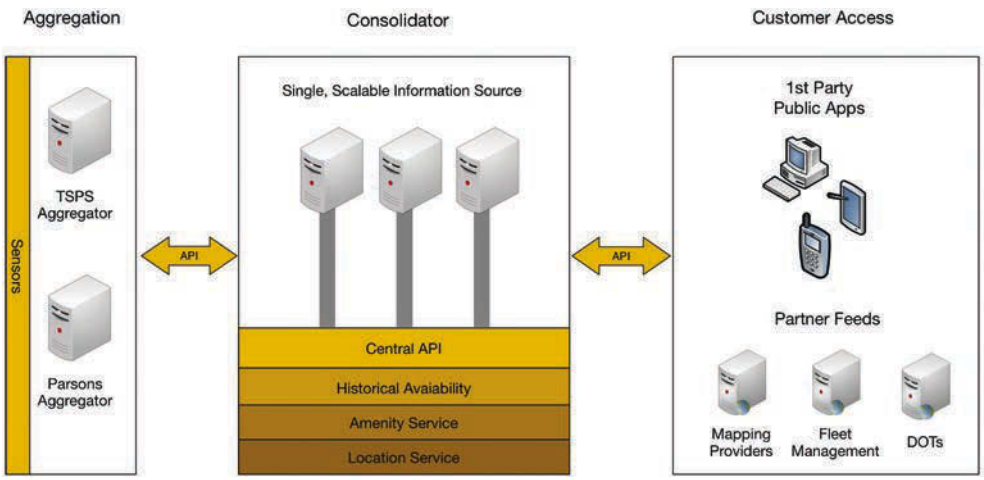
Illustration: Ian Parratt, the-caricatureartist.co.uk

Smart truck parking system set to save the economy over US$40bn

On March 5, 2009, New York trucker Jason Rivenburg was murdered in his truck cab for US$7 – a tragedy that could have been averted had he been able to find a safe place to park. Since that terrible day, Jason's widow Hope (who is also the mother of his three children) has campaigned tirelessly for safer truck parking in the US. July 2012 marked a big victory as Jason's Law, which makes the issue a national priority, came into force as part of the new federal transportation bill, MAP-21. Thanks to this, state DOTs have access to new funding to improve parking availability for truckers. Now Truck Smart Parking Services (TSPS) is helping them make the dream of a truly 21st century truck parking system a reality.

TSPS has installed the nation's first fully operational, scalable, smart truck parking system, on Michigan's I-94. The patent-protected system has a host of tangible benefits. First, of course, it makes truckers' lives safer as they can always find a dedicated place to park. Second, it makes the road itself safer by alleviating the problem of illegally parked trucks and truckers driving over their legal time limits. Truckers are mandated by federal law to pull over and rest after an 11-hour shift; however, if they can't find somewhere to park at the end of their shift, they must either park illegally or continue to drive illegally. Fatigued driving is a principal cause in 17% of all truck/auto crash fatalities: it's a lose-lose situation.

Third, it is generating huge cost savings for the trucking industry. The difficulty in finding a place to park means that many truckers begin looking for a spot as much as an hour before they are due to rest.



(Above) **The TSPS platform architecture**
(Above right) **The TSPS mobile app in action**

Need to know

Truck Smart Parking Services could deliver huge savings for a relatively small cost

- **US$7bn** The estimated yearly cost, in lost working hours and wasted fuel, of truckers not being able to find suitable parking
- **US$35bn** The average yearly cost of goods being stolen or damaged in transit in the USA
- **US$100m** Estimated cost of implementing a national smart truck parking network

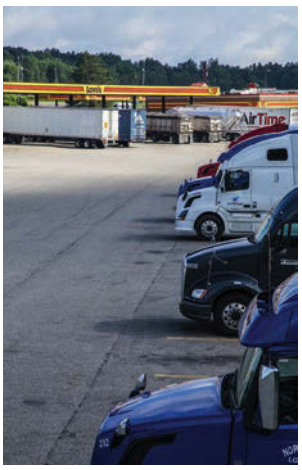
This highly inefficient practice leads to an estimated US$7bn cost per year in wasted fuel and time. Thanks to the TSPS system, which has standardized architecture to make its information easily usable, some of this money is now being clawed back by the truck operators using the I-94 project. Finally, it is helping Michigan DOT, led by Director Kirk Steudle, who had the vision to help deploy the system, to fulfill its charter of maintaining and improving the commercial productivity and safety of state infrastructure.

"The federal government has spent over US$200m on studies to try to understand this problem," says TSPS president and CEO Rick Warner. "It has come to the realization that we need to spend some money on technology, because in essence, information is one of the best ways to optimize the inventory we have. Technically there are enough parking spots on a daily basis, but often their availability is not optimized. All the money that's been spent has actually led to a very clear understanding of how to scale a national network of information. This provides value to all the stakeholders and provides a level of sustainability."

Technical deployment

Put simply, the TSPS system works by using cameras to monitor available truck spaces in real time and then gets that data to truckers via roadside signs, apps or connected vehicle technology (for more detail of the Michigan scheme see our feature on page 20). "It's part of the Internet of Things. What we're about is taking that physical world, digitizing it effectively and making it available to the trucker wherever he or she is," says Warner.

Some feasibility studies have been conducted on similar systems elsewhere in the US. The TSPS system has advantages due to its scalability and ease of installation. "It's one thing to do this in a controlled environment – to get availability information from a public rest area," says Warner. "It's another to get it from an open-air lot such as a private truck stop. Private truck stops are 90% of the capacity of available truck parking on the national highway network. That's the real world. We have learned how to take almost any truck stop, private or public, and design our system into it over a few days. And the physical deployment is very light touch. We can do that in



(Left) **Private truck stops provide nearly 90% of truck parking capacity in the USA, making their inclusion in any smart parking solution essential**

a couple of days. The alternate technologies we've seen deployed are fundamentally more expensive."

Sustainable development

Because the TSPS system provides benefits for both the public and private sectors, it is set to attract investment from both. "This is one of those true public-private partnership opportunities, where the federal government, states, TSPS and private capital are going to come together in a way to build out the network," says Warner. "As we move forward and add more value to the information for truck operators, which they have indicated a willingness to subscribe to, this will ease the operations and maintenance costs. This is very similar to the toll road operations model. The key to this is that over the next three or four years we need to constructively follow our road map to build out the network."

National revolution

The network in TSPS's vision will make movement of goods more efficient, while also improving road safety. "There are about 2,300 key interstate parking facilities that we see networking. With our system, because it's so light touch, with a modest amount of capital backing, we can build the national network. We expect we can be halfway through that build-out in five years."

Warner confirms that other similar systems will have the ability to plug into the TSPS system to help strengthen the national network. "If a state has a certain kind of camera-sensing system in its rest areas, we can integrate it into our platform. What we want to do is knit the information together so that it has the most value for the truckers. And since we know where the key places are to collect data from, we can quickly build a useful and sustainable network for a minimal investment."

Super-efficient future

In the future, Warner sees the TSPS system growing in functionality, so it won't just be about checking real-time availability of truck parking. The system will also enable users to make advance parking reservations, identify and reserve secure parking and plan (or reschedule) itineraries on the fly, based on real-time traffic information and predicted traffic along the route. "We've developed a national network reservation system that will allow truckers to make reservations at truck stops in highly congested areas," says Warner. Although it is only in high-demand areas that reservations are likely to be necessary. As Warner puts it: "Many times it's just about peace of mind at the end of a long road trip.

"Another thing we learned as we started to build the system is that there's the problem of loads being hijacked, as well as drivers being accosted," continues Warner. "In North America, that's a US$35bn a year problem. So we're also developing, ready for our first deployment in June, what we call Sentinel Services, which is a secure monitoring software system that will integrate with our truck parking availability network."

The final piece of the jigsaw puzzle will make the TSPS system a complete itinerary planner for truckers: "Real-time traffic information integrated with real-time parking information and origin and destination information – I think that's really the future, and the ultimate value proposition," says Warner. "The key is building this national network along the major arteries. We know where they should go. We are already talking to the states that are visionary leaders, and working out how we continue to build this out."

Ultimately, however, the biggest victory for TSPS will be at a very human level. Making the lives of truckers better and safer by helping them do their jobs and by preventing tragedies like Jason's ever happening again. It's a bright future that is welcomed by Hope Rivenburg. "I am excited to know there is a service that could be deployed that will help all drivers," she says.

Spotlight on ALPR: challenges, applications and development

The world we live in is constantly evolving and, as such, the requirements of traffic and enforcement authorities are constantly changing. Tattile's key account manager, Massimiliano Cominelli, believes that through constant innovation, ALPR will continue to play an important role in traffic management in the years to come.

What are the biggest challenges facing traffic enforcement in 2015?
Accuracy is very important in traffic enforcement applications, but there is also a requirement to be as environmentally friendly as possible. Today's ALPR devices must be able to handle an increasing number of vehicles on the roads and a variety of complex traffic scenarios.

How is ALPR being used to improve traffic enforcement operations?
The current move toward more sustainable solutions is driving a demand for ALPR-based enforcement systems – for example, in areas where certain vehicles are prohibited or in congestion charge zones.

The aim is to reduce the volume of traffic in the area and therefore reduce the local pollution. The ALPR camera reads and checks all the license plates of vehicles passing a gantry. ALPR is reliable because the data cannot be manipulated or corrupted.

How can ALPR cameras be optimized for different traffic applications?
ALPR cameras should always be targeted and customized according to the final application, taking into account the particular requirements of the situation, as well as the target price, dimension, installation and layout. Every application needs a tailor-made solution.

A manufacturer should be able to meet all the current needs of the user and perhaps also anticipate some future requirements.

Will ALPR technology be compatible with the connected and automated vehicles of the future?
The transportation industry will continue to see rapid improvements in technology and communications – we are already seeing connected vehicle technologies emerging from the automotive industry.

I am certain that there will always be a need for license plates – they are the easiest way for drivers to identify other vehicles. Therefore there will always be a need for ALPR.

In the near future, ALPR should be able to detect signals emitted from vehicles – perhaps from the OBU (onboard unit), or via Bluetooth.

What has been the most important development in ALPR in the past five years?
I think the most important developments have been in recognition and detection rates. There has recently been an increase in demand for ALPR in countries that use different alphabet systems – such as Arabic and Cyrillic –

Need to know

The evolving needs of the global traffic sector require constant innovation in ALPR

- Tattile's Vega Color ALPR system has been developed for traffic enforcement in urban areas, as well as access control and parking
- As it doesn't require an external sensor, it is a non-invasive solution
- Vega Color is an embedded technology system: everything is built in to the camera
- The camera will detect the license plates of vehicles traveling at speeds up to 87mph (140km/h)

License plates in the UAE have created new challenges for ALPR systems

by **Larry Yermack**

Time for a change? How public bodies can use the private sector to more accurately predict the future

(Left) **ALPR plays a central role in London's Congestion Charging scheme**

and that have variations in license plate format.

It has been a challenge for ALPR suppliers to ensure a high recognition rate for the countries that use these systems, but it has been achieved.

There have also been great improvements made in terms of integration. Many devices are now all-in-one solutions. This has made it possible to reduce installation costs and minimize power consumption.

How do you see ALPR developing in the future?

ALPR devices will need to continue to evolve in order to consistently meet market demands. As such, they will need to follow the 'triple S' rule: smart, small and sensible.

Going forward, devices will not only need to be advanced in terms of technology, they must also be competitively priced. I also think that many devices will have extra functionalities that will enable them to meet numerous demands.

Tattile is focused on conducting research that will make the next generation of ALPR devices as efficient, sustainable and user-friendly as possible. We hope to make these available soon. ○

I have been thinking a fair amount lately about the enormous gulf in technology between what the public sector can specify and acquire, and what the private sector can offer. If a public agency were to acquire a new system for any purpose – tolling, traffic management, signalization or traveler information – they would need to write specifications today. That would mean a 2015 document for a system to be purchased in 2016 and that would be expected to last until at least 2021. It's simply an impossible task. Nobody can say today what the state of the practice will be in one year, let alone five.

The problem with the current public procurement model is that it's based on the notion that the work can be specified and then the contractor can be held to the specification – but if the spec ages badly, then so will the system. Instead we need to figure out how to better conceptualize the respective roles. The agency needs to be able to deliver a service to the public and be sure that the contractor is doing it well. The contractor needs to bring to bear new technology as it becomes available. Can we reconcile the two?

The solution may lie in this proposed new model for public-private partnerships, which takes advantage of the strengths of both sides and avoids their weaknesses. It would require new flexibility for the contractor and new contract management tools for the agency.

Let's start with the specifications, which should define what is to be done but not how it is to be accomplished. We can start to diverge from the traditional model with the option for the contractor to pay for the system and collect fees based on transactions or some other monthly metric. It truly gets the contractor more 'invested' in success with a large amount of capital tied up. The third element would be to make extensive use of KPIs (key performance indicators) as the basis for the expected service levels.

I think the next two are the most innovative. The contractor shall prepare a hardware and software roadmap for the entire length of the contract, indicating what elements will be upgraded over what timeframe. Then at the end of the contract the contractor will be responsible for turning over to the agency an up-to-date system (software and hardware), even if it's five or 10 years down the road.

> "Nobody can say today what the state of the practice will be in one year, let alone five"

The key to make this all work is that whatever can reasonably be measured, monitored or recorded is actually measured, and is provided to the agency. It does not matter if it's not the basis of a service level agreement or even if it's an input measure. It will be measured and provided to the agency. It's only in this way that the agency can truly have oversight and control of the system. The database would be extensive and valuable for more than contract management purposes.

In a short column it's not possible to articulate fully the new model, but in longer pieces and meetings with agencies it will be fleshed out. It's not as if we really have a choice now. Do we?

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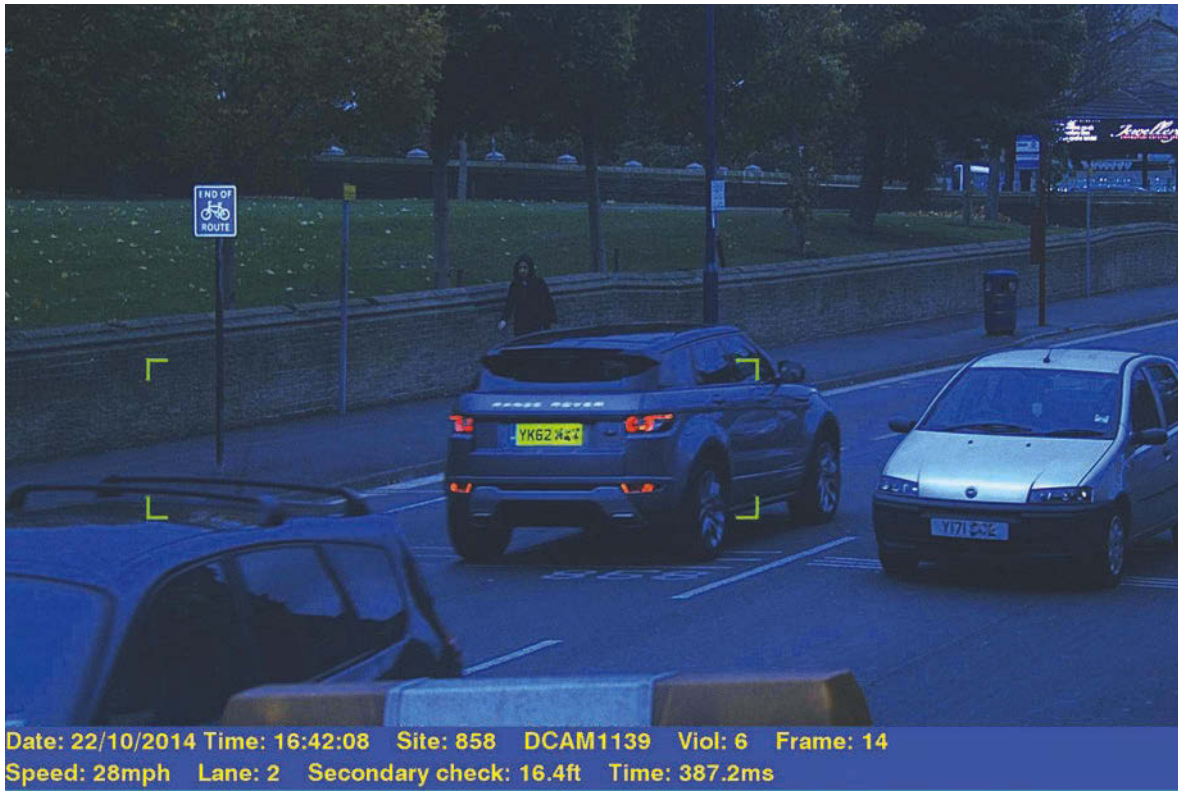
Illustration: Ian Parratt, the-caricatureartist.co.uk

Bidirectional digital camera technology for improved enforcement operations

The West Yorkshire Casualty Reduction Partnership, situated in northern England, operates a traffic light strategy for the implementation of safety camera sites. Locations are rated Red, Amber or Green according to their safety level, and the strategy applies to both fixed and mobile enforcement solutions.

While the Partnership is an established user of Truvelo's LASERwitness digital video speed enforcement system, a site governed by one of its partner organizations – Wakefield Metropolitan District Council – has recently seen the first deployment of fixed Truvelo D-CAM digital speed and red light enforcement cameras that use a simultaneous bidirectional (SBD) site layout.

The D-CAM is a dual-capability speed only or speed/red light camera system. West Yorkshire is currently only using the camera for speed enforcement. The SBD functionality is an important development in that it enables a single camera to capture speed offenses committed by vehicles traveling in two directions.



Flexibility and versatility

The D-CAM has UK Home Office Type Approval for both front and rear photography. Together with various options for positioning the secondary speed-check markings, this greatly increases siting flexibility for both straightforward speed and speed-on-green enforcement.

Three in-ground piezoelectric sensors provide the speed measurement. They maximize accuracy because the positions of both the sensors and the secondary speed check lane markings are known precisely. They also enable axle-based classification and automatic selection of a lower speed threshold where required, as well as lane identification, which is displayed in the data field of images used as evidence.

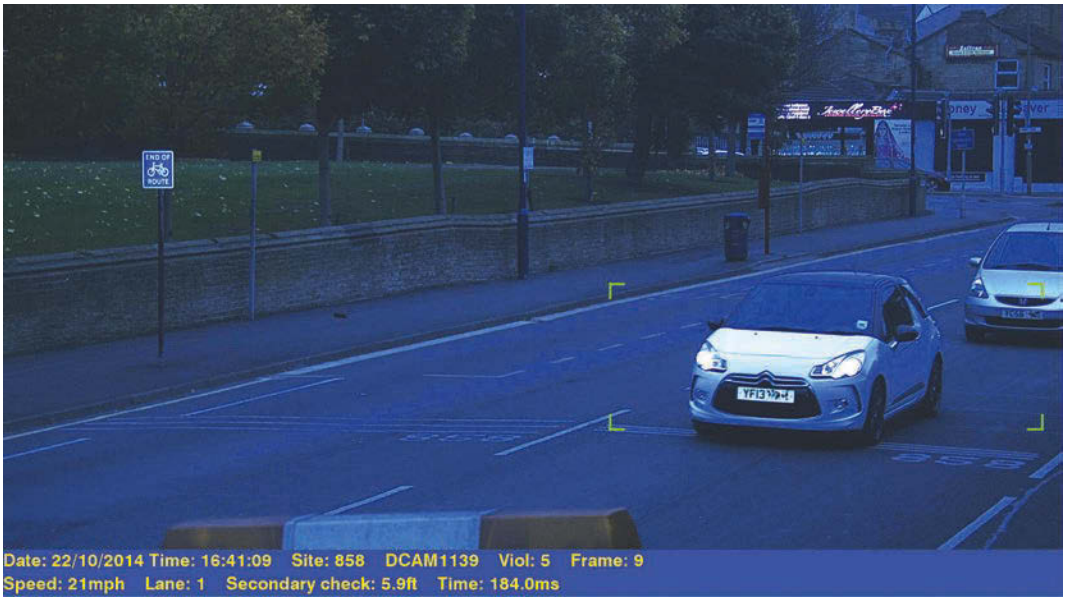
The D-CAM operates as a speed camera during traffic signals' amber and green phases. Single images are used for speed offenses. The secondary speed check road markings are typically situated 1.8m beyond the last of the three piezoelectric sensors, however Truvelo offers the option of a secondary speed check point 5m from the sensor array. This gives greater flexibility, particularly at intersections where there may already be in-ground sensors or access chamber covers.

In red-light enforcement applications, once the amber grace period has passed, the camera switches to red light enforcement mode and captures two images. The first shows true speed and offending vehicles or motorcycles straddling the stop bar. The second is taken at 40-50ft (12-15m) away, depending on junction size, and confirms that a red light offense has taken place. A patented, type approved solution can monitor the signal phases on LED traffic lights.

The D-CAM's type approval covers both front and rear photography. This, combined with a new camera site layout, provides live enforcement in two directions at the same time using a single fixed camera. This is the SBD feature. Front plate captures on vehicles traveling in one direction and rear plate captures on vehicles traveling in the other are possible, with the secondary speed markings positioned at the same point on the road. The camera takes pictures on demand when triggered by either of the two sensor arrays. For straight-road applications requiring speed enforcement in both directions, this represents an appreciable cost saving over previous-generation solutions that needed two cameras. The D-CAM can also be moved between sites, increasing coverage and operational flexibility.

Data management

For back office and communications applications, Truvelo supplies a pair of servers capable of managing in excess of 25 D-Cams. The Truvelo Back Office Server



(Left and right) **Truvelo's simultaneous bidirectional camera in Wakefield, West Yorkshire, captures images of traffic traveling northbound and southbound at the same time**

(TBOS) receives encrypted images and stores/writes them to a CD. The CD is then inserted into the Truvelo Violation Manager (TVM) where the images can be viewed. The D-CAM is compatible with StarTraq and Serco (Cubic) back office systems.

Images are continually transferred via an ADSL (asymmetric digital subscriber line) or a 3G connection. This provides a constant workflow for back office staff. It is also possible to download images to a shuttle PC should there be delays in connecting ADSL to a new site or if there are issues with the 3G service. The shuttle PC is a transfer-only device – images cannot be viewed on it.

Need to know

Truvelo's single D-CAM camera can capture speed infringements in two directions at once

- The West Yorkshire Casualty Reduction Partnership includes five metropolitan district councils (Bradford, Calderdale, Kirklees, Leeds and Wakefield), West Yorkshire's county police and court services and the Highways Agency
- It is responsible for safety enforcement activities across a 783 square-mile (2,029km^2) area
- There were 57 deaths and 757 serious accidents on the county's roads in 2010, which cost the economy more than £280m (US$429m)

First deployment

The A61 is a busy principal road between the cities of Wakefield and Leeds. It passes through mixed residential and retail areas, and between 2007 and 2012, one 1.4-mile (2.3km) section saw 38 accidents – nine of which were serious. Speed was a major factor in these incidents. The limit is 30mph, but many drivers exceed this.

The new cameras' precise locations were determined on the basis of consultations with local councilors and the locations of the serious accidents. Two SBD-capable D-CAM cameras sited half a mile (800m) apart were commissioned in summer 2014.

"During on-site testing, the D-CAMs demonstrated very good image quality in a variety of conditions," says Zafar Iqbal, operations manager for West Yorkshire police. "The SBD feature was able to capture speeding vehicles traveling in opposite directions within the same second."

Iqbal was attracted to the D-CAM as a result of its front-facing capability. "Although English law does not require driver identification in speeding offenses, this is an additional intelligence tool and has already been used to provide assistance to crime officers," he says. "The image quality has been good enough to help secure convictions."

Initial testing has also proved the robustness of the 3G communications, as well as the fuel, vehicle-wear and manpower savings where image collection is concerned, but it is too early to determine the cameras' overall effect on the local accident record. Speed surveys will be undertaken in the coming months.

Multimodal transportation simulation for growing urban areas

When transport planners in the city of Halle (Saale), Germany, wanted to update their outdated transportation model, they turned to planning company Verkehrplus for a solution. Accordingly, Verkehrplus used PTV Visum modeling software to create a modern, finely crafted model with 600 zones.

As a result of shifting mobility trends in urban areas, all modes of transport and their

PHOTOGRAPH: STADT HALLE (SAALE) PRESSESTELLE

interactions need to be considered and analyzed. A truly integrated approach was required. Halle's new model incorporates all modes of transportation and enables the city planners to either tune in to private transportation (PrT) or focus on public transport (PuT).

"In addition, opportunities have opened up for the city on account of updated public transport timetables, newly collected inhabitant data and urban population forecasts, as well as previously unavailable GIS data," says Emanuel Selz, manager of Verkehrplus. "These opportunities could not have been seized with a simple update to the existing transportation model."

To develop the model, Verkehrplus built upon existing networks. "We merged the network models by placing the PuT model stops on top of the PrT model and joining them together at intersections," Selz explains. At the same time, the team updated out-of-date locations. "We also modeled the bicycle and pedestrian paths, which had not been considered in the old model because they were underused. Now, however, we recognize that they have a notable impact on road user route choice."

Demand modeling in detail

Verkehrplus used socio-demographic and behavioral data as input values, based on German household surveys, as well as data on transport supply. The team then condensed the population into behavior-homogenous groups on the basis of city statistics, in order to map their activities and activity chains into a demand model. This phase was created using Visem (urban transport generation model) software.

"We have also modeled education and shopping locations, and in the most recent version we have even taken into account visits to the authorities and doctor appointments," says Selz. "We have mapped all the local businesses, authorities that accept visitor traffic and medical institutions, and weighted each sales area according to the type of business." The model therefore reflects the fact that, for example, a discount store generates more traffic than the DIY store around the corner.

Another exciting element of the model is the temporal resolution. "Mapping the day as a whole, in one time interval, was not precise enough, as the travel times in the local PuT system could not be mapped in detail," says Selz. "This meant that day-dependent events could not be represented realistically."

The team therefore decided to work with travel-time matrices that model each hour separately. "This way, we can accurately model different modal splits during the course of the day," Selz explains.

Microscopic analysis

With this arrangement, the city of Halle (Saale) can now analyze and assess different urban development scenarios. For example, west of Saale, in Halle-Neustadt, the city is still undergoing structural changes. "As part of this development, several bus network variants will be developed based on our

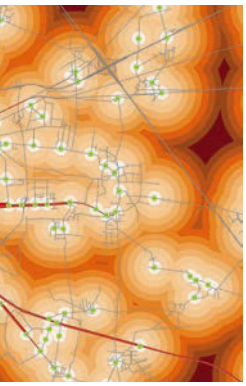
Need to know

A fully integrated transportation model optimizes city management in Halle

- PTV Visum facilitates the creation of detailed analyses, statistics and reports
- City planners can use the model to create: scenario comparisons, matrix histograms, flow bundle calculations, interactive searches for the shortest paths, isochrones, environmental studies and accident data analysis
- PTV Visum can be used to quantify scenario and action developments and prepare them for analysis

by **Sam Schwartz**

Traffic management in an era of near-perfect information



(Opposite and left) **The PTV Visum software provides a detailed analysis of the transportation network** (Opposite below) **The German city of Halle**

transport model," says Selz. "Various line variants were modeled with different choices of routes and destinations, and the effects on demand were evaluated." This made it possible to identify scenarios where some buses were travelling without passengers, while others were completely full. Planners are able to take action and adjust the network at any time, if necessary.

Another example is the microscopic traffic flow simulation of a main road, where the traffic-actuated signal control was examined. "Here, it became clear how advantageous it is to have a finely crafted transportation model," says Selz. "We could practically cut out parts of the network and transfer them via a sub-network generator into the PTV Vissim simulation software, together with the matrices, and create a dynamic environment. Such a large simulation approach made it much easier for us to provide data about demand." ○

When I wore a younger man's clothes (thank you Billy Joel) I drove a taxi cab in New York City. The hours of driving, shuttling people from places familiar and obscure, gave me an intimate understanding of the city's streets. In my mind was a one-of-a-kind map, filled with detailed directions, shortcuts and escape routes. And, among the cadre of cab drivers, everyone boasted they knew the best shortcuts. It was more than just braggadocio: getting your fares there faster meant picking up a few more rides in the day and earning more than a few extra bucks by the end of it. The driver's credo: pick up your fare, get rid of him as fast as possible, and start all over again.

When I later attended graduate school for traffic engineering, I remember being intrigued learning about John Wardrop's theory of traffic equilibrium: travel times on routes used are all equal, and travel times on routes used are shorter than routes unused. In Wardrop's world there were no shortcuts. This flew in the face of what I knew from the streets; surely, my experience made me more clever than the average driver. So, in the early 1990s I authored a book called *New York Shortcuts and Traffic Tips*, to help make driving in New York City easier. But, I realized that it could become a victim of its own success: if it became a bestseller and everyone took the shortcuts, they would fill up with traffic and wouldn't be shortcuts anymore.

Wardrop's theory was based on perfect information, and shortcuts rely on secrecy. We are now upon the era of near-perfect information. The mass adoption of GPS-enabled smartphones has created a huge legion of sensors gathering data. Real-time routing can create a meaningful improvement in traffic performance, diverting drivers and reducing travel times. This coordination can improve daily commutes and isn't far off the 'social optimum' traffic assignment that Wardrop theorized. But real-time routing also means it is open season on detours and cut-through routes via neighborhood streets that were once sought out by only the most wily behind the wheel. In LA, local groups are fuming over a perceived increase in traffic on local streets – which they attribute to way-finding apps – and

"Local groups are fuming over a perceived increase in traffic on local streets … [due] to way-finding apps"

are trying to convince app makers to change the way they route traffic. Route choices may seem inconsequential when they are made by a few individuals, but when technology enables companies to offer these choices centrally and millions follow the advice, that's a whole new component of the transportation system that requires thoughtful management.

There's no doubt in my mind that connected and autonomous vehicles will be part of our future. But how will all these vehicles be routed? What will their objective functions be? Who will decide? As ITS professionals, it is important that we take a step back and evaluate the wider impacts of our innovations. After my book came out, I was called to task by Greenwich Village after people started using a shortcut I had highlighted. Will the ITS community-at-large be called to task and possibly sued because of actions taken based on information they release?

In my next column I will write more about autonomous vehicles and cities; are they incongruous or maybe even superfluous? Stay tuned.

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Illustration: Ian Parratt, the-caricatureartist.co.uk

Comparing the accuracy of different methods for retroreflection detection

When personnel involved in measuring the retroreflection of road markings move from using handheld instruments to mobile retroreflectometers, they are often concerned about the correlation between the two types of instrument. Reproducibility with handheld instruments is typically ±5%. Can this level be achieved by a mobile system? And can mobile systems be used for contractual measurements?

Ramböll RST, a leading northern European road survey company, and Delta, a leading manufacturer of retroreflectometers, decided to carry out a test program in October 2013 to compare the two methods. The tests were undertaken on 10 sites around the Swedish city of Kristianstad, including road stretches used for the annual certification of mobile retroreflectometers operating in Sweden.

Two of Delta's LTL-M mobile retroreflectometers and three handheld instruments (LTL2000, LTL-X and LTL-XL) were used in the test program. A 100m stretch was measured at each test site. The marking types varied between smooth, dropflex, longflex, ladder and checkered.

The sample tests using handheld instruments were undertaken at 2m intervals on continuous lines and with two measurements per line segment on segmented lines. The average of all the handheld instruments was used as the baseline for determining measurement accuracy.

For the mobile instruments, each 100m stretch of road was measured twice. The average result of the center 5cm of the marking was used for comparison to make the best possible correlation with the handheld instrument measurement width.

(Above) **The accuracy of Delta's LTL-M mobile systems was tested in Sweden**

Table 1. Average measurements	
Average absolute measurement error of handheld	1.4%
Average systematic measurement error of handheld	-0.5%
Average absolute measurement error of mobile	2.5%
Average systematic measurement error of mobile	3.1%
Average repeatability measurement error of mobile	1.1%

Need to know

Mobile systems provide a comparable level of accuracy to handheld systems

- Delta's LTL-M can measure road markings at a distance of 30m, with a very high level of accuracy
- The LTL-M can measure white and yellow road markings of up to 25mm (1in) in profile depth
- It also measures R_L (night-time visibility) under dry conditions and daylight contrast, as well as detecting line geometry and missing or non-working road studs

Comparable accuracy

The following results were calculated for each instrument: absolute measurement error, systematic measurement error, and repeatability (see Table 1).

The conclusion of the test is that the mobile systems and the handheld instruments both have absolute and systematic errors well below 4%, providing the same level of accuracy. In addition, the results show that there is a very good correlation between the handheld references and the LTL-M mobile measurement system.

Human visual perception of road markings is, in essence, a result of the retroreflection of the full width and length of a marking, rather than the center value of the stripe. Hence, full width and length measurements, as can be facilitated using the LTL-M mobile measurement system, are more compatible with human perception than a handheld device providing spot measurements.

The next level in speed camera offense processing

According to a 2010 report from the RAC, the use of speed cameras across the UK saves 800 lives every year. With this in mind, the importance of maintaining a robust deterrent to speeding motorists has never been clearer.

The physical presence of cameras means that most people will stick to the speed limit, but there will still be a notable number of drivers who will be caught speeding. The outcome for these drivers is determined by the extent to which they are exceeding the speed limit, and they will either be offered driver education or will be given three penalty points on their license with a £100 (US$152) fine or an appearance in court.

Processing a traffic offense from 'camera capture' to one of these outcomes can be complex. Firstly, a stringent set of rules has to be adhered to in the lifecycle of a traffic offense; for example the cameras have to be type-approved and calibrated, Notices of Intended Prosecution (NIPs) have to be issued within 14 days and speeding bands need to be set for each outcome.

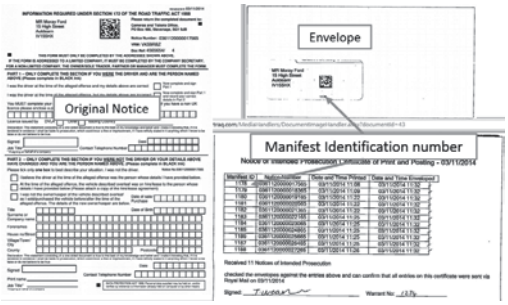
Secondly, if the offending driver has to go to court, all of the evidence needs to be produced to support the case for the prosecution. And finally, it is important to deter errant drivers with camera enforcement, but it is equally important that all drivers are treated fairly. Some police forces have a 'Justice Gap' where a notable number of offending motorists just get away with it. This is clearly unfair.

Data management

Rules, evidence and fairness are key to a successful camera enforcement program and UK police forces are under increasing pressure to process more traffic offenses with dwindling staff resources. To meet this challenge, police forces are turning to technology providers such as StarTraq, and 50% of them have already invested in the StarTraq Dome back office solution for traffic offense management.

The StarTraq Dome is a sophisticated workflow and document management system that enables the processing of traffic offenses from different camera types through to a successful prosecution outcome. It has a modular design, which enables enforcement agencies to invest only in those modules that are appropriate to their requirements.

To help illustrate the capabilities and modules of the Dome, StarTraq has built the Model Office, which shows how to process traffic offenses in the most efficient and effective way possible. The Model Office includes camera integration, verification of offenses, document management, workflow automation, rules management, flags, workspaces, online offense viewing and the production of court files.



(Left) **The Model Office optimizes the handling of court documents**
(Below left) **StarTraq Dome's back office interface**

Recently mail integrity has also been added to the Model Office. This new feature enables scanned images of enveloped documents to be recorded and stored in the database. The document reference numbers are scanned through the envelope window and this electronic image is automatically allocated to the relevant offense record. The software then produces a print manifest that can be signed by a member of the postal service to confirm receipt and collection. This proves that, not only was the document enveloped in a machine-readable format, but also that it has been collected by the postal service.

Reducing the number of deaths on our roads is non-negotiable. Enforcement agencies need the technology to manage the evidence trail of a traffic offense, and ensure that prosecutions and diversions to driver education are conducted efficiently and fairly. A modern back office processing system is the way to achieve this.

Need to know

To ensure fair, effective enforcement, UK police forces rely on modern back office technology

- The browser-based Dome enables enforcers to load offenses from a variety of sources into a secure and user-friendly environment for immediate verification
- It uses intuitive tools for generating statistical and bespoke management reports while managing the workflow of the offense through to its outcome
- The Dome is designed to be flexible – facilitating cost-effective remote working and supporting regional collaboration

Enforcement and privacy concerns call for special image handling

Many ITS applications, including toll collection, traffic violation enforcement and weigh-in-motion, rely on images of vehicles and license plates to calculate travel times, catch violators, or levy fees. Not surprisingly, as image data has become more important, more ITS project specifications are including requirements for verifying the integrity and authenticity of this image data, and encrypting it against unauthorized viewing.

As these steps can add another level of complexity to an ITS project, it is important for system integrators to have a good understanding of the subject.

The whole image

To begin with, there's the issue of image integrity verification. Vehicle or license-plate images often become part of an enforcement package used as proof of some sort of traffic violation. For this reason, it is important to be able to show that the image has not suffered any loss of data as the result of transmission problems between its point of origin and the back office.

Checksum algorithms, such as CRC32 and other cyclic redundancy checks, provide the technology to verify the integrity of an image by sending a checksum value along with the image data. This can then be compared with a value derived from the same algorithm applied in the back office to prove the image is complete.

In most cases, however, system integrators should opt for imaging solutions with the ability to use a cryptographic hash function such as MD5, SHA-0, SHA-1, or SHA-2. These ciphers produce a short 'message digest' of hexadecimal characters, which is more robust than a simple checksum, yet the processing overhead remains fairly low and there are no special 'keys' required for implementation.

Straight from the source

While image integrity verification ensures that the image data is intact, image authentication is designed to prove that the image actually originated at a particular camera or lane location.

This is accomplished by having the camera encrypt the aforementioned message digest using an encryption 'key' before sending the image and digest to the back office. If each camera is provided with a unique (and secure) encryption key, then the back office can verify the origin (authenticity) of an image based on whether the matching key in the back office can successfully decrypt the associated message digest.

Need to know

System integrators can optimize their operations with greater understanding

- Different algorithms produce different levels of cryptographic strength – requiring more or less processing time
- They also increase project complexity by using various 'key' schemes including shared private keys and public-private key pairs
- By selecting a solution that supports several different image-handling methods, system integrators are able to find the optimum approach for a specific project more easily

Again, multiple algorithms are publicly available for encrypting the message digest including HMAC (hash message authentication code), DSA (digital signature algorithm), Elliptic Curve DSA (a variant of DSA) and RSA signing.

No prying eyes

The combination of image integrity verification and image authentication is sometimes referred to as a 'digital signature' for an image. While this makes images more useful in enforcement matters, it does not protect the data against possible interception and viewing by unauthorized parties. Doing this requires the third element in specialized image handling: image encryption.

For system integrators, this means selecting cameras capable of efficiently encrypting the full image. Since this task can be several thousand times more compute-intensive than

(Left) **Open-road tolling systems rely on accurate image data**

encrypting a 16- to 256-byte message digest, the right encryption method is critical to maintaining camera performance.

Symmetric key algorithms such as Triple-DES and AES (Advanced Encryption Standard) provide high security with much lower processing time than well-known public key approaches such as RSA and DSA encryption and therefore can offer strong protection without reducing frame rates.

As is the case with authentication, use of any key-based scheme adds an additional layer of complexity to the ongoing operation of an ITS installation and should be carefully considered before implementing.

Spurred by legal and privacy issues, the demand for image integrity verification, authentication and encryption will continue to grow. By choosing imaging solutions that offer the greatest flexibility in these image handling functions, system integrators can be better equipped to meet the specific needs of each project undertaken. ○

by **Mike Schagrin**

The positive evolution of transportation

NEW COLUMN!

Over the past decade, the USDOT's Connected Vehicle Research Program has been on a long and winding road with several uncertainties along the way, including what it would produce, and sometimes whether or not it would even continue to exist. The good news, however, is that 2014 was a major positive turning point in what has been – and continues to be – an evolving story.

When we at the USDOT envisioned a connected vehicle environment back in the early 2000s, we thought that V2I capability would be deployed first. We worked with car companies and public agencies to plan for the simultaneous implementation of vehicle and infrastructure communications systems. Back then, the focus was solely on DSRC and it was viewed as the technology for supporting all the various transportation-related communications needs (in fact, one of my early managers even referred to it as 'the Holy Grail' for ITS).

However, when it became evident to the industry that the Feds were not planning to pick up the tab for the infrastructure piece, it caused turmoil, essentially leading to a pause on progress. And things got worse from there… by the mid-2000s the use of DSRC technology and future government investment was being questioned entirely.

Fortunately, in the late 2000s, new DOT leadership brought a renewed enthusiasm for DSRC and plans were back in motion. But, notably, our implementation strategy had changed. Instead of leading with V2I, we decided to move forward with a V2V implementation first. This required some bold and explicit steps: first, a 2013 regulatory decision milestone was set for V2V safety; and second, the Safety Pilot Model Deployment Program was established. These two actions restructured the entire ITS research program, while laying out a clear plan toward establishing the DSRC connected vehicle.

Furthermore, the connected vehicle was now no longer just about DSRC. Advances in wireless communications technologies opened the door to a more robust connected vehicle environment, along with applications that we would never have dreamed of originally.

Consequently, the next major DOT initiative is the Connected Vehicle Pilot Program. This looks at how the connected vehicle can address the broader set of issues with surface transportation, using a variety of communications media and data sources. It will be exciting to see how connected vehicle innovations roll out in these pilots, and through other initiatives. Many questions have yet to be answered. To what extent will DSRC be leveraged for more extensive purposes? How will DSRC along with other wireless communications come together as a holistic solution? To what extent will we see convergence with the automated vehicle to deliver the ultimate vehicle capability of what I like to call 'connected automation'?

"We at the USDOT envisioned a connected vehicle environment back in the early 2000s"

While the past 10 years haven't been easy, we've made it to a very encouraging place – one that I believe holds great promise. And I look forward to exploring and talking further about advances with the connected vehicle as they unfold. The next 10 years will be very exciting, as we continue toward our connected future. ○

Mike Schagrin is former program manager for the ITS Connected Vehicle Safety and Vehicle Automation research programs at the USDOT's ITS Joint Program Office. Mike has now established Schagrin Consulting International, supporting clients in connected and automated vehicles. ***mike@schagrin-consulting.com***

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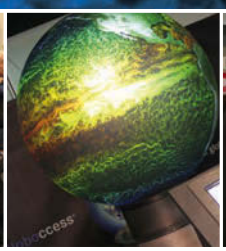


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Thermal sensors facilitate optimized signals for smoother traffic flow

In the heart of the Netherlands, the province of Utrecht was looking for a solution that would enable traffic to flow more smoothly at one of its busiest intersections. The traffic lights at the Wilhelminalaan-Utrechtseweg (N237) intersection needed to more effectively manage both vehicles and cyclists in order to minimize waiting times. In particular, traffic authorities needed to find a way to provide traffic coming from the Wilhelminalaan and from the exit of the KNMI (Royal Netherlands Meteorological Institute) site with sufficient green time to cross the Utrechtseweg.

It was decided that the best way to achieve this would be with vehicle presence information. However, in order to avoid creating unnecessary waiting time for vehicles at the intersection, it was important that the presence of cyclists should not generate green time. At this intersection, cyclists can only turn left or right before the intersection area; they cannot cross the intersection itself. Therefore, for this specific situation, separate regulations for cyclists and motorists were required.

Integrator Imtech Traffic and Infra decided to select the ThermiCam thermal sensor from FLIR Systems for the job. "ThermiCam can efficiently make a distinction between cyclists and motorists in the same traffic lane," explains Guus Sluijsmans, Imtech traffic engineer and account manager.

Sensor specifics

ThermiCam is an integrated thermal camera and sensor system that is designed to detect the presence of individual vehicles and bicycles at signalized intersections. The sensor then transmits the information it collects via contact closures or IP to the traffic light controller. This allows for more dynamic control of the traffic lights.

Need to know

A complex signalized intersection required an intelligent thermal detection system

- ThermiCam's intelligent sensor provides traffic light controllers with specific information on vehicle and bicycle presence, enabling managers to make intelligent decisions and to adapt green times according to road user type
- The system also facilitates vehicle and bicycle counting. This functionality can work simultaneously alongside presence detection, using the same detection zones and regions

As the sensor picks up heat energy emitted from the cyclists and motorists, it is able to use this information to make a distinction between the two. This way, green times can be adapted depending on the type of road user. ThermiCam will also detect cyclists and vehicles at night or when the sun is low in the sky, regardless of whether road users are moving or stationary.

ThermiCam is a flexible and intelligent alternative to detection loops, and it can be used in applications where detection loops would not be effective. In the case of the intersection in Utrecht, it was not possible to use detection loops because the different roads connected on a bridge deck. Furthermore, most detection loop solutions cannot distinguish between cyclists and vehicles.

Smooth moves

The ThermiCam installations at the Utrecht intersection serve two purposes. Firstly, they make sure that cyclists receive enough green time at the traffic lights to access the cycle lanes along the Utrechtseweg. Secondly, they make sure that the presence of cyclists does not generate green time for motorists. The solution has already proven effective in minimizing traffic congestion at the intersection and maximizing the mobility of different road users.

"The ThermiCam bicycle and vehicle detection system is ideal for this difficult, mixed traffic situation," says Imtech's Sluijsmans. "We can now facilitate much smoother traffic flow at the intersection."

(Top and above) **FLIR's ThermiCam detects heat emitted from all types of road users**

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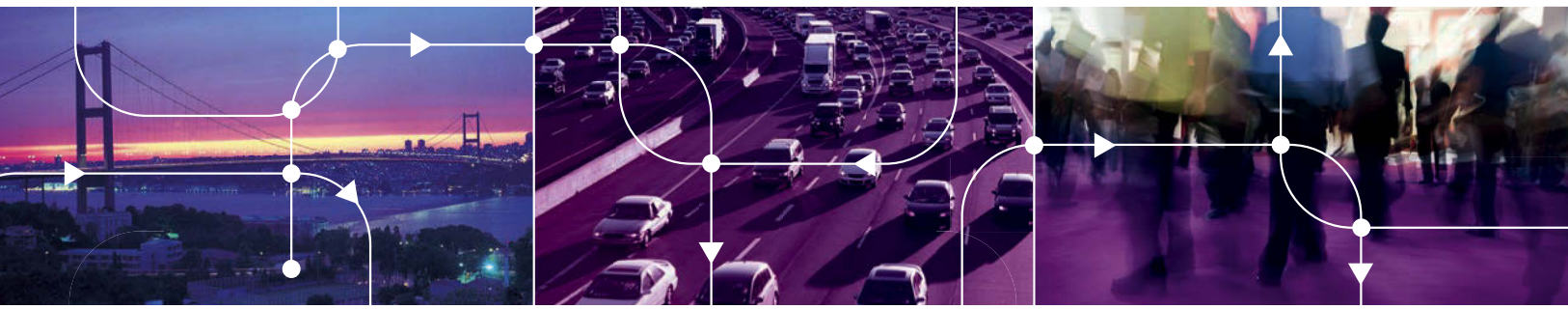

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Express lanes

A quick guide to the biggest stories in this issue and online – from federal funding to workzone safety, and everything in between

Page 36

"There is a recognition that we can't just build our way out of our road shortage. Greater use of technology … will help us make better use of existing networks"

Bill Butler, event director, Traffex, UK

"Live lane crossings are carried out by workers, usually in the dark, with no warning signs"

Ian Smith, the UK Highway Agency's program manager of Aiming for Zero

Page 40

Check out the Highways Agency video of a near miss on a UK road, highlighting dangers faced in workzones

TrafficTechnologyToday.com/workzone

Page 57

"Many of the current challenges are a result of increasing urbanization and mobility demand, combined with increasingly scarce resources and space limitations"

Hermann Meyer, CEO, ERTICO-ITS

"The highway transportation bill expires in May, so after that state governments across the country that rely on these dollars for highway funds will either slow or stop projects"

Anthony Foxx, US transportation secretary

Our video highlights of Anthony Foxx's interview at Google are here: TrafficTechnologyToday.com/foxx

"For those of us in the research community, and other partners and stakeholders in transportation, it is difficult to have long-term projects when the only guarantee you have is short-term funding"

Gregory Winfree, USDOT assistant secretary for research and technology

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