June/July 2016

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Can portable weigh-in-motion systems take the pressure?

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How ever-greater demands are being placed on digital maps, making real-time updates essential

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Andrew Mehaffey
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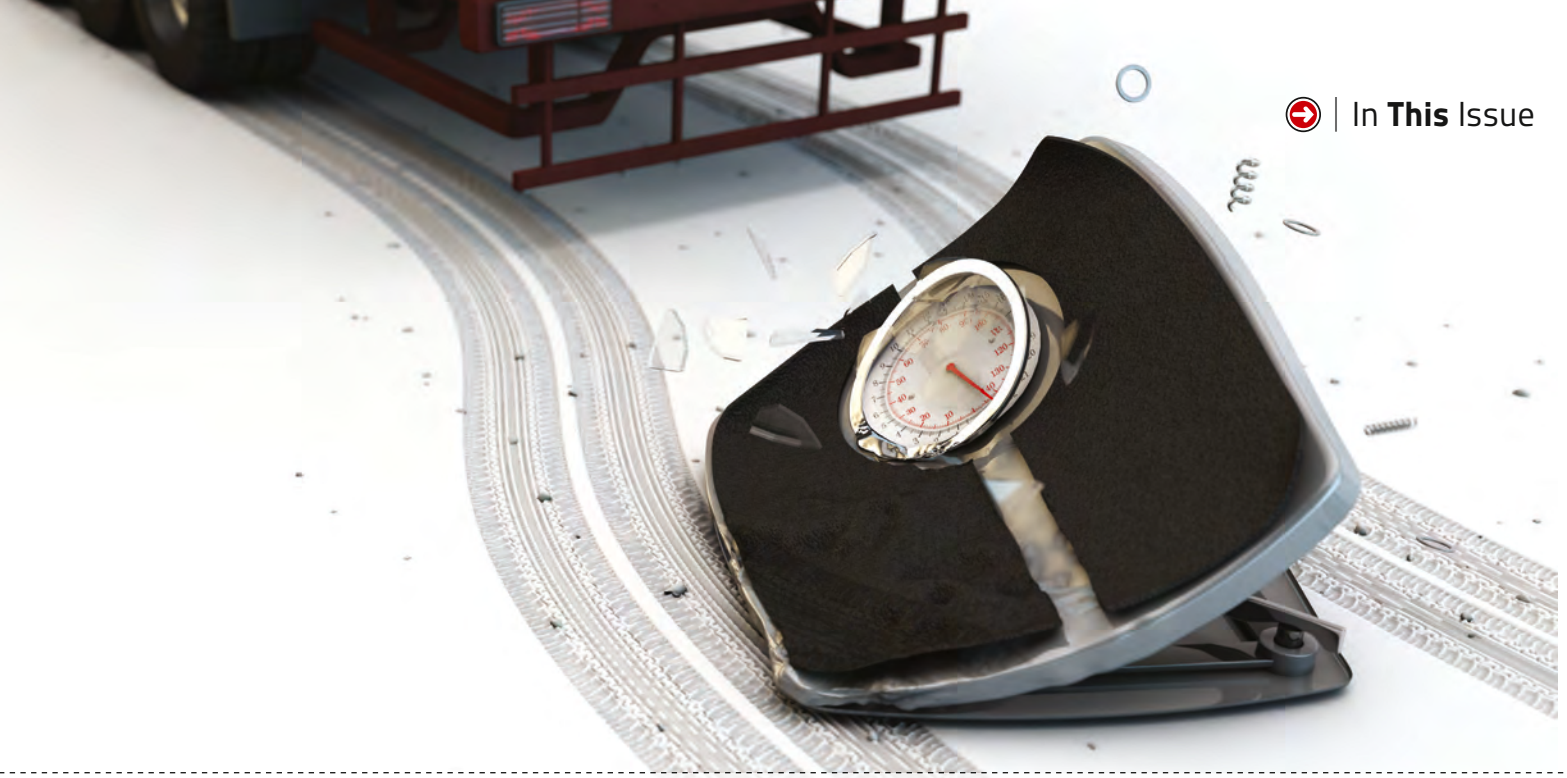
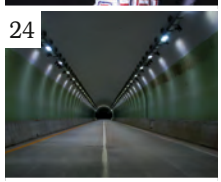


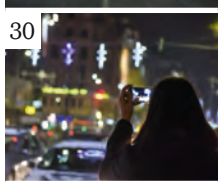
Cover story

36 Stress testing

Can portable weigh-in-motion take the pressure?

Saul Wordsworth asks whether movable weight enforcement systems will ever replace those permanently embedded in roadways





Technology Profiles

Editor's letter

As we go to press, much of the UK is still in a state of shock following the hugely divisive referendum that resulted in 52%/48% decision to leave the European Union (EU). Questions are now being asked about every aspect of Britain's relationship with Europe. In transportation, where cooperation has brought so many benefits, experts in Brussels, the EU's administrative heart, and at the UK's Department for Transport (DfT), were united in their desire to continue 'business as usual', as far as possible.

"The main thing to say at this stage is that we're still a member of the EU for the time being," a spokesman for the DfT told me. "We will continue to engage with EU businesses as normal and be part of the EU decision-making process, although obviously there is a process that is going to have to get underway and we'll know more about how that will develop soon."

"My personal view is that one way or another the UK will always be linked to Europe," Konstandinos Diamandouros, the European Road Federation's head of office, told me from Brussels, when I called him right after the vote. "So, whether it is simply having access to the common market, or implementing all the safety-related standards for vehicles and infrastructure, I just don't see the UK suddenly cutting itself off. A lot of things will carry on being linked, so I feel that the impact will not be as severe as people fear."

We can but hope. Keep up-to-date with all the latest transportation news from around the world every day at traffictechnologytoday.com

In this issue you'll find reminders of ways in which worldwide cooperation is key to our global transportation systems. From Europe there's the Dutch project to better organize traffic for special events (p16); from the USA and Japan there are advances in technology to keep traffic moving in tunnels (p24); and from Australia you can read about the latest intelligent transportation systems in our interview with Andrew Mehaffey (p12), who also looks ahead to October's ITS World Congress in Melbourne.

Elsewhere we report on cooperative systems that are already truly global in nature – traffic app Waze is becoming a valuable incident-reporting tool for public and private users alike (p30), while multinational navigation leaders are delivering real-time map updates at the same time as traffic information (p44). Our transportation systems are increasingly interdependent – let's keep making new connections.

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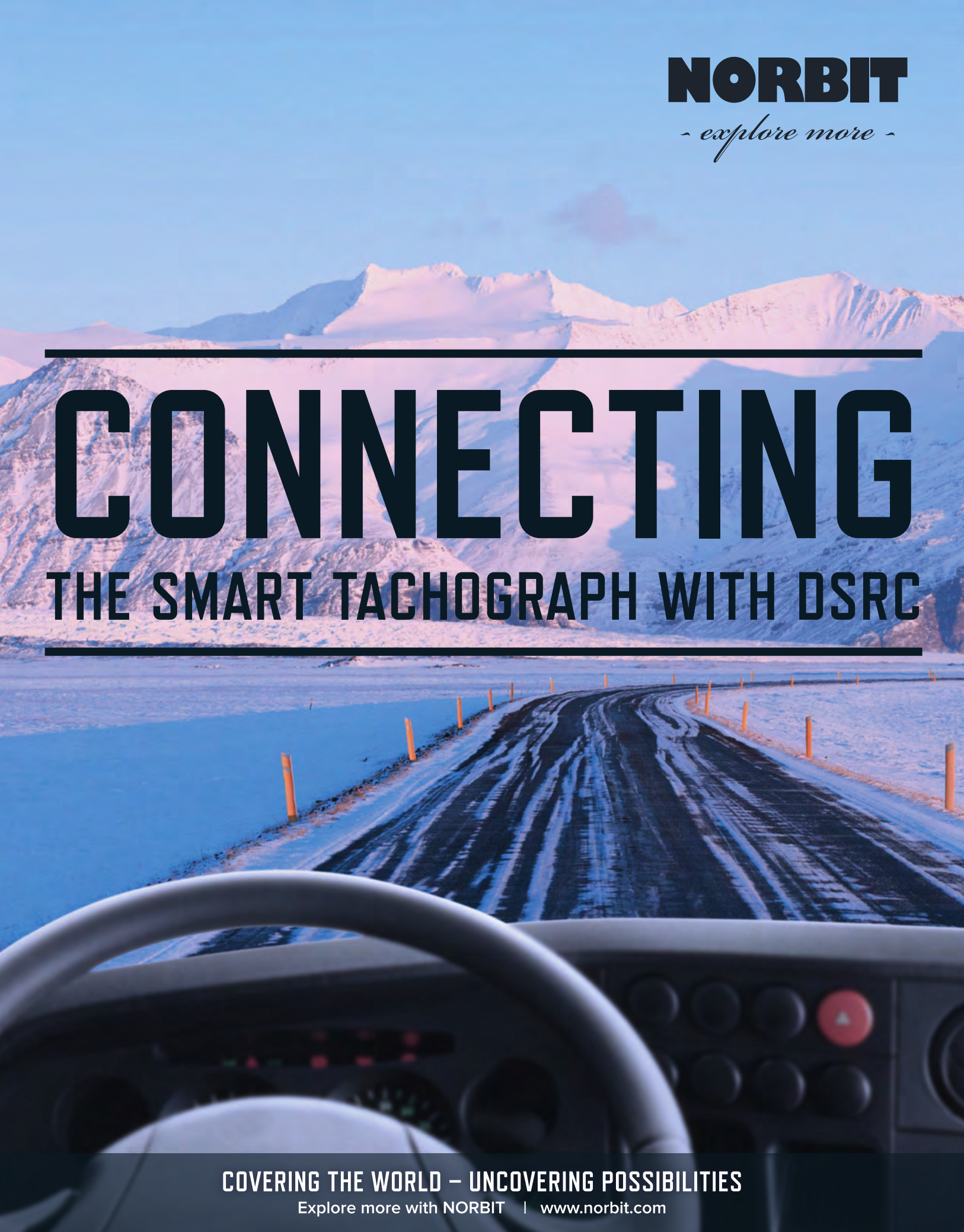
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Congestion busters

Around the world, transportation experts are working on ways to keep our roads moving. Here are three of the most successful projects in recent months

Smart motorway

Highways England (UK) has recently released figures that show that drivers using the UK's M62 'smart motorway' are saving up to 30 minutes of travel time each week, despite the number of vehicles on the road increasing by 6% since 2013.

Smart features include the latest technology to monitor traffic levels, and variable speed limits are displayed on overhead electronic signs to keep vehicles moving. CCTV is in operation 24 hours a day to enable traffic managers to respond quickly to incidents, closing lanes using red 'X's on overhead signs if necessary. Drivers can also use emergency refuge areas if they break down.

The 15.5-mile stretch is Highways England's flagship scheme on the M62. It cost £136m (US$194m) and was completed in 2013.

Read the full report:
trafficTechnologyToday.com/M62

00:24 seconds saved per mile traveled

Interstate express lane

In December 2015, Colorado DOT and its High Performance Transportation Enterprise division opened a toll express lane on the I-70 Mountain Corridor to ease congestion during peak times.

Since the express lane has been in operation, traffic throughput on the 13-mile stretch has increased by 15%, incidents have decreased by 15% and congestion has much lessened, saving drivers 4.5 minutes of travel time.

When the I-70 Express Lane is not open, it is used as a hard shoulder for emergency purposes.

Read the full report:
trafficTechnologyToday.com/I-70

00:21 seconds saved per mile traveled

Incentivized app

Over the past year, users of global app Metropia have driven more than one million miles and saved over 3,500 hours of travel time that would have otherwise been spent sitting in traffic.

Headquartered in Tucson, Arizona, Metropia aims to make cities better places to live by reducing traffic congestion and CO_2 emissions. The app does this by incentivizing its users to make better decisions about their commutes – such as using carpooling schemes – with rewards such as points toward gift cards.

Read the full report:
trafficTechnologyToday.com/Metropia

00:13 seconds saved per mile traveled

Smart solutions

As an increasing number of transportation authorities invest in connected technologies, we take a look at those that are turning the popular concept of a smart city into a reality

Smart City Challenge winner

Columbus, Ohio, wins the USDOT's Smart City Challenge

Columbus, Ohio, has been selected as the winner of the US Department of Transportation's (USDOT) hugely popular Smart City Challenge, with its proposals edging it ahead of the competition's six other finalists, chosen from 78 entrants in total: Austin, Denver, Kansas City, Pittsburgh, Portland and San Francisco.

Columbus will receive up to US$40m from USDOT and up to US$10m from Paul G Allen's Vulcan Inc. to supplement the US$90m that the city has already raised from other private partners. Using these resources, Columbus will work to reshape its transportation system to become part of a fully integrated city that harnesses the power and potential of data, technology and creativity to re-imagine how people and goods move throughout their city.

"While Columbus is the winner of the Challenge, we believe each city has come out of this process with a stronger sense of how to address transportation challenges with technology and innovation," said US Transportation Secretary Anthony Foxx as he presented the award to city representatives (*above*).

Smart lighting network

Partners using streetlighting are set to provide smart cities with an IoT network

Many cities are focusing on smart streetlighting programs because they represent a major financial outlay, have a clear impact on livability, and affect environmental performance.

German smart lighting specialist Osram will equip its smart city lighting products with Paradox's PE.AMI network technology, a future-proof IoT-ready hardware and software network communication platform, to provide cities with the opportunity to turn their public lighting infrastructures into networks that can manage multiple urban services, such as parking, traffic and waste management, and environmental monitoring.

Connected infrastructure

Bradford, UK, has connected its cameras and traffic management devices

A project in Bradford, West Yorkshire, UK, has enabled hybrid connectivity for more than 300 surveillance cameras (manufactured by Axis Communications, Bosch Security Systems and HikVision) and traffic management devices, by integrating multiple information and communication technologies city-wide.

Wireless and radio connectivity is administered by millimeter-wave (mmW) developer Siklu, of Israel, which provides multi-gigabit fiber-like wireless connectivity in urban, suburban and rural areas.

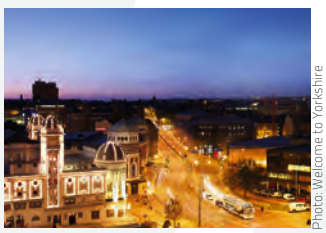


Photo: Welcome to Yorkshire

The mmW system transmits data from hundreds of traffic junctions and 26 variable messaging signs that are used for traffic management.

In areas where the 5GHz noise is high, the city uses a palm sized EH-600 mmW radio from Siklu, which operates in the interference-free 60GHz frequency band.

Designed for installation at street level, the EH-600mmW radio provides long-term gigabit capacity in a small size.

Bradford comprises more than 500,000 residents and is the fourth-largest metropolitan district in England.

Dedicated smart mobility app

World's first all-inclusive mobility service unveiled at the Forum for Mobility and Society debate

Designed to fulfil all mobility needs in one place, the Whim app, which was unveiled at the Forum for Mobility and Society debate on mobility as a service (MaaS) in Brussels, Belgium, in June, takes care of route-finding ticketing and payments.

Whim is produced by Finnish startup MaaS Global, led by Sampo Hietanen, former CEO of ITS Finland and the father of the MaaS concept; offers monthly and pay-and-go mobility packages; and syncs with users' calendars to help plan journeys in advance.

Whim will be launched in Helsinki, Finland, in late summer 2016, with a full nationwide service to follow.

Future of enforcement

Tom Stone reports on a new project in Virginia to prepare for forthcoming changes to traffic enforcement. In a world of increasing connectivity, we are likely to see a shift in the key role of police highway enforcement – from issuing speeding tickets to protecting cybersecurity

The second part of a project researching vehicular cybersecurity and its role in the future of law enforcement is now being planned in the USA, *Traffic Technology International* can reveal.

The first part of the project was carried out as a collaboration between Virginia State Police, University of Virginia, the not-for-profit MITRE Corporation and several private cybersecurity companies. It concluded in October 2015, with important recommendations for ensuring the security of the state's patrol cars (see *Police lines*, right) but leaving more research to be done in the field of detecting cybercrime.

Illustration: BMW

Now, project leader Dr Barry Horowitz, professor and chair of the systems and information engineering department at the University of Virginia, is in the process of gathering players for a second phase.

"The project up until now has been focused on the Virginia State Police and their interest in cybersecurity risks and management," Horowitz tells *TTI*. "Now we're looking to expand it to include a broader set of the state police departments at large. We're spreading to the web to see how many people we can get engaged." It is anticipated that the second phase of the project will begin within the next few months.

Below: **Ford Taurus cruisers and a Chevrolet Impala model, similar to those used in the Virginia cybersecurity project**

Protecting those that serve

Capt. Jerry Davis of Virginia State Police, who has been involved with the project from the outset, tells *TTI* more about how it has been running so far. "It's a two-pronged approach," he says. "How do I, as a law enforcement manager, protect my fleet from cyber issues? And how can I forensically analyze a vehicle at the scene to determine whether or not a hacking incident has occurred?"

So far, after several months of simulated attacks on two types of Virginia State patrol cars – Chevrolet Impala and Ford Taurus models – it has been established that because there are no wi-fi,

> "How can I forensically analyze a vehicle at the scene to determine whether or not a hacking incident has occurred?
>
> *Capt. Jerry Davis, Virginia State Police, USA*

Police lines

Recommendations to state police departments from the Virginia State Police cybersecurity project

- Review or formulate policy for visual inspection of police vehicles prior to duty
- OBD-II port located beneath the dashboard must be included in this inspection. Any device attached to this port should be treated as suspicious
- Monitor new in-vehicle equipment to ensure connectivity or telematics is always optional, not standard
- Department experts should be appointed to keep up-to-date with new developments in the field
- Departments should carry out specific training in cybersecurity, with particular reference to attacks on physical systems
- Police agencies should partner with auto industry, cybersecurity companies and academia to further research
- Review any existing statutes related to computer trespass to ensure they encompass hacking
- Reflect cybersecurity matters in updated public-safety missions.

Source: *Autonomous and connected vehicles: A law enforcement primer, Capt. Jerry Davis*

US$400bn
Estimated annual global cost of cybercrime
Source: Center for Strategic and International Studies

Camera shy

Will connected and autonomous vehicles mean an end to traditional enforcement methods?

It's easy to imagine a future world where V2X technologies identify vehicles breaking traffic laws remotely – and autonomous vehicles are programmed never to break laws at all – thus doing away with the need for traditional camera-based enforcement. However, Capt. Jerry Davis of Virginia State Police doesn't think it will be so simple.

"There will always be a need for traffic-related enforcement activities, because there's always going to be a mixture of car types," he says. Furthermore, when it comes to identifying drivers through connected vehicle data, barriers may persist. "It's reasonable to believe you won't be identifiable through your vehicle," says Davis. "You may have a number that is used, as opposed to your name."

Plus, in a more distant driverless future, police enforcement may still have a role. "Just because a car is autonomous, doesn't mean the tires are not going to wear, the wipers are not going to fade, or lightbulbs are not going to blow out. So that may become more of a focus for law enforcement," says Davis.

1 in 22
The proportion of UK population who were victims of cyber fraud in 2015
Source: ONS

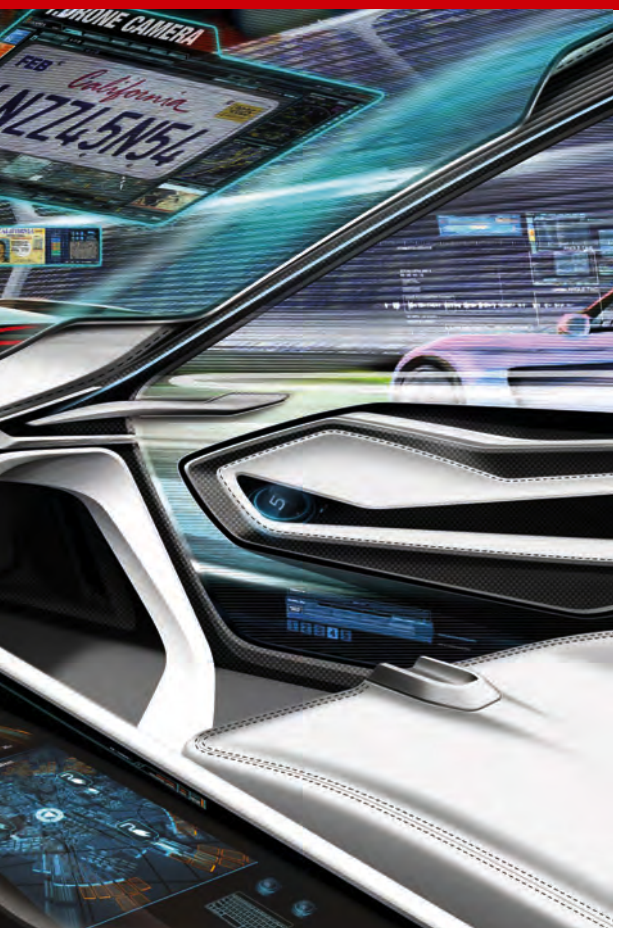
Bluetooth or telematics options in Virginia State police cruisers, the vehicles are safe from hacking, unless an attacker is able to gain physical access to the vehicle. Such access could occur during maintenance by private vendors, via third-party equipment that is installed in vehicles and embedded with malware, or through direct physical access during the course of normal police activity.

"The big issue that arises is that everybody is trying to be more efficient," says Horowitz. "And one way to be more efficient is through telematics. Remote data can tell you how to manage your fleet better. And that opens up the opportunity of connections that you don't anticipate, which could allow someone to take control of your vehicle. So we need to look at ways of introducing telematics with suitable caution."

A further key finding from phase one was that the ability to launch cyberattacks is

Below: **Computer systems in police patrol cars must have no unsecured connectivity to ensure their safety**

> "Car companies are reticent to give out information for reasons relating to proprietary data and trust
>
> *Dr Barry Horowitz, professor and chair of the systems and information engineering department, University of Virginia, USA*



vehicle-specific. "The lessons learned on the Ford product could not be replicated using the same data on the Chevrolet," writes Davis in his paper, *Autonomous and connected vehicles: A law enforcement primer.* "Attacks could not be replicated on different year models using the same data packets. Production variance in electronic control units and related equipment in varying years contributed to some level of protection. Hackers would have to develop multiple attacks for different years, makes and models of agency fleets."

Detecting cyberattacks

The second aim of the project is to develop systems that might aid police officers in enforcement. "Because when you're talking about a hack, you're actually talking about a crime that's been committed," says Davis. "That crime will have to be investigated. So we need to have the capacity to analyze a vehicle at the scene of an incident to determine whether hacking is a possibility – ideally you could plug a device into an OBD-II port and be able to take a snapshot of that vehicle. We've not reached that point yet, but we will be looking at it more in the second phase."

However, issues of setup and data variance between vehicles and models once again create a challenge. "What we discovered is that you can, through what's called fuzzing, discover different attacks in different car models. But it's very labor intensive – it's trial and error," says Horowitz. "So the other approach is for the car companies to give you the information you need. And at this point they are reticent to give out such information for reasons relating to proprietary data and trust. There really needs to be the will to manage it."

While technical challenges are undoubtedly a major factor, it could be that matters of policy and privacy will eventually prove to be even more difficult to overcome.

> "When you're talking about a hack, you're actually talking about a crime that's been committed. That crime will have to be investigated
>
> *Capt. Jerry Davis, Virginia State Police, USA*

As the industry prepares for the World Congress in Melbourne, **Andrew Mehaffey**, principal manager of ITS in New South Wales, notes key Australian innovations

Interviewed by Max Glaskin

When we speak to Andrew Mehaffey he's just traveled 600 miles back to Sydney from the ITS Australia Summit 2016 in Brisbane. Come October, he'll cover a similar distance to attend the ITS World Congress in Melbourne. Between now and then he'll be keeping his head down at his job, working with 80 specialists at New South Wales Roads and Maritime Services as its principle manager of intelligent transport systems, to make sure the right technology is making travel efficient for the state's more than 7,000,000 citizens.

It's a job that requires anticipation based on experience and good information. "We need to ensure all of our road infrastructure is future-proofed so that we'll be able to apply ITS technologies that have yet to emerge – and that's a challenge," says Mehaffey.

The SCATS man

Forty years ago, Sydney traffic managers started to build anticipation and good communications into the city's traffic signal network. Since then, its adaptive traffic management system has become so successful – it is used in 27 countries across the world – it's now normally known simply

> We need to ensure all of our new road infrastructure is future-proofed so that we'll be able to apply ITS technologies that have yet to emerge

Left: **Mehaffey is responsible for deploying ITS to keep traffic moving on the world famous Sydney Harbour Bridge**

by its acronym, SCATS (Sydney Coordinated Adaptive Traffic System). Mehaffey is now in charge of its development.

"SCATS delivers millions of dollars of economic benefits in travel time savings in Sydney every day compared with simpler signal technologies and we've been improving it since the 1970s," he says.

A step-change is now in progress. "New South Wales is investing substantially in transport network improvements. It includes improvements to SCATS we've wanted for a time, but normal funding hasn't enabled us to do. It will allow us to use SCATS in the connected vehicle environment," says Mehaffey.

SCATS enhancements will include new algorithms, different operating models, better coordination between intersections and utilization of upstream detection. "We're developing a sophisticated engine for selective priority to different types of vehicles," says Mehaffey.

Autonomous future

Sooner or later, connected vehicles will likely place different demands on SCATS, as will automated vehicles. When does Mehaffey anticipate AVs will be on his roads? "A lot of people talk about them like they're going to happen suddenly, but really it's going to be a gradual introduction over many years," he says. "We already have some automation capabilities now but fully automated vehicles that come and pick you up are decades away. Yet even with the early stages of automation we can get some significant safety benefits."

One possible consequence New South Wales is anticipating is effects on travel behavior. "We don't want negative outcomes, such as reduced public transport use and increased congestion and urban spread," Mehaffey says.

All around the world

Mehaffey fully anticipates that great ideas will spread quickly when the ITS World Congress opens in Melbourne, Victoria, in October. "The ITSWC in general is an excellent opportunity to keep abreast of the latest developments," he says.

"It's only the second time it has been in the southern hemisphere, the last being in Sydney in 2001, so it's a rare opportunity for people in the Australasian area to experience it. The congress provides opportunities for first hand interaction with international experts and to experience technology demonstrations, which are really beneficial.

"People from other parts of the world now have a good excuse to visit Australia and see what we're doing with ITS," he says, before taking the chance to extoll his home patch: "And hey, don't just go to Melbourne, come to Sydney too!"

What is SCATS?

The Sydney Coordinated Adaptive Traffic System (SCATS) is an algorithm-based system distributed across many computers that uses incremental feedback to optimize traffic flow through groups of intersections. The groupings change dynamically with changes in the traffic. Cycle-by-cycle in real time, it optimizes cycle length, splits and offsets.

The ability of SCATS to cope with heavy traffic flows has been illustrated in Gresham, Oregon, USA. Time-of-day timing plans had been installed, but travel times got longer as traffic volume increased during a six-year period. After SCATS replaced the time-of-day plans, travel times fell to the lowest ever recorded.[1]

SCATS was born in the 1970s, thrived in the 1980s and continues to flourish around the world. It's estimated that half of all traffic signals in Australia today are operated through SCATS. As one of the early intelligent transport systems, it tempted Mehaffey to switch from working in road construction, to managing traffic using software.

1) Adaptive Traffic Signals, Comparison and Case Studies by Kevin Fehon, P.E., PTOE and Jim Peters, P.E., PTOE, tinyurl.com/zumlonp

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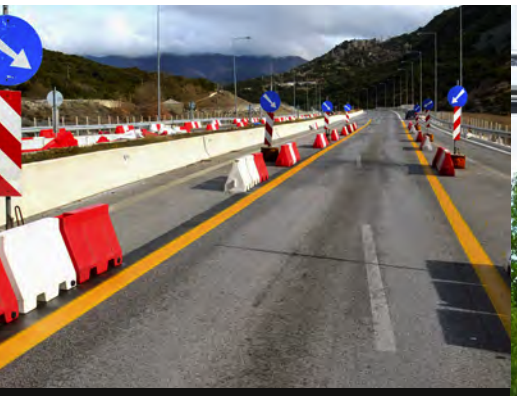

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Ahead of the game

Special-event traffic causes jams on major routes. What if capacity could be increased by spreading vehicles evenly across the entire network? In an era of in-car, real-time, personalized travel information, this dream is finally possible, as **Tom Stone** discovers

It's a frustratingly familiar scenario – you're driving on a major highway when you catch sight of a roadside variable message sign (VMS) with some important information: "Major Event Today – Delays Expected – Use Alternative Routes." Nice to be informed, but what next? Will your sat-nav pick up on any queues ahead? And if you – or your sat-nav – choose an alternative route, will that be suffering the knock-on effects of the congestion? And what if you're actually trying to get to the event itself? Then, perhaps the next VMS you pass is helpful: "Event Traffic – Use Next Exit." Great. But as you attempt to filter off, the queues begin, as 40,000 other eager fans get in line for the big fixture. What follows is the all-too-common nightmare of waiting, as the clock ticks down toward kick-off or the on-stage time of your favorite band, in the hope that you won't miss the start. Meanwhile, the surrounding community must absorb the knock-on effects of a heavily congested road network as residents and visitors attempt to go about their usual business. But, with the amount of technology at the fingertips of traffic managers, does it have to be like this?

A connected solution

Traditional roadside VMS and sat-nav, whether GPS or web-based, provide an imperfect, hit-and-miss solution to such high-volume traffic events. Rerouting can occur too late, or end up taking drivers onto roads that looked relatively clear when the detour began, but quickly become choked with vehicles as the start of the special event draws nearer. Sat-navs can even end up attempting to direct traffic onto roads that have been closed for the event, causing further chaos. What's needed is a

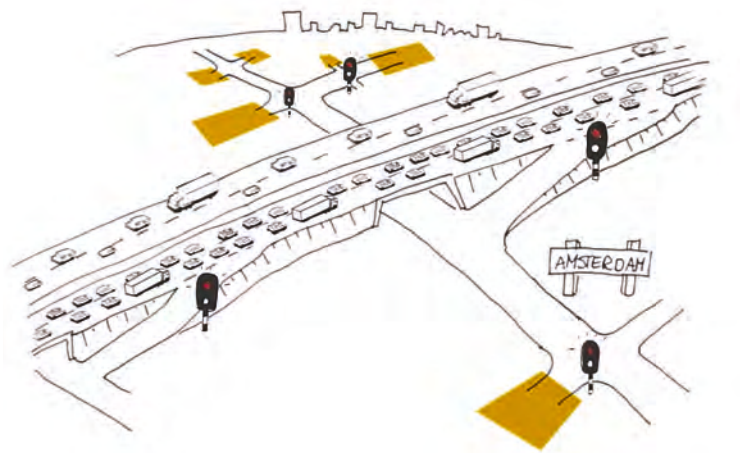

SMART
TRAFFIC
SOLUTIONS

bespoke solution, which is just what is being trialled, for the first time anywhere in the world, in the Praktijkproef Amsterdam (PPA), which translates as Practical Trial Amsterdam. It's a smart-traffic project currently taking place in the Amsterdam metro area, with particular focus on the city's orbital A10 freeway. It is a collaboration between four government agencies – Gemeente Amsterdam, Provincie Noord-Holland, Rijkswaterstaat and Stadsregio Amsterdam – which are working together with commercial companies and academics to bring the four-year project, which began in 2014, to fruition.

Reducing bottlenecks

Phase One of the trial, which concluded late last year, tested two types of traffic technology in isolation: roadside infrastructure, which includes in-road sensors, traffic signals and VMS; and the smartphone apps that are used in-car for fully personalized route information. There were also two distinct types of user – commuters, and those attending large-scale special events at the Amsterdam Arena. The stadium is home to the city's Ajax soccer team, but also plays host to live concerts and other sporting events such as American football matches. It has a capacity of 53,502 for football and 68,000 for concerts. While public transportation options are available, there are also 10 separate parking lots in the vicinity, including a park-and-ride scheme.

Right: **One of the key aims of the Practical Trial Amsterdam was to keep the A10 city-orbital highway moving, using connected signal systems**



> By keeping traffic moving on the A10 we can reduce journey times on all routes
>
> **Micha Sijtsma, accessibility project manager, Stadsregio Amsterdam**

The Arena is located just outside the city's A10 orbital. Micha Sijtsma, accessibility project manager for Stadsregio Amsterdam (Amsterdam City Region), explains why keeping the ring road congestion free is such an important part of this project: "By keeping traffic moving on the A10 we can reduce journey times on all routes, because if people are trying to get into, or out of, the city and there's a big jam on the A10, the

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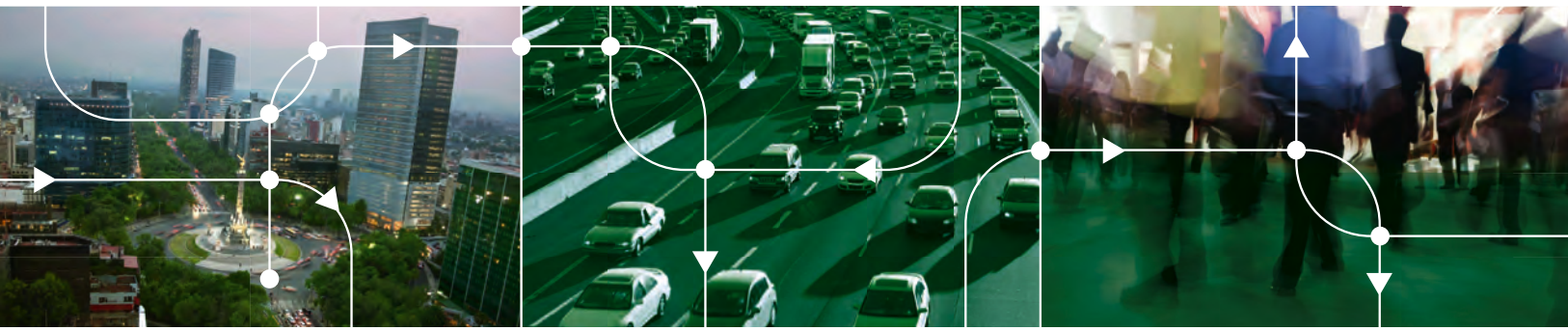

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Smart routing

How smartphone apps can reduce congestion in the event of an accident

An accident happens on a major route...

... Some app users get diverted via one route...

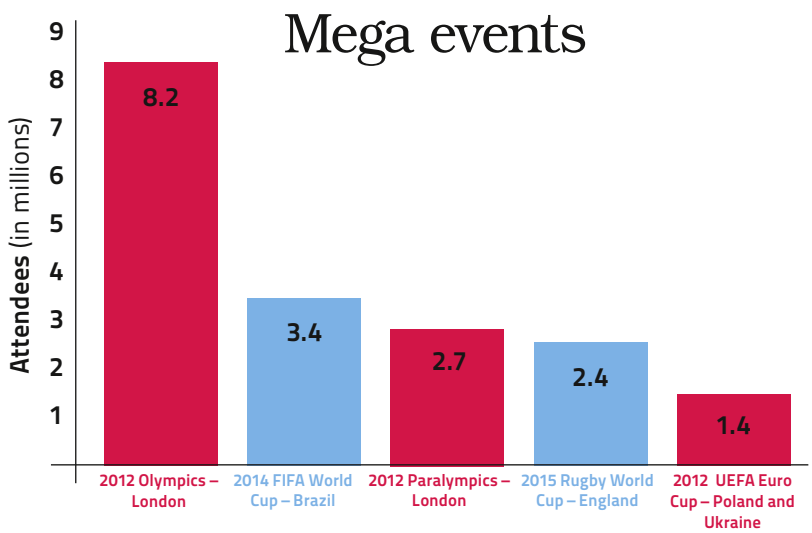
... While others get routed another way, thereby reducing congestion

traffic cannot reach its destination: the A10 is essentially blocking the way because it is not moving at all. So the main goal is to keep traffic circling on the A10."

The regulation of traffic levels on the A10 was successful in Phase One thanks to signal systems being connected and working together. If there is a jam developing on the A10, ramp meters are activated to prevent congestion. However, because this creates congestion on the ramp, it was necessary to connect all ramp meters together. Connecting signals in this way means that traffic can be held on ramps upstream to reduce traffic density on the A10, which in turn enables congested ramps downstream to be cleared, when necessary. Not only that, but local traffic signals are also connected so that buffer zones can be created across the entire surrounding area. Ultimately, this all means that the A10 can keep moving much more freely at busy times.

This time it's personal

The second part of Phase One was in-car oriented testing of smartphone apps. "We agreed on an in-car application that informs road users if, for example, there is an accident ahead and they should take another route," explains Aafke den Hollander, senior advisor for traffic management, Gemeente Amsterdam (Municipality of Amsterdam). "It's in-car, on your smartphone." The beauty of such a system is that every node is connected. So it doesn't send all traffic on the same detour – instead, multiple detours can be pushed out to multiple users, so traffic flows like water, through the paths of least resistance. With often stadium-based international mega events growing in size (*see chart above*) such a system could one day prove essential to their smooth running.



> We agreed on an in-car application, which informs road users if, for example, there is an accident ahead and they should take another route
>
> **Aafke den Hollander, senior advisor for traffic management, Gemeente Amsterdam**

Folkert Bloembergen is a project manager for the Dutch Ministry of Infrastructure and the Environment's Rijkswaterstaat, and is responsible for overseeing the smartphone-based part of the PPA. "We are in a time of transition," he says. "Today, in transportation, what you generally have is collective information, which is given through various media in a collective way. We want to make a transition to making travel information more individual. That's what we are trying in this particular trial. Today we, as a road authority, give information to a road user through roadside systems.

But that's always collective information. So sometimes it will be information that is not of any use to you. Or you need to collate various sources of information and process it yourself to find out what influence it will have on your journey. But, by

One step ahead of the crowd

Today's smartest intersections don't just react to vehicle volumes, but to pedestrian numbers, too

With some modern stadia approaching 100,000 capacity, you can bet not everyone attending an event at one of them will be driving there. In fact, in many locations, the vast majority will arrive via public transportation, pushing extra numbers to bus stops and metro stations across the city. In the past this would mean deploying police and security at key points in order to manage crowds and their interactions with traffic. But now, while security may still be necessary, technology can step in to perform at least some of the pedestrian management tasks.

New hardware such as AGD System's On Crossing Detector and Flir's TrafiOne camera go beyond simple video detection to aid more accurate pedestrian monitoring. TrafiOne combines thermal and visual monitoring, while the On Crossing Detector uses Doppler radar. Both allow for signal timings to be adapted in real time to deal with varying pedestrian flow – extremely useful when there is significantly increased pedestrian traffic before a special event.

Furthermore, rich data streams can be put to use, not only for adapting signal priorities in real time, but also for planning for the future. Long-term data shows traffic managers how pedestrian movement is changing. So, if there is a big event planned, you can find out what that means for the movement of pedestrians, and use that to adapt your traffic planning in the future.

With accurate enough information, it is also possible to make plans for much smaller special events. For example, the arrival of a bus or metro, or the end of the school day, could be viewed as a very small, but nevertheless regular and predictable special event.

asking the service providers to deliver information to road user via an in-car device, it can be geared more to individual needs. So that's what we've done."

Integrating solutions

Phase Two of the project, which has just got underway (June 2016), is beginning to integrate the roadside with the smartphone technology, to get them working together.

It is the in-car element of the PPA that proved particularly useful during Phase One in regulating traffic traveling to special events at the Amsterdam Arena.

"We have four apps, which have had in total 75,000 downloads. And our 40,000 participants have made more than a million trips," says Bloembergen "What we managed to do, through the in-car advice, was to distribute the traffic more evenly over the various inflow routes to the Amsterdam Arena. The venue has various routes from the main arteries into the venue. And, in general, people all tended to take the same one. Sat-nav advises you to take that one. But we distributed the traffic more evenly over various routes and proved that it works. It had never been done before in this manner."

The apps take into account all local restrictions, with direct links to those responsible for managing traffic, including police who might make last-minute road closures around an event. Traditional navigation systems cannot be so closely involved with local authorities, so they can end up making matters worse for the driver. The apps are also linked with real-time congestion data and parking availability. "At the same time, we are able to look at the information coming out of the car – floating car data – that is being brought back to the road authority so that it can be used to make congestion data even more accurate," adds Bloembergen.

> We are able to look at the information coming out of the car – floating car data – which can be used to make congestion data even more accurate
>
> **Folkert Bloembergen, project manager, Rijkswaterstaat, the Netherlands**

In the future, it may be almost unthinkable to drive to a major venue, without first downloading the app that will help you to get there efficiently. Just as apps have revolutionized the way we have accessed the internet over the past decade, by being designed to fulfill one particular purpose, now it seems that they will be put to use in a similar way for specific navigation requirements.

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Underground movement

If you're trying to pinpoint bottlenecks on your road network, the chances are tunnels will be near the top of your list, which is why some serious technology and clever new thinking is going into ways to keep traffic moving through them – as **Max Glaskin** discovers

Drill a big hole through the ground, link it to your road network and funnel thousands of vehicles through it. What could possibly go wrong? Too much, too often, is the reply from responsible tunnel operators, which is why finding ways to keep vehicles moving along smoothly, from entry to exit, is vital.

A first step is to accelerate maintenance procedures that would normally require temporary lane closures because they reduce a tunnel's capacity. Operators of Japan's Central Nippon Expressway realized that cleaning the tunnel's luminaires was just such a task and could be

ound

LED lighting in the Carlin Tunnel, Nevada, helps to smooth the visual transition from interior to exterior. Left: The tunnel before the update to the lighting system

quickened if its washing trucks were able to clean at higher speeds.

"Five years ago, the tunnel light fixtures were cleaned by people in a cleaning truck with rolling brushes. The cleaning speed was 1.2mph max [1-2km/h] and it required lane closures," says Akifumi Shintaku, manager in the maintenance strategy HQ of Central Nippon Expressway. "So we developed a cavitation jet, high-speed cleaner system."

The new, brushless method allows far faster speeds. Jets of bubbles scour the target so effectively that the first version of the technology enabled trucks to do the job moving at up to 31 mph (50 kmph). Two such trucks have been used since 2009. Yet even this massive increase in speed isn't always enough to beat congestion.

"Although this cavitation cleaning truck was fast, there was still a difference in speed between it and other vehicles," says Shintaku. "So we decided to speed it up even further by using an advanced driver assistance system for lane keeping."

The challenge was to design a truck that could keep the cavitation jet spray exactly on target as it speeds along the line of luminaires at up to 50mph (80km/h). Road camber, vehicle suspension and roll all had to be addressed. It took two years but now they have a vehicle where lane

Above: The cavitation jet, high-speed cleaner system, developed by the Central Nippon Expressway maintenance team in Japan

keeping allows them to do the job up to 40 times faster than their original method. "The lane tracing assistance system is almost completed and we have the field test at the expressway this year," says Shintaku.

Yet, no matter how clean tunnel lights are, they can still slow traffic. In the daytime, drivers' eyes can take time to adjust to the darkness as they enter a tunnel and again in the daylight at the other end. At night, when the tunnel is brighter relative to the open air, the same might happen the other way round. This transition between light and dark can cause drivers to instinctively brake, potentially triggering shockwave congestion. LED luminaires are changing this.

Right: **Dramatic lighting in caves in the Lærdal Tunnel, Aurland, Norway**

Smoothing the way

"The challenge is to mitigate glare at the transition so that drivers aren't dazzled by excessive light. The traditional high-pressure sodium [HPS] luminaires don't dazzle because they are very orange, with a color temperature of 2,700K," says Eric MacGill, senior traffic designer responsible for signals, lighting and ITS at Nevada DOT. "When the first LEDs came in, they didn't produce enough light to be effective in tunnels. But around 2012, white 4,000K LED luminaires reached a point for enough light to be delivered and it became practical to use them because they were controllable. That is a big advantage of LED luminaires over HPS, which is basically on or off; LEDs can be dimmed from 100% to 1% brightness. This helps avoid issues of glare at the transitions."

> The maintenance routine goes from every four or five years, to maybe every 20 years
>
> **Eric MacGill, senior traffic designer, Nevada DOT**

By late 2014, Nevada DOT had replaced the 1,219 HPS luminaires that lit its 1,400ft (425m) two-bore Carlin Tunnel with 774 LED luminaires from Schréder, controlled by Nyx Hemera units. "The dimming capability meant fewer units were needed to meet the range of requirements for tunnel lighting to match ambient conditions," says MacGill.

There are other benefits of LED luminaires that help maintain traffic flow. HPS luminaires have an average life of 30,00 hours and getting them replaced upon failure involves work that could result in lane closures. On the other hand, each of the many diodes in an LED luminaire has an average life of 100,000 hours and even when one fails, the rest keep on shining, so illumination barely changes. "The maintenance interval goes from every four or five years, to maybe every 20 years," says MacGill.

Uphill struggles

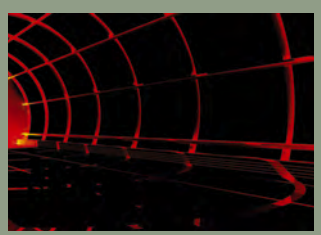
Tunnel design itself can cause traffic to slow, and those that go under rivers can be particularly vulnerable.

Virtual solutions

Advanced simulators mean that training for tunnel operators can be carried out without having to close lanes

The finite extent of a road tunnel, compared with an open road network, means that relatively compact 3D virtual models of the entire underground environment can be created, along with the portal zones. Then they can be used for a series of simulated scenarios that can be presented to staff to rehearse the management of non-emergency events that might compromise the flow of traffic, such as poor visibility, concentration of emissions gases, or failures in ventilation, lighting and power.

Eltodo, headquartered in Prague, Czech Republic, supplies turnkey simulation training for tunnel operators.



The simulation mimics the views captured by the tunnels' CCTV cameras and emulates the sensors that inform tunnel staff and the controllable signs they have for advising drivers. The simulation is used at 25 tunnels in Turkey and the Czech Republic, including several on the D-400 highway in southern Turkey and Prague's inner ring road, where running full scale rehearsals aren't practical because of the disruption they would cause.

As well as the periodic training of operators, these kinds of simulations give senior management a way of checking their employees' reactions in unexpected or critical situations. They can also be used to help tunnel operators acquire qualifications and can present many combinations of faults and events. Therefore training staff through on-screen simulations is a viable alternative for making them familiar with actions that will enable vehicle movements to continue safely.

THE LÆRDAL TUNNEL, AURLAND, NORWAY

Length: **24.5km (15.2 miles)**
Completed: **2000**

The Lærdal Tunnel is so long that, in an attempt to break the monotony for drivers, it was built to open out at three points into giant mountain caves, which are brightly lit. The tunnel links Oslo and Bergen, doing away with ferry and mountain crossings, which can be dangerous or even impossible in winter.

YAMATE TUNNEL, TOKYO, JAPAN

Length: **18.2km (11.3 miles)**
Completed: **2015**

The second-longest road tunnel in the world forms part of the ring road that circles Tokyo – the Central Circular Route (C2) of the Shuto Expressway. Construction began in 1992, meaning it took 23 years to complete.

The road descends and then rises up relatively steeply as it climbs toward the exit on the opposite bank. It's known as a 'sag curve' and the change in gradient inevitably slows vehicles, which reduces capacity and, depending on traffic volume, creates a bottleneck in the tunnel or possibly extending beyond the entrance. To reduce the chances of these sag curve tailbacks, Dr Mecit Cetin of Old Dominion University, Virginia, and Dr George List of North Carolina State University, are investigating how connected vehicle (CV) technology can help tunnel operators to actively manage the problem so that traffic flows through smoothly.

They are planning field trials at the Hampton Roads Bridge-Tunnel (HRBT) on the I-64, which connects the communities of Virginia Beach and Norfolk to Newport News and Hampton. Up to three million vehicles use the 3.5-mile (5.6km) tunnel every month, about 90,000 every day, with peaks of more than 100,000 daily in the tourist season.

The effects of bottlenecks on the capacity of HRBT are striking. "At this particular tunnel we observed about 3,000 vehicles per hour when there is congestion inside the tunnel, and about 3,500 when there is no congestion," says Dr Cetin. Conventional approaches for maximizing throughput at choke points such as sag curves include adaptive ramp metering, dynamic lane use and dynamic speed limits, which usually require installing variable message signs. The promise of CVs is that such installation costs would be avoided.

> We observed 3,000 vehicles per hour when there is congestion in the tunnel, whereas the observed flow was 3,500 when there is no congestion
> **Dr Mecit Cetin, Old Dominion University, Virginia**

"Through V2I and I2V communications, system operators can relay messages to connected vehicles, instructing them to slow down, increase gaps, change lanes, divert to other routes, etc, so that overall system operation is improved," Cetin and List say in their project synopsis. First they want to see if data from CVs will reveal traffic flow patterns and critical levels of volume in real time. Then they will develop a control strategy to regulate speeds as vehicles approach the sag curve. They are well aware that it will take time for CV technology to be adopted, so they will also investigate how their control strategy is affected by market penetration.

The US$146,000 project is sponsored by the National Transportation Center at the University of Maryland and USDOT, and is just gaining momentum. "We are hoping to complete at least the simulation part of the study by the end of this year," says Cetin.

Operating at capacity?

Getting accurate information about traffic flow is increasingly important at tunnels that are approaching capacity. The Limfjord Tunnel in

Quicker quenching cuts queues

Tunnel fires can be extremely dangerous. New technology can put them out more quickly than ever to minimize disruption

The newly commissioned, fixed, fire suppression system in the two bores of the 9,800ft (3,000m) long Eisenhower-Johnson Tunnels on the I-70 should help Colorado DOT re-open the route to traffic more quickly after any blaze.

It's a deluge system that supplements a transverse ventilation system and a network of fire hydrants in the tunnel. Fires are sensed by a linear heat

detector and cameras. When an alarm is triggered, the system opens a valve and dumps water onto two 100ft (30m) zones – generally the zone containing the fire and the next downstream zone. A storage tank provides one hour of flow into two of the zones, plus flow through a hydrant.

"To keep the system from freezing in the alpine climate, the water is heated by a natural gas boiler and circulated whenever the air temperature is below 5°C [41°F]. So, even in extreme conditions the time from an alarm to water deluging the fire is less than 15 seconds," says Stephen Harelson, program engineer at Colorado DOT. "As far as possible, the fire suppression system stands alone, so it will not rely on the older equipment that is used for other purposes in the tunnel."

The fire suppression system is designed to keep the fire small and provide space for the tunnel staff to extinguish the fire completely, as well as allowing motorists to escape.

Aalborg, Denmark is getting close to its maximum of 80,000 vehicles a day, so the city and the Danish Road Directorate have installed inductive loop and ALPR systems to monitor travel times through the 1,900ft (580m) six-lane freeway tunnel. But there is another method that can do the job and Dr Bahar Araghi, who is now ITS project manager for Copenhagen, recently led a team that assessed whether harvesting Bluetooth signals at each end of the tunnel would generate accurate travel times.

The team found that this form of monitoring works well – as long as the number of vehicles sampled is at least five. "Results of the sensitivity analysis show that although the minimum sample size threshold varies in each case, the optimal range for situations analyzed in this paper seems to be between five and 15," the team reports.[1]

Their experience matches that of Dean Zabrieszach when he was director of road operations at VicRoads, Australia, when Bluetooth beacons were used to monitor traffic to maintain flow in tunnels. "They enabled us to measure travel times in conjunction with the City Link Tunnels closure and the West Gate Bridge closure," he says Zabrieszach, who is now chief executive at HMI Technologies.

"The beacons were deployed quickly and easily. We installed them two weeks before the maintenance-related closures. During the closures, we provided affected motorists with real-time, accurate travel time information and we were able to compare the travel times with those pre-closure," he says.

"The end results of the well-planned closures were reduced delays compared with what was originally expected by the community and the media."

While road tunnels have presented special problems for keeping traffic flowing smoothly, it is clear that the smart use of new technologies is reducing their dark reputation. As they say, there is light at the end…

ZHONGNANSHAN TUNNEL, SHAANXI, CHINA

Length: **18km (11.2 miles)**
Completed: **2007**

The Zhongnanshan Tunnel, the world's third longest, goes under the Zhongnan Mountain, meaning the bore reaches a maximum depth of 1,640m below the surface. It forms part of the Xi'an-Ankang Highway from Changan to Zhashui. The total cost was RMB3.2bn (US$410m).

> As much as possible, the fire suppression system stands alone, so it will not rely on the older equipment that is used for other purposes in the tunnel
>
> **Stephen Harelson, program engineer, Colorado DOT**

1) 'Accuracy of Travel Time Estimation Using Bluetooth Technology: Case Study Limfjord Tunnel Aalborg', by Bahar Namaki Araghi, Kristian Skoven Pedersen, Lars Tørholm Christensen, Rajesh Krishnan and Harry Lahrmann in International Journal for ITS Research , published online June 18, 2014; retrieved April 7, 2016

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Power to the people

As advances in smartphone technology enable the public to report incidents and congestion faster – and arguably more efficiently – than official transportation agencies, **Rachelle Harry** talks to DOTs in the US that are successfully harnessing the power of apps such as Waze

It's difficult – and for some, impossible – to think back to a time when we didn't rely mainly on cameras and the police to monitor traffic and report road incidents. They are now such an integral part of life on the road that we rarely give them a second thought – unless, perhaps, we're stuck in a traffic jam, questioning what could be the cause up ahead.

Until 1961, when Detroit made history by becoming the first city in the world to be monitored and regulated in real time using a CCTV surveillance system, it was down to police on patrol to monitor congestion and report road incidents, and of course they couldn't cover the entire network at once.

Traffic cameras have since evolved to perform additional functions beyond video surveillance including ALPR, red light enforcement, classifying and counting vehicles, and speed enforcement – to name but a few. Such technologies, along with road sensors, have dominated traffic management for the past four and a half decades. But after a solid period of effectively monitoring and surveilling our roads, is the 'reign' of the traffic camera coming to an end?

> Real-time data is powerful. If a road incident occurs, you can see in real time how that is impacting your arterial signal network
>
> **Michael Pack, director, Center for Advanced Transportation Technology Laboratory, University of Maryland**

Apps take over

We are now in an era where our smartphones fulfill more than just our social and business needs. In traffic management, crowd-sourcing apps enable the public to get involved with the reporting and sharing of traffic information.

One such app is Waze, which allows its 50 million registered users to share traffic and road information with each other in real time, for free. As well as helping its users to stay aware of what is happening on their travel routes, Waze also runs a Connected Citizens Program – a two-way data-sharing incentive comprising partnerships with local governments, law enforcement agencies and DOTs.

The program, which is free to join, allows its partnering parties to obtain powerful information about their

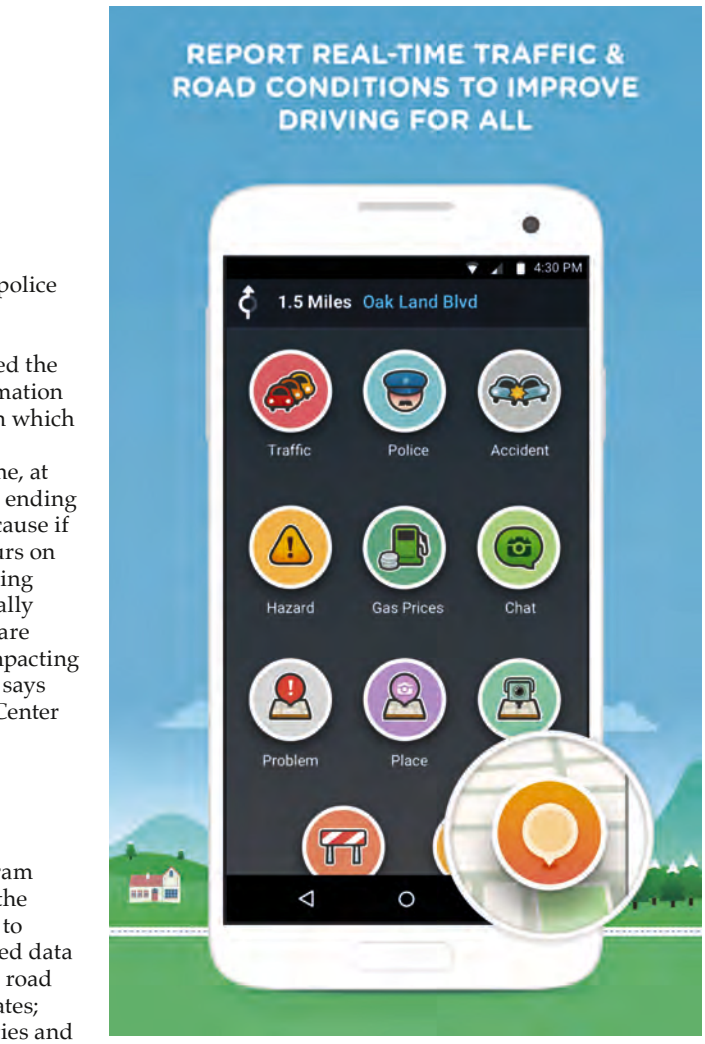
streets without having to use police patrols or traffic enforcement cameras. Instead, they rely on 'Wazers' who have downloaded the app to collect and share information in real time about the roads on which they're traveling.

"When you look, in real time, at where people are starting and ending their trips, that's powerful because if you have an incident that occurs on the roadway and you start telling people to divert, you can actually see in real time where people are diverting to and how that is impacting your arterial signal network," says Michael Pack, director of the Center for Advanced Transportation Technology Laboratory at the University of Maryland.

Eye spy

The Connected Citizens Program creates wins for both sides of the partnership: Waze gets access to official, reliable, agency-sourced data and state information, such as road closure and construction updates; meanwhile government agencies and state DOTs can receive information about road traffic and incidents being reported via the app by the public from areas beyond cameras' reach.

"We understand that crowd-sourced data can be beneficial as an additional tool for our traffic operators," says Brad Freeze, director of the traffic operations division at Tennessee DOT, which partnered with Waze in March this year, and had previously relied solely on sensors and cameras for incident detection. "We use the Waze program both for incident detection and to get targeted information to the public quickly. It is also a way of calculating and providing travel times to areas outside of major urban cities."



Above: **The Waze app allows users to report congestion and incidents**

Clifton Curtis, program manager at Maine DOT, (known collectively with New Hampshire DOT and the state Vermont Agency of Transportation as the Tri-State), which has been involved in the Connected Citizens Program since October 2015, is also taking advantage of the benefits of the crowdsourcing. "The program enables DOTs to save huge capital and maintenance costs because they don't have to install traffic monitoring systems on heavily traveled corridors," he says. "In the event of an incident, we can rely on Wazer-reported information to develop response plans for emergency situations on the road."

> The app updates in real time and helps to divert road users when an incident or traffic jam has been reported by a member of the public
>
> **Denise Markow, administrator of transportation systems and operations, New Hampshire DOT**

Denise Markow, administrator of transportation systems and operations at New Hampshire DOT, Tri-State, adds, "The app also updates in real time and helps to divert road users away from the most dangerous or congested segments of the road when an incident or traffic jam has been reported by a member of the public."

Using an existing app to collate and share crowd-sourced data saves partnered parties the time and cost of creating their own app, as well as removing the limitations that would arise with an app built to serve just one state. "It was already part of the Tri-State initiative to seamlessly share traffic information across state boundaries. Waze does this and has enabled us to do so," says Markow.

Onboard reporting

Nexar, which enables iOS and Android smartphones to be used as ALPR dashboard cameras (dashcams), is another app that challenges the effectiveness of traditional traffic cameras. When

6 million
driver profiles have been created by Nexar

DIY traffic reporting

Three more smart, camera-free traffic tools

1 **Twitter**
The global app that allows users to publicly share whatever's on their mind – in 140 characters, of course – continues to be popular among commuters wishing to instantly share information about #delays to their journey, often long before official announcements are made by transportation operators.

2 **Beat the Traffic**
This app shows its American and Canadian users their fastest route before they set off on their journey. Setting the app to allow real-time traffic push notifications will enable the journey to be updated on the system's navigation. Additionally, users can report road incidents with the 'Share to report' feature.

3 **Moovit**
This navigation tool can be personalized to display users' favorite venues and points of interest. It can plan the fastest route to any destination, and its 'Live reports' function allows its users to both report and share traffic congestion and incidents as soon as they have occurred.

used by members of the public, particularly those who spend a lot of time driving – such as taxis, delivery drivers, chauffeurs and commuters – it can effectively collect data about other road users' driving styles for Nexar analysts to study. It can also spot incidents and violations on roads, and make predictions about how traffic flows at certain points of the day, week or year. Video footage from the app is automatically uploaded to Nexar's server, without the user having to actively send it.

Nexar's founder and CEO, Eran Shir, tells *TTI*, "There are two ways that Nexar can help keep drivers safe and prevent accidents. One is to identify, predict and prevent accidents in real time. The other is to provide incentives for individuals to become better drivers."

Nexar is currently working to build profiles for drivers in the 130 countries in which it is used. They operate in a similar way to credit scores: good behavior results in a good profile, and bad behavior leads to a poor profile. Profiles are created using data captured by Nexar ALPR dashcams-at-large, which are able to identify and monitor the behavior of each vehicle they've encountered. At present, driver profile information is not shared with authorities or the public and there are not yet plans to do so in the future.

> When the video reached the press and internet, the cyclist was able to obtain it and use it as evidence in court. We're thankful that our app could help in that case
>
> **Eran Shir, founder and CEO, Nexar, Israel**

With help from the public, crowd-sourced data captured from dashcams also enables Nexar to monitor traffic and assess roads. "In real time, using sensors from the app, we can pinpoint drivers' locations and identify road features such as potholes and speed bumps, to help us figure out what's happening on the roads, and where," Shir says.

And when it comes to incident detection, Nexar's 'eyes on the streets' have not only captured thousands of violations missed by

standalone cameras, they have also helped to strengthen the pillars of justice in court. "There was an incident in San Francisco recently where a police car ran into a cyclist who was riding in a cycle lane. The cyclist, who ended up in hospital, was unaware that the incident was captured by a Nexar user. Meanwhile, the police tried to make out that they had accidentally hit the man while they were on duty, speeding with the sirens on – but that wasn't the case. When the video hit the press and internet, the cyclist was able to obtain it and use it as evidence in court. We're thankful that our app could help in that case."

Shir is quick to point out, however, that Nexar can be used on a bigger scale than incident detection alone. "Our focus isn't on reporting drivers after one violation – say, running a red light. In the long term, we want to work with insurance companies to alert them of both good and bad drivers, in the hope that they will be able to give personalized insurance plans, based on driver profiles."

Traffic reporting: the future

Whether it is in the form of reporting and sharing an incident, tweeting about a lane closure, or capturing footage of a violation, thanks to the rise of apps and the Internet of Things, traffic operators are now able to collate data from a multitude of sources rather than their limited number of cameras and police teams. And so the question arises: will this vast number of essentially portable reporting devices eventually lead to cameras becoming unnecessary?

"When it comes to keeping roads safe, apps can make more of a difference than, for example, a single ticket from a speeding camera," says Shir. State DOTs, however, believe that although crowd-sourcing has huge benefits for traffic reporting, cameras are here to stay.

"As technology advances, more specific information can be reported and shared, which offers a better awareness of what's happening on the road for all entities in the transportation area," says Robert White, state of Vermont Agency of Transportation, Tri-State. "But in the future, a mixture of technology and people will still be needed to report on traffic in remote areas."

"There is no doubt that we now have more tools to detect incidents on roads and the speed at which technology is benefiting the public and private is amazing," says Chris Wright, ITS traveler information and operations performance measures program coordinator, Oregon Department of Transportation. "Although partnerships, such as ours with Waze, enable emergency teams to respond to and clear incidents more quickly, I think there will always be a need for cameras and police enforcement in Oregon."

"I envision the future of congestion management and incident detection to consist of a mixture of sources," adds Freeze. "Police devices, such as cameras and radar, will continue to be used, as well as apps such as Waze, which TDOT is currently using."

Eyes on the buses

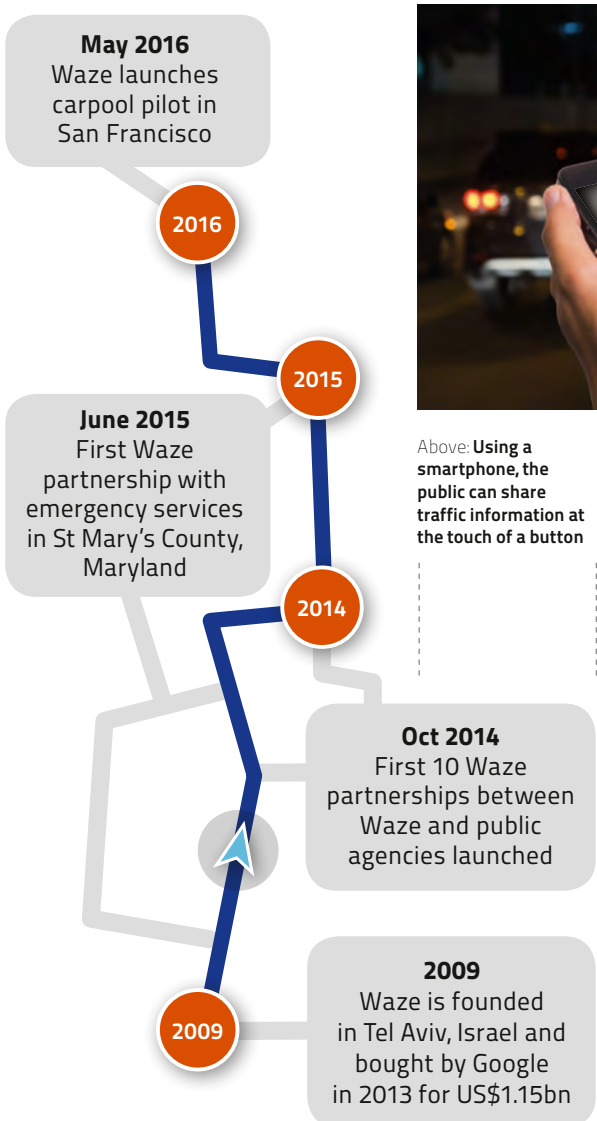
Research by Paula Syrjärinne, University of Tampere, Finland, demonstrates how incidents can be detected in real time, using sensors affixed to buses

Syrjärinne's research paper, titled *Incident detection based on bus data*, won the Best Scientific Paper award at the ITS European Congress, Glasgow, UK, in June 2016. Following her research, the city of Tampere now uses bus data to detect incidents.

"In Tampere, all of the public buses transmit information about their location once per second," says Syrjärinne, whose research inspiration came from an already existing system of data collection. "Until recently this information was only used by passengers wanting to know when their bus would arrive.

"Buses travel around the city throughout the day, so they give a good sense of the traffic flow. At the university, we've been collecting this bus data for a couple of years," she says. "From it, we made a model of how traffic usually looks in Tampere and we were also able to calculate how long it would take to travel between different points in the city.

"If there is a significant slowdown of traffic, you can systematically conclude that it's likely that an accident or some other type of incident has happened," says Syrjärinne.



Above: **Using a smartphone, the public can share traffic information at the touch of a button**

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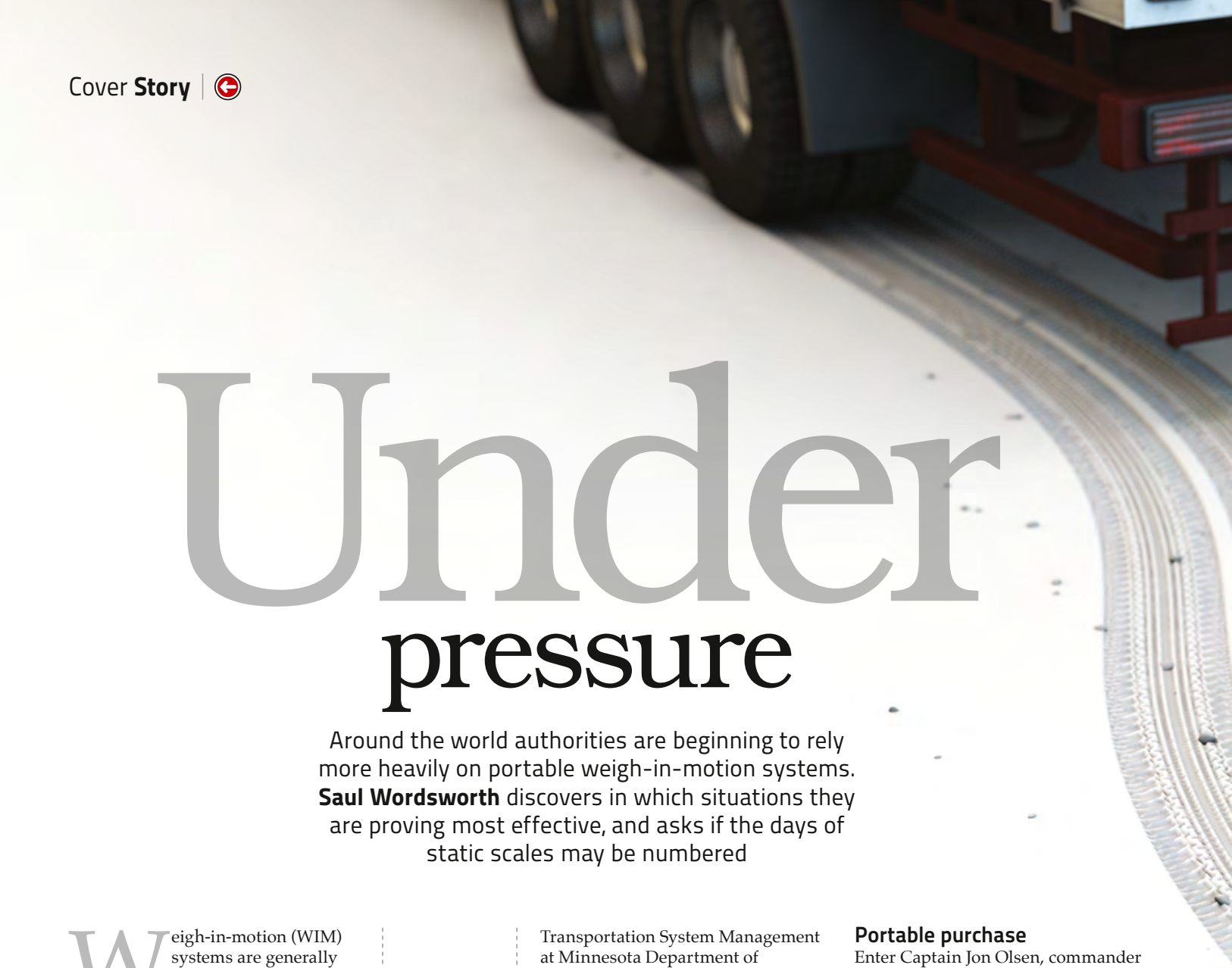

Under pressure

Around the world authorities are beginning to rely more heavily on portable weigh-in-motion systems. **Saul Wordsworth** discovers in which situations they are proving most effective, and asks if the days of static scales may be numbered

Weigh-in-motion (WIM) systems are generally permanent, requiring expensive roadwork and time-consuming installation. Less is heard about portable systems, yet they are viewed by some as the surprise weapon in the WIM armory.

Our story begins in Minnesota, where in 2009 the legislature issued a ruling that all state roads, unless labeled otherwise, were to be a 10-ton design. The authorities suddenly started to take more notice of how many overweight vehicles were on their roads and think about what kind of damage they were inflicting.

"Not only was the state concerned about general road use, it was also worried that new aggregate mining might see certain routes suddenly overloaded with heavy commercial vehicles," says Ben Timerson, transportation data and analysis program manager with the Office of Transportation System Management at Minnesota Department of Transportation (MnDOT). "We looked for a low-cost portable WIM system."

The University of Minnesota Duluth teamed with Timerson and the MnDOT Office of Transportation System Management to develop such a portable WIM system (see page 41).

> We could install four low-cost WIM systems developed by the university for less than US$220,000. We demonstrated pre-screening WIM for Minnesota State Patrol
>
> **Ben Timerson, transportation data and analysis program manager, MnDOT**

"We could install four low-cost WIM systems by the university for less than US$220,000," says Timerson. "We even demonstrated our pre-screening WIM system for the Minnesota State Patrol. Unfortunately it was too much work for them to install and in the end the project was mothballed."

Portable purchase

Enter Captain Jon Olsen, commander of the commercial enforcement division, Minnesota State Patrol. "After ruling out the university option, we investigated a number of portable WIM systems and purchased three," he says. "We saw this as our own little research project on how we could conduct enforcement better and take the focus away from fixed scales."

Portable WIM could be considered an unusual choice, particularly in the USA. The most common worldwide combination is high-speed WIM on highways providing pre-selection, followed by static weigh stations or portable scales for vehicles suspected of being overweight.

"We don't use portable WIM every day, but once or twice a month we'll head to a chosen location and do a saturation," continues Olsen. "This means setting up at unannounced, unplanned sites with as many personnel as possible and weighing every truck that passes. That gives us

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US$25m

The world's biggest ever traffic fine, reported to have been levied on Chinese trucker Mr Zhang for driving his vehicle, overloaded with sand to around 120 tons, onto a bridge near Beijing on July 19, 2011, causing it to collapse

the ability to screen and weigh 1,000 trucks a day that otherwise would pass by such remote locations. We focus on areas away from fixed scale facilities or use them in places where we know there's a high probability of commercial vehicles trying to bypass them. When a commercial driver knows they are overweight they may attempt to find a route around a fixed scale. Some truck stops have maps showing the location of all the scales and information regarding hours of operation. The USP of portable WIM is the element of surprise."

Olsen sees the solution as a low-cost, effective way to screen trucks, though crucially not to enforce. Enforcement is left to the five fixed-scale facilities across the state that screen 70-80,000 trucks per month, along with portable weigh scales. Under North American Standards Handbook 44 (Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring), enforcement via high- or low-speed WIM is not allowed in the USA, thereby limiting their application to pre-screening. However, recent OIML (Organization Internationale de Métrologie Légale) certification for certain WIM systems has led some jurisdictions around the world to set up the legal framework necessary for such setups to be used for enforcement.

Vehicle weight spot checks being carried out by in Minnesota State Patrol, using portable WIM

> When a commercial driver knows they are overweight they may attempt to find a route around a fixed scale… The USP of portable WIM is the element of surprise
>
> **Captain Jon Olsen, commander of commercial enforcement division, Minnesota State Patrol**

User experience

"I wouldn't say we found low-speed portable WIM ineffective, but there were definitely some pitfalls," says Olsen. "If the driver brakes or steers over the WIM strip it can disrupt measurement. You also require a true surface. Plus, weighing a truck roadside via a weigh station or static scales only takes one person, but at times we needed up to six people with the portable WIM: one to run WIM system itself, one to explain to the driver to move across the scale at 10 miles per hour and another to notify the first person if the vehicle is overweight. After that you still need others behind the scenes using portable scales to weigh the vehicles that have been flagged."

Terry Bergan is president and CEO of International Road Dynamics (IRD) and an old hand at WIM. He acknowledges the rarity of portable WIM use in the USA but stresses their usefulness when there are rapid changes in circumstance, such as when exploratory drilling rigs are set up, creating the need to react quickly, especially on secondary roadways.

"Portable WIM is very popular in Latin America on remote roadways where they're not going to build a weigh station," he says. "They find a space at the side of the road and pull the vehicles in. The European and North American concept of highway safety doesn't necessarily exist elsewhere. We supplied a low-speed portable WIM to India and they placed it on the shoulder of the road. There were inches between the operators and the trucks going by."

"Most road damage is caused by overloaded axles," says Kees Hersback, chief inspector at the

University challenge

Academics are helping to power the drive toward lower cost, portable WIM

The University of Minnesota Duluth was tasked with designing a low-speed, portable weigh-in-motion (WIM) system in 2013 that could be installed on county roads and lower-volume trunk highways. The sensors deployed were RoadTrax Brass Linguini class 1, encased in the same material that is used for conveyor belts. The belts were 1in (25mm) wide and 24in (610mm) long, and were secured to the pavement with anchors drilled into the bitumen. The prototype could be installed in just over half an hour.

"To install the system you need to perform a lane closure with traffic control and a crew of at least two," says MnDOT's Ben Timerson. "In 2013 we tried to run the tests for seven days. Almost half of the setups didn't make it. Several were pulled up accidentally and at least two were deliberately removed from the road pavement. In 2014 we went down to a 48-hour test. We didn't lose any data that way."

Though the project was shelved, the university remains in discussion with the State Aid office with a view to installing a low-cost system on county routes for US$50,000.

"For MnDOT, a typical two-lane WIM in a new location with Kistler piezoelectric quartz sensors and an IRD WIM controller costs about US$220,000 and the weight data would be 90-95% accurate, compared with our 80%," says Timerson. "We have had information requests from a couple of DOTs but they haven't gone beyond the initial conversation."

400 tons
The weight of the heaviest load ever to have been transported on US roads – a power station generator

Human Environment and Transport Inspectorate (ILT) in the Netherlands. "Most damage to viaducts and bridges is caused by overloaded total weight. Portable WIM systems make it possible to weigh each axle separately, one at a time. Other systems only weigh the total weight. However, we have chosen not to use portable WIM because of the lack of enforcement."

Like many other operators, ILT uses high-speed WIM for pre-selection followed by portable weighing scales that have been sanctioned for enforcement but bring their own challenges in terms of time and manpower.

Right and top right: **The first field test of the portable WIM, designed by University of Minnesota, was on US53 near Cotton, Minnesota**

Enforcement at low speeds

While low-speed WIM is not used for enforcement in North America and much of the western world, it has been sanctioned as a means to penalize overweight vehicles in tiny pockets of South America, the Middle East and Eastern Europe. Brazil started its partnership with Haenni at the start of 2000 and ordered its first portable sensors five years later. Felipe Fernandes de Paula is an electrical engineer for Politran Tecnologia e Sistemas Ltda, provider of Brazil's enforcement solutions: "In Brazil we are highly reliant on road freights. Thus the best choice for our scenario is portable low-speed WIM sensors. They are necessary to weigh trucks without a great impact on the road traffic and to minimize the increase in travel time to the destination. While we also use static sensors for many other applications, we think the advantages of the portable WIM system is the short weighing time. For example weighing a truck with five axles using our WIM takes 30 seconds whereas a static system may take three minutes."

> High-speed enforceable WIM is a technical challenge for manufacturers and it is a legal challenge to get it accepted. But it does exist
>
> **Hans van Loo, weigh-in-motion consultant, Corner Stone International, Switzerland**

40 tons
The maximum gross vehicle weight normally allowed to travel on roads in the USA

In order to use portable WIM for enforcement in Brazil, the site must first be certified by the regulatory agency, which uses its own rules based on those of the OIML. All vehicles are required by law to visit the weighing sites – or face a fine – and unless informed otherwise it is

893 tons

The fully loaded gross weight of the BelAZ 75710 – the world's biggest, highest capacity haul truck. Not suitable for use on normal roads anywhere

obligatory for heavy goods vehicles to enter the weighing area.

"We use dynamic WIM systems at four sites," says Fernandes. "The sites are made exclusively for weighing. We have 60m [200ft] of extension and less than 3% of inclination to ensure the greatest accuracy. Because of that we cannot do 'surprise' operations with dynamic WIM systems."

High-speed solutions

All vehicle weighing systems have pros and cons. Portable WIM gives flexibility but is personnel-heavy and not always enforceable; weigh stations are extremely accurate but they are also very expensive; portable scales are flexible but cumbersome and time-consuming; high-speed WIM is efficient but unenforceable. Or is it?

"High-speed enforceable WIM is a technical challenge for manufacturers and it's a challenge to get it accepted legally," says Hans Van Loo, an independent WIM consultant focused on both user and vendor. "But it does exist."

Above: **Customs officials use WIM systems to help in their task of checking for people traffickers**

In 2011 the government of the Czech Republic passed a law enabling the deployment of high-speed WIM for direct enforcement. A system created by Camea in conjunction with Kistler was subsequently approved for direct enforcement by the Czech Meteorology Institute (CMI). Since the start of the year, high-speed WIM has been certified as being able to create legally valid data for enforcement.

"There have been test cases in the Czech Republic's high court where the legal acceptance by CMI has been deemed sufficient," continues Van Loo. "The system is based on Kistler sensors. Great sensors are important but they're only one aspect of the system. What you can't afford to do is to ticket a truck that is not overloaded."

> We have a number of stations in the Czech Republic based on direct enforcement that have been operating since January
>
> **Emil Doupal, MD of RST Consulting, Switzerland**

The need for high-speed enforcement cannot be underestimated. A small-scale project has been established in Russia, with tickets already being issued. High-speed enforceable WIM is also being used to protect the city of Prague. Pilot projects have been rolled out in a clutch of African countries, plus Brazil. Kazakhstan is soon to embark on the legal enforcement stage.

"We have a number of stations in the Czech Republic based on direct enforcement," says Emil Doupal, managing director of RST Consulting and instrumental in the Czech project. "I am not at liberty to say how many penalties have been enforced, but we finished certification last November followed by a two month trial. We have been operating direct enforcement since January."

Over the past decade France has invested heavily in sensor technology, and according to Doupal, the authorities have expressed great interest in the Czech project. Were France to certify the use of high-speed WIM for enforcement, a major precedent would be set.

Fast forward

According to Timerson a new static weigh station was recently installed in Minnesota at the cost of US$10m. Meanwhile rehabilitation on an existing site cost taxpayers US$100,000. Such decisions look increasingly anachronistic and hard to justify against the backdrop of budget cuts. For this reason it is likely that portable WIM and, in time, high-speed enforceable WIM may become commonplace.

Body check

Weigh-in-motion can be used to check for stowaways

Are there uses for portable, low-speed weigh-in-motion technology, beyond simply catching overweight vehicles? On the border between Afghanistan and Pakistan, one has been found. A short-term portable low-speed WIM system was installed in 2009 by the US military. The weighing process was less to detect goods, more to detect people. People-smuggling was a problem at the time. A truck may be able to hide a person, but it cannot hide weight. Vehicles would roll over the WIM system at 10mph or less and inspectors would check for unusual numbers based on the weight listed for the vehicle. Any disparities could be investigated further using heat-sensitive cameras.

Weight monitoring on bridges and motorways

Weigh-In-Motion with WIM-DSP 32

WIM-DSP 32 is a Weigh-In-Motion system for up to 8 lanes. It accurately determines the distance between axles to ±1 cm and speeds in the range from 10 km/h to 120 km/h to ±1 %. It is capable of weighing vehicles with up to 18 axles while on the move. The results can be saved locally and the weight displayed lane-by-lane on Variable Message Signs (VMS). The data can also be signed and transmitted to a central control room.

A certificate of conformity in compliance with OIML R 134 is in progress. This will enable WIM-DSP 32 to be calibrated and used independently to provide photographic documentation for prosecuting instances of overloading.

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5 future map-making essentials

Smart devices, GPS and connected-vehicle systems all mean that now it's not just traffic information that can be delivered in real time – updates to maps can be, too. **Jan Stojaspal** looks to a near future where so much up-to-date detail will be required in maps used by drivers and traffic managers that 24/7 connectivity will be essential

Imagine a world where traffic managers know where everyone is and where everyone is going. A world where cars are reporting not only that their windshield wipers are on, thus helping traffic managers pinpoint the location of a sudden downpour, but are also reporting that their traction control has been engaged, which may be a sign of black ice forming or that their fog lights have just been switched on, which can pretty much mean only one thing.

Imagine a world where each instance of road maintenance begins with a scan of a continuously updated, high-definition digital map of signs of potholes forming, traffic signs with poor visibility, or roadside vegetation in need of a trim.

Thanks to advances in connected vehicle probes and digital map making, this world is starting to become a reality. What's more, with autonomous features increasingly being included in production vehicles, there is broad agreement that this kind of accurate map isn't just nice to have, it's essential to safety.

"High-definition digital maps are an enabling feature of autonomous driving. You need a recent version of the map to know what's around the corner," says James Hodgson, research analyst, autonomous driving and location tech, ABI Research. "If they're out of date, then at best they become useless and at worst they become dangerous."

Turn the page for five major trends shaping the future of mapping.

1. REAL-TIME TRAFFIC

As vehicles and drivers enjoy greater levels of connectivity, real-time traffic information and mapping are increasingly linked. Data is reported by connected devices and enhances situational awareness for traffic managers, bypassing traditional roadside monitoring equipment, so it's becoming easier than ever for the system to automatically plot those red lines on your route.

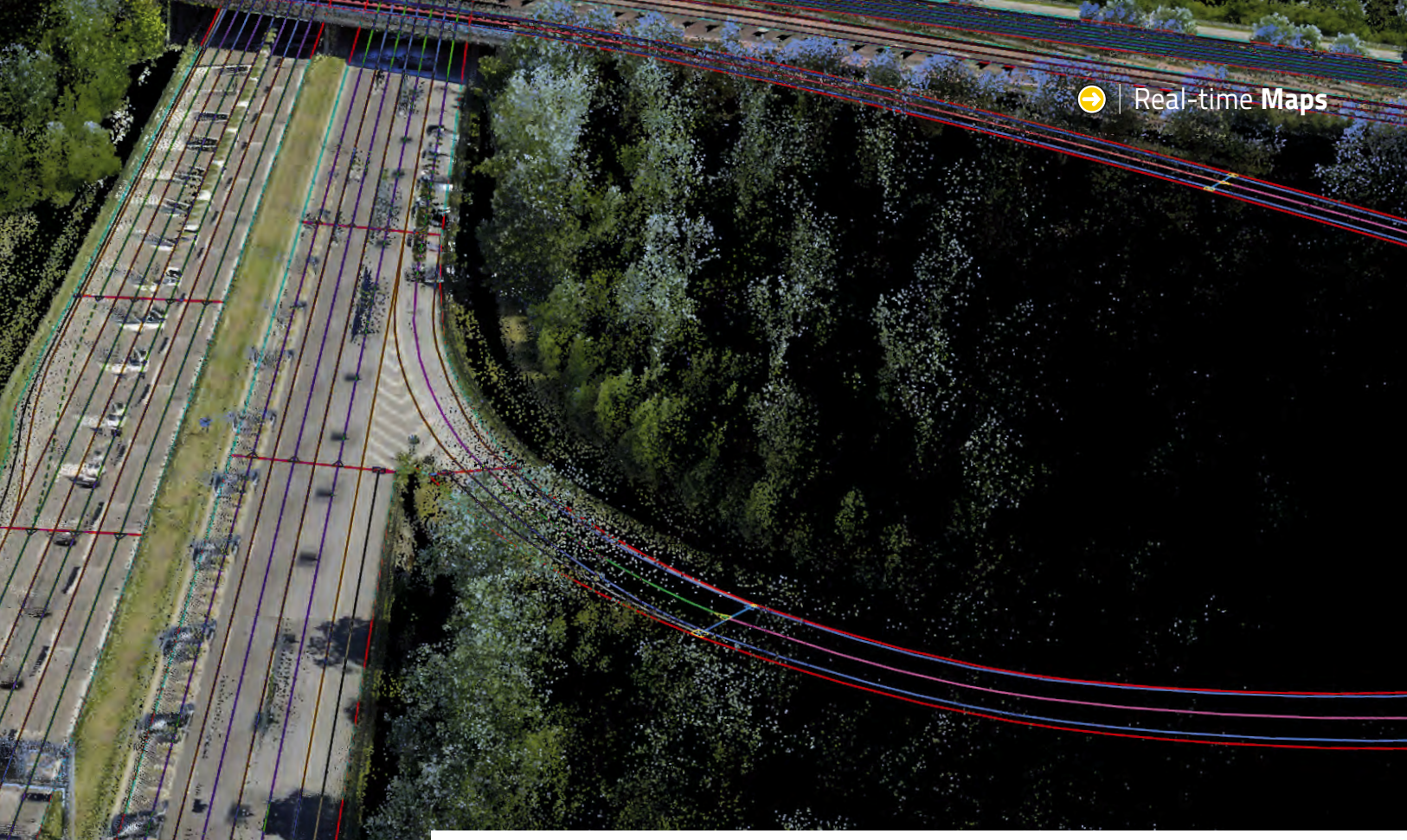
TomTom, for example, recently amalgamated map-making with traffic data when it switched from batch processing of map changes to a transactional engine, which enables every change to be put through individually and for the database to be releasable on a continuous basis as a result.

The release frequency depends on the kind of data that is transmitted. Real-time traffic information, which is probably the most time-sensitive, is already sent out to navigation devices every minute in most circumstances. Changes to base road geometry will also require high-frequency updates, and so do points of interest, such as parking that is available nearby. But when it comes to 3D map content, which is mostly used for visualization and adding comfort while driving, can wait to happen overnight while the car is garaged and connected to a local wi-fi hotspot.

> Speeds get averaged out and in some cases this is wrong – for example, when a highway is completely blocked and ramps are at full speed
>
> **Tony Belkin, head of traffic and dynamic content, Here**

While smart devices are helping to make the most up-to-date maps ever produced, conversely, real-time traffic data sourced in this way still has some way to go before outclassing roadside infrastructure. Where it has fallen short so far is in multilane scenarios where individual lane traffic runs at different speeds. "Nowadays speeds get averaged out and in some cases this is wrong – for example, when a highway is completely blocked and ramps are going at full speed," says Tony Belkin, head of traffic and dynamic content for Here.

Reporting speeds and congestion with lane-level precision is still some three to five years away, according to Belkin, so traffic information providers are starting to take the intermediate step of providing real-time traffic information that is broken down along main road categories, such as highways and adjacent off-ramps. Here calls it 'split level traffic', and will report two speeds at crucial road segments such as highway junctions.



2. CROWD-SOURCED MAP DETAIL

A lidar-equipped mapping vehicle is a great way of sourcing highly detailed map content, but it is not feasible for smaller updates, such as to lane markings and street signs. In the future these will likely be picked up by vehicle or roadside sensors and reported back to map makers, through what is known as 'passive community input'.

Already map makers and traffic service providers are using GPS traces from connected devices to draw conclusions about new restrictions. These could be indicated, for example, by vehicles suddenly stopping during a turn on a street where there are no known restrictions.

"In the future the whole system will only be scalable if we can rely heavily on passive community input," says Jan-Maarten de Vries, vice president of product management and marketing automotive at TomTom. "You have to drive all the roads to make the initial highly detailed maps, but you can't do it again at the same scale year after year – nobody could afford it."

It is a function that is expected to be taken on in the future by vehicles with autonomous features, via their sensing technology, which will report changes on everything from road geometry to potholes.

The goal is to automate data collection and interpretation as much as possible, but human input will continue. For example, Inrix still relies on a manned operation center to augment traffic incidents with information from other sources, including Twitter. Meanwhile, both TomTom and Here provide online tools by which people can submit not only map changes but also report road closures and incidents.

> You have to drive all the roads to make the initial highly detailed maps, but you can't do it again at the same scale year after year – nobody could afford it
>
> **Jan-Maarten de Vries, vice president, product management and marketing automotive, TomTom**

The north of Finland, where roaming reindeer cause more than 4,000 serious accidents annually, is one example of an area where Here envisions human input for years to come. "Cars can detect deer on the road," says Belkin. "But if the deer is on the side of the road, the car may not detect it, but the human can."

3. GOING BEYOND GPS

For a fully autonomous car, if you are trying to get a fix on its exact position, GPS will only get you so far.

"There is a perception that GPS gives you everything," says Stan Young, research scientist and transportation specialist at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. "That's not really the case. It lets you know where you are within about 100 yards – sometimes less, sometimes more. But once you are within those 100 yards you need high-definition maps."

A solution to GPS's inability to pinpoint a location to the meter is high-definition (HD) maps, which are laser scans that add up to a highly accurate 3D model of the road and its immediate surroundings, which can then be used by a vehicle to pinpoint its location by measuring its distance from a variety of stationary objects, such as street signs and traffic lights. HD maps will play an important role in fully autonomous driving. But they can also help traffic managers analyze their assets and figure where maintenance is needed.

According to Michael Pack, director of the Center for Advanced Transportation Technology Laboratory, University of Maryland, because HD maps are so accurate, they can go as far as helping traffic managers to remotely assess the reflectivity of a particular stop sign and whether it needs to be rotated to optimize its performance.

As these maps will be continuously updated by passing vehicles, they may also be used to check the needs of the area surrounding a road, for example, a cracking on a guardrail that needs repairing, or roadside vegetation requires a trim.

But before this becomes a possibility, map data analytics must improve. "Right now these high-definition maps have so much information in them it's overwhelming," Pack says. "DOTs don't want to have to analyze the data, they just want someone to come and tell them where the problems are. There will need to be someone in the middle to do that for them."

> There is this perception that GPS gives you everything… Well, not really. Once you are within 100 yards, you need high-definition maps
>
> **Stan Young, research scientist, NREL, Colorado**

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4. RETHINKING OLD MAPS

As vehicle sensors multiply and their ability to provide 360° awareness of what is happening around the vehicle improves, the question may become: Are maps even necessary?

Experts at Here are convinced they will be, as they will not only serve to localize autonomous cars in their immediate surroundings, but also extend their planning horizon far beyond in-built sensors, enabling vehicles to adjust driving strategies well in advance.

But Amnon Shashua, CTO and chairman of Mobileye, a leading developer of vision-based advanced driver assistance systems, is less sure. "The assumption that you need maps is questionable," he said at a CES 2016 press conference. "We – humans – don't need maps to drive. We can go to a new place, rent a car and drive safely. Of course we feel more comfortable in a place we have driven many times before, but even if not you can still drive. So there is a proof of concept that we don't need maps."

Admittedly he did not argue for eliminating maps completely, but instead of high-definition, lidar-based maps he suggested something more akin to the pacenotes that are used by navigators in rallying, and for them to be compiled entirely by connected cars reporting back to the cloud. A race driver "has a map of landmarks and takes action upon reaching each one", he said. "This is exactly what we are doing here… The cloud integrates the data from all the cars and for all the landmarks, and improves the accuracy of the data. It builds a global map by using local coordinate systems."

> We could all be playing with and experimenting with data, and learning what the next greatest thing is in the operation center
>
> **Michael Pack, director, Center for Advanced Transportation Technology Laboratory, University of Maryland**

It is also important that such a map comes to only about 10KB per kilometer when transmitted, which is crucial for crowded bandwidths.

Pack agrees that now is the time to begin exploring these new possibilities. "While we are spinning our wheels and trying to find the funds to deploy all this equipment, we have hundreds of thousands of vehicles in the USA that are already live-streaming that type of data," he says. "We could all be playing with and experimenting with that data, and learning what the next greatest thing is in the operation center and what we could do with the information."

5. CONNECTED SYSTEMS

Ultimately automotive maps, whether used by the driver or the machine, are expected to become part of what Here calls "a dynamic index of the real world, a vast index of people, places and things".

One one level they will underpin the entire journey of the driver and passengers. "When we think about the breakdown of car ownership and driverless vehicles you summon on demand, we think more about navigating the person than navigating the car," says Hodgson of ABI Research. "You need to know where your driverless car should pick up, or where the train station is after you get dropped off."

When it comes to navigation for vehicles, there are two challenges for traffic managers. First, DOTs and providers of in-car navigation services need to get on the same page to avoid a situation where in-car navigation systems give contradictory information to what is posted on variable message signs, for instance.

But a far bigger challenge stems from the fact that the more people use traffic information to navigate around traffic jams, the less effective their choices become. According to TomTom, the cut-off point is around 15-20% of drivers trying to make the same choice.

> When we think about the breakdown of car ownership… we think more about navigating the person than navigating the car
>
> **James Hodgson, research analyst, autonomous driving and location tech, ABI Research**

"If more people detour from traffic, they create the next jam themselves," says Belkin. "It starts to become a flickering element – an unstable system. It's a perfect opportunity to think about a new traffic management system, fully centered on navigation on the car."

At this point there are a number of views as to what shape or form such as new traffic management system could take. Belkin suggests a central traffic management body assigning a route to every car, much as an air traffic control center manages airplanes today. Others envision a self-tuning system that will ensure optimized road use for everyone. On page 16 you'll find our report on a prototype app-based solution that has been developed to route traffic into special events at Amsterdam Arena, in the Netherlands.

What is sure, however, is that traffic management will require a holistic approach. "I can't focus just on the road," Belkin says. "I have to think about shared economy. I have to think about bikes, pedestrians and public transit."

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Thermal imaging cameras provide a smart solution to tunnel fires

Tunnel fires can have devastating effects on both people and infrastructure. In the worst cases, they can result in severe fatalities, material damage and the disruption of important infrastructure lines. Tunnel operators and emergency response teams have always relied on intelligent technologies to support them in fire prevention, detection and control to lower costs and ultimately save lives – and thermal imaging is one of them.

The thermal advantage

In the case of a traffic accident in a tunnel, it is extremely important for emergency services to be responsive and fast, to avoid secondary accidents or incidents such as a fire. Effective incident management depends entirely on fast incident detection and verification.

Tunnel operators can use thermal imaging cameras to detect vehicles that have stopped, vehicles driving the wrong way, queues, slow-moving traffic, fallen objects and pedestrians in a matter of seconds, which can help to prevent secondary accidents from happening.

Thermal imaging cameras are especially effective when installed at the entrance and exit of a tunnel, because that's where CCTV cameras can experience difficulty capturing images, due to direct sunlight and/or precipitation. Flir's high-performance thermal imaging cameras give tunnel operators uninterrupted detection of vehicles, pedestrians and cyclists, regardless of the amount of light available.

Fire check

Fire can cause severe damage to tunnel structures, which leads to high repair costs. Thermal imaging can help to prevent fires, by detecting risk areas that are high in temperature ('hot spots') and detecting early-stage fires before they have a chance to spread. Thermal cameras, such as Flir's ITS-Series AID, can monitor tunnels continuously and can be configured to generate a direct alarm output to a control room operator when user-defined maximum temperature thresholds are exceeded.

Above: **An early-stage tunnel fire is detected by a Flir thermal imaging camera**

Need to know

Flir's thermal imaging cameras deliver a huge safety advantage over CCTV incident detection alone

- Flir's ITS-Series AID can be configured to sound an alarm directly to a control room operator when user-defined maximum temperature thresholds are exceeded
- Using thermal imaging, the ITS-Series AID can overcome traditional CCTV camera challenges such as saturation, reflections, dynamic shadows, fog and darkness
- Operational temperature range between -50°C and 75°C
- Meets IP66 requirements against dust and water ingress

Helping firefighters

Even in dense smoke, thermal imaging cameras can identify objects. This enables firefighters and other emergency service personnel entering a tunnel that is on fire to quickly work out their help strategy, locate hot spots and save lives.

A thermal imaging camera can also give an indication of when a dangerous flash-over (explosion) may occur. They enable firefighters to get a clear idea of the size of the fire and

Left: **Flir's ITS Series-AID**

get themselves out of harm's way if a more threatening situation occurs.

The ITS-Series AID

Flir thermal imaging cameras are commonly integrated into traffic video detection and monitoring solutions. They do not need light to produce an image and can be used for a wide variety of traffic applications and to detect fire in tunnels. As with all thermal imaging cameras, Flir's ITS-Series AID works well in combination with video analytics.

Flir's ITS-Series AID camera overcomes the challenges that solely CCTV-based camera systems are faced with, including saturation, reflections, dynamic shadows, fog and poor visibility in darkness.

The ITS-Series AID camera is available in different resolutions and with different lens options. They are also easy to install because they have both hybrid IP and analog video out.

With its vital core being well protected to meet IP66 requirements against dust and water ingress, and with its operational temperature range between -50°C and 75°C, the robust ITS-Series AID is ideal for all climates and circumstances.

by **Neil Hoose**

If we are not fully aware of how our ITS systems work, how will we manage when it comes to automated and connected systems?

Recent experience makes me wonder about the state of the ITS that has been deployed and the impact that the economic climate is having. How many systems are actually working as expected and, perhaps more importantly, are the anticipated benefits being realized?

ITS is generally relatively low in capital cost, although associated civil engineering in the initial deployment can be substantial. ITS does have ongoing costs for maintenance, repair, tuning and upgrade and these are under a lot of pressure because of austerity and the pressures on revenue expenditure in the public sector. Proposed cutbacks in ITS operation, for example real-time bus information, increasingly feature in public sector spending plans.

Widespread deployment of automated transport is some way off, but ITS benefits are available here and now. Investment in new ITS is continuing but I would contend that many existing investments are no longer delivering benefits because the systems are not up to scratch. This drop-off in performance may not solely be down to lack of financial support. In deploying systems, particularly when the scale has increased after a pilot scheme, facilities and processes are rarely put in place to monitor the validity of the outputs. This is not the same as fault monitoring. The system may appear to be working but the data being output may be superficially plausible yet completely wrong. The plausibility may lead to the impression that all is well and that outcomes are being achieved, but that may not be the case.

The attention of the press and politicians is being grabbed by the excitement surrounding automated driving. There is still a debate about the extent to which connectivity between vehicles, and between vehicles and infrastructure, is necessary for mass deployment of automated cars, buses and commercial vehicles. Equally, what assumptions are the developers of automated transport making about the extent and effectiveness of existing ITS? If a new system or concept comes along that is based on assumptions about the performance of an existing ITS then major problems could ensue. For example, how will an automated driving systems interpret a single blank lane control signal in a gantry of four signals? Will it comprehend that there are faulty signs and interpret the situation based on the remaining signals, or will it change its driving behavior accordingly? In some circumstances, the behavior of other vehicles may limit any change, but there is no guarantee that will be the case.

> How many ITS systems are 'tuned' so that the anticipated benefits are realized?

The challenge here is to fully understand the interconnectivity between different systems, either passive as in the example above, or active, and dynamic communication between the vehicles and with the roadside could mitigate the situation I describe. However, if we are not fully aware of how our current ITS systems are working, and cannot afford to keep them up to scratch, how are we going to manage when we have to deal with a highly automated and connected transport system?

Neil Hoose is an independent ITS consultant and owner/director of Bittern Consulting Limited ***info@bittern-its.com***

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

Parking violation system contributes to better traffic flow in cities

In recent decades, city authorities have been challenged by rising numbers of vehicles on the roads. This increase, combined with limited – and often extremely pricey – parking spaces, can lead to congestion while drivers circle the area searching for somewhere to park.

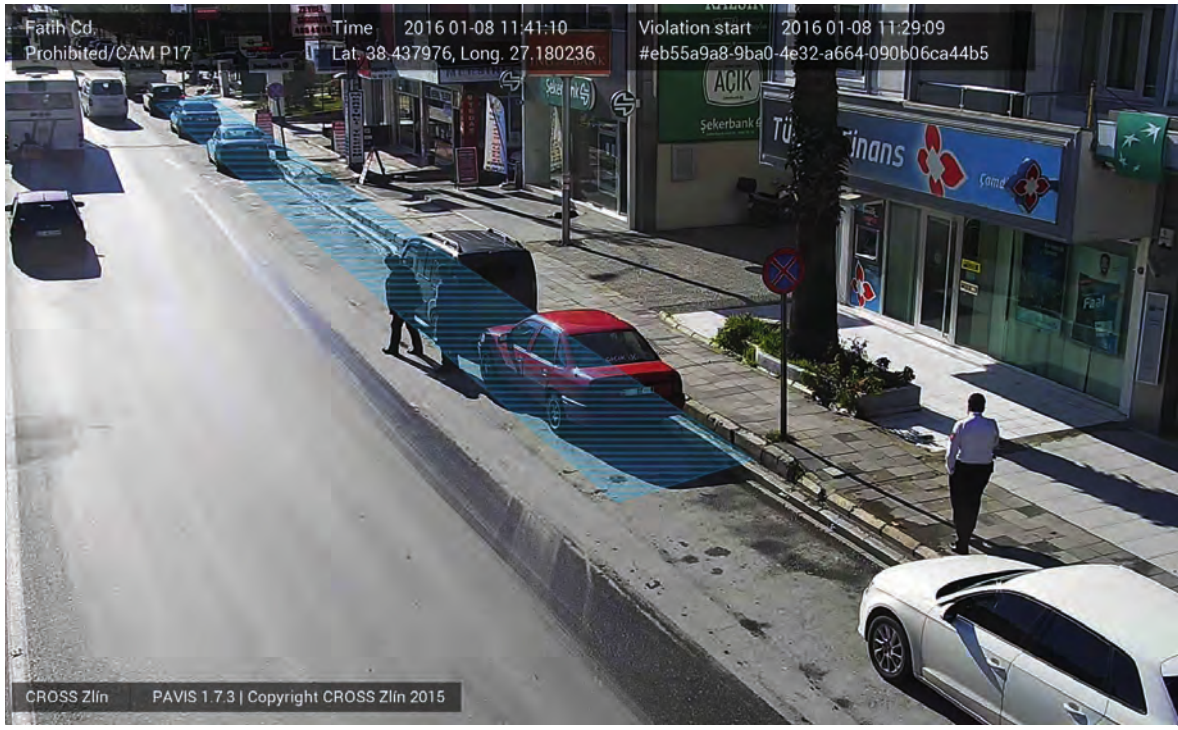
Dynamic navigation to parking spaces can provide some relief to this congestion, but it ceases to be helpful when there are no convenient spots available. When drivers can't find a suitable space, they might feel inclined to try their luck parking in prohibited areas, in the hope that parking attendants won't notice.

Policing poor parking

Parking in prohibited areas can inconvenience other drivers and lead to problems such as blocked streets and, ultimately, congestion. In cities where there are not enough policemen or parking wardens to establish order, an independent, fully automated technology can serve as a permanent watchdog.

Keeping streets clear and safe is the ultimate goal of the Parking Violation System (PAVIS), developed by Cross Zlín of the Czech Republic.

PAVIS is a fully automated system that detects illegal parking in predefined zones. It can effectively monitor areas where cars are not permitted to stop or park, such as disabled bays, or areas with a limited parking time. The system helps to reduce the number of illegal parking incidents and protect private and reserved parking spaces, as well as reducing traffic density and preventing congestion. Furthermore, it helps to improve the flow of traffic, ultimately enabling services such as public transportation vehicles, taxis, garbage collection trucks and emergency service vehicles to operate more efficiently.



PAVIS notices a stopped car in a prohibited area, which is marked in blue

PAVIS in Izmir

Cross Zlín is currently deploying PAVIS in the Turkish city of Izmir. From the US$24.5m budget for Izmir's ITS projects, 116 PAVIS installation points were planned, 62 of which are now installed and fully operational.

At present, the PAVIS network in Izmir detects more than 300,000 vehicles and identifies up to 3,000 parking offenses per day. In future phases of the project, which is scheduled to be completed by the end of this year, most key areas of the city will be under the supervision of PAVIS.

In Izmir, a number of specific customer demands were implemented into PAVIS, underlining the vast spectrum of its capabilities. For example, the municipality in Izmir decided to configure PAVIS to specifically target illegal parking on pedestrian crossings, sidewalks, taxi stands, near fire hydrants and at bus stops. Additionally, a functionality for double parking detection was added to the system.

Although PAVIS is an advanced system, it operates on a simple principle: it checks predefined areas by zooming in on them with a pan-tilt-zoom (PTZ) camera, or cameras. It

Need to know

Cross Zlín's PAVIS detects illegal parking in predefined zones

- Modular: can operate offline and online
- The pan-tilt-zoom's infrared illuminator capabilities allow for 24/7 observation
- Uses OCR and ALPR technology to identify stopped or parked vehicles in prohibited parking areas
- Images from PAVIS are used to support parking violation tickets

Above: **PAVIS uses pan-tilt-zoom (PTZ) cameras to monitor parking and non-parking areas**

then checks whether the area of forbidden parking is occupied by a vehicle. If a car is detected, PAVIS uses an OCR engine to capture its license plate number and subsequently checks the vehicle's details. This integrity check is crucial, especially in cases where dense illegal parking (as is often seen in Turkey) causes a clustered view of license plates. In the next step, the license plate is run through a whitelist database consisting of buses, police vehicles, freight vehicles, taxis and other vehicles with permission to park in that area. If the identified license plate does not belong to any of the whitelisted vehicles, PAVIS creates a detailed violation report. This report consists of a time-stamped parking photograph and a second photograph showing the vehicle exceeding a 'tolerance time', which is usually set at five minutes. Further images included in the report are a vehicle overview photograph and license plate details.

Above: **PAVIS uses OCR and ALPR technology to identify the car's details**

Depending on local legislation, the violation report is used as material for proof in either an offense follow-up procedure or the issuing of a direct ticket.

24/7 surveillance

PAVIS can operate in online and off-line modes. If the server connection is lost, violations can be stored in the system's local memory and upon reconnection are sent in batches to the violation server. Furthermore, the PTZ camera's infrared illumination and zoom capabilities enable uninterrupted operation around the clock, as well as a violation detection range of up to 100m from each camera's location. With its embedded thin web client, PAVIS can be set up with any web-enabled device and used for enforcement within minutes after the power is switched on.

As is customary with all Cross Zlín products, PAVIS is a solution that can be easily integrated into any third-party enforcement and violation solution, as well as into an umbrella monitoring system. PAVIS has already been integrated into the violations module of Cross Zlín's smart city platform, InVipo, the overall winner of Intertraffic Amsterdam's Innovation Award in April 2016.

Solar-powered data gathering system enables more accurate traffic planning

It is a common problem in traffic planning: models are often not well suited to assist in planning new road construction or adding/changing capacity of the existing road network. This is not because the models are not good, but because their input data is inaccurate or is purely based on assumptions. This is not a good starting point when deciding where to invest limited funds. But there is help at hand…

The BS2-TS solar-powered station manufactured by ADEC

Need to know

An easy to install, wireless traffic data gathering system

- The BS2-TS uses up to three passive infrared (PIR) sensors
- It weighs just 3.5kg and can monitor up to three lanes of traffic
- Just one hour of sunlight per day is enough to power the system
- Data is transmitted via the cellular network

Above: **The BS2-TS is an easy to install solar-powered traffic data collection unit**
Left: **The web-based interface gives detailed data breakdown**

Technologies retrieves traffic data from up to three passive infrared (PIR) traffic detectors and sends it to a secure server. Historic and up-to-the-minute traffic data can be viewed and downloaded via any internet browser. The PIRs are directly connected to and powered from the BS2-TS; no other power source is required.

The BS2-TS, including solar panel and battery, is small and lightweight (265 x 220 x 90mm, 3.5kg). This permits the mounting of the BS2 on lampposts in urban areas or overpasses on highways. Two to three lanes can be monitored per BS2-TS. While the system is suitable for temporary traffic counts thanks to its straightforward installation, permanent solutions can be quickly realized as well.

Charging ahead

A BS2-TS with two detectors trickle charges the battery even on cloudy days. One full charge could power the system, including two PIRs, for about five days in complete darkness. With an hour of sun per day on average, the system can power three TDC1 detectors.

The BS2-TS transmits the data to a secure server. The front end of the system is the web browser. Thanks to the web interfaces on the server, the traffic data is accessible to any third-party software with internet access (and proper credentials) via secure https.

The BS2-TS uses the cellular network to transmit the data. Depending on the specific application, the BS2-TS can transmit single vehicle records or averaged data. Transmitting single vehicle records leads to greater data usage. As a rule of thumb, when transmitting each vehicle's properties (speed, length, gap), 15,000 vehicles per day consume about 2.2MB (this data volume does not linearly increase or decrease with the number of vehicles; half as many vehicles require somewhat more than half of that). Depending on the data plan on the uplink, it may not be optimal to transmit the traffic data of each vehicle, so the BS2-TS can be configured to average the data on an interval basis of 2, 5 or 10 minutes, and to only transmit the aggregated values, substantially reducing the data usage.

Larger customers (based on their buying power) typically use their own data plans. But for

those who do not have such an option, ADEC Technologies provides SIM cards in the BS2 that cost as little as US$0.08 (€0.075) per MB, plus an additional US$3.33 (€3.00) per month in Western Europe.

Easy installation

On the server, the stations are installed in so-called portals. Each customer account can set up a number of portals; each portal is a collection of one or more BS2-TS station, preferably within geographic proximity to be able to take advantage of the map feature in the browser.

All aspects of an installation are done through the web-browser. The account credentials are shared among the individuals within the organization who need access. Next, a portal is installed to group the BS2 stations to be commissioned. The station and the detectors are added to the portal using their respective IDs. This can be done on-site or later on in the office. The system is operational and traffic data is retrieved, transmitted and stored from the moment the station is added to the portal.

The BS2-TS with up to three TDC1-PIR traffic detectors is the smallest station for monitoring up to three traffic lanes available on the market today. Combined with its universal, secure and user-friendly browser access, the solution is a perfect tool for traffic data acquisition for any individual, community or authority wanting to get a clear understanding of what really happens on roads.

by **J J Eden**

New, integrated tolling technology is now being demanded by customers – the industry must respond

It wasn't too long ago that collecting tolls didn't involve making complex decisions about financial business rules, post-paid revenue, interstate enforcement and private sector integration into revenue collection.

'Back in the day' we had a uniform, well-accepted cash payment system. Around 1978 (yes, that was almost 40 years ago!) traffic and right-of-way restrictions combined to jeopardize our ability to effectively serve our customers. As agencies, we reacted by finding RFID technology developed by the military that we thought would solve the growing toll plaza congestion; thus electronic toll collection (ETC) was born. We sought the public's interest in ETC but received little encouragement. Facing growing complaints about toll plaza congestion, the industry pushed ahead and soon realized that this technology, which promised to improve our lane operations, was impacting every department in our authorities. With the first implementations came accusations of privacy violations. After a year, success came as more and more customers saw the benefits of ETC.

AET (All Electronic Toll Collection) was the industry's next advancement. If ETC proved to be disruptive, then AET changed everything. Not only did it change the business model of toll collection once again, but it opened the floodgates to new players and services because it was a mobile payment system. The services ranged from managed lanes and their DOT or private operators, to private sector companies buying into an agency's fleet account process in order to gain access to an entire region's multimillion customers with proprietary technology.

These changes were more customer-driven, but our customers have changed. Their habits and demands for up-to-the-minute technological conveniences will disrupt our industry once again. Unlike our customers in 1978, who saw technology and payment systems as intrusive, today's customers use payment systems to pay for pretty much everything. Younger customers are driving less partly due to ride-sharing services, they value time over money, and they don't want to stop to pay a toll. However, if they have a problem with a toll system, they demand a high level of customer service. More importantly they want combined billing systems so that all of their mobile payments can be made on one device. Sure you can utilize the same payment card on your Apple Pay, Google Pay, EZPass, Sunpass and SpeedPass, but you would need multiple devices to achieve it, and if there was a problem it would result in multiple phone calls.

> Younger customers value time over money; they don't want to stop to pay a toll

In 1978 the toll industry was far too small for banks and large companies to take an interest in. Today, the in-car mobile payment market estimates exceed US$50bn per year so we are seeing a push into the tolling/mobile payment market. This influx of interest from big financial and tech giants, coupled with customers willing to embrace the idea of getting the government out of the tolling business will result in yet another new business model that could topple our existing structure.

It is high time for us to lead these changes, not obstruct them!

J J Eden is director of tolling at Aecom
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Illustration: Ian Parratt, the-caricatureartist.co.uk

Innovation that makes traffic information more precise

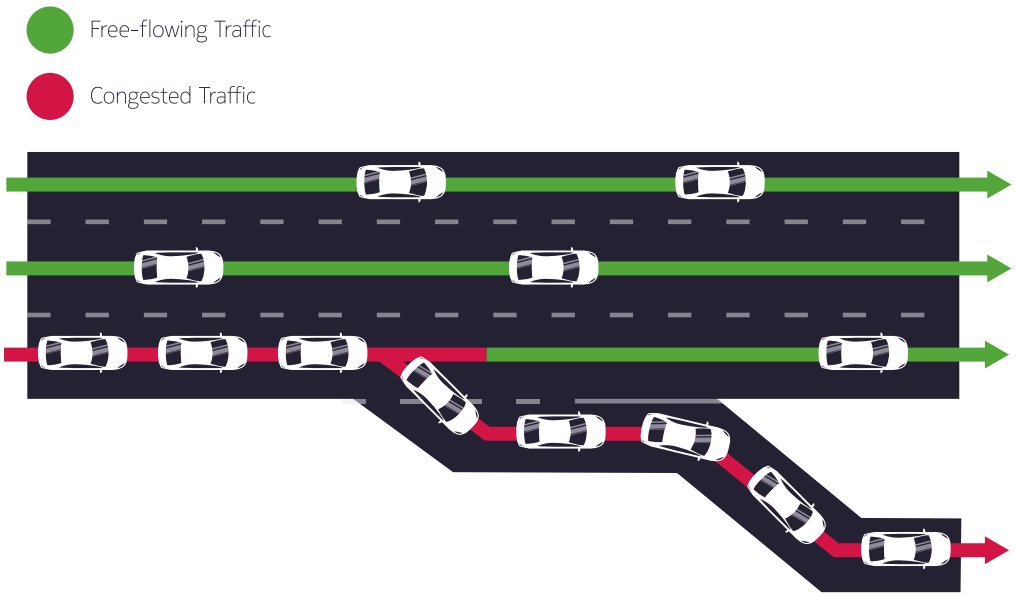
Traffic congestion costs time, resources and negatively impacts the environment. It is estimated that the average US consumer spends 38 hours each year in traffic due to congestion – costing US$818 in terms of lost hours and wasted fuel. Optimizing traffic flow offers an opportunity to decrease unnecessary expenses by minimizing commute time.

Keeping drivers informed about traffic congestion is key in the battle to keep cars moving. Highly accurate traffic data services from suppliers such as HERE enable navigation systems to guide drivers around jams.

In 2004, HERE kicked off its traffic business in the USA with a traffic information service that was included as standard in many Acura RL vehicles by Honda. At that time it was the nation's first satellite traffic information service that enabled a vehicle's on-board navigation system to display current traffic information for a chosen route. Twelve years later, HERE monitors data from hundreds of sources 24 hours a day and seven days a week. It processes billions of probe points daily and updates traffic information every minute – publishing insights to onboard devices and consumer devices. This includes current traffic flow, as well as congestion, road works and accidents.

Real-time limitations

Current real-time traffic products only provide the harmonic weighted average speed of all vehicles across road lanes. Showing only the average speed of vehicles traveling on a road isn't entirely helpful in all cases, because there are situations around junctions where the traffic that's trying to turn off is backed up, but the inside lane is clear (and, sometimes, vice versa).



Above: **HERE's Split Lane Traffic (SLT) system is able to detect flows on individual lanes, thereby showing if a ramp is blocked when the main road is free flowing**

Need to know

HERE's Split Lane Traffic (SLT) technology makes its Real Time Traffic function more accurate

- Two algorithms make SLT possible – Multi-Modal Speed Detection and Magnitude (MDM) and Dynamic SLT Aggregation (DSA)
- MDM detects when there are diverging speeds in adjacent lanes, using speed cluster data
- DSA uses probe data to scan the road in real time
- Dynamic sub-links help to make the data as accurate as possible
- SLT means that personalized journey and arrival times can be predicted with greater accuracy than ever before

The average speed of those lanes at these times is misleading.

Understanding these conditions can help to calculate a more accurate estimated time of arrival (ETA), more intelligent traffic management solutions and help drivers make the most informed decision about which lane to use during their journey.

The latest real-time traffic reporting innovation from HERE is Split Lane Traffic (SLT) at junctions, which addresses this challenge by analyzing road speeds in detailed segments. It gives drivers the information necessary to make informed decisions before and during their journeys to avoid congestion.

The new algorithms that drive SLT are able to split traffic by lane before junctions, and into discrete segments of the road, to see how far the delays extend before the junction. So, instead of seeing the entire road marked 'yellow', HERE can accurately show which of the lanes next to the congested off-ramp are 'green' and free-flowing.

How SLT works

When initially developing this innovation, the HERE team scanned HERE maps for junction and highway splits, and identified divergent conditions in more than 100,000 places across the globe. Next, the detection and interface architecture of split lane traffic was designed – separating junctions into logical links and road segments. This allowed the team to report traffic at a lane level when divergent speeds are detected where the two roads divide.

This is done using two algorithms: Multi-Modal Speed Detection and Magnitude (MDM) and Dynamic SLT Aggregation (DSA). The MDM algorithm accurately measures speeds and the differences between speed clusters. MDM places data from moving vehicles into multiple speed cluster buckets and compares them. A cluster difference higher than a predetermined threshold indicates a significant level of multimodality.

Above: **By splitting the road into smaller road segments HERE can analyze changing traffic speeds and report traffic levels at a lane level**

If diverging speeds are detected at the junction, the DSA algorithm is activated and scans the first road segment (S1) in real time. Starting from the initial link (L1), the DSA algorithm begins, evaluating probe data from the first road segment. The left and right roads beyond the split (S2 and S3) are showing multimodality and the initial link. From there, the probe data from the road leading up to the junction is scanned backward from L1 to determine how much of the road leading up to the junction is multimodal. To make this as accurate as possible, this section of road is divided into sub-links and the DSA continues to scan probe data until it finds two subsequent links that show the same speed. Multimodality is published starting at the link that is the last to show divergent speeds.

Personalized benefits

The importance of SLT is that when HERE is calculating a route using its Real Time Traffic system, or showing an ETA, it is personalized to the user's journey and the lanes they're going to use. By measuring, detecting and publishing divergent speeds at junctions on a multiple lane basis, SLT will significantly contribute to the accuracy of HERE routing and real-time traffic services. It's a massive, industry-leading step forward in accuracy.

SLT does not only improve the understanding of today's road conditions, it is also a foundation for the future. As vehicles become more highly automated, this improved awareness of real-time traffic will be essential to their ability to evaluate situations, offer the best advice and, eventually, make decisions on our behalf.

Intelligent video enforcement brings us closer to Vision Zero

Twenty-five years ago driving in Europe was more dangerous than it was in the USA. However, since Swedish parliament approved the Vision Zero initiative in 1997, the opposite has become true. In 2015 road deaths in the USA averaged 102 per million, according to the NHTSA. The average number of road deaths in Europe was 51.5 per million according to the European Commission.

But even with the adoption of Vision Zero's active and passive safety technologies, reducing traffic fatalities to zero is still an elusive goal. "We have achieved impressive results in reducing road fatalities over the past decades," says EU Commissioner for Transport Violeta Bulc. "But if Europe is to reach its objective of halving road fatalities [from 1997 figures] by 2020, much more needs to be done."

Changing drivers' behavior

Surveys show that drivers are open to changing their attitudes toward driving. A 2015 Traffic Safety Culture survey conducted by the AAA found that the vast majority of drivers recognize behaviors such as speeding, using cell phones and running red lights as being serious threats to their safety. Eighty percent of respondents support adopting Vision Zero, despite 87% of them admitting to at least one of those violations in the past 30 days.

This indicates that drivers are willing to accept enhanced traffic enforcement technology that positively influences driving behavior and ultimately increases their safety.

Cameras don't lie

Cameras with or without automatic license plate recognition (ALPR) demonstrate the effectiveness of photo enforcement in changing driving behavior. These systems have been used to reduce aggressive driving in countries where they have been implemented. But because cameras are set up at fixed locations, they only provide limited traffic enforcement, as they can't go everywhere and they don't catch everything. RoadMetric is changing that.

RoadMetric is advancing technology to modify driver behavior with video enforcement. Incorporating four full HD cameras and a powerful processor, the Enforcement Deputy system enables police officers to automatically monitor and record multiple violations

Need to know

The Enforcement Deputy is an in-car video enforcement system with ALPR and automatic mobile enforcement

- Consists of four cameras with a 90° range, comprising a 360° view
- Can capture license plate images at distances of 82ft (25m), at speeds up to 150mph (240km/h)
- Data can be stored locally or transferred via networks such as a secure online mobile connection or a dedicated WiFi network
- Easy to upgrade. Users can have system functions added based on budget and need with out having to replace the cameras or system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OBLIGATION NUMBER: 0000000078

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INFRINGEMENTS COURT CASE NUMBER: 1253907233

DATE OF ENFORCEMENT ORDER: 04 April 2015

AMOUNT DUE: $339.40
DUE DATE: 31/12/2015

Infringements Courts as full payment of the infringement penalty and prescribed costs ement order has been made against you.
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INFRINGEMENT PENALTY: $244.00

PENALTY REMINDER NOTICE COSTS: $22.00

LESS AMOUNT PAID TO AGENCY: $0.00

UNPAID AMOUNT: $266.00

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Above: **Bulgarian traffic police using RoadMetric's Enforcement Deputy**

Left: **Citations show the multiple images captured by the Enforcement Deputy**

in the time it would take to issue a single citation.

"We continuously record high quality video in four directions and capture images of violators' license plates," explains Max Rosenblum, COO, RoadMetric. "This provides superior evidence for any type of violation."

RoadMetric's open platform software and intuitive human-machine interface enable the efficient review of violation videos and the processing of citations.

Vision Zero can be made more effective if RoadMetric cameras are installed in police patrol cars. If road users are aware that their driving style is being monitored by the police, they will think twice about how they're driving.

"Enhanced traffic enforcement technologies, such as those being developed by RoadMetric, can help advance Vision Zero by increasing the limited deterrent effects of established enforcement methods," says Richard Retting, a pioneer in photo enforcement in the USA, director of safety and research at Sam Schwartz Transportation Consultants, and chair of the Vision Zero committee of the Institute of Transportation Engineers.

Get taught, not caught

Educating drivers about Vision Zero making use of video enforcement will hugely improve the efficiency and effectiveness of police enforcement. This will translate to better driving behavior and bring us a lot closer to our target of zero fatalities.

by **Larry Yermack**

How can we achieve the MaaS future that is essential if we are to manage the transportation network?

In my previous column I mused on the Mileage Based User Fee approach to transportation funding and how the nascent field was focusing its attention on proving the concept with the simplest architecture, rather than planning for a more integrated payment system, as would be the case with Mobility as a Service (MaaS). Though I see this as a failure of vision, it is not irreparable because ultimately, any amount of miles driven can be charged. The broader question is: how does transportation payment interoperability get built?

It was not long ago that all transportation systems (tolling, transit, parking) were interoperable. All they took was cash, which was good anywhere within a country.

Then agencies started to print their own tokens, fare cards, etc., which were not interoperable with any other system. In the broader economy, payment mechanisms such as credit cards achieved interoperability, but in the post-iPhone period (the iPhone didn't come along until 2007), new payment methods became more popular – like PayPal, LevelUp and PayByPhone – which were once again, incompatible systems.

Interoperability in society has had a complicated history, but among public agencies, is much simpler. The process became more simplified when E-ZPass began a toll collection scheme in the northeast USA. The two key elements were an account-based system to identify and communicate with each customer, and the ability of that account to use multiple facilities. Voilà! – interoperability.

Over the past several decades the toll industry has seen interoperability emerge in at least four areas in the USA: the Northeast, Florida, Texas and California. The systems can't operate across regions: the hardware is different, the business rules are different and there is no national clearinghouse. Negotiations are all bilateral in nature. There has been an effort to achieve national interoperability, which was spurred by elements of the last surface transportation bill.

> It's a lot easier to build interoperability in from the start than grafting it on later

Credit needs to be given to the International Bridge Tunnel and Turnpike Association (IBTTA) for leading the efforts for national toll interoperability, but the obstacles are massive and optimistically we, in the USA, are still several years from any real national interoperability.

What does all this tell us about the challenges that lie ahead when it comes to achieving the MaaS future that is so essential if we are to manage the transportation network?

The first thing is that it's really hard and even a big stick from the federal government does not guarantee rapid success. The second is that the for profit economy figured out what sacrifices to make so that their businesses would succeed. But the third lesson is most important and we saw it at the beginning of the E-ZPass. It's a lot easier to build interoperability in from the start than graft it on later. Now is the time to start speaking across our silos about what a common payment system will look like.

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

Testing the temperature limits of portable weighing systems

How can a customer be sure about the reliability of a product? Some product features are easy to check before purchasing. With Haenni scales, for example, specification information, including their low profiles, weights and large active measuring surfaces, is accessible to the customer.

OIML test reports are also made available to the customer, although such reports can sometimes exceed 100 pages.

With it being impossible to find out about many other features of a product before purchasing it, testimonials from other buyers are essential and Haenni is a manufacturer that can confidently base the views of its customers worldwide on the reliability of its products.

Above: **A truck being weighed in Oman with a portable weighing system**

Above: **A 24/7 spot check by Manila North Tollways Corporation in the Philippines**

Whatever the weather

Haenni scales are used in more than 115 countries, for different purposes and in a range of environmental climates and conditions. They can operate in temperatures from 60°C to -20°C, from the heat of the Arabian desert to the cool of Canada, exceeding OIML requirements by more than 10°C in either direction.

An example of Haenni scales being used in a hot, humid climate is their use in the Philippines. For almost 12 years, they have been used by the country's Manila North Tollways Corporation (MNTC), and aside from occasionally needing minor repairs, they operate faultlessly.

Law-breakers busted

Daniel Kneubühl, managing director at Haenni Instruments, credits Haenni scales as being robust, with mean time between failures of more than 10 years.

When truck weight checks were first introduced in Oman in February 2015, there were incidences of trucks weighing 100% more than the law permitted. Vehicle weighing in Oman takes place in temperatures exceeding 50°C (with the asphalt reaching up to 80°C). Despite these conditions, Haenni's electronic WL 103 scale is able to withstand both the temperature and the weight of overloaded trucks.

Need to know

Haenni's robust portable weighing scales function in a range of climates and temperatures

- The Haenni WL 103 scale can operate in temperatures exceeding 50°C
- Since February 2015, Haenni scales have been used in Oman, where some trucks were previously found to be 100% over the weight limit
- Haenni's low-profile scales can withstand a virtually unlimited weightload because of their special tube sensing elements

Weight management

Haenni's low-profile scales are built with flat oval tubes that act as sensing elements. In the instance of the scale being overloaded, the tube walls compress against each other, ultimately enabling them to withstand a virtually unlimited weight load.

In addition, the scales' user manual will instruct the user how to prevent overloading it. For example, when loading the scale, all sensing elements must be loaded uniformly; not doing so could reduce the lifetime of the outer parts.

Scale requirements

Portable scales must not exceed a weight of 20kg, in order for them to be operated by a single individual. The height of the scale should be less than 20mm (for the mandatory leveling compensation), to enable the easy leveling of the trucks' wheels and to avoid a shift in axle loads when they mount the scales. Users of portable scales should bear in mind that driving onto a 17mm scale is comparable to a 5% slope. To minimize this slope effect, the ground plate of the portable scale should be placed flat on the ground, without the use of legs that could potentially damage the ground.

A long battery life is also essential and can help operators to reduce downtime. The longer the scales' operating time, the less charging time there is, creating more productivity time for the user.

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Multipurpose WIM system detects offending trucks on highways

Sterela's weigh-in-motion (WIM) systems have been available for 20 years. The company's new product, the Global-WIM, can detect a range of unsafe vehicles, as well as those that are overweight.

A Global-WIM site in Habay, close to the Luxembourg border. It is one of five sites installed in Belgium in 2015

Multiple sensors

The Global-WIM is based on the functionality of traditional WIM system equipment, but is built with additional sensors that enable it to obtain more data. Its piezoelectric sensors can determine the lateral position of a vehicle in a lane and it can detect twin wheels on the axles. It uses contextual cameras to obtain a diagonal image of the front and side of the vehicle, automatic license plate recognition (ALPR) cameras and dangerous goods recognition (DGR) cameras to identify vehicles and the goods transported by analyzing the vehicle goods labels.

The Global-WIM system can also be fitted with different dimension sensors: infrared optical barriers to detect vehicles that are too tall; and laser scanners to measure the dimensions of vehicles and determine their 3D profile. An example of a Global-WIM station using these sensors is in Habay, Belgium, where there are more than 30 sensors installed to monitor a three-lane highway and its emergency lane.

Detects offenders

The primary function of the Global-WIM system is to pre-select offending vehicles; it can also be used to make interceptions safer by controlling dynamic display panels that order vehicles to leave the highway and enter the inspection area. The Global-WIM can identify if a vehicle is overweight: gross weight depending on the vehicle category, axle load depending on its type (steering or carrying) and the type of wheel (single or twin), and axle-group load depending on the distance between axles. The system can also detect other vehicle offenses regardless of whether it is overweight or not. These offences include exceeding the speed limit, depending on the vehicle category and the type of goods transported; exceeding the length, depending on the vehicle category; going over the permitted height restriction; driving on forbidden lanes, taking into account the type of goods transported; and driving on days that are not permitted.

Highly efficient

The statistics compiled by the Global-WIM system have enabled authorities to optimize inspection scheduling by identifying the time periods where most offenses are committed. Moreover, data collected from the network of Global-WIM stations across the country enables controllers to access the traffic history of the vehicles stopped. This information can help to detect fraud by highlighting inconsistencies in driving times, rest times and transport dockets relative to the journeys made.

The regular use of the pre-selection network installed in France has increased the effectiveness of manual controls from an average of 25% to 96%.

The next step is direct enforcement. With high accuracy in measuring vehicle speeds – a maximum error of less than 0.4km/h (0.2mph) – the Global-WIM station is ready for speed enforcement. It has an advantage over existing solutions based on radar, as it can easily apply regulation depending on the category of the vehicles and the type of goods being transported. Regarding the enforcement of overloaded vehicles, Sterela is part of an experiment taking place in France to bring an operating WIM system to market as soon as possible.

Need to know?

Sterela is also developing a new WIM solution that operates at medium speeds

- The medium-speed WIM system will be able to weigh vehicles at speeds between 6-24mph (10-40km/h)
- Ideal for ports, landfills, shippers of bulk materials, and logistics platforms
- Compared to static weighbridge or low speed axle scales, the system allows vehicles to be weighed without needing to reduce their speed, enabling traffic to flow more efficiently

Advances in technology lead to better-performing WIM systems

With the improvement of sensor technology and electronics, the collection of vehicle data using weigh-in-motion (WIM) systems is approaching the performance range typically reserved for static weighing.

When deciding which sensors to employ at in-road WIM sites, the operator needs to answer several questions. What type (or class) of performance is required? Does the WIM site exclude certain civil works as an option? What does the operating environment consist of? And, additionally, and importantly, what is the budget? Taking these questions into account enables selection of the best equipment for the application.

Several factors can alter the performance of WIM systems. The condition of the pavement, site configuration and the environmental circumstances, such as temperature fluctuations, all contribute to the performance of sensors. With the development of WIM technology to address these factors, Intercomp WIM strain gauge strip sensors enable the operator to meet the performance requirements.

Strip sensor installation

Need to know

Intercomp is the world's largest manufacturer of portable weighing and measurement products

- Intercomp strain gauge strip sensors can weigh vehicles at speeds up to 80mph (130km/h)
- They are designed to operate with ASTM E131809 and COST 323 requirements
- Cost-effective, versatile and can be installed quickly – in a single day
- The strip sensor is cost-effective because of the minimal time and labor required for installation and maintenance

Above: **An Intercomp strip sensor**

Pavement conditions

Organizations such as the American Society for Testing and Materials (ASTM) and the European Cooperation in Science and Technology (COST) have put forward WIM guidelines that outline pavement conditions that will maximize the performance of WIM sites. Level and smooth roadways minimize the incurred oscillations in vehicle suspension that can adversely affect any sensor, although increased numbers of sensors can provide additional data that minimizes the effects of substandard roadways and vehicle suspensions. Intercomp strip sensors have been installed in a variety of roadway surfaces in a single day, without the need for major civil works, proving that the WIM strip sensors are versatile enough to be used in a wide range of conditions.

Site configuration

Intercomp WIM systems can operate with strip sensors in pairs, while acquiring wheel, axle and gross vehicle weight measurements. As the systems and sensors meet performance requirements for ASTM E131809 and COST 323 methods, and can be paired with cameras and other equipment, the applications in which they are employed have included data collection, screening for enforcement and tolling.

One pair (two sensors) is recommended for data collection, while installations of up to four pairs are used for highly accurate tolling operations. Sensor spacing in the installation depends on the expected vehicle speeds for an installation, with higher speeds having larger spacing between rows. Applications from low speed up to highway speeds can be addressed with these configurations, with similar accuracy performance across a wide range of speeds.

Operating environment

As the sensors are embedded in the roadway surface, they

experience a wide range of temperatures, depending on the climate of the country they are installed in. However, in desert and arid locations, for example, Intercomp has observed large site temperature fluctuations within a single day. Ideally, the performance of sensors across these fluctuations would be stable enough to ensure the collection of good vehicle data.

A unique feature of the technology used in Intercomp strip sensors is that temperature compensation is done at the sensor, freeing the integrator and electronics from developing the compensation required for other WIM technologies. This increases precision over time without the environmental effects being observed within the reported vehicle information.

With WIM applications demanding a variety of different configurations across a wide range of speeds and in varying environmental conditions, Intercomp strip sensors offer a cost-effective, versatile solution.

In a rapidly developing field such as ITS, adapting WIM technology to the current and future needs of the industry will help to give reliable weight-based information in an affordable way. ○

by **Don Hunt**

State DOTs must plan for the multigenerational workforce of the future

In a time of change, it's difficult to think about how an organization needs to evolve to continue to be successful. There are plenty of examples of private-sector companies that could not adapt their business, products and services to changing needs, including Netscape Navigator, Palm, Gateway and Blockbuster. Adaptation for a private company is about survival; for a government entity it's about relevance and public trust.

State DOTs are characteristically slow to adapt to change. Change created by tech-enabled transportation is going to affect not only how work is done, but also what the focus of the work will be and who the future employees of state agencies will be. State transportation agencies have plenty of employees trained to build highway capacity projects and few workers with the skills necessary to analyze data, evaluate supply chains, estimate economic outcomes, target cost-effective project solutions, manage highways in real time and integrate intermodal systems.

Transportation agencies are plagued by being data-rich and information-poor. With new data about to pour in, the right skills are needed to turn it into information for operations and decision making. Workers will need the tools and skills to communicate and collaborate to get work done, leading to an increased focus on the upskilling and training of current staff.

Another challenge that DOTs can expect is high levels of turnover due to an aging workforce (baby boomers). There is a need to be prepared for the next generation of workers – millennials, a technology driven, data consuming, digital group of thinkers looking to accomplish work with a swipe of a finger. As this new millennial generation enters and grows its presence in the workforce, how can DOTs blend their multigenerational workforce's motivations, perspectives, communication styles, skills and knowledge?

Colorado DOT (CDOT) is taking a unique approach to planning for the workforce of the future. The department is engaging PwC, a top human resource firm, to evaluate its employee structure – job descriptions, locations and skill composition – and develop alternative workforce skill scenarios for the future. The scenarios will incorporate how DOT business could shift over the next decade, and what the workforce composition will need to be to respond to 2025 targets. Will CDOT need minor shifts in workforce skills, or will there need to be major new skills such as data scientists, economists, operations research analysts, system integrators, communications engineers and logisticians? And how can all this change be addressed through natural attrition, without increasing the amount of government resources?

> Adaptation for a government entity is about relevance and public trust

State DOTs are facing their biggest mission challenge since the Interstate Highway Program in the 1950s. Increasingly, rapid technological change is about to affect transportation in the same way it has changed other industries, such as finance, retail and the media. Connectivity, big data and automation will bring new efficiencies to transportation – if state DOTs can envision the potential benefits they will unlock. While the future is an unknown, it is organizations that can find the common threads leading to the future that will best serve their residents and customers.

Don Hunt is a transportation consultant and former director of Colorado DOT ***dhunt@anteronet.com***

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

Simulation software gives insights to Lyon's traffic operators

The Opticities project gathers 25 partners from across Europe, including city councils, service providers, car firms and research laboratories to use interoperable ITS solutions to optimize urban logistics operations. The Metropolis of Lyon, France (also known as Grand Lyon), is one of six test beds, and a key aim of this part of the project is to test the integration of traffic prediction tools into the city's traffic control systems.

The Grand Lyon Opticities project is expected to demonstrate that a prediction tool can help traffic operators anticipate and mitigate peak congestion by forecasting future network flow patterns that will result from various traffic management actions, providing accurate strategy comparisons and allowing efficient implementation of the most suitable strategies.

A traffic prediction tool

The traffic prediction tool that SPIE (a provider of multi-technical services in the areas of energy and communications) chose to use for the experiment is Aimsun Online, provided by TSS-Transport Simulation Systems. Aimsun Online's dynamic, high-speed simulation of large areas enables traffic operators in Lyon's traffic management center (called CRITER) to visualize traffic conditions before they unfold, which enables them to anticipate future events. Three to four minutes is all that is needed to produce traffic predictions for the next hour.

Aimsun Online continuously processes live field data, simulating vehicle movements inside the Lyon study area, which covers approximately 870 miles (1,400km) of roads.

Lyon is the second-largest metropolitan area in France after Paris. It has 600,000 inhabitants over 60km²

Need to know

Opticities is a three-year project that tests ITS innovations in urban contexts

- Aimsun Online enables traffic operators to visualize traffic scenarios before they unfold
- The Lyon study area that Aimsun Online simulates comprises 870 miles (1,400km) of roads
- Aimsun Online uses real-time data inputs from the CRITER traffic management center to simulate future traffic scenarios; 3-4 minutes of live data from CRITER is all that is required to produce 30 minutes of traffic predictions

By combining live traffic data feeds and high-speed simulations with the emulation of congestion mitigation strategies, Aimsun Online can accurately forecast future network flow patterns that will result from a particular traffic management strategy.

Taking simulated action

Operators can simulate different scenarios, according to different strategies and travel policies (based on control plan configurations), to assess their relative impact on the network. Scenario results are ranked according to defined indicators. For each simulated scenario, the traffic state is displayed and operators can then apply simulated actions. In order to compare scenarios, four indicators were chosen: global fluidity, dynamic congestion, road level hierarchy and indicators for pedestrian data.

These indicators help traffic operators select the best strategy to apply to recurring congestion and unplanned incidents. This then enables operators to target specific areas where an intervention is necessary in order to minimize personal journey times, to analyze the impact and effectiveness of strategies deployed, and to build and refine a library of intervention strategies for future applications.

To provide precise predictions, the modeling team has to integrate the following data into Aimsun Online's model of Lyon: static model, public transport data; the control plan for all traffic light controllers; traffic demand data, history of traffic data; and definition of events and response scenarios. The historic traffic data is used to generate patterns for real-time simulation. As well as this, definitions of events and response scenarios are used to execute predictive simulations when special events happen.

An effective tool for special transport management

To avoid a limited approach to calculating the safety of a bridge, the SiWIM bridge weigh-in-motion (WIM) system is used as a tool to create calibrated structural load models and to instantly calculate bridge safety levels under any traffic load, including special transports – vehicles that exceed weight regulations (per axle, gross weight) and permitted size dimensions. These include loaded or empty vehicles whose weights and dimensions are within permissible limits, but exceed any of the specific limitations indicated by traffic signs on a road section.

By assessing all bridges on a route with a portable bridge WIM, on a single occasion, data can be used repeatedly for route assessments with any type of special transport.

Such special transports require a permit that defines the procedures and conditions of the journey to be made, and the fee charged for the transport. When a permit application is received, the authority has to perform a route survey. If the special transport is over the legal load, typically 36-54 tons (40-60 metric tons) gross weight, all bridges on the route must be reassessed with regard to their structural safety under the specified higher loading. If necessary, special conditions, such as no other traffic on the bridge at the time of crossing, or a reduced speed limit during the crossing of a critical bridge, may be imposed.

Surveying style

A typical approach to perform a route survey is to identify all bridges along the proposed route (from a bridge database or a bridge management system) and to calculate their structural safety, taking into account: available information on the structures (their load bearing capacity, degree of deterioration); and axle loads and gross vehicle weight of the particular special vehicle. When applying standard analytical methods based on design codes, older and more deteriorated bridges often fail to pass the assessment. The main reason for this failure is that the procedures for calculating bridge safety tend to be too limited. The procedures do not take into account reserves in capacity and in structural behavior that bridges usually exhibit, and they cover the entire lifetime of the bridge, not individual events, such as the crossing of a special transport. Thus, the applied levels of safety tend to be too high for a well-defined special transport.

Static weighing of a special transport after detecting overloading with SiWIM

Need to know

SiWIM is a portable WIM system used to weigh vehicles and monitor bridge behavior

- For installation, it is placed under the bridge and onto the superstructure, without damaging it
- It analyzes bridge behavior in response to traffic weight loads and reduces the need for unnecessary bridge closures and repairs
- It enables weight checks for special transport vehicles, while analyzing the behavior and safety of the bridge on which it has been placed

Bridge behavior

As the SiWIM system measures the actual behavior of the bridge under the traffic load (influence lines and load distribution over the structural members), bridge structural models can be fine-tuned to account for their reserves in capacity and load effects (for older bridges in particular, bending movements can be considerably lower than first assumed in theoretical bridge models). This method is known as soft load testing (SLT) of bridges. A specific benefit of SLT with a SiWIM system is that once a structural model is optimized with the true influence lines and load distribution factors, it can be reused to instantly calculate a bridge's structural safety under any traffic load, including special transports.

Apart from monitoring, the SiWIM system can also detect special transports as they pass the instrumented location. They are identified by combining a vehicle classification system with an automatic license plate recognition (ALPR) camera. A positive match for a special transport is compared against the database of all approvals, to identify vehicles without permits. Live data from the bridge WIM site feeds to a traffic operations center and a negative match is either forwarded to the enforcement team or stored for later processing. More and more countries are recognizing that special transports without permits are a serious problem.

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Express lanes

Your shortcuts to just some of the big stories in this issue – and beyond!

"We are able to look at the information coming out of the car – floating car data – which can be used to make congestion data even more accurate"

Folkert Bloembergen, project manager, Rijkswaterstaat, The Netherlands

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"A commercial truck driver may attempt to find a route that avoids a fixed scale. The USP of portable WIM is the element of surprise"

Captain Jon Olsen, commander of Commercial Enforcement Division, Minnesota State Patrol

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"A huge benefit of the foam injection is that it seeks out voids. It stabilizes the soil underground and provides a smooth, safe road surface up above. It's a cost-effective, permanent solution"

Jesse Gutierrez, deputy state engineer, operations, Arizona DOT

See how ADOT is using biotech analysis and foam injections to even out road surfaces without digging them up: trafficTechnologyToday.com/ADOTroads

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"Speeds get averaged out and in some cases this is wrong – such as when a highway is blocked and ramps are going at full speed"

Tony Belkin, head of traffic and dynamic content, Here

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Facts & Figures

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- Operating in over 80 countries
- 480 staff working on traffic solutions
- >50 million plates read every day

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