January 2017

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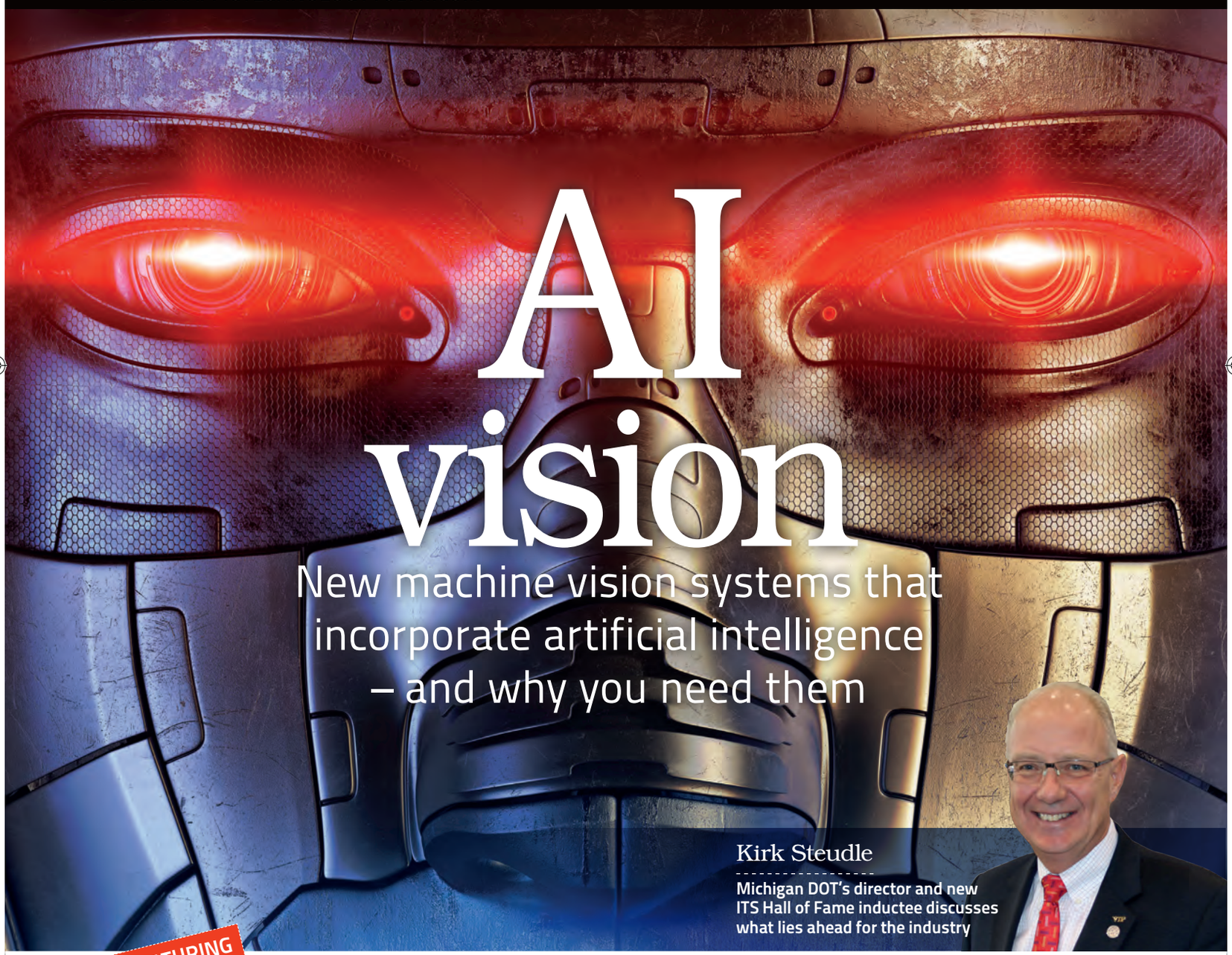

AI vision

New machine vision systems that incorporate artificial intelligence – and why you need them

Kirk Steudle

Michigan DOT's director and new ITS Hall of Fame inductee discusses what lies ahead for the industry

FEATURING

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Your essential guide to the future of transportation communications

V2X to beat the weather
The USDOT's Connected Vehicle Pilot is using smart communications to make snowy, icy roads safer

Wi-fi in lampposts
How street furniture is being equipped with new comms tech to meet rising transportation demands

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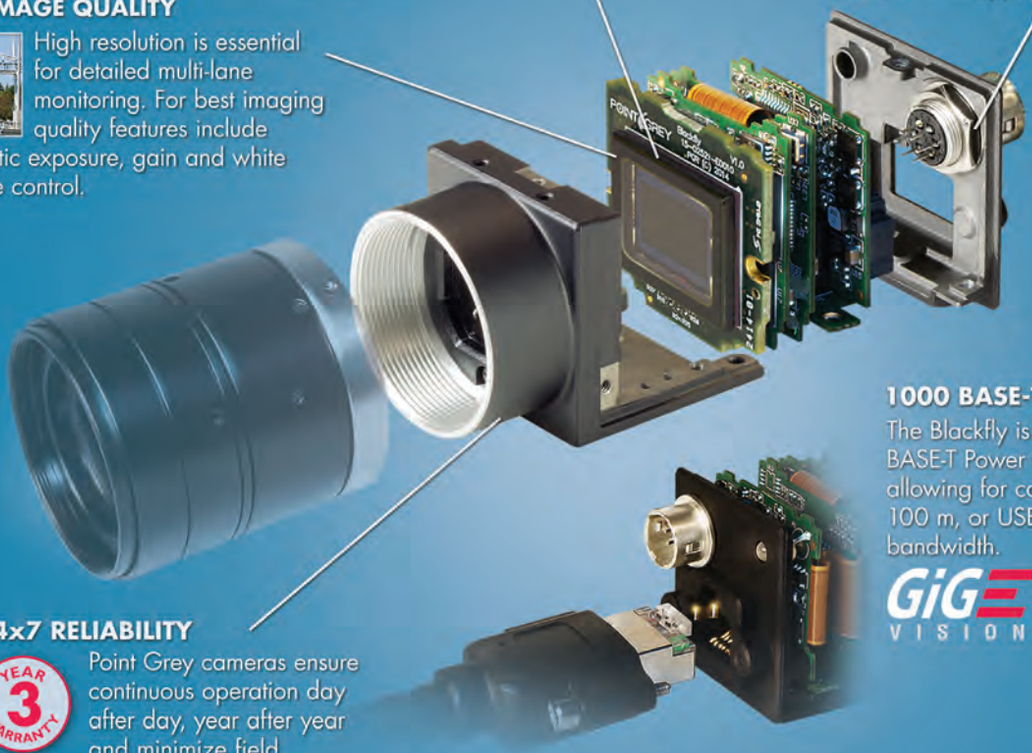

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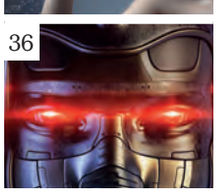
Innovation in Imaging

Cover story

36 The future of machine vision

Artificial intelligence technology is adding 'brains' to cameras

If processing can be done at the roadside, the speed and versatility of smart infrastructure can be enhanced. Saul Wordsworth reports



In **This** Issue

Technology Profiles

Regulars

Editor's letter

How will history record 2016? Will it be 'the year everything went wrong'? Or maybe simply 'the year everything changed'? One thing's for sure – the twin political upheavals of Brexit and the USA's presidential election are certain to leave the world a significant legacy that will be forever intertwined.

Indeed, there is much to connect the two. Setting aside fears surrounding rampant populism and rising racism, both movements are turning to similar panaceas to ailing economies and disaffected workers – investment in infrastructure being foremost among them.

As this issue goes to press, here in the UK our Chancellor, Philip Hammond, has just made his Autumn Statement – the first big economic announcement since the EU referendum – in it he outlined a plan to invest £1.1bn (US$1.4bn) in transportation infrastructure by 2020.

Reaction to the news came in fast. Adrian Tatum, conference director for the UK's biggest transportation expo, Traffex (see p71 for more on 2017's event), said, "It's great to see the government valuing the importance of investing in our infrastructure, especially at a time when budgets for other longer-term investments risk being cut."

However, others sounded a more cautious tone. James Stamp, head of transport at KPMG UK, said, "Even with investment in specific schemes, a stark fact remains: demand for transportation will always be ahead of our ability to pour more concrete. Making more from the capacity we have is – and will stay – key. It is therefore vital that investment tackles not only the issues of today, but also how and why people will travel in the future. Translating the potential of Mobility as a Service to reality must be a key aim."

Indeed, while the UK government seeks to distance itself from Europe, it should not disregard the groundbreaking transportation projects being implemented on the continent. From the cooperative platforms that should, as Stamp hopes, help to make Mobility as a Service a reality (p6), to the live testbeds that seek to be a proving ground for next-generation 5G communications (p51), Europe still has much to recommend it to anyone seeking plans for a brighter transportation future.

In the USA, where infrastructure spending is also being pushed up the political agenda, DOTs can call on the latest technology to ensure their new assets remain safe (*Protecting bridges*, p16) and turn to V2X technology to improve traffic flows as the USDOT continues to take an international lead in its development (*Serious state*, p52). But, of course, many of these projects wouldn't even get off the ground if it wasn't for inspirational leaders such as Michigan DOT's director, Kirk Steudle. I was lucky enough to meet him at the World Congress in Melbourne back in October. Find out what he had to say on page 14. The future is what we make it.

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LEADING THE WAY

Aussie rules ITS

A successful World Congress marks the beginning of a new chapter of growth and innovation for host ITS Australia

The 23rd World Congress in Melbourne proved beyond doubt that ITS is thriving. With more than 11,000 delegates from around the world, it became the largest international conference held in Australia in 2016 and benefited the national economy by an estimated US$18.5m (A$25m).

For Brian Negus, ITS Australia president, the Congress could not have gone any better. "We were aiming for 7,000 visitors, so to get close to 11,500 was outstanding," he says. "We were also pleased with the number of attending ministers, mayors and senior executives and, while it's too early to put a dollar figure on the business activities, we're aware of a large number of MoUs signed, and partnerships and initiatives developed at the Congress."

Visitors were treated to 236 speaker sessions featuring 663 speakers, while 659 technical tours were conducted and 3,618 delegates enjoyed technology demonstrations on Melbourne's public roads and at Albert Park, home of the Australian Formula 1 Grand Prix.

Susan Harris, chief executive for ITS Australia, says the organization is determined to build on the success of the event: "The end of the Congress marks the start of a new period for us. We have a membership base of more than 100 organizations and we're well on track with our plans to continue to support them alongside our ongoing promotion of the industry as a whole."

Plenary sessions at the Melbourne Convention Centre were packed

Below: **Interactive displays gave delegates the opportunity to experience different ITS from around the world**

At the closing ceremony Brian Negus, president of ITS Australia, passes the ceremonial globe to the next host city, Montreal, via chiefs of the world's other ITS regions

Above: **Susan Harris, chief executive of ITS Australia, welcomes delegates from around the world to Melbourne**

Left: **Brian Negus (right) signs just one of the many MoUs that were forged at the Congress**

Left: **School students explain their autonomous vehicle challenge as the Congress succeeds in engaging the next generation in ITS**

Closer to MaaS

MOBiNET aims to enable mobility services to become more closely integrated right across Europe and it's now moving into a new phase

December 2016 marks the beginning of the next stage of the MOBiNET platform as it is opened up to external stakeholders, in order to further explore its potential. MOBiNET has been drawing together services and businesses to build an 'internet of mobility' marketplace for almost four years, and is seen as being a key potential enabler of Mobility as a Service (MaaS) across Europe.

With the launch of MaaS Global's pioneering Whim app in Helsinki, Finland, earlier in 2016, MaaS has already started to disrupt traditional ways of thinking about transportation. MaaS promises travelers a seamless door-to-door travel experience using the most suitable public, shared and private transportation, offered through a mobile app with a single user account.

33
Number of partners involved in MOBiNET
Source: mobinet.eu

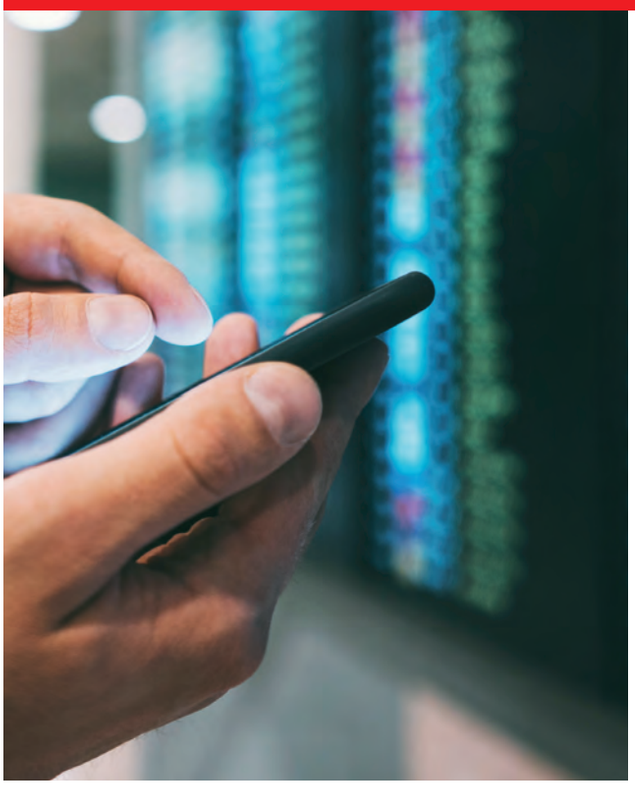
For MaaS to be deployed widely in Europe, its providers need an easy way to find and access the many mobility options, transportation and traffic data in each new market location. MOBiNET (www.mobinet.eu) will help. It enables the interactions between suppliers, developers and users of mobility-related content and services. It includes a directory for publishing and editing business-to-business (B2B) and business-to-consumer services, as well as functionality enabling and supporting interoperability between data sources. The services will be offered across Europe without the need for standardized hardware.

"If you are providing, let's say, a parking service app in Italy, you can, through MOBiNET, find the equivalent parking services in other cities and link with them so your app can be used for parking services anywhere in Europe," explains Rasmus Lindholm, partnership services director at ERTICO – ITS Europe and project coordinator for MOBiNET.

New connections

For users, it promises a view of local mobility services, and to service providers a view of all connected users. In addition, MOBiNET provides tools for the B2B community for automatic negotiation of service agreements when adding extra service components and data sources to existing service offerings.

> "If you are providing, let's say, a parking app in Italy, you can, through MOBiNET, find equivalent parking services in other cities and link with them, so your app can be used anywhere in Europe
>
> *Rasmus Lindholm, project coordinator, MOBiNET*



The structure of MOBiNET could help a MaaS service provider to extend his business. On a local level, it could provide a platform where transport operators can publish their services and data in the directory. From this, the MaaS provider could find all the services and data, instead of going to all the different operators.

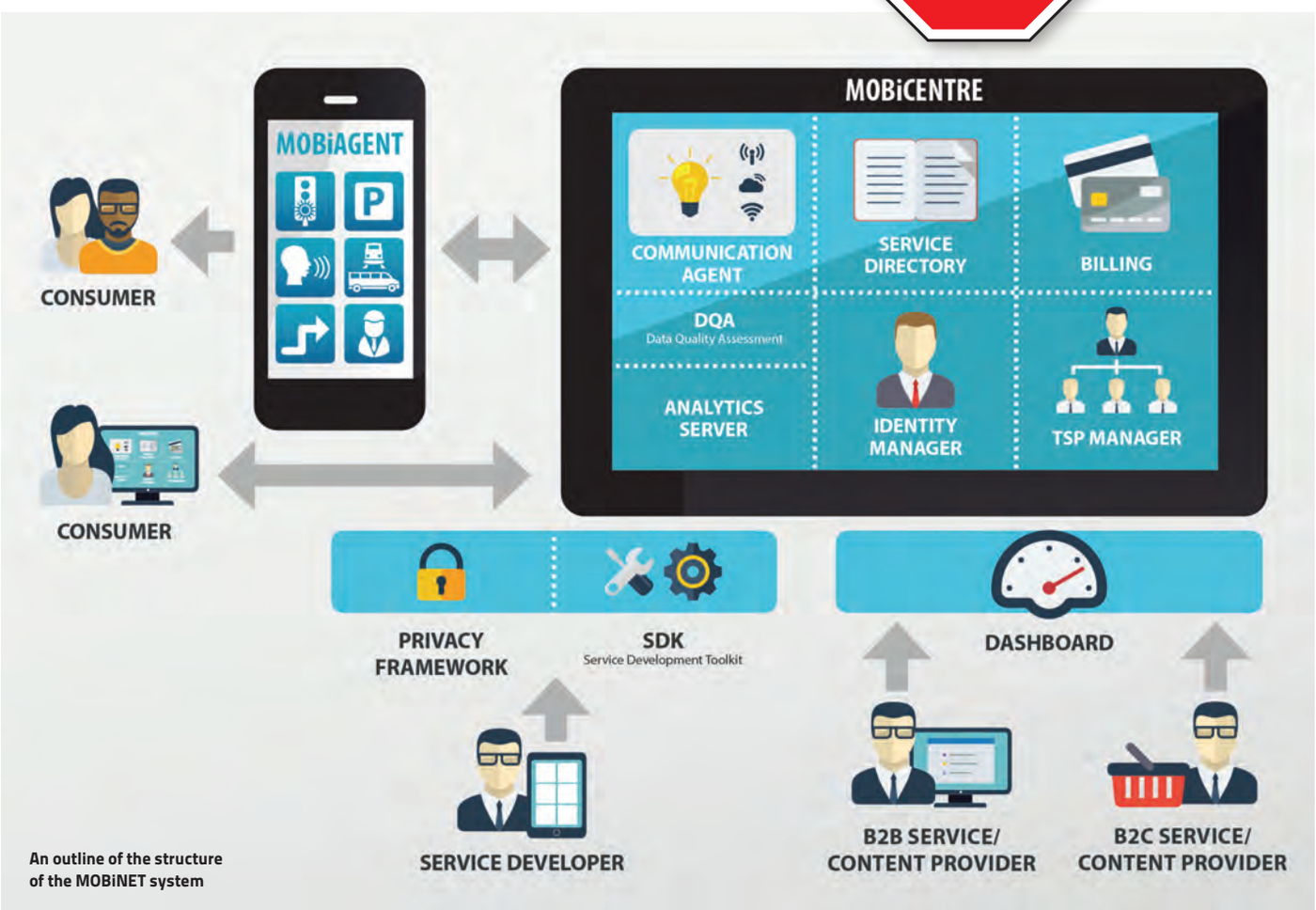
MaaS operators are able to see each other's service offering through the MOBiNET platform. For example, whenever a MaaS provider in one city has published its service in MOBiNET and finds the required transport service, another MaaS provider in a different city can also see what they are offering. By linking and using some of the components, including the billing and the clearing developed in MOBiNET, the customers of the MaaS operator in the first city would be able to use the same app or services when they are in the second.

"We have focused on businesses because what we have seen that there is more value to add in the B2B area than in reaching out to the end user," explains Lindholm. "We've tried to come up with a service directory where all mobility services and data can be found."

Key MOBiNET innovations

- A unique directory of all European online data and services for transport and mobility
- An identity authentication and management scheme for single sign-on by any user for multiple services
- A unified billing and clearing framework to support roaming by users and payment clearing between providers
- A secure operating environment for user devices, both in-vehicle and portable

€15.6m
Total MOBiNET budget (US$16.5m)
Source: mobinet.eu



An outline of the structure of the MOBiNET system

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Mapping point

From public transit monitoring to underground infrastructure planning, the traffic industry has many uses for the latest cartographic technology. **Rachelle Harry** rounds up the latest advances

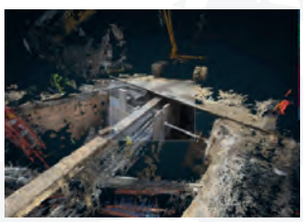
Underground planner

Underground infrastructure mapping will reduce the impact of construction works on traffic

City Digital, a Chicago-based UI LABS collaboration, has developed the underlying technology components required to create a new underground infrastructure mapping (UIM) platform, which will generate, organize, visualize, and store 3D underground infrastructure data, saving cities and utilities millions of dollars in construction and planning processes.

Using the City of Chicago as a testbed, the pilot team is deploying the new technology to create an accurate 3D map of underground assets.

An engineering-grade, cloud-based data platform enables this critical infrastructure information



to be securely stored and shared among city departments and utilities.

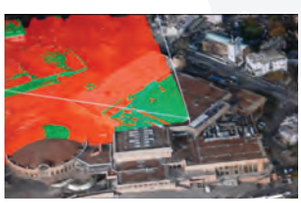
Many construction projects involve digging up a city's streets, disrupting its traffic. Inaccurate or obsolete data on below-ground assets means an underground utility line is hit on average every 60 seconds, according to the American Public Works Association. Accurate underground maps will help to prevent these incidents.

5G network assist

Ordnance Survey to create maps for 5G roll-out

The UK's Department for Culture, Media & Sport (DCMS) has chosen UK mapping agency Ordnance Survey (OS) to develop a groundbreaking mapping tool that will be instrumental to the national roll-out of 5G wireless technology, which will connect new devices to the internet.

OS will lead a consortium, including the 5G Innovation Centre and UK weather service the Met Office, in building a 'digital twin' map of the real world, which will help pinpoint



locations for the antennae needed to enable a 5G network.

The tool will be trialled in the south coast town of Bournemouth *(pictured)*, and if successful, it can be scaled to cover the UK and other countries that develop their 5G networks.

Nationwide transit map

USDOT releases first-ever National Transit Map data

The US Department of Transportation's (USDOT) Bureau of Transportation Statistics (BTS) has released the National Transit Map, a geospatial database of information that will provide users with open, machine-readable data on stops, routes, and schedules.

The new map of fixed-guideway and fixed-route transit services in the USA is openly available and will allow USDOT to address gaps in access to public transportation.

The initial National Transit Map consists of General Transit

Feed Specification (GTFS) data feeds registered with BTS in response to a March 2016 request for the data from US Transportation Secretary Anthony Foxx.

Almost 200 transit agencies submitted data on over 385,000 stops and stations, and on nearly 10,000 routes. USDOT hopes to include more transit agencies for the second version of the map.

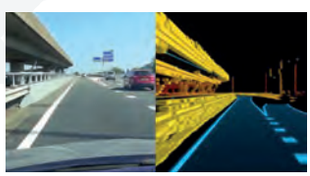
HD mapping for autonomous cars

TomTom and Nvidia are to develop real-time updating of expanded HD map coverage

Dutch mapping and navigation group TomTom is partnering with Nvidia, a leader in computing systems for self-driving vehicles, to develop a cloud-to-car mapping system for self-driving cars.

The partnership pairs TomTom's high definition (HD) map coverage, which spans more than 120,000 miles (193,000km) of highways and freeways, with the Nvidia Drive PX 2 artificial intelligence (AI) computing platform.

The Nvidia DriveWorks software development kit integrates support for



TomTom's HD maps, and is available to all auto makers and Tier 1 suppliers that are working to develop autonomous vehicles.

Nvidia vice president and general manager of automotive Rob Csongor commented, "Self-driving cars require a highly accurate HD mapping system that can generate an always up-to-date HD map in the cloud."

Collaborative future

Instead of public agencies and private navigation companies keeping traffic data to themselves, the new TM 2.0 platform aims to open up lines of communication so that information can be shared between all parties, leading to faster, more accurate travel advice for road users. **Andrea Toth** looks forward to the next generation of traffic information

Following successful 'value-chain definition' and 'value-chain creation' phases, the innovative new traffic management platform, TM 2.0, is now moving toward its third phase: real-world deployment in a number of European cities and regions.

The ERTICO-ITS Europe-backed project aims to bring 'traditional' traffic managers together with mobility services to facilitate dynamic information exchange. The candidate areas selected for deployment are BrabantStad, Ghent, Salzburg, Thessaloniki, Verona and Vigo.

The members of the platform (at the latest count, 34 private companies and government agencies – see *TM 2.0 members*, right) have been preparing for deployment for more than three years, working in groups to complete specific tasks.

All of them are driven by the common desire to enable vehicle interaction with traffic management. The most significant elements are traffic management centers (TMC) and traffic information service providers (TISP) who serve drivers through in-vehicle devices and apps, such as TomTom.

When in-car navigation systems join forces with traffic management centers, the quality of information will show a marked increase

Reciprocal exchange

"In essence, the TMCs need to act as a hub for collecting, analyzing and distributing information derived from the many data sources," says Dr Johanna Tzanidaki, chair of the TM 2.0 platform. "The more accurate and precise the information, the better the decisions that can be made by the TMCs on how to manage traffic and, as a result, on the routing advice they broadcast. Close cooperation between TMCs and TISPs enables a more informed traffic management. Not all TMCs have the resources and the ability to collect, analyze and distribute the plethora of traffic information available."

The TM 2.0 platform members believe TISPs can fill those gaps for TMCs. TISPs are able to collect their own GPS data, know the positions of cars connected to their system and, if they have sufficient market penetration, can deduce the traffic conditions on any road in the area

they cover. It is these TISPs that are able to enhance the traffic management of TMCs.

"Unless the TMCs share their traffic information with the TISPs, and unless this is a reciprocal exchange of information, traffic is not managed in an optimal way," says Tzanidaki. TM 2.0 is a leap forward, not only in gathering data, but also in delivering advice to drivers.

TM 2.0 fits into a larger picture of mobility and transport. Vehicles, infrastructure, cyclists, pedestrians and other vulnerable road users will be sensing and talking to each other, giving real-time updates on their status and position, which will all rely on interactivity and connectivity.

This approach also enables active moderation. This is the ability to directly influence the routes of many drivers, both personal and commercial, to guide them around road closures and inform them about potential danger.

The TM 2.0 platform is, in effect, a proposal to city administrators and traffic managers, drivers and TISPs for a mutually beneficial solution. City administrators could gain a tool that can help avoid congestion and traffic collapse. It is predicted that it will eliminate 6% of emissions and decrease the average network delay by up to 13%. The data that is received will be more accurate than the roadside cameras and loop detectors, helping traffic managers gain more precise information about what is happening on the road network, both currently as well as in the immediate future.

Personalized for everyone

Drivers will be able to receive relevant regional information and best route options – directly in their vehicles – enabling a more relaxed driving experience. Making traffic management more interactive, enabling information flow to the

13

The percentage decrease in network delays predicted when TM 2.0 is fully operational

Source: ERTICO

> "TMCs need to act as a hub for collecting, analyzing and distributing information derived from the many data sources
>
> *Dr Johanna Tzanidaki, chair, TM 2.0 platform*

TM 2.0 members

- ATOS
- AustriaTech
- BMW Group
- ITS Agency BrabantStad
- CERTH-HIT
- Continental
- CTAG
- Dynniq
- ERTICO – ITS Europe
- Swiss Federal Roads Office (FEDRO)
- Finnish Transport Agency
- Here
- ICCS
- Inrix
- ITS Czech
- Kapsch TrafficCom
- Region of Central Macedonia
- NPRA
- PTV Group
- RACC
- Rijkswaterstaat
- Federal State of Salzburg
- Siemens
- Swedish Transport Administration
- IVA Mobiliteitsbedrijf Stad Gent
- Swarco
- Technolution
- Transport for London
- TNO
- TomTom
- City of Verona
- Vialis
- Concello de Vigo
- Vlaamse Overheid

Benefits of TM 2.0

For city administrators/ traffic managers...
- Avoid congestion and traffic collapse
- Avoid unnecessary emissions
- Improve transportation management plan (TMP)
- Complement or replace loop detectors and enhance accuracy
- Floating car data-enabled traffic management, even on roads with no ITS

For drivers...
- Avoid congestion, more relaxed driving
- Receive relevant regional info in-vehicle
- Improved road safety through smoother traffic flow
- Best route options aligned with TMP

For traffic information service providers...
- Provide best route option for destination (not only fastest)
- Provide solution (best route option) not the problem (congestion info) well in advance
- Regional information becomes part of an integrated service

When TM 2.0 is fully operational traffic managers will benefit from more accurate data

TMC and back to the driver via the TISPs will deliver personalized solutions for drivers. The TMC and the TISP will be able to cater for the drivers' individual needs. For example, they may deliver a specific routing or a particular diversion for an individual vehicle rather than for the entire flow of cars traveling in that general direction. This interactivity will result in a better functioning city.

Such personalization is not going to be authoritarian under TM 2.0. "Receiving the best route information via the TISP would also include the TMC's suggested route and it would be left to the driver to make an informed decision on whether, for example, to follow the fastest or the most environmentally friendly navigation advice," says Tzanidaki. Also, the TISPs would be able to provide an enhanced service to their users.

28
The percentage of global CO_2 and greenhouse gas emissions that are emitted by road vehicles
Source: erticonetwork.com

Time for TM 2.0

It's no easy job managing a city with a growing population: housing, health care and mobility are all taking hits in an effort to tackle the challenges of a more urbanized Europe.

Efficient mobility, or the lack of it, can make or break a city. It isn't only about the nuisance of traffic jams; congestion is a major contributor to air pollution taking a toll on the environment and the health of the city's population. Making it easy for citizens to travel and reducing their time spent in traffic also greatly contributes to the economy of the community.

Managing the flow of traffic at all points in time on every single day is the job of the TMC, the ones who keep tabs on the pulse of the city: monitoring, re-routing, incentivizing or penalizing to enable a better functioning mobility system.

The TM 2.0 concept is key to providing a holistic information loop between the vehicle, the TISPs, the infrastructure and the TMCs. It aims to enable traffic managers to inform and guide the road network users to their destination, while time optimizing the road network by responding to the prevailing traffic.

When TM 2.0 is deployed, the cooperation and information exchange between TMCs and TISPs will benefit individual drivers en masse and, ultimately, entire cities.

> "It would be left to the driver to make an informed decision on whether, for example, to follow the fastest or, on the other hand, the most environmentally friendly navigation advice
>
> *Dr Johanna Tzanidaki, chair, TM 2.0 platform*

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Following his acceptance of an ITS Lifetime Achievement Award, **Kirk Steudle**, director of Michigan DOT, spoke exclusively to *TTI* about his vision for the future

Interviewed by Tom Stone

He is a civil engineer by training and used to think that connected and autonomous vehicles were science fiction. It's funny how things change, because now Kirk Steudle, director of Michigan Department of Transportation, is in the ITS World Congress Hall of Fame with a Lifetime Achievement Award to hang on the wall of his office. How did that happen?

"I was very skeptical about automation and connectivity. I was a construction engineer, a very practical person, and I looked at it in the 1990s and said, 'This is all Buck Rogers – way too far out. It's only presentations. There's nothing happening'."

Scoff if you like, but two decades ago that view was common. Steudle, though, got an early revelation about the future. "I happen to live close to a General Motors test facility and was invited to come look at their latest technologies. In 2005 or 2006 I rode in the V2V Cadillacs, which were the first ones. At the time I think they were the only ones of their kind. They communicated back and forth," Steudle recalls, "The trigger for me happened after we were passed by the companion car, which then stopped in our lane. We went at 60mph toward the back of

> In the past six months the automated side has advanced tremendously. The safety benefits happen when we get to connected automation

Above: **Steudle accepting his award at the ITS World Congress in Melbourne**
Below: **Michigan's CAV testing facility, Mcity**

Big achievers

As is traditional at the ITS World Congress, which took place in Melbourne, Australia in October 2016, three new members of the community were honored with lifetime achievement awards – one from each of the three global regions.

Dr Hiroyuki Watanabe was the winner from the Asia-Pacific region. The former chairman of ITS Japan spent more than 40 years in automobile research and development at Toyota, where he was involved in product design projects with innovative technologies, such as electronic stability control, hybrid powertrains and fuel cell batteries. He introduced the concept of integrated approaches to policy, infrastructure, advanced vehicles, participation of the general public and ITS technologies as an enabler.

From Europe, Professor Eric Sampson of Newcastle University was recognized for his tireless work with ITS UK and the major impact he made on intelligent transport systems development and deployment over a 45 year career in the public sector. This has also included roles at the UK's Department for Transport and as one of the founders of ERTICO – ITS Europe.

that car and our driver did nothing – and the car stopped on its own. After going 'Phew!' I said, 'Okay, this is real.'"

Steudle's ability to accommodate new technologies is evidenced by Michigan's support for everyone striving to improve travel and logistics. "I said, 'We're in the perfect spot. We need to be talking with the auto companies about what they need.' Then this last year we rolled out our umbrella, Planet M, making southeast Michigan the place to develop a vision for a connected vehicle environment. So we've formed pretty unique partnerships in Michigan."

Forward thinking

As someone who has the ultimate responsibility every day for 10,000 miles of state road, 4,000 bridges, 2,500 employees and a US$4bn annual budget, Steudle is always thinking ahead, accepting the latest developments and considering what part they will play in future road transport. "If you'd asked six months ago what my vision was, I'd have said it was moving a lot more in the direction of connectivity," he says. However, other advances have shifted his view. "In the past six months the automated side has advanced tremendously. For me, the safety benefits happen when we get to connected automation – that's why we need connected automated vehicles."

He's also synthesizing the potential impact of Mobility as a Service (MaaS). "I come from Detroit, where we sell a lot of cars, but MaaS has pushed me into thinking about how we harness technology to increase the efficiency of mobility," says Steudle.

So far, the issue of MaaS has raised more questions in his mind than answers. "How does it fit with traditional public transit? Is it going to be a replacement for that? What happens with the revenue it creates? Is this a purely private thing, purely public or a public-private mix?" he asks. "I view it as a question of how the technology can be harnessed for the good of society. We have to make sure that when we're done we've helped all of society move forward and we're all in a different place, as opposed to something that we just let happen. I think there's a fine line between forcing it to happen and removing barriers."

Public duty

There's little doubt that Steudle has used his role at MDOT to enable new technologies to be applied to vehicles and traffic, removing barriers to allow innovation to blossom, yet keeping some safeguards so that it's not a free for all. His approach to MaaS is similar. "I do think there's a role of government to make sure that we're serving all people. There's an equity component here. We have to make sure we haven't provided this pay system or this public or private system that allows individuals who have the means to opt into some other solution," he says.

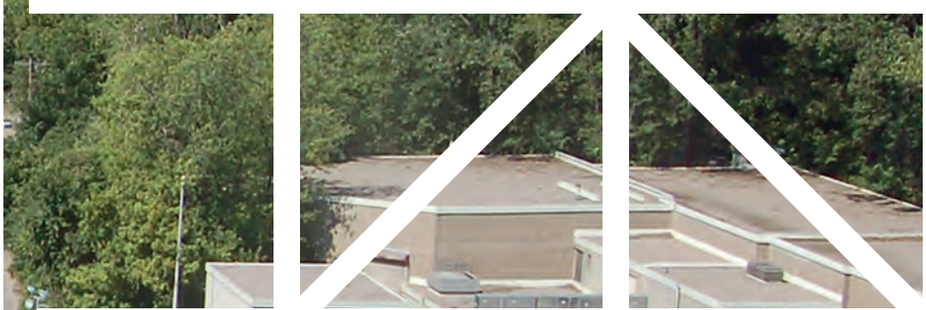
"I think it's the appropriate time to be having these discussions, as opposed to just letting everything fly and then a year or two from now wake up and say, 'Wait a minute, we've created something that does not work, and now we've got to retrofit it back.' We're in the early stages, so it's the perfect time to be having the conversation."

Those are sound words from someone who readily admits that he hasn't always seen the future coming but somehow has to prepare for it anyway. "My average day could be dealing with some legislative issue or it could be dealing with a driveway; it could be dealing with a US$100m construction project. It could be dealing with the future that's 20 years away. I deal with everything, from what happened yesterday to what's going to happen 40 years from now. That's exciting."

One of the most obvious rewards of such a varied role is the opportunity to try tomorrow's technology today. Is there another element of the job that keeps Steudle going to work every day?

"What do I get out of it?" he asks, "I get the ability to bring people together to look at a larger situation for the common good of society. I'm a public employee, right? What ultimately drives me is what's good for society. How do we make good public policy? How do we make good decisions?" So, it seems he's not about to quit and read sci-fi comics. "I'm going to be in this job as long as I'm having fun and the Governor wants me to be here." A statement that means Michigan is likely to be at the forefront of transportation innovation for many years to come.

Protecting bridges



Technology can span the gap between dangerous ignorance and informed decisions. **James Gordon** explains how safety and maintenance are enhanced by the latest smart systems

13
Fatalities when Bridge 9340 in Minneapolis collapsed

Left: **The disastrous and lethal failure of Minnesota's Bridge 9340 has prompted the introduction of new safety sensors and technologies**

For some of us, crossing a bridge awakens a fear lurking deep in our subconscious. As toddlers, it's played out in nursery rhymes, as teenagers in disaster movies, and as adults in our worst nightmares. But, tragically, for the families of an unlucky few who lost loved ones in one of America's most devastating bridge collapses, the scenario was all too real.

On August 1, 2007, 13 died and 145 more were injured when Bridge 9340, an eight-lane steel truss arch construction on the Mississippi River in Minnesota, suddenly buckled in the middle of the evening rush hour.

A new crossing, I-35W Saint Anthony Falls Bridge, now sits in the same spot. Remarkably, the bridge opened to the public on September 18, 2008, just 13 months after the original structure failed. It comprises two parallel bridges – one transporting traffic northbound, the other southbound.

However, for Dustin Thomas, a bridge construction engineer at the Minnesota Department of Transportation (MnDOT), who worked on the US$234m construction project, the I-35W is more than just a replacement bridge.

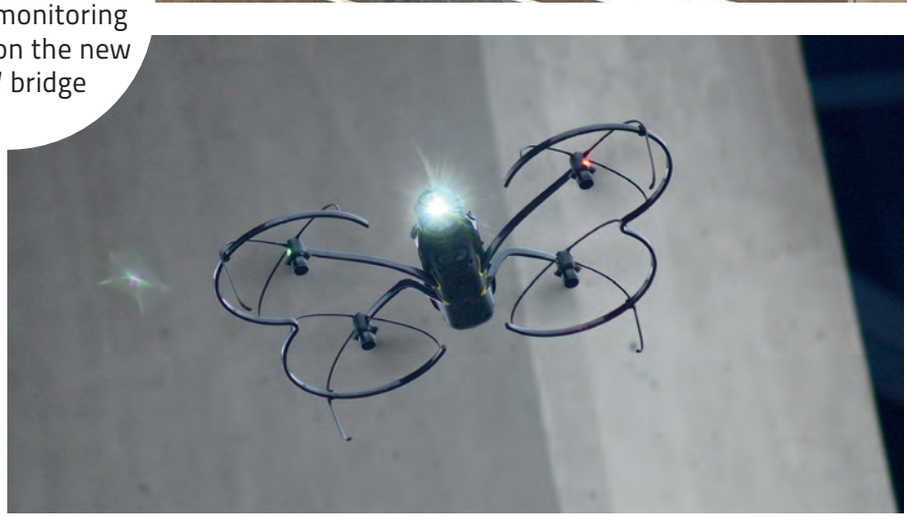
"An investigation by the National Transportation Safety Board revealed

500+
The number of sensors monitoring changes on the new I-35W bridge

a design fault in the original bridge as the reason for the collapse," says Thomas. "In regard to the new crossing, MnDOT's chief aim was to ensure a sound, durable, aesthetically pleasing structure was built as soon as possible. The replacement bridge not only met those goals, but is also equipped with state-of-the-art monitoring technology, which provided data for up-to-the minute health checks during construction and continues to do so today."

Above: **The new I-35W Saint Anthony Falls Bridge opened in 2008, 13 months after the old one collapsed**

Right: **The SenseFLY Albris's infrared camera detects concrete deterioration on bridge decks**



Health checks

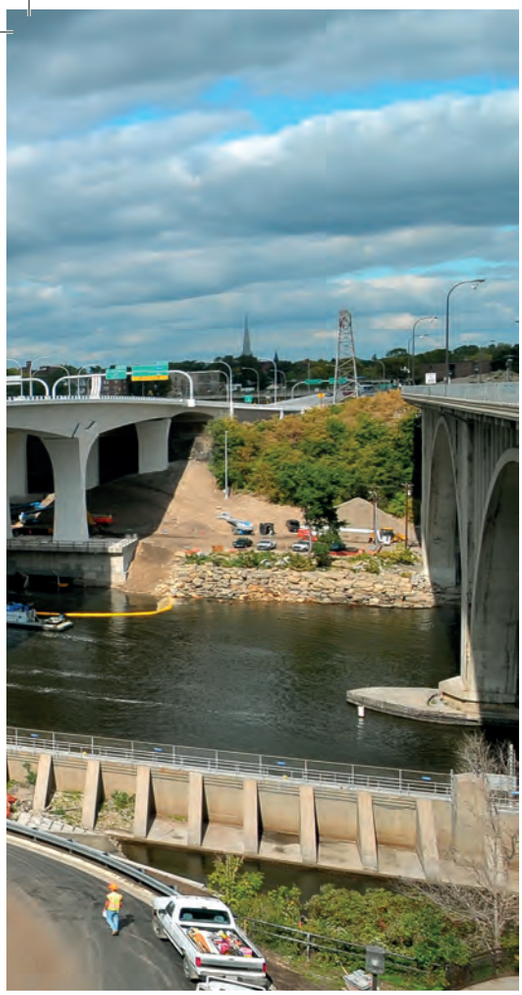
So what role does technology play in protecting the new 1,225ft box-girder structure? "The bridge's health monitoring system is one of the most advanced in the USA," says Thomas, "Embedded under the concrete deck and piers are over 500 sensors that measure deflections, strain, temperature change, expansion and contraction on the crossing."

The data collection and monitoring systems cost around US$200,000. Each sensor feeds real-time data back to a central data collection system in a control room nearby. From there the information is streamed direct to MnDOT and also to the University of Minnesota's Civil Engineering Department, which has spent the past eight years analyzing it.

> Intelligent robotics technology is advancing at a fast pace. I believe that employing drones could cut inspection time by around 30%
>
> **Jennifer Zink, state bridge inspection engineer, MnDOT**

"Initial analysis validated that the post-tensioned concrete was performing as planned in the design stage," says Thomas. "Post-tensioned concrete bridges shorten over time due to the onset of creep and shrinkage. Further study will be conducted to evaluate the long-term effects of creep, enabling our structural engineering team to determine which theoretical models we can employ to accurately predict the bridge's structural behavior."

Nevertheless engineers can draw on data from a myriad of sensors on a daily basis as well as for the week-long inspection that is carried out every two years. For example, the 12 linear potentiometers on the expansion joints measure the



contraction and expansion of the 17 million pounds of reinforcing bar, 740 miles of strand and 50,000 cubic yards of concrete of the bridge.

Weight and see

Elsewhere, 10 double inductive loop speed detectors at the south end of the bridge and 20 inductive loop traffic detectors under the pavement and the main deck measure the speed and volume of traffic, which is currently 164,000 vehicles each day. There are also eight single inductive loops for the entrance and exit ramps at each end of the bridges.

However, for Thomas and his team, establishing exactly how much weight the bridge can handle in one single crossing was far more important. "Prior to the opening we carried out a series of mini-load calibration tests," says Thomas. "By loading eight snow plow trucks with sand and deploying them strategically across the bridge, the health monitoring system was tested and we found the crossing could easily accommodate weights of 178 tons without incurring any damage. This is well above the state truck weight limit laws, which prohibit any single vehicle weighing over 36 tons from traveling on Minnesota's roads without a permit.

"While the heaviest permit-carrying vehicle tested during the design phase weighed 116 tons, in the future, when additional analysis has been conducted, the bridge may be cleared to accommodate even larger single-trip licensed trucks," he adds.

Above and below deck

When it comes to harnessing pioneering technology under the main deck, there are few restrictions. With the help of Collins Engineers, a Chicago-based consultancy, MnDOT is currently in the middle of a four-year research project, investigating the effectiveness of drones as a tool for bridge inspection purposes (see Dangerous Crossings, *TTI* February/March 2016, p49-50).

"We are currently using the SenseFLY Albris, which costs around US$40,000 for the drone and software," says Jennifer Zink, MnDOT's state bridge inspection

> "UAVs could transform inspections in many areas, including evaluating the 873 reinforced elastomeric bearings and shock transmission units that sit between the main and bridge decks
>
> **Firmino Sá, operations and maintenance, Ponte Vasco da Gama, Lusoponte**

US$2.15m
Annual maintenance spend on the Vasco da Gama bridge

Bridging troubled water

Scotland's longest river crossing is decked out with an array of sensors; now new ones are planned beneath the water level

With a collective value of US$6.9bn (£5.5bn), it's no surprise that Transport Scotland uses a vast array of technology to protect its 1,933 bridges. Its annual average maintenance spend is US$37m (£30m) and that excludes the US$17.5m (£14m) renovation costs of Scotland's longest crossing, the Forth Road Bridge.

"The main deck of the bridge, the suspended span and towers are equipped with a structural health monitoring system," says Cameron Gair, Transport Scotland's bridges asset manager. "It includes a new weather station for wind speed, direction, humidity, air and deck temperature, along with main cable acoustic monitoring to detect wire breaks, main cable dehumidification and geospatial sensors for movements in real time."

"Electronic strain gauges and tilt meters have also been installed on all 16 structural truss end link members on the bridge, in eight locations. The sites allow us to monitor actual stresses, strains and movement and collate against actual wind speed, temperature and traffic load effects."

And what innovations has Transport Scotland deployed to eliminate scour (riverbed erosion), a leading causes of bridge failure?

"We carry out visual and physical inspection from the bank and in the watercourse, as required, using divers, and a range of technologies including probing, sonar, modern digital photography and lidar," says Hazel McDonald, network bridges manager.

"Currently, known scour or flood risk structures have river level gauges that alert us to incidents that direct inspectors and engineers to the locations most at risk. We are actively working with Strathclyde and Heriot-Watt universities to develop scour sensors in the riverbed or on the structure, which could be deployed in the near future."

engineer. "The infrared camera has proved highly effective in detecting concrete deterioration on the decks."

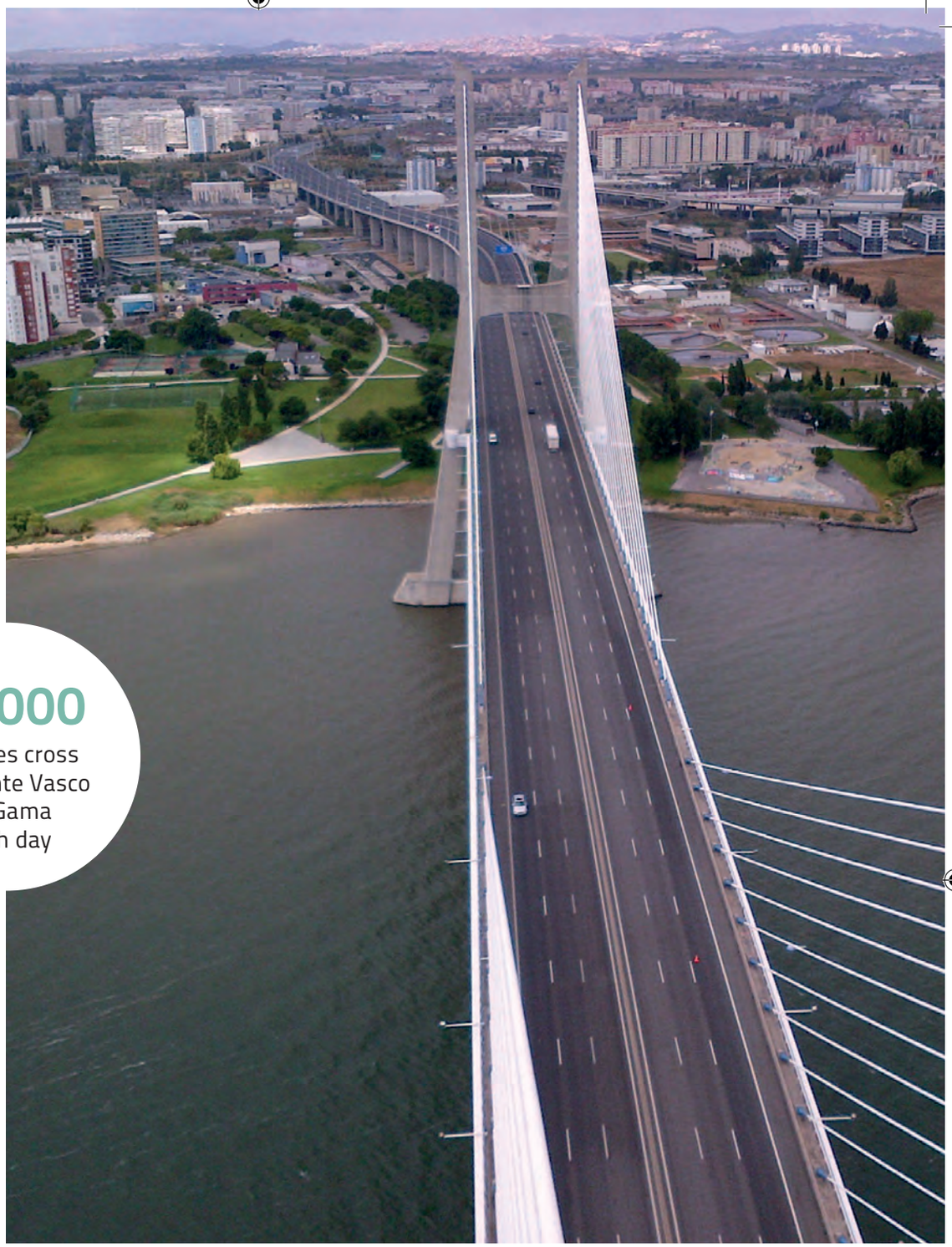
So, does Zink believe that drone technology could ever replace humans or will they merely improve inspection efficiency? "Intelligent robotics technology is advancing at a fast pace," she says. "I believe that employing drones could cut inspection time by around 30%. A recent study I carried out using UAVs to assess the approach spans on the Blatnik Bridge, Minnesota's second largest crossing, revealed major cost savings. Given the time, safety and access advantages of using UAVs, we believe this technology will be cost-effective in the future.

"I don't see drones taking over just yet, as even the most leading-edge drones cannot take detailed measurements of defects, nor are they able to conduct non-destructive testing, such as ultrasonic evaluation to determine steel-section loss."

59,000

Vehicles cross the Ponte Vasco da Gama each day

Some 4,000 miles east of Minnesota, in the Portuguese capital of Lisbon, Firmino Sá has been using drones to inspect the Ponte Vasco da Gama, Europe's longest road bridge. Sá has worked for Portuguese bridge operator Lusoponte for over 20 years and is responsible for operations and maintenance on the US$1.2bn (€1.1bn) crossing. "Every year we spend around US$2.15m (€2m) on maintenance," says Sá. "The crossing and the cable-stayed structure is so vast and circuitous that it takes two engineers a year to inspect a third of it. Potentially UAVs could transform



Above: **Ponte Vasco da Gama traffic is monitored by a SCADA system**

Left: **Detailed inspections can confirm issues raised by in-structure sensors**

Right: **The Ponte Vasco da Gama is a crucial link in the road network for Lisbon**

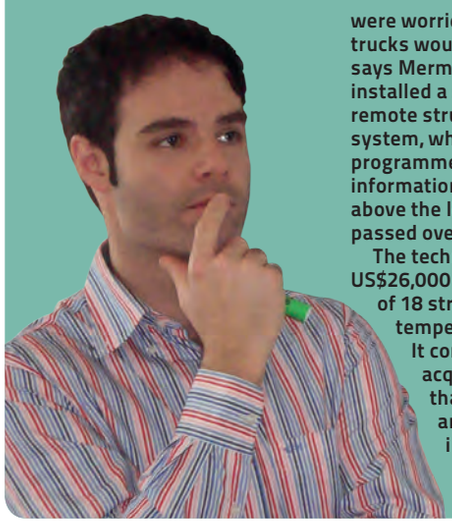
Taking the strain

New technology in Ontario measures the maximum pressures heavy trucks are putting on one of its older bridges, enabling timely maintenance

Kris Mermigas (below) is a busy man. As head of bridge management for the Ontario Ministry of Transportation (MTO), he and his seven-strong team are responsible for inspecting 2,880 provincially owned bridges in Canada's most populous province. One of his greatest challenges is to protect the public from creaking bridge infrastructure. Take, for instance, the Grand River Bridge in Cayuga, a steel-truss crossing an hour's drive from Toronto.

"The bridge was built in 1923 and was deteriorating rapidly due to old age. We were worried that overloaded trucks would cripple it," says Mermigas. "So we installed a state-of-the-art remote structural monitoring system, which was specially programmed to collect information whenever a truck above the legal weight limit passed over the bridge."

For safety, bridge stresses must be monitored



The technology, which cost US$26,000 (C$35,000), consists of 18 strain gauges and two temperature sensors. It connects to a data acquisition system that transmits data and photographs in real time to the bridge office.

"Whenever an oversized vehicle passes over the bridge, it activates a strain-gauge channel, enabling us to view live strain data for a seven-second period," says Mermigas. "It also captures a photograph of the vehicle and its license plate on the crossing. Our main concern is the safety of the public. We estimate that structural monitoring instrumentation will enable the MTO to defer building replacement bridges by up to five years."

inspections in many areas, including evaluating the 873 reinforced elastomeric bearings and shock transmission units between the main deck and the bridge deck which need expensive equipment to access."

He admits it may be several years before the technology is adopted widely by bridge inspection teams in Portugal. "I think that there are more questions and answers at present. From a legal perspective we would need to obtain the necessary permits from the Instituto Nacional de Aviação Civil. Secondly, with the crossing often affected by high winds, which sometimes reach 35mph, it may not be the best environment for operating drones. Thirdly, I am not sure if the emergence of UAVs will make inspections cheaper, as you would still need two engineers – one to evaluate the bridge deck, the pavement and the safety rails, and the other to assess the underside of the bridge with the drone."

> The bridge was built in 1923 and was deteriorating rapidly due to old age. We were worried that overloaded trucks would cripple it
>
> **Kris Mermigas, head of bridge management, Ontario Ministry of Transportation (MTO)**

Satisfying insurers

While the crossing, which opened in 1998, may not be quite ready to embrace UAVs, the authority has invested heavily in leading-edge technology that continually monitors the bridge's condition. "The Vasco da Gama has a serviceable life expectancy of 120 years and to satisfy

75mm
The width of road-surface channels (3in) that need to be cut to install Intercomp WIM strip sensors

Embedded solutions

Weigh-in-motion strip sensors from Intercomp can help with bridge protection

The protection of transportation infrastructure such as bridges and tunnels is a natural extension of roadway pavement management. More is being understood about the stresses that vehicle traffic puts on structures such as bridges, and more is being done to actively protect them with ITS systems, to keep motorists and the infrastructure safe.

Weigh-in-motion (WIM) systems detect and monitor vehicle traffic counts, and axle and gross vehicle weights (GVW), to measure effects on structures.

WIM strip sensors from Intercomp are integrated into 3in (75mm) channels cut in the roadway surface. They give transportation officials the same highly accurate strain-gauge technology used in enforcement scales, but employed in WIM applications at highway speeds. There are two ways to use them for bridge protection: data collection, or detect and divert.

Upstream of the structure to be protected, WIM sites are installed to capture vehicle counts and information to passively monitor traffic crossing the bridge. These quantify traffic counts and vehicle classifications and are similar to a highway data collection site, enabling officials to monitor what weights the structure is experiencing on an ongoing basis. Sites are placed close to the bridge in order to capture accurate vehicle information. Adding peripheral equipment such as automatic license plate recognition (ALPR) and scene view cameras is common, especially when a more active approach needs to be taken.

With 'detect and divert', WIM sites are placed further upstream, with real-time active identification of vehicles that exceed the structure's recommended load ratings. Electronics identify the vehicle, and signage diverts vehicles off the roadway before the bridge.

As part of these protection systems, WIM strip sensors integrate proven performance of strain-gauge sensor technology that is integrated with various electronic operating systems. With straightforward installation and low costs, officials can protect existing structures and confidently plan for the future for infrastructure needs.

our insurers, we have employed innovation to the full," says Sá. "There are 22 accelerometers, 26 inclinometers and 154 extensometers that provide important structural behavioral data. The real-time information is analyzed each month and also after a freak event."

The sensor technology has proved invaluable when evaluating the 20 expansion joints that absorb movement on the deck. "Six of the largest joints have been fitted with 18 temperature sensors and six gap measurement devices," says Sá. "If there is a problem, the cells will send an alarm to the traffic controller. A patrol team will carry out an initial assessment and request the technical team if maintenance is essential."

A plethora of technology helps monitor the 59,000 vehicle crossings daily including a highly developed supervisory control and data acquisition [SCADA] system, eight overhead gantries with traffic signals and VMS boards, 91 CCTV cameras, 37 emergency phones, three vehicle detection loops and 12 automatic incident detection cameras. Information is fed from the 12 toll plazas to the Traffic Management Center and to an operational and maintenance team 24/7."

If 100,000 vehicles have crossed in a day, the two shoulders on the six lane bridge are opened. However, the weight of traffic has little effect on structural integrity.

Above: **Protecting bridges from overweight vehicles safeguards the structure from undue and damaging stress**

"It was built to withstand an earthquake greater than the 1755 quake and tsunami that destroyed large swathes of Lisbon," says Sá. "So exceptionally high traffic flow would not damage it.

"Additionally," he adds, "our statistics show only 1.8% of traffic on the crossing are heavy goods vehicles, so weight is not really an issue. That said, any vehicle of more than 60 tons requires a permit before it can use the crossing and the adjoining roads. And the maximum allowable weight for HGVs is 180 tons."

Weather proofing

New technology is helping road authorities protect highways from becoming hazardous when nature does its worst, as **Max Glaskin** discovers

The cost of adverse weather is clear. Heavy rain can increase journey times by 30% and low visibility can cut highway capacity by 10% or more. The USA spends US$2.3bn a year to control ice and snow on roads. So technologies that improve the safety and operations of all roads in all weathers are as welcome as rainbows. Here are five of the newest…

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Blast off

Lasers and explosions are unusual tools for highway operators, but they are coming into their own in mountainous US states in keeping roads safe from avalanches. Jeffrey Deems, a research scientist with the National Snow and Ice Data Center, is using lidar to measure the effectiveness of sonic blasts that can shift snow in a controlled and timely manner.

"We map the terrain in 3D using laser scanners before the snows arrive and again as they build up. Then we subtract the former from the latter to see exactly the depth and volume of snow throughout the survey area," Deems tells *TTi*.

Avalanches tend to start on land where the slope angle is between 22° and 45° and the initial work has surveyed some of these sites in the Loveland Pass, Colorado, where US Highway 6 crosses the Continental Divide at almost 12,000ft (3,660m) above sea level in the Rockies.

To protect roads from catastrophe, avalanches are triggered artificially before snow volumes pose a danger. Explosives can be dangerous so Colorado DOT has turned to a remotely activated system, called Gazex.

> We map the terrain in 3D using laser scanners before the snows arrive and again as they build up… to see exactly the depth and volume of snow throughout the survey area
>
> **Jeffrey Deems, research scientist, National Snow and Ice Data Center**

Avalanches are deliberately started to clear snow and protect Highway 6

Gazex systems are constructed on the mountainside before snows arrive. They consist of a gas storage unit linked by pipes to a series of exploder assemblies located at likely start zones. After a snowstorm, the mix of propane and oxygen is fed from the storage unit to the exploder assemblies, where detonation produces a concussive blast, and the shockwave trips an avalanche.

While the process helps Colorado DOT to maximize the viability of Highway 6, there is still more to learn to make sure it is optimized. "We scan before and after the Gazex blast to re-examine the avalanche release areas," says Deems.

When enough is understood about the best locations for Gazex units the new system could help protect other avalanche-prone highways such as the I-70 in Colorado and I-90 in Wyoming. The DOTs from both states, along with Alaska, Utah and Washington State, have committed to the FHWA's Transportation Avalanche Research Pool fund, which is supporting the lidar survey.

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Street seen

The high density of roads in urban centers means a small weather event can affect traffic across a whole city. So the granularity of the Array of Things (AoT) that's evolving in Chicago is being watched keenly. It's an extraordinary experiment in environmental monitoring that could generate data to boost the effectiveness of a Traffic Management Center (TMC).

Up to 50 sensor nodes are to be fixed to signal poles and buildings, measuring temperature, pressure, humidity, light, standing water and wind. "What's really going to help is the camera technology," says Rob Jacob, computational climate scientist at Argonne National Laboratory and head of climate research for the AoT. "There is a camera in each node facing down into the street to collect images. Algorithms will be developed to recognize whether the street is flooded, or if there is standing water or ice, or even if there are cracks."

The TMC will be able to access all of the data and it might even benefit from third-party analytics. "The information from the nodes will be shared directly with all the city's agencies, including those responsible for the streets, and it will also be made public so that anyone can design an app for it," says Jacob.

The AoT could provide localized info to help TMCs prepare for imminent events. "Each node also has an upward facing camera to look at cloud cover, which will also be analyzed by image-recognition algorithms, to give info about weather systems. We'll also be able to tell something about the air pollution," says Jacob. Researchers in other cities around the world are now partnering with Chicago and are expected to install their own AoT nodes.

Main image: **Chicago by night**
Inset: **One of the city's AoT sensors**

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Pass notes

An innovative technology for gathering and sharing information has been trialled in New Zealand, to minimize the delays that can occur due to adverse weather in winter.

The RouteTIP trial was limited to a specific route between Christchurch and Queenstown, and volunteers were recruited to take part. They were able to download a smartphone app that received location-specific weather information and other data, and used audio to deliver it to the driver. "It is too early to say that the system has proved itself. However, the trial ran over the New Zealand winter and there were instances in late July and early August where we were able to provide real-time updates on road closures and re-openings," says Deryk Whyte, project manager in the New Zealand Transport Agency's Highways & Network Operations Group. These included notices that the highest road on South Island's network, through the 3,000ft-high Lindis Pass on State Highway 8, would receive up to 8in of snow overnight, making driving hazardous if not impossible.

Sixty locations were selected for the low-cost beacons that communicated with the app.

New Zealand's mountain passes present unique problems for traffic managers

"So far, the system has been free of any significant technology issues," says Whyte. "We did encounter some third-party mobile communications issues, which resulted in the loss of some transmitters' capability to receive real-time information during these periods. Minor technical issues have been experienced with the handset linking to the vehicle systems. We are working through these issues and hope to make some improvements as part of the next stage of this project."

> "The trial ran over the New Zealand winter… we were able to provide real-time updates on road closures and re-openings"
>
> **Deryk Whyte, project manager, New Zealand Transport Agency**

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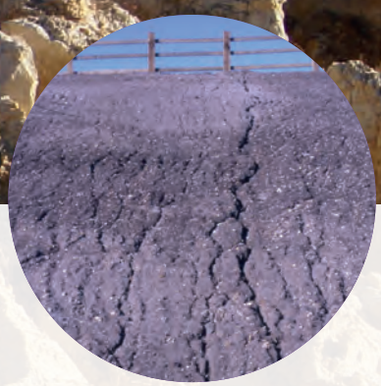


Slide away

Embankments and cuttings level out road gradients, but the soil slopes constructed on either side of the blacktop are vulnerable to erosion in heavy weather that could jeopardize the highway. Traffic could be endangered if the road surface slumps when an embankment is washed away, or if a cutting fails, dumping tons of earth onto the asphalt. So Prof. Jane Rickson at Cranfield University in the UK is using technology to predict when storm events will erode these highway features and to suggest how best to protect them.

"Cuttings and embankments take up a lot of land area. When land is expensive or it's not possible to take up such a wide swathe, then the soil slopes are made steeper and this affects their stability," says Rickson. "The steeper the slope, the more likely rainfall and run-off will wash away the surface. Wind erosion can also be a problem on newly constructed slopes. There are some simplistic models that forecast the change in the risk of erosion as the slope angle increases, but the real world is much more complex."

> The steeper the slope, the more likely rainfall and run-off will wash away the surface. Wind erosion can also be a problem on newly constructed slopes
>
> **Prof. Jane Rickson, Cranfield University, UK**

Roadside soil erosion is a problem all around the world, from Heilongjiang in China (main) **to Cambridgeshire in the UK** (inset)

For example, rainfall itself varies in storm duration, intensity, frequency and raindrop sizes, and soils have different characteristics that affect their looseness and mobility. Slope height and length are important erosion risk factors, as well as gradient, along with the type of vegetation on the slope. "We use thematic GIS layers of the factors affecting erosion to build up a risk map that pinpoints vulnerable areas," says Rickson, who is called upon when new road corridors are being planned. "So far, our results have been pretty sound at showing relative differences between areas of high and low risks," she says.

When high-risk sites are identified, the road builder has a choice. They can put protective geotextile blankets on the bare earth or they can seed the slope and hope vegetation grows fast enough to bind the soil before heavy rain falls that could wash it away. "That's a gamble and it can cost a lot in remediation and re-seeding if the gamble doesn't pay off," says Rickson. "The cost is probably an order of magnitude greater than using geotextiles to prevent erosion in the first place."

True grit

> The data our sensors collect and transmit can make it easier to decide precisely where to grit and salt, reducing waste and costs by up to 50%
>
> **Prof. Lee Chapman, University of Birmingham, UK**

The cost of gritting and salting ice-prone roads could be halved if cheap new road temperature sensors perform well in UK trials this winter. The test units contain a Melexis infrared thermopile to take spot-readings of the road surface temperature and a communications card to transmit the data in real time.

"They complement road weather stations and can be placed above locations where it's likely to be cool, such as bridge decks," says Prof. Lee Chapman of the University of Birmingham, UK, leader of the Wintersense project. "The data they collect and transmit can make it easier to decide precisely where to grit and salt, reducing waste and costs by up to 50%."

The UK spends over £150m (US$186m) annually on ice-mitigation, so sensors could quickly pay for themselves. "We've got each node to below £100 [US$124], partly by avoiding cellular comms which need relatively expensive SIM cards," he says. Instead the test units use wi-fi to share their data and the project is still open to all low-cost transmission technologies, including sub-GHz wireless for rural areas. "It's like the VHS versus Betamax battle and the cheapest method will win," says Chapman.

Working with roads maintenance company Amey, there will be more than 50 trials underway this winter.

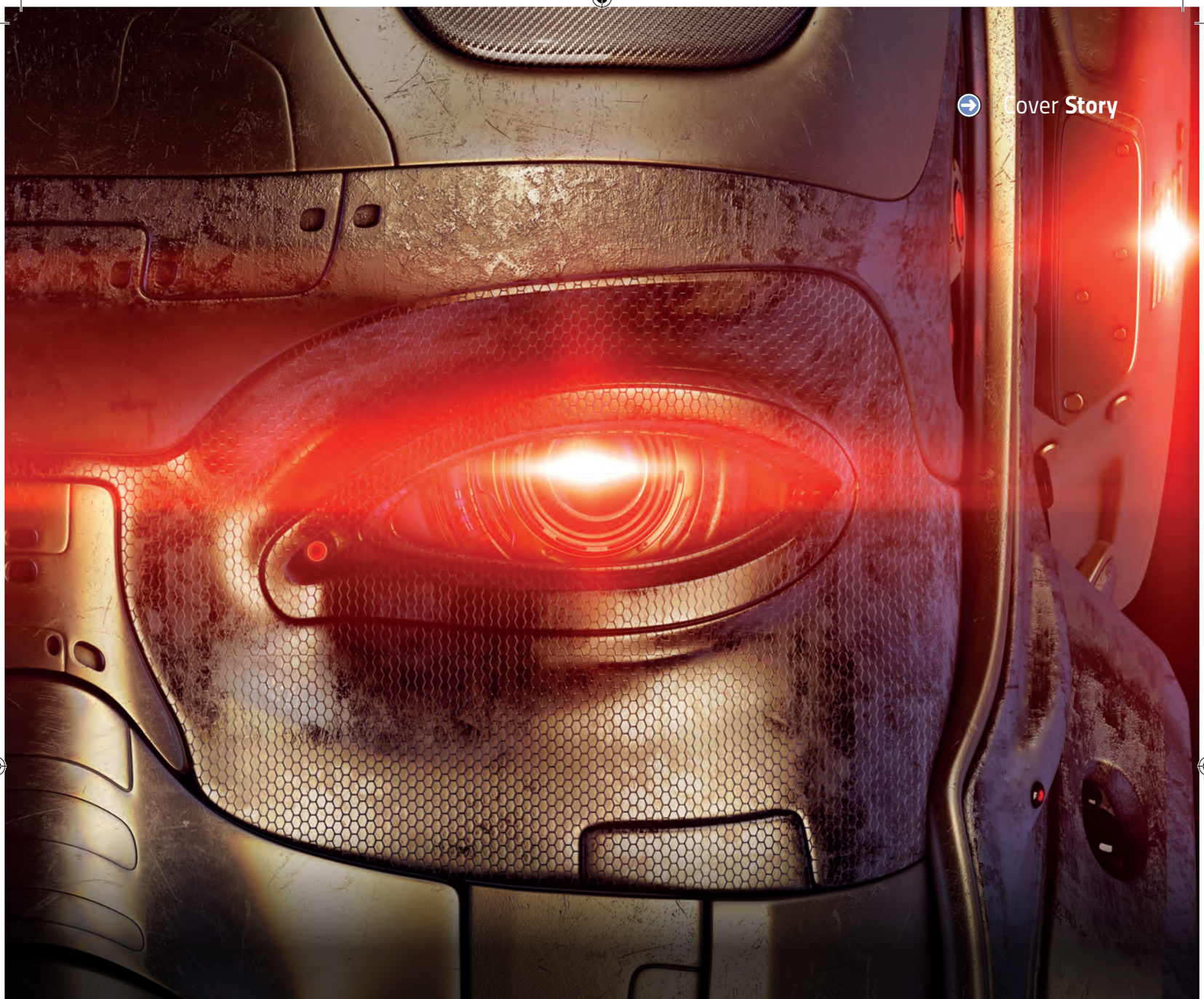
"Each deployment we've done has been a little bit different and has been tweaked. We want to get some universality so that the finished nodes can work everywhere," says Chapman. They're small enough to be clipped to signposts and lampposts and function at up to 19ft (6m) above the road surface. The lithium-thionyl chloride batteries last for up to three years.

The UK spends over £150m (US$186m) on salting roads every year

AI vision

Roadside cameras that capture images that are then analyzed elsewhere are becoming increasingly outdated. Modern traffic managers are beginning to demand cameras with intelligence and learning built in, thereby improving the speed and versatility of such systems, as **Saul Wordsworth** discovers

Illustration: Ociacia



Cameras are blind. They capture an image but they can't interpret it. Until recently, that task fell to humans. Today, however, digital technologies offer machine vision (MV), where cameras, image sensors and other types of image acquisition devices transmit an image or data to a processing unit for use in a larger system. In layman's terms, it's helping machines see.

Traditionally MV has been used for high-volume solutions such as traffic-counting, speed-enforcement and license-plate recognition, although its use has been restricted by the speed at which the system can identify and compute fast-moving, fast-changing environments.

> There's more to 3D scene perception than any one solution. MV gives you one source of information but it's only one source
>
> Dr Charles Fox, Institute for Transport Studies, Leeds University

"We're getting to a point where MV software is playing an increasing role in identifying things in a given environment," says Alex Shikany, director of market analysis for AIA, the world's largest MV trade association. "This includes being able to see events taking place within vehicles. There's a lot of new technology in MV that's going to help to take ITS application to the next level."

"Today you don't really want to be talking about MV as one discrete subject," says Dr Charles Fox, fellow at the Institute for Transport Studies, Leeds University. "Historically in academia MV has functioned as one subject. In a computer science department you'll find people who say they do MV

and there are journals on MV, but now it's all getting fused together."

While what could be termed 'simple' MV solutions still retain their place, a new vision is emerging that incorporates other technologies.

Seeing inside cars

In 2015 Dubai installed new cameras across the emirate. These used lidar sensors, and were intended to catch drivers speeding, overtaking illegally, driving on the hard shoulder or without a license plate. However, the system is able to ensnare drivers for in-car violations such as not wearing a seatbelt or using a mobile phone. Such uses of MV are new to ITS. In the 11 months after installation, 51,891 drivers were caught for an assortment of these violations, most notably on the Sheikh Zayed Road, Dubai's main throughway, which hosts 52 cameras.

"Drivers think the cameras target only speedsters but they can actually detect more than a speed offense in both directions," says Colonel Saif Al Mazroui, director of the General Department of Traffic. "We are focusing on Sheikh Zayed Road given its heavy traffic and the high accident rate. In the first nine months of this year, these accidents killed 122 people compared with 131 in the same period last year," he said.

Above: **New machine vision cameras in Dubai reportedly have the ability to recognize if a driver is wearing their seatbelt or not**

Vehicles must stay 5m apart or drivers risk a fine of Dhs400 (US$108) and four penalty points, with similar fines for phone users. All of this is possible with the aid of housing units that are known colloquially as 'Al Burj' because they share their sleek appearance with the proposed Dubai skyscraper of the same name. The MV technology is by Vitronic, which refuses to comment on how in-car violations are identified.

> It's almost easier to think about IoT and MV in terms of robotics. A robot can be trained to do a task a thousand times over to find the most efficient way to do it
>
> **Alex Shikany, director of market analysis for MV trade association AIA**

Although it is unclear which specific technology has been

No text please, we're British

Combining cellular phone signal detection with smart cameras has provided the basis for a new kind of enforcement system in eastern England

In-car cell phone use is a chronic hazard. One in every four accidents in the USA is caused by texting while driving. In the UK half a million people admit to regularly using their phone behind the wheel. In an effort to crack down on this, one English county, Norfolk, has run a pilot scheme using an innovative new technology to detect drivers on their phones.

"The technology we provided for the test was based on radio waves, similar to mobile phone detection systems used in prisons and for anti-industrial espionage," says Tim James, senior technician with Westcotec, specialists in road-safety technologies. "It is based on a commercially available system to detect active phones on GSM (2G) and 3G networks. It is positioned at the roadside,

in advance of a warning sign. Once a vehicle carrying a cell phone has come into range, the detector sends a radio signal to the sign, which provides a visual reminder to the driver."

In much the same manner as a speed camera, a photograph is taken, although, this being a trial, no fines were issued. The downside to this method of detection is that some phones are updating automatically in the background or being used using legal hands-free systems. This can cause a false positive but, as the project was to increase awareness among drivers, it was not considered a big issue at the time.

"It was very much a testbed for the technology and we always knew that it would be a work in progress," says Iain Temperton, team manager, casualty reduction at Norfolk County Council. "However, the media attention that the sign generated allowed us to spread our specific messages about cell phone use to the driving population of Norfolk and further afield."

> As machine learning approaches get better, we're going to see video analytics systems approach the level of competency of having a pair of human eyes on every video feed
>
> **Gary Brown, electrical engineer and vice president, Movidius**

deployed in Dubai, there is a fair chance it involves the Internet of Things (IoT) and cameras embedded with artificial intelligence.

"It's almost easier to think about IoT and MV in terms of robotics," says Shikany. "A robot can be trained to do a task a thousand times over to find the most efficient way to do it. Once it learns, the IoT enables it to transmit that information back to the cloud and then help other machines involved in the same application to learn how to do it instantaneously."

Embedded intelligence

The IoT effectively makes the MV cameras much more powerful, particularly those that have a sophisticated video processing unit (VPU) and are embedded with artificial intelligence. They are able to run deep neural network algorithms that allow computers to see the world much more like humans, recognizing objects and classifying events, actions and situations.

"Hikvision is using our VPUs as the front-end vision processor in a new line of intelligent cameras," says Gary Brown, electrical engineer and vice president at Movidius, a leading processor manufacturer with which Hikvision is collaborating. "These cameras are unique in that they deploy deep neural network-based video analytics and they are doing it right at the edge, rather than in the cloud. Thanks to a VPU being able to deliver computer power at the edge, they can deploy MV functions. While connected to the smart network video recorder (NVR) system, the cameras can also leverage modern IoT principles, so the whole system works in unison."

Deep neural networks have shown themselves to be superior to traditional computer vision approaches. Features detectors do not have to be hand-coded – instead the system 'learns' salient features. In addition, these algorithms are tuned

on massive data sets that give significantly greater accuracy than traditional approaches. The resulting algorithms are more capable and more accurate, right down to seatbelt and phone use detection, car model, make and color identification.

"As these machine learning approaches get better and better, we're going to see video analytics systems approach the level of competency of having a pair of human eyes on every video feed," says Brown. "This will turn our camera networks into proactive systems that can flag events as they happen, rather than passive systems that resemble what we have today."

Things... and beyond

Michael Klatsky, a project manager for New York City Department of Transport (NYCDOT), manages freight activity and uses machine vision to help in his job.

"A lot of camera technologies tell you what's going by. What's difficult is identifying each object. Most analytics software just sees a vehicle," says Klatsky. "We're moving to an era where we'll train computers to learn to recognize things." The DOT will tap into a network of cameras and sensors, its own and those of other agencies, to process the video data with mainframes. Currently it is a pilot scheme, using software by Worknet Analytics.

"IoT provides raw data but it's not really processed," says Klatsky. "The next stage is the Internet of Recognition (IoR). We have recently been compiling a safety report on crashes between trucks and bikes. With IoR we hope to have video running constantly that recognizes the truck and bike, and when the two get close the computer creates an alert. We capture each occurrence and recognize there are close calls on that corridor. All of this will help us make better informed decisions to service our citizens and users better."

Not everyone agrees connectivity is the way forward. Some feel uncomfortable about the interrelationship between objects, and believe it could be dangerous. "I am rather negative about the IoT," says Roy Davies, professor of machine vision at Royal Holloway, University of London. "It has recently been cited as a way of breaching personal security. It seems rather an unneeded optional extra that will only create problems."

Fox agrees that rushing ahead with more machine vision could create problems. "One thing that worries me is the privacy issue around roadside detection data," he says. He was part of a project that breached the data privacy protection process for the ALPR cameras on the M25 London orbital."[1] So in general I am worried about how recognition technology will continue to interact with privacy concerns," says Fox.

Whether or not these fears are founded, it's clear that by working with other solutions and interacting with its environment, machine vision looks set to shape important aspects of ITS in the coming years. ○

1) Origin-Destination Analysis On The London Orbital Automated Number Plate Recognition Network (tinyurl.com/m25study)

Right: **The latest cameras have built-in 'deep neural' video analytics, so no longer need to rely on cloud processing power**

Eyes on the road

Machine vision has been utilized by Highways England as a way of quickly and accurately surveying thousands of miles of roadway

When the Highways Agency became the government-owned company Highways England (HE) in 2015, a full asset inventory was required. This meant gathering data on 22,000 miles (35,300km) of roadway. It was a project that, from the outset, looked likely to be costly in terms of lane closures – and inherently dangerous. But then HE teamed with IBI Group to create a highway-speed information gathering system.

The mobile mapping solution combines IBI's Routemapper – a geo-referenced highway video system – with lidar to enable high-quality data to be collected at high speed then back-office processed. Data gathering is performed by a vehicle decked out with cameras and lidar-sensing technology, which travels at a speed appropriate to the surveyed road. High-resolution images are recorded before machine vision technology is deployed to scan the vast numbers of images generated.

Illustration: Octacia/shutterstock.com

> "IoT provides raw data but it's not really processed. The next stage is the Internet of Recognition (IoR)
>
> **Michael Klatsky, project manager of freight mobility, NYCDOT**


FUTURE SIGNS
BUS

As wireless communications become more efficient, **David W Smith** discovers that the number of places it is possible to deploy fully connected VMS is rapidly growing. In London they can now even be found on the backs of buses

Transport for London (TfL) has a reputation for coming up with innovative ideas but, even by its standards, the decision to attach portable variable message signs (VMS) to the backs of London's iconic red buses was an eye-catching move. The concept is so unique that it has attracted publicity from around the world, including from TV stations in Australia. The VMS are being trialled on two busy central London bus routes and, if the experiment is successful, they could become a common sight across the capital's network of 8,000 buses.

"We've long had an ambition to get real-time traffic updates onto the network that are relative to the driver's position," says Christian van der Nest, TfL's surface integration manager. "We already have 150 VMS in London, but it's not easy to find locations and you often need planning permission, yet buses are perfect. Car drivers can see them easily, we don't need planning permission and they travel along predetermined corridors that are well-known to regular drivers."

> Buses are perfect for VMS. Car drivers can see them, we don't need planning permission and they travel along predetermined corridors
>
> **Christian van der Nest, surface integration manager, TfL**

Van der Nest and his team did some digging around and couldn't find evidence of anyone trying out similar ideas. "The press release got a lot of attention because of the originality. We're lucky at TfL because we have a lot of assets and infrastructure, and a big transport network that is ideal for carrying out

150

The number of 'standard' VMS controlled by Transport for London

Source: TfL

500

The number of London bus routes that could feature portable VMS if the current trial is expanded

Source: TfL

small trials. Smaller municipalities might not have the resources to test such concepts," he says.

Real-world deployment

The first six-month trial of the boards began back in August on five buses along the 344 bus route between Clapham Junction and Liverpool Street. A second six-month trial on another five buses will begin soon on route 415 from Tulse Hill toward Old Kent Road. The sturdy signs are vandal-proof. They are enclosed in steel boxes and fixed securely onto the bus frames.

"The aim of the signs is to reduce congestion and pollution from engines idling along the routes. For example, on the 344 route, Tower Bridge is currently closed for maintenance, so drivers traveling along Battersea Park Road to Liverpool Street will see that information and be able to make an informed decision. They could possibly use Blackfriars Bridge instead," he says.

The boards are necessary, van der Nest adds, because car drivers rarely consult traffic information before setting off. TfL research has shown that tube and bus passengers are much more likely to find out about delays before they travel. "Drivers only discover later on that there's congestion. There's car radio information, but visual clues are much more powerful and effective," says van der Nest.

The boards are not just for live information. They can carry warnings about imminent road closures caused by major scheduled events, such as the annual London marathon. The boards might indicate, for example, that there will be extensive road layout changes two weeks ahead of the race. Drivers can plan in advance which alternative routes to take.

When is a VMS not a VMS?

Technically, the signs are not standard VMS, but 'digital information boards'. When TfL ran the tender for the trials, no manufacturer of VMS applied for the job. Both tenders were won by software companies. Equitech IT Solutions has made the signs for the 344 route buses and BrightCove has mode those for the 415 route. "To be defined as VMS, it has to meet certain standards to be put on the road. Strictly speaking, it's a dot matrix digital information board on the back of a bus, although it looks the same as a VMS," van der Nest says.

Above: **Transport for London's bus-mounted VMS**

Right: **A temporary VMS system in use at the approach to London's Tower Bridge**

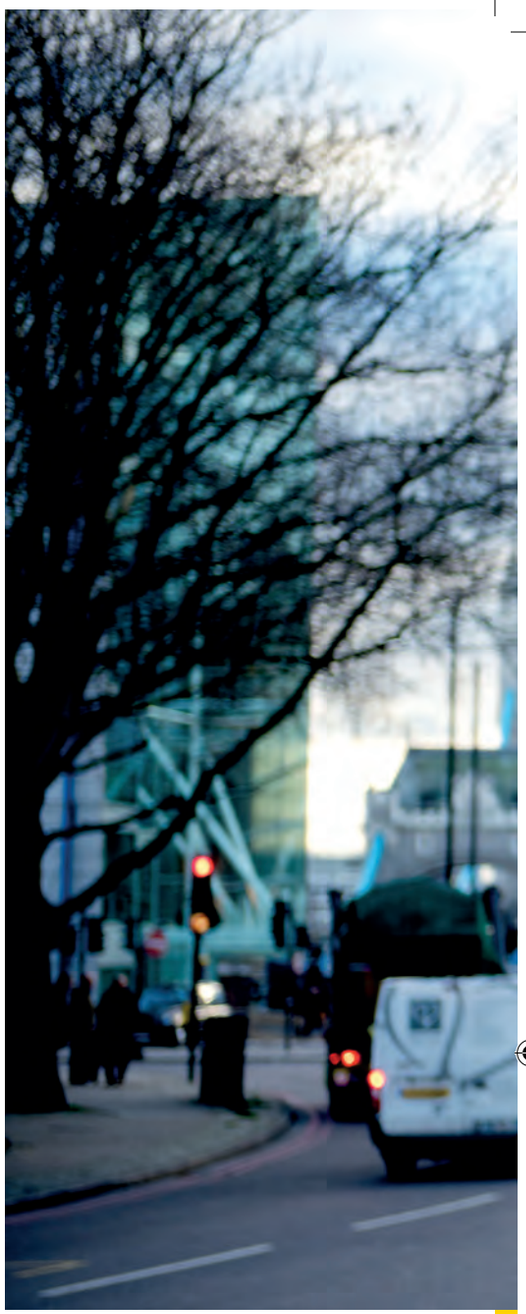
The bus boards receive the same real-time information as London's 150 standard VMS. The information comes from the TfL VMS network, which in turn is fed by TfL's 24-hour traffic control center. But the bus boards are more flexible than standard VMS. They are able to change the messages shown on the screens as the vehicle moves through different locations.

> We've created a geo-fence around each of our 150 VMS with a radius of about two miles. Any bus entering that radius will show the same messages that are displayed by the fixed VMS in that area
>
> **Christian van der Nest, surface integration manager, TfL**

"We've created a geo-fence around each of our 150 VMS with a radius of about two miles. Any bus inside that radius will show the same messages that are displayed by the fixed VMS in that area," explains van der Nest.

Even if the bus diverts from its standard route, it will still display the correct messages for its new location, which it picks up from the geo-zone information. "If we moved the standard VMS sign, we'd have to go into the platform and change the message for that particular geo-zone. The bus boards will even show two or three different signs if they are on the borders between different geo-zones. It cycles between them every 10 seconds," he says.

One of BrightCove's specialisms is providing the boards that sit atop London taxis like shark fins showing adverts. When TfL first mooted the idea of attaching signs to vehicles, they conducted an ingenious proof-of-concept trial on these boards between December 2015 and May 2016. "Before we started asking companies to make the hardware for the buses, we wanted to make sure it was possible for the boards to pull



Idle hours

A pilot project on London's Tower Bridge in 2016 used portable VMS in an attempt to get drivers to turn off their engines while waiting

As part of TfL's 'no idling' campaign to reduce pollution and emissions, AECOM integrated Bartco portable VMS with the traffic lights on Tower Bridge, within a trial system in 2016. The eight solar-powered VMS informed drivers when the bridge was raised and said they should switch off their engines. The trial ran from February through to September.

"Normally, when Tower Bridge lifts, drivers on the approach roads queue with engines running. Excessive idling, particularly of HGVs, significantly increases emissions in the local area," says Paras Shah, AECOM's principal consultant.

"The trial was designed to reduce the amount of idling and also to raise awareness of air quality issues. We're still analyzing the data to determine the influence of the signs."

Each sign was fitted with wireless networking equipment that allowed a back office system to communicate with it and activate the messages when a bridge lift was in operation. A traffic signal controller at the junction of the northern approaches to Tower Bridge received the data feed from a relay on the bridge, via a communications cable. It signaled for the bridge to come down, or go up, and triggered the traffic signal plans. "We placed wireless communication equipment next to the controller and a parallel output of the data feed transmitted the status of the bridge to the back office system to activate messages on the VMS when a bridge lift was in operation," Shah says.

through the VMS data and beam it onto the platform. The adverts on taxis were periodically interrupted with TfL's VMS messages, and our research showed that 50% of people we contacted had seen them," van der Nest says.

The taxi trial was a success, but the backs of buses should prove a more congenial location. On the taxis, the display is to the side and less visible to drivers. The bus boards also have the same visual characteristics and size as standard VMS, so traffic information jumps out. Also, TfL has not allowed them to carry adverts. "They only have traffic information as we didn't want to dilute the messages. There was a danger drivers would think, 'Oh, it's another advert' and not pay attention," he says.

Following the trials, a research company will carry out qualitative

Left: **Flashing signs can alert drivers to hazards on the road ahead**

Below: **Dynamic messages that can also be transmitted to in-car screens are an effective way of alerting drivers to workzones**

research to determine their impact. "We want to know two things about how people are engaging with the information. The first is more practical – will it make them re-route their journeys to avoid congestion? The second is more psychological – are they happier sitting in traffic with the knowledge of why they are sitting in traffic? After all, there's nothing worse than not knowing why you're stuck," he says.

Whether the signs help to reduce congestion on the roads will be harder to assess in such a small trial. There are too many variables and more detailed research will be required to identify those kinds of secondary effects. Nevertheless, any such detailed study could provide enough relevant feedback to know whether the goal of wider deployment is a consideration that is worth pursuing.

Above: **The C-ITS Corridor runs between Rotterdam and Vienna, utilizing V2X technology across three countries**

40

The percentage of the average car journey in which the vehicle is idling

Source: Professor David Begg

"So far the trial has been operating brilliantly. The platform itself has been shown to be stable and the hardware has been absolutely as solid as a rock. The suppliers say that the messages have been displaying successfully," says van der Nest.

"If we decide to go ahead with wider deployment, we might start with 500 of the busiest routes and then go from there."

Van der Nest's enthusiasm for the project is evident. He delights in tracking the buses on his smartphone, and is able to log in to the operating platform and watch the trial unfolding. "I can sit at my desktop computer or watch at home on my smartphone and see where each bus is and the direction it's traveling and what message it's showing at any moment," he says.

Going Dutch

Meanwhile, in the Netherlands, EBO van Weel, the largest provider of portable VMS, is providing innovative vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) communication from its VMS trailers for the C-ITS Corridor project between Rotterdam and Vienna. The transport ministries of the Netherlands, Germany and Austria have signed a joint agreement to develop 'cooperative' technologies that make the long corridor safer and improve traffic flow. Participants include BMW, Daimler, Open and Volkswagen. The objective is to develop a common European standard for V2X-communication and establish a system that can be used in the future.

> We've done trials in the Netherlands showing we can contact vehicles 1km before road works. By the time they reach the VMS, they have already changed lanes and decreased speeds
>
> **Rene van Weel, managing director, EBO van Weel**

The trailer-mounted VMS send out messages to alert drivers to road works ahead using GPS and wi-fi technologies. "We've done trials in the Netherlands showing we can contact vehicles 1km before road works. By the time they reach the VMS, they have already changed lanes and decreased speeds," says Rene van Weel, managing director, EBO van Weel. The company will trial the technology in front of its C-ITS partners in late November.

The warnings are sent in two ways. The first path is through V2X. The message travels from the portable VMS system via the traffic control center, to the driver. The second path involves the more direct V2V approach. The portable VMS system sends information regarding its position straight to the approaching vehicles.

The company is also working with the makers of the popular Dutch travel app Flitsmeister to alert drivers ahead of time about the presence of road works.

The Flitsmeister app shows all mobile and temporary speed cameras in the Netherlands and is used by a million drivers. Now there are plans to integrate detailed information about the whereabouts of all VMS on the road network.

The more that new technologies can be used to deliver relevant and specific information only at the right times and only to drivers in the right places the more efficient the entire network will become.

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Future road

A 19-mile live testbed on Germany's A9 will be a proving ground for V2V and V2I communications via 5G

Swedish telecommunications company Ericsson has announced that it is deploying a dedicated 5G network using the 700MHz waveband, on one of Germany's main highways for the testing of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.

The 18.6-mile (30km) test route is along the A9 motorway between Nuremberg and Greding. The stretch is part of the 'Digital Test Field Motorway', which was set up by the German government as an area where the automotive sector, digital economy, and research institutions can trial pioneering systems and technologies under real-world conditions.

The infrastructure has already been completed on the first sections, meaning live tests can now begin.

Testing from the project will provide traffic managers and vehicle manufacturers with a better understanding of how connected and autonomous vehicles will operate on public roads, en masse, in the future.

"With the next mobile network standard, 5G, we are firing the starting shot for the digital real-time era," said Alexander Dobrindt, Germany's Federal Minister of Transport and Digital Infrastructure. "5G is a key technology for automated and connected driving, enabling direct data communication between vehicles and infrastructure."

52 – Serious state
With new technology, USDOT's Connected Vehicle Pilot Program is helping drivers in Wyoming to safely navigate a treacherous stretch of I-80 during winter months

56 – Beacons of bandwidth
As vehicles place increasing demands on data networks, transportation agencies are turning to static infrastructure to act as new network nodes

USDOT Connected Vehicle Pilot Program (Phase 2) Update

Part Two

Wyoming

Serious state

In the second of our comprehensive updates on USDOT's Connected Vehicle Pilot Program, James Gordon visits Wyoming, where winter 2016/2017 is bringing with it hope that, in the future, technology will help drivers to safely navigate a notoriously treacherous stretch of I-80

Photographs: Tim McGary/WYDOT

400

The total number of vehicles being equipped with DSRC-enabled onboard units in Wyoming

Interstate 80 is one of the USA's longest and most-used roads. You could be forgiven for thinking that the most perilous sections are located close to the major population centers of San Francisco, where the road starts, and New Jersey, where it ends.

But just over 1,000 miles east of San Francisco, in the USA's least populous state, Wyoming, is a part of the road that is so treacherous that even the cast of *Ice Road Truckers*, some of the nation's most fearless drivers, might struggle to negotiate it.

Staggeringly, last year there were 1,500 crashes involving over 1,900 vehicles on this 402-mile stretch of highway in Wyoming. The collisions resulted in 253 injuries and claimed 13 lives. Trucks were involved in 653 crashes in the same period, with eight fatalities.

"Sections of I-80 between Cheyenne and Laramie saw 250 hours of road closures last year primarily due to weather or weather-related incidents," says Vince Garcia, Wyoming Department of Transportation's (WYDOT) GIS/ITS program manager. "For every hour that the road is blocked, the cost to the economy is US$1.3m. In the past 11 months, we estimate that closures and crashes cost US$1.1bn. There were also more than 180 hours where light and high-sided lorries were restricted."

Getting connected

In September 2015, USDOT selected WYDOT as one of the three pilot sites for the Connected Vehicle Program. The goal of the pilots is to demonstrate the value of next-generation V2X technology to improve safety and mobility.

In Wyoming, the pilot is an opportunity to reduce the impact of inclement weather for trucks using the mountainous corridor, which has a peak elevation of 8,638ft (2,633m). Funded largely by USDOT, the

US$5.2m pilot, which is scheduled to be operational by 2018, has been divided into three phases. The team – ICF International, Trihydro, McFarland Management, the University of Wyoming, the National Center for Atmospheric Research and WYDOT – completed the concept development phase in late September.

The scheme is aiming to recruit 200 large rigs and 100 small- to medium-sized trucks, which will be equipped with onboard technology with dedicated short-range communications (DSRC) capabilities. The pilot will also equip 100 WYDOT highway patrol cars and snowplows. Led by Vince Garcia and Ali Ragan, WYDOT and the team are working with freight partners to identify other vehicles for the pilot.

"Our pilot focuses on the needs of the commercial vehicle operator whose job compels them to be on the roadway during adverse weather," says Ali Ragan, WYDOT's deputy lead for the pilot. "Through this initiative, we hope to give them the tools to ensure they get home safely."

> Our pilot focuses on the needs of the commercial vehicle operator whose job compels them to be on the roadway during adverse weather
>
> **Ali Ragan, deputy lead, Connected Vehicle Pilot, WYDOT**

Below: **The Connected Vehicle Program will see 100 WYDOT vehicles, including snowplows, equipped with onboard technologies**

Real-world deployment

But what does this exciting new digital landscape look like in physical terms, more importantly, and how does it work from a technological perspective? One man fluent in the language of IT infrastructure is Tony English. English, who has worked for Wyoming-based engineering and environmental consulting firm Trihydro Corporation for 20 years, is the project's systems development lead.

"The first hurdle is to equip 400 vehicles with onboard units," says English. "These units will allow a vehicle to share and receive information via DSRC from other connected devices [vehicles and roadside units], broadcast and receive a standardized basic safety message [BSM], and receive traveler information messages through a human-machine interface that allows alerts to be communicated with the driver. These units will support applications such as collision warnings, alerts of downstream conditions such as closures, spot weather impacts, and workzones. Through these warnings, a driver with this technology will have a heightened situational awareness of road conditions on I-80.

"In parallel, we will install 75 roadside units [RSU] on I-80, each one compliant to USDOT RSU 4.1 specifications. The RSUs communicate and receive information from equipped vehicles. As this stretch of road is so vast, it's not practical or cost-effective to equally space the RSUs. Instead, we have identified strategic locations, key interchanges, crash hotspots and parking locations, where the DSRC can have the most impact. In addition, we will be delivering these messages to a subset of our vehicles using satellite," explains English.

Working proof?

The theory is that the WYDOT Transportation Management Center (TMC) receives road condition information from sensors mounted on WYDOT fleets, which transmit the data via RSUs. In addition, WYDOT uses a road condition monitoring system on I-80 to supplement the mobile fleet operations. Using this information, the TMC generates localized alerts and advisories that are transmitted to the relevant RSUs and then to passing vehicles that have the onboard technology.

"Locally, what is groundbreaking about the pilot is the operational use

75

The total number of roadside units being strategically placed along I-80 in Wyoming as part of the pilot

Above: **Ice, strong winds and heavy snow make I-80 arguably the USA's most hazardous interstate in the winter months**

Tampa, FL

The third location in the USDOT's Connected Vehicle Pilot will focus on using the technology to manage reversible express lanes. Look out for our full report in the next issue

New York

Last issue, we brought you a report on the first location in the USDOT's Connected Vehicle Pilot, New York City. To read it you can access the issue online for free at tinyurl.com/nycpilot

of the V2V communications that enable equipped vehicles to talk to each other," says Vince Garcia, WYDOT's program manager.

"Let's picture I-80 in January. In the heart of winter, motorists are subjected to a myriad of natural hazards including blowing snow and high winds. Our snowplow operators have to be out on the roadway during these times and ensuring their safety is critical to WYDOT. Imagine a situation with poor visibility and a slow-moving snowplow. Behind it is a heavy-freight vehicle that is equipped with our technology. The trucker cannot see the snowplow yet, but his vehicle receives a BSM from the plow alerting it of its presence. The truck system can then warn the driver of the slow vehicle ahead, preventing a rear-end crash. This is one of the many scenarios that our pilot is looking at," says Garcia.

Counter (flow) intuitive

WYDOT has also developed technology to reduce the number of vehicles involved in a crash. A Distress Notification application allows vehicles traveling in the opposite direction to carry a distress message.

"We believe that the Distress Notification technology will reduce the number of vehicles involved in pile-ups," says English. "If a vehicle fitted with DSRC is stopped for a mechanical issue, for example, a distress will automatically be sent out. It will alert any DSRC-enabled vehicles within a 300m (1,000ft) range. A V2V alert will immediately be relayed to a vehicle traveling in the opposite direction. The truck traveling the other way immediately rebroadcasts the message with the location data of the stationary vehicle to the nearest RSU, which will in turn relay the car's positional data to the TMC. And as countermeasure to avoid a pile-up, the truck will also issue an alert to those driving in the opposite direction for about five miles, who might be unwittingly heading for the vehicle."

New meets old

The system is at its best when it fully utilizes V2V, V2I technology and the existing traveler information services. "Our 511 app and commercial vehicle operator portal (CVOP) will continue to be an important way for us to amplify the messages to drivers on I-80. We've seen a huge interest in the 511 app, with over 26,000 downloads in just seven months of operation. We see over 800 firms from across the country that are subscribing to our forecasts on the CVOP. By utilizing connected vehicle data to improve these services as well, WYDOT can get the message out to the travelers on the roadway."

> The truck system can warn a driver of the slow vehicle ahead, preventing a rear-end crash
>
> **Vince Garcia, lead, Connected Vehicle Pilot, WYDOT**

Moving toward public deployment is still some way off, but with the second phase in full swing, Deepak Gopalakrishna, the program management lead from ICF, outlines the remaining tasks to be completed: "We need to formalize agreements and finalize the system architecture, procure and install equipment, and develop the applications. During the next year, we'll finish installing the equipment and integrate the systems within the TMC. Initial testing will take place in the winter of 2017 using WYDOT fleets. Our operational readiness test will be in the spring of 2018. If all goes well, the system will then go live in mid-2018."

The successful completion of the first phase is evidence of the leadership and support provided by the USDOT and the collaborative approach used by the three pilot sites, notes Garcia. "We appreciate the opportunity provided by USDOT to bring cutting-edge technology to bear on I-80. We are creating a scalable and replicable model for connected vehicle deployments for other rural but critical corridors such as ours," he says.

11.5bn

The predicted number of connected mobile devices on Earth by 2020 (1.5 for every person alive)

Source: Cisco

Beacons of bandwidth

With connected vehicles placing increasing demands on already stretched data networks, transportation agencies are turning to static roadside infrastructure, such as lampposts, to act as nodes in a smarter network. **Max Glaskin** shines a light on their new role

Lampposts, the traditional props for drunks, can also support communications technologies for transport. Low-powered radio access nodes, known as small cells, are being installed in the ubiquitous lighting poles and other common street furniture to link vehicles and others with wider networks.

Small cells typically have a range from 10m to a few hundred meters and may operate in the licensed mobile or unlicensed wi-fi spectrums. With global mobile data traffic predicted to grow ninefold in the four years to 2020, and much of that likely to be taken up by V2X communications, they are a smart way to increase capacity where it will be most needed.

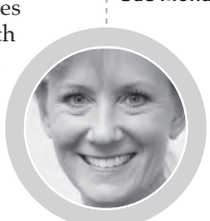
The city of San Jose, California, is piloting 50 Philips SmartPoles that combine LED lighting with Ericsson's wireless broadband technology. Los Angeles is installing another 100 of them. Every pole has a fiber connection and they accept FCC-licensed wireless mobile network operator equipment, providing an alternative way to deploy 4G/LTE broadband services.

Left: **Philips SmartPole's are being installed in California to provide 4G broadband via a fiber network**

While some cities have the resources to install brand-new lampposts, others with more modest means might be interested in a retrofit solution such as those designed by UK consultancy The Technology Partnership (TTP). Its eNodeB is based on NXP Semiconductor's QorIQ Qonverge processor, incorporating LTE access. It has a design range of 50m to support 32 active users at potential downlink rates of up to 100Mbps.

53
The percentage compound annual growth rate of mobile data traffic between now and 2020
Source: Cisco

> "Hosting small cells on lampposts offers a number of obvious benefits to mobile operators, but also some challenges – not least of which is the limited space available"
> **Sue Monahan, chief executive, Small Cell Forum**



The eNodeB plugs into a lamppost's standard photocell socket to minimize the installation process and doesn't require any other modifications to the pole. "Since it was launched in 2015 there's been good interest in our solution and now we're working with a 4G operator to take it toward commercialization," says TTP's Steve Baker.

Lighting the way

Sue Monahan, chief executive of the Small Cell Forum, explains the appeal of the street lighting poles as locations for base stations: "Hosting small cells on lampposts offers a number of obvious benefits to mobile

100
The number of Philips SmartPoles (LED lighting columns with wi-fi) being installed in Los Angeles, California
Source: Philips

operators, but also some challenges – not least of which is the limited space available." So should mobile operators consider sharing small cells in lampposts with one another?

"While sharing is relatively common with macro networks, it is new territory for operators deploying small cells," says Monahan. "Macro site sharing is typically based on Multi-Operator Radio Access Networks (MORAN), with the same base station supporting multiple radios running different frequencies. However, integrating several RF units in a small cell would make it too bulky and heavy for deployment on many sites, such as lampposts, street furniture and street signs. More suitable for small cells is a Multi-Operator Core Network (MOCN) configuration in which operators use one base station and share their frequency bands, linked to each other's core network."

32
The maximum number of users that can access 4G/LTE via eNodeB, which plugs in to a lamppost's standard photocell socket
Source: TTP

Small cell deployments

Arqiva in the UK began trialling small cells on lampposts in the city of Southampton in 2014, and John Lillistone, the company's head of telecoms product, tells *TTI* it is still developing. "Arqiva continues to roll out small cells at various sites across London, including on street furniture such as lampposts, along with our established indoor coverage solutions," he says. "While our current Internet of Things/machine-to-machine (IoT/M2M) networks can support transport solutions, we are aware of the potential for some 4G variants and 5G in that arena and are in active dialog with a number of interested agencies, including Highways England."

Lampposts are not the only small cell hosts, and other familiar objects can be better suited because they have more space available for bulkier equipment. Outdoor advertising company JCDecaux is partnering with Verizon Wireless to deploy 4G LTE small cells in several cities in the USA and has reconfigured advertising columns to integrate small cells in San Francisco. Also, it can modify illumination within the traditional 2m² advertising panel in its bus shelters, replacing the bulky fluorescent tubes with edge lighting to create enough space for four small cells. The antenna is on the roof of the shelter. Like lampposts, this kind of street furniture is always found on the sides of roads, and therefore perfectly located for serving the increasing bandwidth demands of connected vehicles.

"It took some time working with Ericsson, Alcatel, Lucent/Nokia and Huawei to finalize the design and layout so that up to four small cells can be installed by different operators, sharing the costs of fiber, power and rent," says Marc Merlini, business development manager at JCDecaux Link.

The system serves current cell communications standards and will come into its own when 5G arrives in 2020. The higher bands it will use, above 24Ghz in the USA, will require smaller cells with line of sight and, more often than not, bus shelters in cities meet those requirements.

The idea of using lampposts and street furniture to host communication nodes has a long history. Metricom installed its Ricochet wireless internet access units on lampposts in US cities as far back as the mid-1990s, long before even GPRS was available, and in the UK, T-Mobile designed new lampposts incorporating 3G connectivity in 2003. The lessons learned from those projects are now being used by the current innovators to make use of the drunk's best friend in a smart and sober way.

> We are aware of the potential for some 4G variants and 5G in transport and are in active dialog with a number of agencies, including Highways England
>
> **John Lillistone, head of telecoms, Arqiva, UK**

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traffic TECHNOLOGY INTERNATIONAL

The simplicity of precision

The first mobile wheel-load scales were heavy, bulky, high in profile and equipped with an analog indicating device. About 40 years ago the first low-profile scales were introduced into the market, still with an analog indicator. At the same time electronic wheel-load scales with a digital indicator appeared. Haenni's WL 103, a low-profile scale with digital indication, could be linked with others of the same model or to a separate printer/indicator, giving greater convenience. With the WL 104 model, a combined solution for static measurement and WIM functionality now also exists.

"There remains a large customer base of around 60% that is still using analog scales and only 5% that's using WIM," says Daniel Kneubühl, managing director of Haenni Instruments. To understand why that is, it's necessary to go back in history.

Above: **Handcrafted Haenni scales are made in Switzerland**
Left: **Haenni's WL 101 scale in use**

Need to know

The WL 104 acts as a solution for static measurements and WIM functionality

- Two or more scales can be lined up to form a seamless weighing strip
- The scale is easy to transport and can be used at any time, without ramps
- The WL 104 is capable of weighing static vehicles to OIML R76 certified accuracy
- It can also weigh dynamically – after a vehicle has passed the scale, its weight, velocity and axle spacing are calculated

User error

Until the 1960s, the platform scale was considered the sole usable means of determining the weight of goods vehicles. The introduction of portable static wheel-load scales led to a considerable rationalization of weight enforcement because measurements could be quickly taken almost anywhere. However, there was also a problem with the accuracy, which was frequently, and incorrectly, attributed to the scales. On closer examination it was established that, in most cases, the errors arose from faulty use, for instance through the omission of leveling during the sequential measurement of multi-axle systems.

Today these problems are known to users, so errors are avoided and the use of portable static wheel-load scales for weight enforcement has become a generally recognized method. Their accuracy lies only slightly below that of a weighbridge, as long as the product used is of corresponding quality, i.e. that it has been approved in accordance with the International Organization of Legal Metrology (OIML).

These days, with the increasing spread of WIM systems, there are difficulties similar to those experienced earlier with portable wheel-load scales. The errors of that time are not being repeated, but new ones are occurring. In addition, for many users knowledge is still rather patchy regarding the achievable precision of WIM systems. Some users may require precision in the order of 1%, even at high speed. Others may require even greater levels of accuracy. Where does the truth lie? To get to the bottom of this, one must delve into the theory of scales.

Confounding factors

The size of measurement errors due to vehicle oscillation

depends on various vibration exciting factors – vehicle speed, road quality and vehicle quality. In the best scenario, when a vehicle with the best suspension is traveling at 3mph (5km/h) on a very good road, these factors' combined error is no more than 1%. At 30mph (50km/h) it is 2% and at 60mph (100km/h) it is 3%.

However, the influence on precision changes dramatically when road quality is only average and the vehicle has poor suspension. At 3mph the error multiplies eight-fold to 8%, at 30mph it's a worrying 30% and at 60mph it's a startling 40%.

So, in principle, good results are only possible with the best possible road quality and with vehicles with good suspension. This highlights the first fundamental point of dispute. The manufacturer of the weighing system is responsible for the accuracy of the sensor but has only a very limited influence on road quality and its deterioration over time, and certainly has no influence on the quality of the truck.

Could this be a reason for continuing to use analog scales? Beat Cotting, sales manager at Haenni Instruments, is convinced of it: "Our best-selling WL 101 is the only pure wireless scale on the market, the thinnest mechanical instrument and is almost maintenance free. It's the right tool for the demanding professionals."

Maybe he is right. Sometimes the simple solutions are the most valuable. ○

by **Neil Hoose**

We must prepare for all real-life autonomous driving scenarios

When I started to write my previous column on the relationship between autonomous and connected automation, I asked myself how much knowledge an autonomous vehicle would have to have and understand to complete an end-to end journey. The more I considered it, the more of a challenge it became. The situation is complicated by there being multiple levels of automation and varying road environments.

By definition, SAE has six levels (0-5) of automation. We can also identify five major road environments: multilane highways, single carriageways, rural roads, urban main roads and residential streets. The outcome is a 6x5 matrix of scenarios that need to be considered. However, that simplification may be illusory because the five main categories of road that I have identified can be further divided. In England (but not in the other countries in the UK) there are three varieties of motorway, depending on whether there is an emergency lane – and if there is, whether it can be used by traffic under certain conditions. Similar motorway arrangements exist in Germany and the Netherlands.

Rural road types can be segregated into dual carriageways; single carriageways; two-lanes; and two-lanes with an additional lane in the middle for overtaking – and this latter road type may be restricted to one direction or it may be used by both directions of traffic.

In urban areas there are further permutations, as well as additional facilities for buses, trams, cyclists and pedestrians. It is clear that there is a lot to know and work out for a single journey.

Into all this we are now bringing automated vehicles and it is clear that there will be many types. SAE levels categorize these types at a basic level, but each vendor will want to have its own differentiating factors. The behavior of vehicles operating at levels 3-5 is determined by their programming, but who determines what that programming will be?

Will a vehicle be dominant if it has to arbitrate with other vehicles when merging onto a motorway or emerging from a priority intersection? Will the vehicle strictly obey traffic regulations or will it exercise some degree of judgment depending on the situation?

"Will the vehicle strictly obey traffic regulations, or will it exercise some degree of judgment?"

It is not clear whether the attributes of 'character' have yet been explicitly defined and who will be responsible for determining them. It could be the role of governments to determine the limits of character, or they could be set by the manufacturer. Or it could be the vehicle user who selects the character of the automated driver they want. Further, with connected, automated vehicles there is also the potential for the road manager to step in and externally influence the character of a group of vehicles on a certain stretch of road to improve the traffic flow situation for all vehicles.

The potential of automated vehicles and connected highways raises questions that have hitherto been seen as a matter of public education rather than actual traffic management. As we embark on what may prove to be a major shift in the way roads are used, we need to think about such matters. Once the scale of autonomous vehicle use has increased, it will be impossible to go back, and the result could be a flawed system that does not deliver fully on its promise.

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

Driving on thick ice

Seven hundred years ago it was possible to travel on an ice road across the frozen Baltic Sea for more than 300 miles (480km), from Estonia's largest island, Saaremaa, to Lübeck in Germany. Establishing ice roads and driving on them has a long history in Estonia and many road users look forward to it every winter.

When the weather is right, around 10 official ice roads are established in Estonia, the longest of which is 15 miles (25km) and the shortest up to 1.2 miles (2km). In 2010 and 2011, the ice road between the country's second largest island, Hiiumaa, and the Estonian mainland was the longest in Europe, at about 14 miles (22km). The responsibility for the establishment and control of ice roads lies with the Estonian Road Administration.

How does one start to make an ice road? "God provides the weather first," chuckles Roger Õiglas, who is a recognized Estonian ice road expert. There must be five to six degrees of stable cold and preparation begins when the ice is 4-5in (10-12cm) thick at the shore, strong enough to walk on.

"We walk and see how the flow sites and the so-called breathing sites are freezing over. Those are the places where the salty water begins to press up and which are free of ice for longer," explains Raivo Õiglas, who has been working as an ice road expert for more than 40 years. He taught his son Roger how to do the job, too.

Controlled drilling

Next, father and son use a navigational chart to enter the coordinates of rocks and other obstacles into a GPS unit. Then, with the unit in hand, they set off to follow a notional route. At least every 100m, controlled drilling must be done. "You will either go right or left but you must stay in the corridor that you have established before, with the chart. An ice road cannot be made across a shallow place or across rocks," says Roger Õiglas. "You walk with a drill in your hands. You drill, measure and, if the ice is suitable, you mark it with a juniper tree."

Raivo Õiglas stresses several times that the weather is the most important factor. "For example, if it is very windy, the water does not freeze. The height of the tide is important as well. It is best if the tide is about 12 inches (30cm) during ice formation," he says.

Drilling test holes into the ice has become easier with a drill because, previously, they were cut by hand. While carrying a drill, the hand must be trained to sense which places have thawed and what the ice structure is like. "When you are drilling, the top layer of ice may be so hard that the drill does not want to go through. Then there may be a layer which the drill will sink through with its weight. The ice may be 40cm thick but its supporting strength is very low if it is watery. The thickness of ice alone isn't the only thing that matters," says Roger Õiglas.

Need to know

Ice roads are created in Estonia when conditions are ideal during harsh winters

- Each winter, 10 official ice roads are established, which cars can drive on during daylight hours only
- The Estonian Road Administration builds and maintains the ice roads
- The roads are created with controlled drilling, and marked with juniper trees and vehicle tracks
- Speed limits on the ice roads depend on the thickness of the ice

Soft layers

The structure of ice is important. "In addition to measuring the thickness of ice, drilling is at least as important for learning about the ice structure," Raivo Õiglas says.

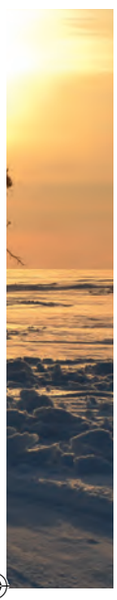
When the ice road has been marked down with junipers, the men will drive with their car to establish visible, physical tracks. They then hope that there will not be any snow or a blizzard. "If a blizzard fills them, we must go back a step and drive new tracks," Raivo Õiglas says.

Has the fear really not disappeared for a man who has been making ice roads for 40 years? "No, it has not; ice is a wet material. Ice picks are always in your pocket because you cannot pull yourself back onto the ice with your fingernails," he says.

According to Roger Õiglas, the ice road is a real tourist attraction. Viewers want to feel the chills of fear prompted by driving a car on the sea. Surveillance must be maintained and record books filled at both ends of the ice road on a daily basis. The registration numbers of all cars using the ice road are among the details recorded.

Ice road safety

Traffic is allowed on the ice road during daylight hours only. It is halted when visibility falls below 1,000ft (300m), and vehicles may join the ice road only at the designated places. The doors of each vehicle must be easy to open and the passengers must not wear seatbelts. Vehicles driving onto the ice road are required to remain at least two minutes and 800ft (250m) apart. Passing,



Left: **Local juniper trees are used as ice road markings in Estonia**
Above: **Roads are then made more visible with physical car tracks**

overtaking and two-way traffic on the same stretch of ice road are prohibited.

The permitted driving speed is in the range of 6-15 mph (10-25km/h) and 25-45 mph (40-70km/h). If the ice is over 20in (50cm) thick, drivers have the option of speeding up to 45mph (70km/h). Driving off the ice road is prohibited.

There are strict and possibly alarming protocols to follow when things don't go according to plan. If the ice and weather conditions make it impossible to continue, the driver has to turn back immediately and not only warn the vehicles behind but also inform the ice road surveillance service. Finally, if it seems that the ice is going to break and the driver asks, passengers are obliged to get out. The driver may continue the journey alone – with open doors. However, such events are incredibly rare and the thrill of crossing the sea by driving over ice remains a temptation irresistible to many.

by **J J Eden**

New transportation technologies will succeed if current systems adapt

Disruptors. We've all seen them. They can be people, companies, technologies or even just concepts. They have been around for a long time. We've seen disruptive technologies in movies and media for decades.

I remember when Sony's Betamax was first introduced. I wondered if this technology would really change the way we watched movies. Many thought that Betamax was just too limiting. It really didn't have the capacity to show movies the way that we are used to.

With the launch of video home system (VHS), a lot of the technological obstacles of watching full-length movies or concerts disappeared. VHS enabled many new opportunities for businesses to spring up around the world. Businesses that rented out movies (like Blockbuster) became a success overnight. Many people thought that being able to rent a movie and watch it at home would be detrimental to the movie industry and movie theaters, as people would go for convenience over the traditional movie theater experience.

VHS was soon disrupted by the advent of the digital versatile disk (DVD). Once again many members of the general public doubted that the DVD would really catch on, especially in the short term. People who had bought VHS tape players would now need to switch to a completely new system – the DVD player. In addition, DVD players were not reverse compatible with the old VHS. This disruptive technology once again created more opportunities for those entrepreneurial business leaders prepared to take advantage of the expanded capabilities of this new format.

The DVD lasted a long time and many people thought it was the be all and end all for storage, particularly movie and media renting, sharing and playing. However, this disruptive technology was overshadowed by faster internet speeds that opened up the world of streaming. This latest new technology has had both a positive and negative impact on innovations and business models that relied on now-obsolete technologies. We saw businesses like Blockbuster fade into the sunset. But where there was darkness for some businesses, there was sunshine for others. We saw many streaming technologies launched, among them Apple TV, Netflix and later Amazon TV, which rapidly became the new competitive standards for watching movies, TV programs and even live events.

"If electric vehicles catch on, what will happen to the tens of thousands of gas stations?"

Today we are seeing disruptive technologies and new business models in almost every area of our lives, particularly in transportation. We've seen how Uber and Lyft have been accepted by commuters and travelers while disrupting taxi service models. If electric vehicles catch on, what will happen to the tens of thousands of gas stations? Will they disappear or adapt? Will the electrical grid be able to support the potentially millions of electric vehicles on the road? And will the mass acceptance of autonomous vehicles impact the insurance, legal and related transportation industries? We may even see a disruption in municipal funding as driverless vehicles disrupt fine structures.

With disruption comes the need for adaptation. Time will tell what new and innovative transportation products and services will come out of this latest round of disruption.

J J Eden is director of tolling at Aecom
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Signs of the times bring benefits to traffic applications

When designing an ITS or any system to convey messages to drivers, you have a choice to use a very versatile but expensive dynamic message sign (DMS) or a cheaper blank-out sign (BOS). To know when to use a BOS rather than a DMS, users must first understand the main differences and benefits of both products.

The display of a DMS is full matrix and, sometimes, full color, while only a few messages or symbols are available with a BOS. A DMS needs a local controller and remote software, but a BOS can be controlled by dry contact and can be connected to a traffic signal controller. As for National Transportation Communications (NTCIP) compliance, there is little difference between the capability of DMS and BOS, and both can be made to any size.

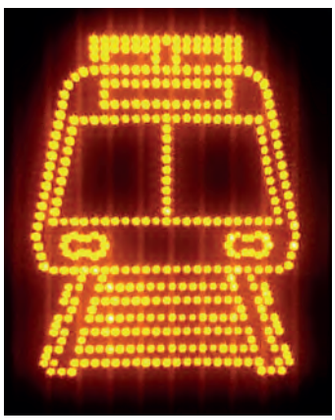
A BOS needs energy only when a message is being displayed, not when it is blank, so a DMS needs approximately 50% more energy, depending on its size. Some of the power for a DMS can be supplied by solar panels, but not enough for color displays, and relatively few manufacturers offer solar-powered amber DMS. On the other hand, BOS can be powered by solar and can display messages of any color. Finally, a DMS costs at least 50% more than a BOS, and the larger the sign, the bigger the price difference.

BOS can display only a limited number of messages or symbols, which must be defined at the time of order, so they are only suitable for some applications.

The best applications

As BOS can display only a few symbols, they are useful only when it's known in advance what message will need to be displayed. This is the case, for example, when manual on uniform traffic control devices (MUTCD) symbols or messages are needed to regulate traffic, or when a dedicated message has to be displayed to the attention of targeted drivers; these are mostly warning messages such as 'Prepare to stop' or 'Truck must enter weigh station'.

So the best applications for BOS include traffic regulation with MUTCD symbols such as 'No right turn' and 'No entry', or as a lane control sign to display a red 'X' and arrows in green or amber. A BOS is also appropriate for many kinds of specific warning messages. For example, a BOS displaying 'Danger/Over height' can prevent trucks from entering a low tunnel and 'Road under water/Detour' can warn drivers when a road is flooded.



Left: **Blank-out signs such as those pictured by SES America, are a cost-effective alternative to dynamic message signs**

Need to know

Blank-out signs can provide fully sized messaging functionality at a fraction of the cost of DMS

- SESA BOS meet MUTCD requirements
- They are also are built to comply with NEMA 3R standards
- SESA's multiphase BOS are built without a polycarbonate panel to eliminate glare, which can distract drivers, while still maintaining high contrast ratio

An important function of messages is to enhance traffic calming and road safety. This is where BOS can come into its own as it can be vehicle activated. When a vehicle arrives at a predefined distance to the BOS, it lights up, flashes or alternates several symbols. It is ideal to reduce speed, for example, on an approach to a dangerous curve, or hazardous section of infrastructure such as a road crossing.

Building BOS

Most BOS manufacturers have a list of BOS on the shelf with pre-existing and predefined messages. Over the years, they have developed a printed circuit board (PCB) that can generate several letters, symbols and characters, and they build the BOS around those existing symbols.

The problem with this design is that it limits flexibility and it is very difficult for them to adapt to specific needs or to create new messages. Also, most of the time, those vendors cannot provide a large enough BOS suitable for highway use.

Alternative methods exist, such as using LED strings to create the desired message. This new technology is very economical and ideal for creating and customizing new BOS for any application.

Versatile and cost-effective

Messaging technology expert SESA has completely remodeled the concept of BOS in order to provide several cost-effective solutions for state and municipal agencies. The idea is to provide versatile BOS as an alternative to providing expensive, full matrix DMS when it is not necessary to display more than three or four messages or symbols. SESA proposes a

multiphase BOS customizable for each project and client in any size or dimension. SESA's design uses robust LED technology that enables its engineers to design a wide variety of symbols and text, and accommodate them within standard-size or custom-built housings.

All signs meet MUTCD requirements and the housings are built to comply with NEMA 3R standard. SESA's multiphase BOS are built without a polycarbonate panel, eliminating the phantom effect, which can distract drivers, while still maintaining high contrast ratio. Several options are available, such as vehicle activation, remote control and visors. Consistent with all SESA products, these BOS were designed with high energy efficiency and most can be solar powered – a technology mastered by SESA in other product lines such as SolarSign.

SESA's BOS have proved their worth on many highways. For example, they have been used on the roadside and overhead for lane management on Champlain Bridge in Quebec, Canada, where truck symbols combined with green and red circles and amber arrows indicated whether lanes were open, closed, or about to close. Compared with full matrix DMS solutions, the BOS offered savings of 65%. In Georgia, USA, a SESA BOS was used to inform truck drivers about their requirement to enter a weight station. It saved the operator 55% compared with a DMS.

by **Larry Yermack**

What will happen to toll roads if road user charging takes over?

Will the toll roads of the future be all highways? If so, what are the implications for the toll industry, the departments of transportation (DOTs) and drivers? I ask this question because of all the changes swirling about tolling at traditional authorities, as well as emerging road funding schemes and how they will impact several existing industries.

Toll roads started out simply as roads where enterprising entrepreneurs set up pikes, or movable barriers to stop vehicles to collect the toll. How quaint. The 20th century saw the struggle between a national system of toll highways as advocated by Franklin Delano Roosevelt and the ultimate adoption of a national interstate highway system advocated by Eisenhower and ultimately adopted. For the past half century the primary system to pay for roadway maintenance has been the gas tax, with direct user charges as the model for a smaller segment of the network: toll roads and bridges.

However, today's trends in both tolling and funding hint at a different future. Tolling is shifting from a tolling infrastructure of toll booths to overhead gantries, from human interaction to tags and license plate readers. At the same time, states are exploring alternatives to the gas tax that will charge by the mile.

I have written a fair amount about mileage-based user fees (or 'road user charging') and I'm beginning to believe that it is a future that will actually arrive. The trends of hybrids/plug-in electrics and national politics suggests no way to increase Federal funding to fill in the huge hole in budgets, so the states are truly on their own. Oregon and California have pilots, and while Oregon struggled to find volunteers, California, a much larger state, is oversubscribed. Both states have a history of progressive policies and both could lead the nation. If California established a program to charge 32 million vehicles for their road usage, imagine the impact that could have on other states.

The two distinguishing characteristics of a toll road are toll collection and a superior roadway. A premium price needs to come with a premium service. You knew that you were on a toll road because you had an account with the authority. You had a smooth ride and quality roadside services. How would things evolve if you were a customer of both the state DOT and the toll authority?

> "The is no way to increase Federal funding to fill the hole in budgets, so states are truly on their own"

You would have personal accounts for mileage with the state and toll road usage with the authority. The two government entities would need to cooperate so as not to charge mileage for toll road usage, so that system would need to evolve beyond the simplistic odometer readings twice a year. With a guaranteed source of income, the state could do a better job of roadway maintenance. So what's the difference between tolling and road user fees? Not so much anymore – and the bigger political stick is with the DOT. Is the toll road of the future a highway? Could be…

Larry Yermack is strategic advisor to Cubic Transportation Systems, USA. lyermack@gmail.com

Flexible, modular parking system with remote access

Vision Components' ITS package, Carrida, is an automatic license plate recognition (ALPR) solution for applications such as access control, tolling and speed control, traffic analysis and fleet management. The package comprises the Carrida software engine, the Carrida Cam, the VC (Vision Components) flash infrared area lighting module, and the Q-Board.

Carrida Cam

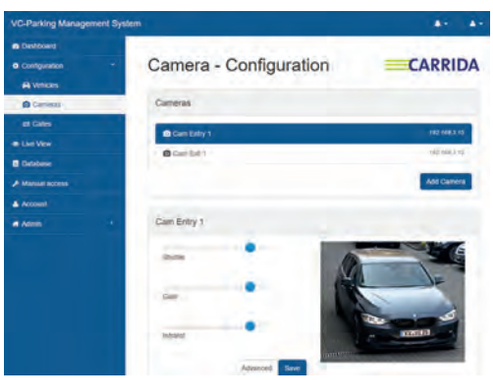
Carrida is a modular parking system that provides its users with the components needed for an ITS. It can be operated as a complete system or integrated into other system components.

The Carrida Cam brings fast and accurate ALPR functionality via the robust and compact VC pro Z camera, which measures 3.4 x 2.2 x 1.4in (88 x 58 x 36mm). The Carrida Cam can operate integrated into an ITS, or as a standalone device when powered by solar cells.

IP camera 'upgrade'

A Q-Board is included with the Carrida system. This printed circuit board is an easy-to-integrate hardware solution with ready-to-use functions. It enables users to benefit from the functionality of a smart ITS camera with an existing IP camera. The compact board, which measures 1.5 x 2in (40 x 50mm), is based on the 2 x 866MHz ARM dual core processor ZYNQ. Carrida's ALPR software engine comes as part of the package.

The Q-Board can be connected to any conventional IP camera to convert it into an ITS device with video streaming facilitated by the integrated FFmpeg library. The Q-Board enables easy integration of video-streamed footage into the user's data network because it supports almost all standard IP streaming protocols, video codecs and container formats. Connected via a switch, Carrida automatically receives the video stream and the Q-Board directly processes the incoming data.



Above: **Vision Components' VC Flash infrared area lighting module, Carrida Cam, and Q-Board**

Left: **Screenshot of the Carrida parking management system**

Infrared lighting module

Vision Components' powerful VC flash infrared area lighting module was developed primarily for use in traffic surveillance applications. It can be combined with the Carrida OEM board camera and the Carrida software engine to make a highly efficient and comprehensive package. The lighting module is fitted with 24 high-power LEDs to ensure optimal illumination without a glare effect that could endanger drivers, while illuminating an area of up to 25 x 16ft (7.5 x 5m), from a distance of 66ft (20m). Maximum brightness can be achieved by activating several connected video camera flash modules. The VC flash operates with a central wavelength of 85nm and a spectral width of 30nm. Power consumption peaks at 36W for the highest pulse duration and pulse frequency levels. A trigger

Need to know

Vision Components' Carrida parking management system...

- Is a flexible system that is easy to integrate inside or outside existing infrastructure (such as parking barrier systems)
- Includes: Carrida software engine; Carrida Cam; VC flash infrared area lighting module and Q-Board printed circuit board
- Can be accessed and used via a remote web GUI and/or from handheld devices

regulates pulse duration of between 10-500μs, with automatic switch-off at the upper threshold. VC Flash also features an integrated lighting controller and status LEDs that signal various modes of operation.

Parking management

Vision Components has also developed Carrida Park, a solution for parking management that can be easily incorporated into existing barrier systems or parking lot infrastructures. The fully automatic standalone system includes the Carrida Cam in combination with an OEM web-based parking management software module.

The system detects and reads license plates on vehicles approaching a barrier or gate and then, after referring to a vehicle black/white list, processes the data and decides on subsequent actions such as opening or closing the barrier. Carrida Park can be accessed remotely via a web GUI, for example, from tablets or similar handheld devices, and it can operate in networks with other parking management equipment such as under-vehicle surveillance systems (UVSS), ticket printers and barriers. An integrated real-time clock ensures internal data logging is completed with precise time stamping, and all collected data is archived for monitoring and statistical reporting.

by **Don Hunt**

Automated vehicles – it's time for states to step up

In September 2016, the US National Highway Traffic Safety Administration (NHTSA) issued its highly anticipated Federal Automated Vehicles policy. While the policy is only advisory, it sets out a reasonably complete direction for highly automated vehicle (HAV) safety regulation in the USA. The policy recommends a framework for voluntary HAV manufacturer submittals, including a 15-point safety assessment for new driving systems. Perhaps the biggest proposed change in approach by the USDOT would be a move to government pre-certification of vehicles and systems, abandoning the current process of industry self-certification. The policy "strongly encourages states to allow [US]DOT alone to regulate the performance of HAV technology and vehicles".

What will be the role of state transportation agencies, motor vehicle departments, law enforcement and insurance regulators in managing the roll-out of HAVs? NHTSA outlines a Model State policy to describe the respective roles of federal and state government. The recommendations include: identification of a lead state agency for HAVs; state permitting of HAV testing; and establishment of a regulatory framework and removal of unnecessary barriers for HAV testing, deployment and operations.

The range of regulatory challenges for states is a daunting one. The NHTSA policy list of regulatory issues for states includes: law enforcement, emergency response, vehicle insurance, crash reporting, accident liability, education, vehicle safety, vehicle maintenance, and environmental impacts.

The NHTSA policy calls for identification of an agency to take on this leadership task. As a veteran of state government, I can say the call for a lead agency for HAV regulation is premature. Since motor vehicle regulatory functions are very scattered in most states, it will not be beneficial to start with designation of a single lead agency. HAV deployment is an expansive and complex issue for state government oversight, and it's important that state response starts with the chief executive of each state – the governor. Each state governor could designate a 'czar' to begin the process of HAV response on a cross-cutting rather than siloed basis.

Equally important, a 50-state forum to support discussion and organize

> "I say the call for a lead agency for HAV regulation is premature"

integrated state response is a critical function. The creation of a national forum for the 50 states is not addressed in the NHTSA policy. There are national associations that support individual functions related to HAVs, for instance the American Association of State Highway and Transportation Officials, National Association of Insurance Commissioners, Governors Highway Safety Association, American Association of Motor Vehicle Administrators, and multiple national law enforcement associations. Each of these will play a functional role.

But the next action should be for each state governor to create a central point of leadership to balance HAV deployment safety and benefits, and a national convening group to start a cohesive discussion. Perhaps the USDOT can take on this coordination assignment, but other groups may be even more effective. The National Governors Association may be a good alternative organization to assist states in implementing early cross-cutting HAV deployment work. The need for quick and coordinated state response makes HAV deployment one of the greatest government challenges in decades.

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

Forecast: better road management decisions for DOTs

Weather affects lives around the world every day, and in the USA 90% of adults consume weather information on a daily basis. But what about businesses?

It's not unusual for corporations to blame poor performance on the weather. It affects virtually every sector of the economy, accounting for US$500m in economic impact annually in the USA alone. The Weather Company, an IBM business, has been working across myriad industries – from energy to media and from pharmaceuticals to aviation – to help businesses anticipate the weather and take action.

Data power

The transportation industry has been slow to appreciate the major impact real-time weather data could have on daily operations. And when it comes to using real-time weather in decision-making processes, departments of transportation (DOTs) and US trucking fleets are way behind their aviation and rail industry counterparts.

Each day The Weather Company delivers around 20 billion forecasts, which are updated every 15 minutes for 2.2 billion locations around the world. As a result, the weather data provided for businesses is the most granular available, making it incredibly rich and valuable for a wide range of analytic applications.

Trucking fleets rely on historical data about traffic patterns and average journey times to estimate how long routes will take. They consider weather forecasts but not real-time data.

"When you make decisions in real time you know whether you will get to the destination earlier or later, and you can adjust your departure times accordingly," says Mark Gildersleeve, president of business solutions, The Weather Company. "You also know much earlier whether you should cancel the route altogether, for example, when temperatures could reach freezing and potentially damage the cargo. Another advantage is that you can alert your customers earlier to changes of plan, which will get you higher satisfaction ratings."

Planning ahead

The accuracy of real-time data also enables trucking fleets to make spontaneous decisions to carry out preventive maintenance, as accurate weather forecasts help businesses understand which days are best for traveling. In instances like this, reliability leads to more confident decision making. "We've improved accuracy every year for the past 25 years, but never more so than in the last two. Today we apply 162 forecast models to create intelligently weighted forecasts," Gildersleeve says. "Once the trucking industry realizes the financial advantages of real-time data, it will embrace it," he predicts.

Some companies are already getting the message.

"The truck industry runs on slim margins and is breathtakingly good at optimizing its fleet operations based on static historical trends and experience. For example, a fleet operation typically knows the average length of time it will take to drive a route. The next leap is to be able to make optimization decisions dynamically, based on the most up-to-date road conditions, and traffic and weather forecasts available at the time of the vehicle's departure," Gildersleeve explains.

Need to know

The Weather Company's forecasts enable industries across the globe to react to and adjust operations according to the weather

- 45 billion requests for weather information received every day
- Forecasts made for 2.2 billion locations around the globe, updated every 15 minutes
- Low- and high-probability forecasts are based on 162 models
- DOTs can use this real-time data to make better decisions, such as well-timed road closures, in the face of bad weather

Far left: **DOTs can make better traffic management decisions with real-time weather data**

Above: **Thanks to weather forecasts, businesses can schedule cargo to be transported with minimal weather-related disruptions to the route**

Meanwhile, the aviation world has been quicker to understand the value of weather data analysis. The Weather Company already counts half of the world's top 100 airlines among its customers.

Potential for the roads

The work of DOTs could be helped by real-time analytics. Gildersleeve says they would be able to make decisions on congestion relief or road closures much more quickly in the face of major weather events. "One example is the snow storm that hit Atlanta in January 2014. The city failed to close the roads early enough and tens of thousands of people were stranded. In an instance like this, earlier decision making through real-time analytics could have avoided a lot of pain," he says.

The ability to react early to prevent serious flood events is another major advantage. When a storm is sweeping through a city, DOT operators can watch the movement of the heavy rain in real time, on a dashboard, and assess which areas are likely to be inundated.

The Weather Company applies advanced prediction models to live weather data, much of which is sourced from a network of 200,000 local weather stations.

"You can see the weather across an entire metropolitan area in real time and understand hours ahead where the worst flooding will be," Gildersleeve says.

On a more sophisticated level, the models are able to assess the likelihood of a lower probability bad weather event. Such occasions might be rare, but they are disproportionately costly and disruptive.

"Even if the likelihood is that it won't be bad, the DOTs need to prepare for extreme events," Gildersleeve says. "For example, if the likely forecast is for two inches of snow in New York, and there's a 90% chance that there won't be more than four inches, a DOT would respond differently compared with a likely forecast of two inches, but a 20% chance of an extreme snowfall of 12 inches.

"In all these scenarios the main consideration is making the right decision for businesses and their customers." ○

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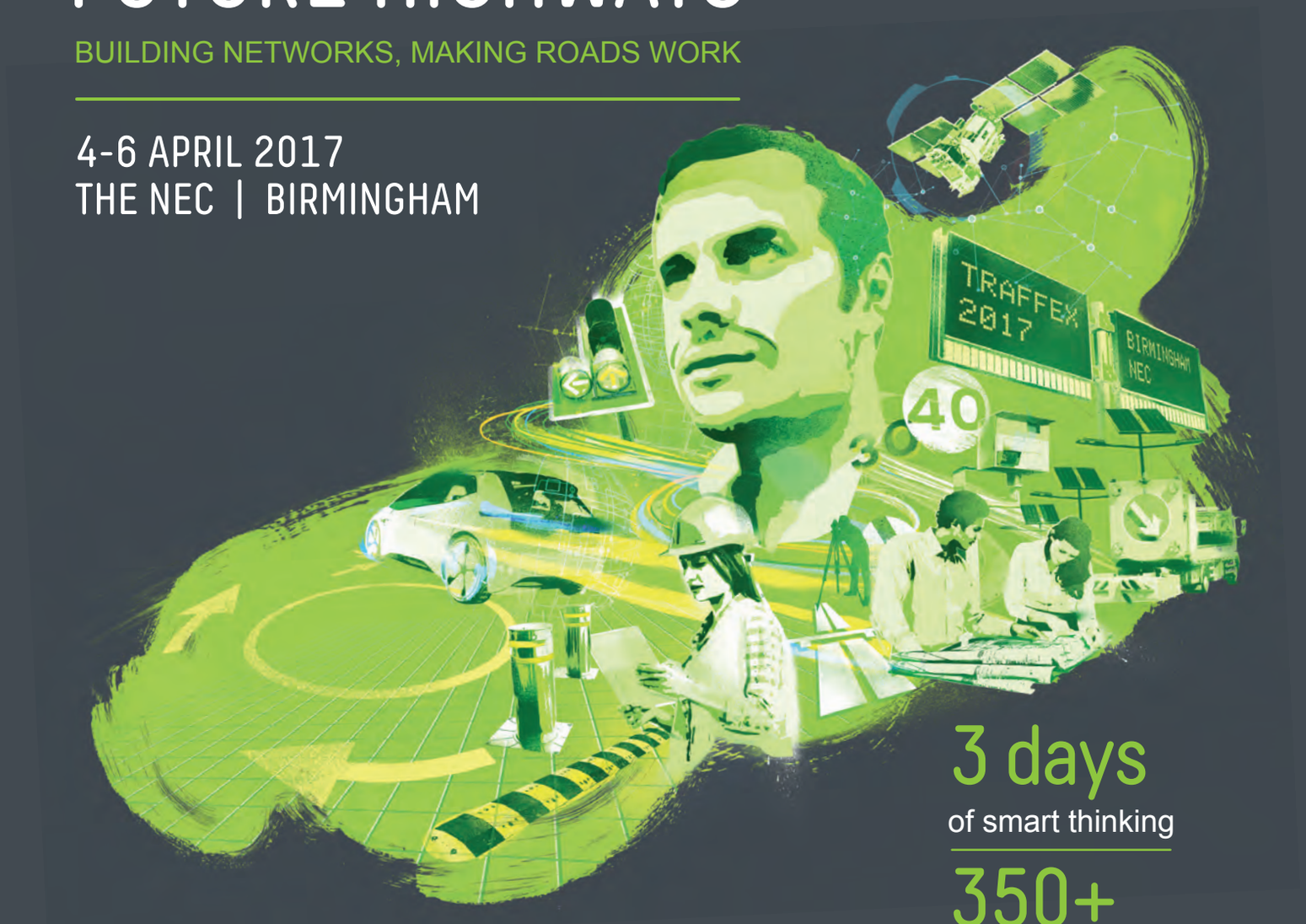

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"UAVs could transform inspections in many areas including evaluating the 873 reinforced elastomeric bearings and shock transmission units that sit between the main and bridge decks"

***Firmino Sá**, operations and maintenance, Ponte Vasco da Gama, Lusoponte*

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"There's more to 3D scene perception than any one solution. Machine vision gives you one source of information, but it's only one source"

***Dr Charles Fox**, Institute for Transport Studies, Leeds University*

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"We're trying to understand the gap between technology, the road network, and critically the user. Somewhere between those three points, there's an area that we just don't understand"

***Tony Meehan**, consultancy director, Atkins*

Find out more about the University of the West of England's (UK) trials for the Venturer autonomous vehicle project traffictechnologytoday.com/venturer

"The power is centered on the ability to predict 'at risk' locations. The proof is in the data; we are seeing a significant reduction of fatalities and serious injury crashes on Minnesota roads"

***Victor Lund**, traffic engineer, St Louis County, Minnesota*

Find out more about how Minnesota is using data to make its roads safer in this video report traffictechnologytoday.com/mndotdata

"Safety-wise, roundabouts are so much better than a signalized intersection on a high-speed road"

***Gary Stockhoff**, county engineer, Washington County, Oregon*

Learn more about Oregon DOT's roundabout installations at busy intersections traffictechnologytoday.com/odotround

"We've created a geo-fence around each of our 150 VMS with a radius of about two miles. Any bus entering that radius will show the same messages that are displayed by the fixed VMS in that area"

***Christian van der Nest**, surface integration manager, TfL*

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