traffic
TECHNOLOGY INTERNATIONAL

October/November 2013

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Innovative practices in road weather management

Countryside alliance
The technology champions bringing ITS to our rural areas

Blinded by the truth?

Does the multibillion-dollar red light camera sector owe its existence – and profits – to traffic engineers' misapplication of the yellow change interval formula?

PLUS

Coming soon…
With driverless cars nearing the production line, how will they alter your ATMS landscape?

Rooms with a view
How smart thinking in the control room is redefining collaboration – and reducing operational costs

Dr Alan Stevens, TRL
"Step by step we're getting to where there'll be completely autonomous vehicles in certain situations"

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Answers for industry.

Cover story

56 Defying the laws of physics?

Why traffic engineers could be introducing error into intersections

Brian Ceccarelli and Dr Joseph Shovlin may ruffle a few feathers with their theory on why we have red light runners

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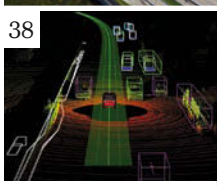

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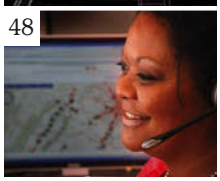

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Technology Profiles

Foreword

"There are no such things as stupid questions, Master Bradley, just stupid people!" That's what my mathematics teacher, Professor Rottenbury, used to revel in telling me – regularly – as he watched me struggling with long division, algebra and in the end even turning up for classes. But after a few retakes, some private tuition and what I like to refer to as state-of-the-art cheating, I got my pass – just. Physics was a complete non-starter, though.

But it's what Brian Ceccarelli, author of our cover article (and the man behind the *www.redlightrobber.com* website), excels at. And following citations for running red lights back in 2009 – in one case by 0.34 seconds on a yellow duration that he says was 0.5 seconds short of the DOT's own spec – he's been on a mission to apply his expertise in the field to prove that the reason most people run red lights is because traffic engineers have simplified, misinterpreted and misapplied the 1959 amber light duration formula (p56). "The formula was developed by three physicists, not traffic engineers," Ceccarelli tells me.

Perhaps it's down to my failings in the math department, but I've lost count of the times I've heard "the minority often shouts the loudest" in the context of why so many people are seemingly against what numerous respected bodies and researchers categorically state is a life-saver.

Ceccarelli's campaign is certainly loud. Yet he insists he is not against red light cameras *per se*; he's against the way the signal formula has been applied and as a result induces red light running and is the very reason the red light camera sector exists. In February of this year, he ramped up his efforts by bringing a lawsuit against Cary, the North Carolina city in which he was ticketed. Ceccarelli lost. "The judge used a city ordinance to trump the laws of physics – a decision that made it irrelevant whether those engineering practices were correct," he explains.

One industry professional who agrees with the Cary crusader is Professor Alexei Maradudin – the inventor of the amber light formula. "Physics is an open book," Ceccarelli says. "I can look at his equation and know with 100% certainty what it means. Physics and math is a *Lingua Franca*, but unfortunately – and surprisingly – the collective body of traffic engineers doesn't seem to know."

I'm sure some of you will dispute Ceccarelli's findings – even be incensed by them – but something I've learned from traffic engineers is that this isn't an industry that subscribes to the 'if it ain't broke, don't fix it' school of thought.

As you'll read in our feature on road weather management (p22), there are always gains to be had – and sometimes we have to break from convention to get them. Our feature on page 14, meanwhile, highlights how technology is improving mobility and safety in our rural areas, where intersections especially are a cause for concern. And not a red light camera in sight!

While on the subject of improvements, you can now download *Traffic Technology International* as a free app for use on Apple and Android tablets. Whichever platform you're on, enjoy the read!

Nick Bradley, Editor-in-chief

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SEEING IS BELIEVING

Pedestrian aware

Yet another cooperative vehicles project has reached a conclusion, adding more weight to the notion of an accident-free society. **Adam Saunders** discovers the Ko-FAS project is not all about cars – vulnerable road users are set to benefit too

Photographs courtesy of BMW

Funded by Germany's Federal Ministry of Economics and Technology, the four-year Ko-FAS Cooperative Vehicle Safety project concluded in September with an event in Aschaffenburg and final presentations of the three subprojects – Ko-TAG, Ko-PER and Ko-KOMP.

"We took a lead role in the Ko-TAG and Ko-KOMP projects," reveals Dr Ralph Rasshofer, BMW Group representative on the Ko-FAS steering committee, when asked about the German car-maker's involvement. Improving road safety was the primary goal. "Our approach centered on accurate detection of traffic environments using cooperative sensing and perception, comprehensive situation assessment to precisely evaluate collision risks, and subsequent activation of appropriate advance protection measures," Rasshofer explains.

Researchers involved in Ko-TAG, the successor to AMULETT, previously featured in *Traffic Technology International*, looked specifically at enhancing the capabilities of cooperative transponder technologies, with a view to enhancing safety for pedestrians and cyclists in particular. "We gave them miniature transmitting and receiving devices and when the transponder received an interrogation signal from the test vehicle's onboard locating system, they sent back information indicating, among other things, the type of road user wearing the transponder as well as their location relative to the car," Rasshofer continues. And to alleviate any privacy concerns about tracking, the transponder is identified by means of a code that is frequently and randomly changed, hence making it impossible to link the transponder to the person wearing it.

"Our effectiveness studies show that the transponder system investigated in this project offers a great deal of potential for mitigating or even preventing accidents, by warning drivers of hazards much earlier and in a much more effective way."

In future, the combination of Ko-TAG transponder systems with Ko-PER cooperative perception could deliver huge benefits. "By selectively combining different communication technologies we can move a step closer to realizing our vision of accident-free mobility," believes Rasshofer.

The transponder system developed under the Ko-TAG project is extensively based on the WLAN standard IEEE 802.11p. In contrast to the system used in the previous project, AMULETT, it features extensive synergies with C2X communication. Further miniaturization – reducing the tag to the size of a chip – would allow future transponders to be fitted in items such as school satchels or even walking sticks. Of course the distinctive feature of the technology is that it makes it possible to detect people even when they are not visible to the car driver at the time of the hazard.

Cooperative perception techniques suitable for use in parallel traffic and at intersections were a big part of the research in the Ko-PER subproject – in Dr Ralph Rasshofer's words to "improve the driver's foresight in traffic". The goal was to provide the fullest possible traffic detection, based on the cooperative exchange of information between vehicles. "At accident hot spots, this information can be supplemented with infrastructure-based information," continues Rasshofer. "In these various ways it is possible to eliminate the effect of obstructions in both the driver's and the vehicle sensors' field-of-view. Drivers can therefore be alerted to hazards at an early stage, allowing them to take appropriate action."

On the horizon

'Anticipatory driving' is the ultimate aim of a new partnership announced by IBM and Continental at the IAA in Frankfurt, Germany and will pave the way via a next-generation 'electronic horizon' platform to automated driving (see *Countdown to autonomy*, page 38). Vehicles with embedded sensors will receive data and transmit information such as position, speed or deceleration to the cloud, where the data will be processed, analyzed and acted upon. The result will be a real-time map that will enable a vehicle to literally look around the corner. "The vehicle will not just be connected to the internet; it will become part of it," predicts Dr Elmar Degenhart, chairman of Continental. "Networked, intelligent mobility opens up enormous potential for innovation and will enable several new functions for drivers. These include real-time traffic flow data exchange and anticipatory driving based on online and navigation data."

8,000
autonomous vehicles will be on our roads by 2020, according to a Navigant Research report – a number that will swell to 95.4 million by 2035

> "Selectively combining different communication technologies we can move a step closer to realizing our vision of accident-free mobility"
>
> *Dr Ralph Rasshofer, Ko-FAS steering committee*

Keep on movin'

From tolling and social media to autonomous vehicles and smarter highways, **Lloyd Fuller** and **Leanne Keeble** round up some of the ways that we're thinking differently about safe and efficient mobility

A federally funded pilot program to equip up to 500 city motorists with transmitters that collect data from their cars' onboard computers is to be launched by New York City's DOT (NYCDOT). The data will flow to certain smartphone applications, supplying drivers with statistics on everything from fuel mileage to the average speeds at which they move through city traffic. The NYCDOT will also be able to monitor the same data and will be able to evaluate how and where cars are moving through the city, and analyze the data to find specific problems that plague certain streets. With the pilot program, the DOT hopes to comb through data to detect various problem areas, such as stretches of road where many drivers have had to slam on the brakes or swerve out of the way of a collision.

Currently the agency is dependent on less sophisticated measures to get a sense of which streets are dangerous.

(nyc.gov/dot)

Cleared for takeoff?

GeoToll's ISO/IEC 18000-6C-based smartphone RFID Mobile Payment Solution (MPS) device has passed 6C certification testing by OmniAir Certification Services (OCS), the toll industry's certification arm. Receiving OCS Certification is a major milestone for GeoToll as it enables the Washington State Department of Transportation (WSDOT) to start conducting a formal model deployment test. The three-part test plan began in August, when GeoToll devices were benchtested to confirm performance in a lab environment. The next step is now underway, with GeoToll RFID-equipped smartphones deployed inside vehicles traveling on WSDOT toll roads. Initial results have been positive and upon successful testing in real-world conditions, WSDOT will test GeoToll's innovative HOV Designation Solution. **Tech stat: GeoToll uses an active DSRC system to improve its readability from gantry equipment, even with passive variants such as 6C, Title 21 and ATA**

(www.geotoll.com)

Emissions check

A group of Spanish research centers and companies that includes the Universidad Carlos III de Madrid (UC3M) has created what it says is the first infrared and remote system able to detect pollutants from cars on highways of up to three lanes. Working within the framework of the European INNPACTO project and led by Technet, the group includes researchers from CIEMAT, Tevaseñal and the UC3M. The prototype – which has been developed and is now ready to be marketed – can make an intelligent measure of highway traffic by collecting real-time data about traffic density, emissions and consumption associated with each vehicle, and weather conditions. With this information, the impact of traffic on the environment can be analyzed and road safety improved. **Status: To test the effectiveness of the system, the researchers recently carried out a final demonstration on the A6 highway near Madrid**

(www.uc3m.es)

Cooperative society

Transport for London's (TfL) Traffic Directorate (TD) plans to improve the flow of traffic on its roads through the use of cooperative networks and social media. Cooperative networks could, the TD believes, provide granular data in real time, without the need for costly infrastructure, to help ease the flow of growing congestion on London's roads. It hopes to exploit this data through what it states would be 'proactive traffic management measures across the traffic corridors'. The TD also believes that it can reduce London's carbon footprint, by encouraging smoother driving practices while also reducing braking and congestion. Ultimately, TfL wants to provide a two-way link between the customer on the street and the city's traffic management operations via social media sites, with the aim of making the customer 'part of the journey'. A planned supplier engagement day will be used to discuss the plans and develop a multiuser proof of concept. **Traffic stat: Congestion costs the UK economy around £4.3bn a year, of which the London area accounts for 40%**

(www.tfl.gov.uk)

Dutch designer Daan Roosegaarde has won two of the 2013 INDEX Awards for his Smart Highway concept, which would modernize European roadways into interactive experiences, paving the way toward environmental sustainability and greater public safety. The biennial awards include a monetary prize and a touring exhibition. Roosegaarde won in the Community Category and also the People's Choice Award. Tech stat: **The concept uses visual aids to communicate dangerous road conditions and traffic jams**

(http://designtoimprovelife.dk)

Safety drive

When it sent its S 500 Intelligent Drive research vehicle along a historic route in August 2013, Mercedes-Benz became the first automaker to demonstrate the feasibility of autonomous driving on both interurban and urban routes. In the heavy traffic of the 21st century, the self-driving S-Class had to deal autonomously with a number of highly complex situations – traffic lights, roundabouts, pedestrians, cyclists and trams. Based on a standard Mercedes S-Class, the S 500 Intelligent Drive research vehicle was equipped with special sensors for the project. **Did you know? Covering the 100km (62 miles) from Mannheim to Pforzheim, the route retraced the one taken by motoring pioneer Bertha Benz, wife of Carl Benz, exactly 125 years ago, when she set off on the very first long-distance drive**

(www.mercedes-benz.com)

Singapore's Land Transport Authority (LTA) has begun a program to enhance the electronic variable message signs (VMS) that provide real-time traffic information along the city-state's expressways. The 380 existing Expressway Motoring Advisory System (EMAS) electronic signboards island-wide will be replaced and 13 additional signboards will be installed. The new signboards will be more readable, as they can display text and simple graphics in up to seven colors, including green, cyan and purple. It is hoped that the enhancements will help motorists make better travel decisions. The LTA thinks the extension of EMAS coverage to major arterial road corridors will offer better information dissemination to motorists, which should result in better traffic flow on the island-wide road network in the future. **Status: The first signboard batches are expected to be completed by the first half of 2014, with the entire project due to complete by 2017**

(www.lta.gov.sg)

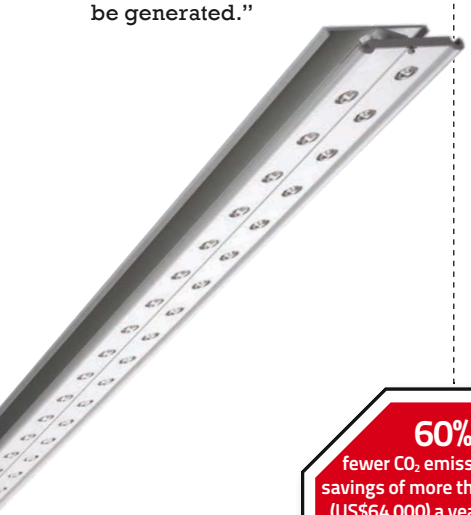
Collision avoidance

Two experimental safety technologies aimed at reducing the potential for collisions between automobiles and pedestrians, and between automobiles and motorcycles, have been demonstrated by Honda. The advanced Vehicle-to-Pedestrian (V2P) and Vehicle-to-Motorcycle (V2M) technologies, while still in the research and testing phase, are intended to demonstrate the company's vision to advance safety for all road users. The V2P technology uses cooperative communication between an individual's smartphone and nearby vehicles and provides auditory and visual warnings to both the pedestrian and drivers, in order to mitigate the potential for a collision between the two.

(www.honda.com)

Controlled light

The lighting in the Meir Tunnel is dimmed continuously during daylight hours in line with the dynamic external luminance (L20). "As natural daylight levels increase, so too does the light output of the tunnel lighting to maintain a critical ratio that avoids drivers approaching a 'black hole'," points out Richard Owen from the company that installed the new technology. "At night-time, a lower light level is maintained by dimming selected luminaires to complement the streetlighting level on the approach roads. Wall-mounted control panels in each plant room display status and alarms and allow maintenance reports to be generated."



Payback time

Delivering maintenance and cost savings of 82% a year, this LED tunnel lighting installation in the UK will also, reports **Adam Saunders**, pay for itself in less than three years

Photographs courtesy of SPIE WHS

60%
fewer CO_2 emissions and savings of more than £40,000 (US$64,000) a year resulted from an LED light installation on London's Upper Thames Street tunnel – the UK's first LED light deployment back in 2011

> A key benefit of using a linear lighting design is that a failed luminaire has very little effect on the overall scheme

Prior to a recent LED upgrade in the 284m (932ft) Meir Tunnel in Stoke-on-Trent, UK, the lighting was designed to comply with BS 5489-1:2003 – an older standard for tunnel lighting. Achieved using a combination of fluorescent and high-pressure sodium (HPS) sources, the result was a relatively energy-inefficient system with high maintenance costs. The latter factor was a vital consideration for the tunnel's operator, the Highways Agency (HA), as frequent re-lamping caused regular closures and disruption to the traveling public.

The decision was therefore made to install LED technologies to improve environmental performance as well as the quality of the lighting for motorists, all while reducing lifecycle costs. The work was carried out by the Industrial Services North West division of SPIE for AMEY – the principal contractor for the HA – and involved completely stripping out the existing lighting system and replacing it with more than 600 Philips T-line LED luminaires.

"The fast-track project was carried out on a rolling night shift, with the tunnel's traffic management system removed every morning to enable normal use during rush-hour," reveals Richard Owen, general manager, SPIE WHS. "We completed the work a week ahead of program, which saved substantial traffic management costs."

Linear scheme

The new system has been designed to BS 5489:2 2008 and uses two versions of the T-line road tunnel luminaire from Philips to provide a true linear lighting scheme with much improved uniformity and greatly enhanced color rendering compared with the previous scheme. "A key benefit of linear lighting is that a failed luminaire has very little effect on the overall scheme," Owen adds. "Whereas a point-source installation can fall below minimum light levels if only a few lamps fail."

The use of LEDs also delivers instant start-up following a power failure, which eliminates the potentially dangerous re-strike period required for HPS. Furthermore, the LED light sources are less susceptible to low ambient temperatures, which can greatly reduce the lumen output of fluorescent lamps. These LED light sources are also fully dimmable (see *Controlled light* sidebar).

"Two versions of the T-line luminaires have been used to achieve the required luminances," Owen advises. In the threshold zones, luminaires with a lumen output of 13,650 lm have been used to achieve 3,900cd/m^2, while a lumen output of 5,560 lm is used in the interior zone to provide a luminance of >2.0cd/m^2 in the day, dimming to >1.5cd/m^2 at night.

The result of the upgrade project is that the annual energy consumption of the tunnel lighting has been reduced from 660MWh to 154MWh, cutting carbon emissions by some 275 tons a year with a financial saving on energy costs of nearly £64,000 (US$102,000).

"A further benefit is the reduced maintenance costs, as the original light sources had a life of around two years," explains Owen. "The new LED light sources have a projected life of 20 years, which is expected to save a further £28,000 [US$45,000] a year, so the total financial savings will be around £91,600 [US$145,000]. The fiscal savings over a 20-year lifecycle are predicted to be nearly £850,000 [US$1.3m].

"We're delighted to say that due to completing the project ahead of schedule, management costs were reduced in addition to the predicted fiscal savings," concludes Owen. "This is a great achievement for all the team involved."

Traffic flow looking good

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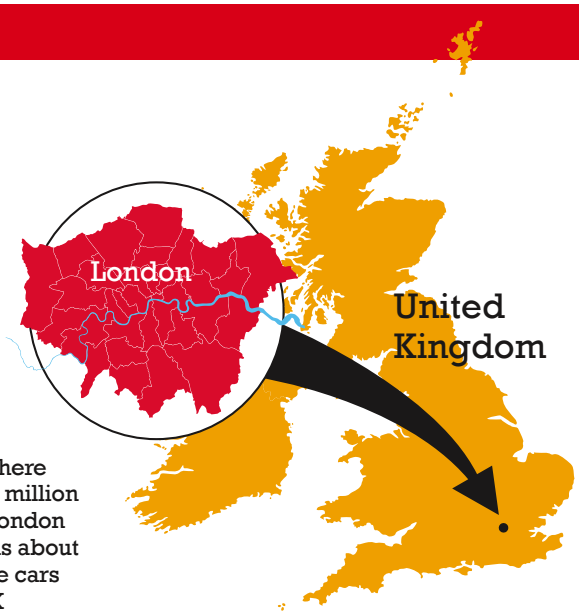
London crawling

Even factoring in a 22% reduction in traffic due to its much vaunted Congestion Charge, **London** still has some of the worst jams worldwide. Fortunately it also has one of the most innovative authorities in place to help resolve them

Infographics courtesy of Andrew Locke



Transport in the British capital is managed by **Transport for London (TfL)**, of which **Sir Peter Hendy CBE** is commissioner. **London Streets** is responsible for the management of London's strategic road network

2.5m

In 2011 there were 2.5 million cars in London – which is about 9% of the cars in the UK

On average, drivers spend

76 hours

a year idle in London jams

The London Road Safety Council estimates that around 28,000 people will be injured on roads in the Greater London area in 2013, with

3,000

of those being classified as killed or seriously injured (KSIs)

7 cyclists have been killed on London's roads so far this year, five of whom were involved in accidents with trucks

8.3m

According to data from the Office for National Statistics, London's population jumped up to a new post-war high of 8.3 million in 2012 – making it the most populous municipality in the EU

Close to a third of London's roads will experience illegal and harmful levels of nitrogen dioxide (NO_2) within seven years, new figures have revealed. This 2013 scientific research was conducted on behalf of the Mayor of London's Office

The city of London has

9,205

roads in total, which encompasses A roads, minor roads and motorways

TfL research from 2010 shows the total motor vehicle kilometers traveled on all roads in London was

31.4 billion

– its lowest level since 1995 (19.4 billion of those kilometers are on major roads)

Delays and disruption caused by roadworks are estimated to cost London's economy approximately

£750m

(US$1.2bn) a year

There are up to

10,000

unplanned incidents and around 750 planned events in London each year

The average daily traffic flow in London is up to

40%

higher than average flows in other urban areas of England (including Tyne & Wear, Greater Manchester and Merseyside)

Intelligent thermal sensor for traffic control

NEW

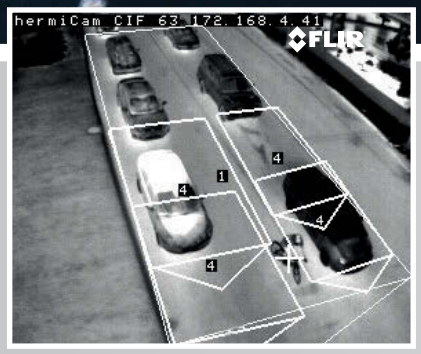
ThermiCam

Vehicle and bike presence detection and counting

FLIR's ThermiCam offers smart vehicle and bike presence detection and data collection for intersection applications. FLIR ThermiCam detects vehicles and bicycles at and nearby the stop bar. The intelligent ThermiCam sensor will transmit its detection information over contact closures or over IP to the traffic light controller and will thus allow a more dynamic control of traffic lights.

ThermiCam makes use of thermal video images to analyze the traffic scene. When it comes to intersection control, thermal imaging offers some undeniable benefits:

- Distinguish between vehicles and bikes
- Guaranteed detection, day and night
- Detection in difficult weather conditions



Bike and vehicle detection

FLIR ITS, intelligent systems for making traffic easier, safer, smoother.

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www.flir.com
Intelligent Transportation Systems

Put to the test

A variety of technical systems were deployed within the Testfeld Telematik project, ranging from in-vehicle road signage to hazardous location notifications to traffic jam warnings. Several traveler information systems were also tested.

As Güner explains, "Kapsch contributed with the delivery of roadside units, in-vehicle equipment, system design and implementation know-how."

The Kapsch ITS G5/WAVE transceiver MTX-9450 is installed at 13 sites along the FOT route. The interconnection to the back-office system is via ASFINAG's roadside system, which uses Ethernet."

Kapsch also provided the ITS in-vehicle station gateway, TS3306. "This is an ITS station designed for in-vehicle use as an aftermarket device," Güner says. "It has an integrated GPS receiver delivering GPS information with 100ms location resolution. It provides one 5.9GHz IEEE 802.11p compliant radio unit. In the project a 5.9GHz radio was configured to use the external antenna."

A smartphone/tablet was used as a user display and control device, which was connected to the TS3306 via its Bluetooth interface.

The €18.5m
DRIVE-C2X FOT project concluded in 2013 after collecting data for six months on 100km of test corridors and involving 24 vehicles with 45 drivers

> "A large number of cooperative services has been selected, implemented and tested

Field day

Lessons learned about 5.9GHz DSRC from the Testfeld Telematik project show there are exciting times ahead for V2X communication, reports **Andrew Morgan**

Images courtesy of Kapsch

With vehicle-to-infrastructure (V2X) communication rapidly gaining ground, projects such as the Testfeld Telematik field operational test (FOT) are helping to demonstrate use cases and functionality. "The cooperative nature of V2X involves a number of business-related and technical challenges that must be addressed," explains V2X program manager Tugrul Güner from Kapsch, one of the project's partners. "Accurate vehicle positioning data, a viable security concept, scalability of the overall system to millions of vehicles and fast penetration of the technology into all vehicles are among the major issues," he elaborates. "Such a complex and huge system requires a thorough understanding of the underlying technology and system aspects across the entire value chain."

Austria's Testfeld Telematik project was established to demonstrate and prove the V2X communication link in an existing end-to-end system, providing the real-time information exchange between vehicles and the infrastructure needed to improve safety, mobility and environmental efficiency. "Specific focus was set on multimodal transportation, giving the user real-time information about availability of public transport, parking and traffic," Güner states.

The project ran from March 2011 to October 2013 and was funded by the Klima- und Energiefond (Climate and Energy Fund). Various types of user equipment were put to the test, including navigation devices, smartphone apps, tablet apps, vehicle-integrated solutions, and more. Alongside Kapsch in the project were partners including ASFINAG, AustriaTech, Fluidtime, Siemens, Efkon, Swarco, Bayerische Medientechnik, Hitec Marketing, ITS Vienna Region, Audio Mobil and TomTom. Visitors to the World Congress on ITS in 2012 were given a demonstration. The main test route was approximately 45km and was situated around Vienna's A2/A23-A4-S1 intersections and featured various types of roadside ITS.

End results

According to Güner, the project achieved what it set out to accomplish. "A large number of cooperative services has been selected, implemented and tested. The objective was to present the capabilities of the technology and gain experience and feedback from the users about benefits and usability of the solutions. The use cases are focused on infrastructure-to-vehicle (I2V) information provided by the ITS-G5 communication link."

Looking at this project within the bigger picture, Güner says that standards are only one prerequisite for the market introduction of V2X. "Joint efforts from all stakeholders are needed to establish hotspot areas, consisting of roadside infrastructure, back-office systems and customer-relevant services."

Testfeld Telematik is the first real end-to-end FOT that has delivered extensive experience in the planning, design, implementation and validation of a cooperative end-to-end system based on V2X. "The recent ITS-G5 standards are applied and tested in a multi-supplier environment. Different stakeholder views and expectations are considered," Güner concludes. "It was of great significance that the extensions were added into ASFINAG's existing system and are operated in seamless manner."

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Countryside alliance

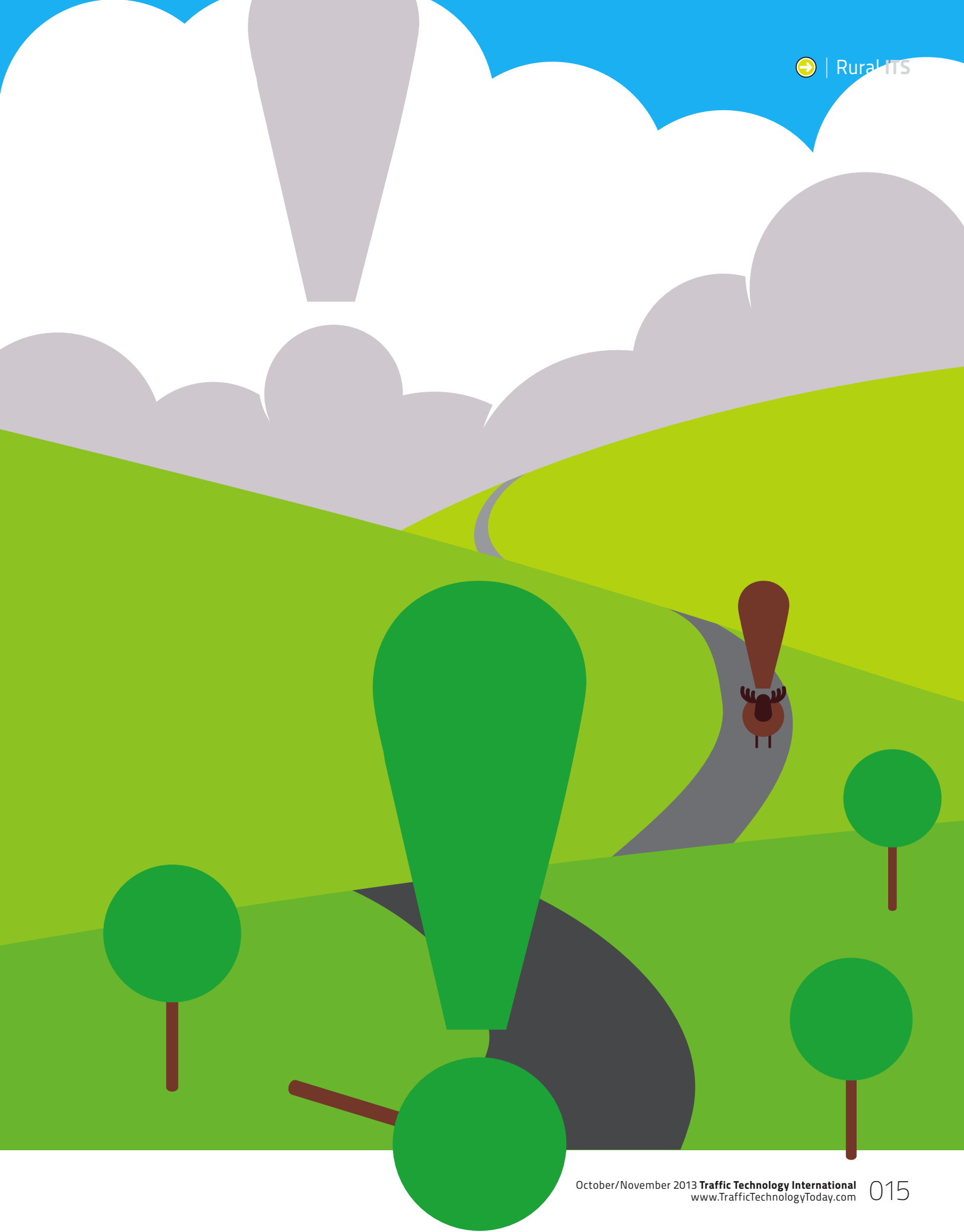
Timothy Compston looks into the specific challenges of deploying and maintaining ITS solutions in rural locations and speaks with the experts championing the cause

Illustration courtesy of Patrick George

Given the scale and isolation of our rural areas, it's hardly surprising there are hurdles aplenty for ITS solutions to overcome for them to be as effective as they are in our cities and urban regions. Providing power and links to the wider communication infrastructure are a constant source of consternation, while even simple maintenance tasks can be complicated, especially with devices in the field being hundreds of miles away from where DOT resources are concentrated.

By the same token there are specific rural problems that require the development of specialized systems – wildlife detection being a fine example – many of which are unlikely to feature high on the agenda in the urban domain. Maybe ITS has more of a role to play in the big country. Despite the lower traffic volumes, rural roads are proportionally the scene of more accidents per mile traveled than in our urban areas (the fatality rate for rural crashes is more than twice that for urban crashes). And when such incidents do occur, emergency response times just aren't on a par with our cities, so preventing accidents from happening in the first place is key. From a safety perspective, technologies that are paying dividends include rural intersection conflict warning systems to address right-angle collisions, the use of dynamic speed feedback signs on dangerous curves, and in-road sensors and RWIS to provide a better indication of the conditions that drivers are likely to face.

Such solutions are a relatively inexpensive way of addressing blackspots or points of concern, as opposed to physically remodeling



Strategic importance

Jon Jackels from **Minnesota DOT** reveals some of the benefits to agencies of uniting with private industry in order to improve safety, reduce maintenance costs and enhance operational and logistical efficiencies in our rural areas

As far as maintenance and operations management go, thinking strategically is of vital importance when it comes to rural ITS. Having taken part in a panel discussion at the National Rural ITS Conference, Jon Jackels from Minnesota DOT says that one of the challenges is that the counties and smaller towns don't have the technical expertise to maintain what can often be high-tech electronic systems. "You'll find there's much resistance to adopting that technology and putting it at the roadside for safety and warning applications," Jackels says, offering an example. Minnesota DOT operates around 1,700 traffic signals and has the electronic capability to manage these systems. "But continually adding systems without being able to add the personnel and extra hours to conduct the necessary maintenance on them is a resources challenge," he explains. "What happens is that we realign our priorities depending on which system is more important. Is a traffic signal more important than an intersection warning or curve warning system, for instance?"

> "It's financially impossible to spend millions on every intersection – a warning system may be a better option

So are there any solutions to such dilemmas? Jackels believes there are some opportunities that need to be explored. "One of those is reflected in an ongoing project on rural intersection conflict warning systems," he responds. "These can provide a dynamic warning to an approaching driver on the through road that a vehicle waiting is entering the intersection and, crucially, the driver at the intersection is alerted to traffic on the through road." Right-angle crashes tend to be severe, and Jackels says, "Without building an interchange or completely changing the geometry of an intersection – it's financially impossible to spend millions

hundreds of junctions or road features. And with developments in wind and solar power offering options to keep systems up and running, the potential to deploy a credible, effective ITS capability in challenging rural locations has never been greater.

Weather warnings

And Iceland is a good place to start. With a population of just 322,000 people and only 245,500 vehicles in an area the size of England, the country's road administration, ICERA, is responsible for 12,898km of roads outside of Iceland's towns and cities. At the mercy of the North Atlantic and being so close to the Arctic circle, the organization certainly appreciates the challenges that rural deployments present ITS managers.

According to Einar Pálsson, the chief of technical development in ICERA's service department, Iceland's inclement weather drives much of its ITS deployments: "We have weather stations on our high passes in the mountains, but more recently we've been adding them in the lowlands as slippery road surfaces are more of a problem there, so it's important for us to let travelers know about the conditions." The 95 or so weather stations the ICERA has deployed are more often than not situated well away from any power source. "Hence we produce the electricity for the stations ourselves, which can be a challenge because although Iceland is a very windy country, we do have periods without wind for several days and in the cold dark winter months you can't really rely on solar power either," Pálsson explains. Fuel cells have been called upon from time to time too. "We have found ourselves using them for our cameras, but due to cost if we can avoid using this technology, we will."

ICERA's variable message signs (VMS) are highly valued by Pálsson and his colleagues. "They're typically placed in the highlands before drivers start ascending our mountain passes so, if necessary, travelers can stop and evaluate if it's safe for them to pass – should there be high winds, for example."

For many of the high passes, Pálsson says that ICERA must refrain from servicing the roads during winter when the windspeed is more than 15m/s: "You can have snow blowing and zero visibility so we can't conduct any maintenance in those conditions. We can display a message on the VMS about road blockages or closures, with specific details about why there are problems. And we

Variable message signs are used by Iceland's ICERA to show windspeed, wind direction, temperature and, in extremely exposed areas, wind gust

on every intersection – a warning system may be a better option."

Addressing how the remote system is maintained, Jackels says the contractor doing the design and installation agreed to operate and maintain it for three years. "One of the reasons for this was to shift the risk element on the contractor so if they don't do a good job on the design, or have unreliable components, they have to sort things out themselves."

Jackels sees the project as a test to ascertain whether the private sector and contractors can fill in some of the rural capability gaps. "Our forces might take three hours getting to a site and back so there might be a way to reduce travel time by using resources that are spread out a little differently in the state. The local electrical contractor could for instance be trained to conduct the minor maintenance of the systems out there."

(Above) **A rural intersection crash avoidance system in Wisconsin** (Far left and below) **The systems provide drivers (on both the major and minor roads) with a dynamic warning of other vehicles approaching the intersection**

normally integrate CCTV with our weather stations so we can remotely assess the road conditions."

ICERA also receives valuable data from specialized freezing depth sensors that down to a depth of 1.2m measure temperature and conductivity (moisture) in the road structure: "Their primary purpose is to monitor the layers in the road and their load-carrying aspects for the spring thaw," Pálsson explains. "We're using them in all of the main roads where the road structure is not solid enough and there's likely to be heavy traffic and especially heavy trucks.

"If warmer temperatures come in and we experience a thaw, the top layers of the road melt while what lies beneath remains frozen," Pálsson says, detailing the impact trucks have on the roadway. "As the wet layers at the top are now weaker in regard to their carrying capacity, heavy vehicles can rather quickly cause a lot of damage." With asset protection in mind, ICERA monitors the situation carefully and if necessary puts restrictions on certain stretches. "We need at least 24 hours of advance notice about the likely conditions," Pálsson confirms.

Asked as to how technology is helping ICERA manage its network elsewhere, Pálsson says there is a strong focus on the winter service: "It's a high-cost activity so we have GPS on all of our winter equipment monitoring where they are, the salt they are carrying, where it is being used and the quantities – how many grams per square meter, for instance."

> Objects of a certain size will trigger the system and a beacon on a sign in the area will be activated to warn approaching drivers
>
> **Erik Minge, principal – ITS, SRF Consulting Group, USA**

Animal alerts

Of the 8.4 million lane-miles of roads in the USA, more than six million lane-miles are rural, hence why it's a big topic and even the focus of dedicated annual events, not least the National Rural ITS Conference. As delegates to the 2013 installment in St Cloud, Minnesota, heard at the end of August, wildlife is one of the major dangers to drivers, with between one million and two million wildlife-vehicle collisions (WVCs) estimated to occur in the USA each year – and going up. Erik Minge, principal – ITS, SRF Consulting Group, was one of the key speakers discussing his experience with rural wildlife detection.

(Right) **Highway managers can employ a wide variety of wildlife vehicle collision mitigation techniques to reduce the risk of encountering wildlife on the road** (Below) **Volvo Cars' response to WVCs is an active safety system that warns and automatically brakes for animals on the road**

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Minge cites four deployments of the technology, two in Minnesota, one in Idaho and the other across the border in Ontario, Canada. "They're all similar in that they use a passive infrared detection system – you could call it a cordon or virtual fence," he explains. "Objects of a certain size will trigger the system and subsequently a beacon on a sign in the area will be activated to warn approaching drivers."

As to facts underscoring the positive impact of these systems, Minge says it is difficult to obtain good before-and-after data, although in one case the Minnesota DOT was tracking the number of deer carcasses removed from the side of the road. "That revealed a 60-80% reduction in wildlife vehicle crashes following a deployment," he says.

So where's best to deploy such a system? For starters, and thinking practically, there needs to be room at the side of the shoulder for the sensors: "You also have to think about the roadway geometry so there is a clear line of sight. A relatively straight roadway allows a 400ft spacing. On a curved roadway you have to shorten up the post spacing to follow the curve."

Mapping out workzones

Peter Rafferty from the University of Wisconsin-Madison was also present at the rural ITS conference. As the ITS program manager at the Wisconsin TOPS (Traffic Operations and Safety) Laboratory, he gave a presentation on behalf of the Great Lakes Regional Transportation Operations Coalition (GLRTOC) on multistate operation coalitions, specifically in the area of workzones.

The primary motivation for Rafferty's work for the GLRTOC was the realization shortly after its formation three-and-a-half years ago of the need to improve the coordination across state borders for the highest impact workzones. "The FHWA's Work Zone Safety and Mobility Rule has provided guidelines for users to target for individual workzones but it breaks down where one agency is achieving its goals but a workzone just across the border isn't.

"From a traveler's perspective, they're not concerned about jurisdictions – what they experience are multiple workzones that are causing them bothersome delays," Rafferty adds. To remedy this, every year during the first week of February all of the GLRTOC agencies come together and map out the workzones to identify potential conflicts. "It allows us to see the places where we may want to do more with traveler information, for example. Getting together like that really improves agency-to-agency coordination."

Initially the workzones were highlighted on a GIS map, although this has more recently moved on to a Google Maps API. The next stage will be a Multistate Corridor Operations and Management (MCOM) program of the FHWA, which is providing funding to the GLRTOC. "One of our tasks is to develop the next generation of workzone mapping applications that will really be available for anyone, even another coalition," Rafferty reveals.

(Right) **An electronic sign can warn drivers of potentially unsafe conditions at intersections in rural locations** (Below) **There are benefits to be had from coordinating projects between transportation agencies, utilities, and other agencies that may need to do construction in the public right-of-way**

> The FHWA's Work Zone Safety and Mobility Rule breaks down where one agency might be achieving its goals but a workzone just across the border isn't
>
> **Peter Rafferty, ITS Program Manager – TOPS Laboratory, University of Wisconsin-Madison, USA**

Cross-border traveler information

Situational awareness across local and state boundaries is especially useful in a rural context and is something that Caltrans and the Western Transportation Institute (WTI) have been implementing to great effect.

Doug Galarus, program manager – systems engineering, development and

Intersection action

The potential of rural intersection conflict or collision warning systems is something that's caught the attention of Dennis Tessarolo, an ITS specialist who works at Ontario's Ministry of Transportation (MTO). MTO is a member of the Enterprise Pooled Fund Study, which has representatives from the USA, Europe and Canada.

"I sit on the board of that group and we undertake and conduct a substantial number of ITS reviews and minor projects, primarily in rural areas. One of these was an intersection collision warning system and in this phased project, we're looking to develop a standardization for approaches to rural intersections – how you sign them, how you identify them, particularly in high incident areas."

Tessarolo reveals that the project leader for this initiative is from Minnesota and the FHWA has picked up on the project as well: "We're actually at the stage of looking to put this into the Manual on Uniform Traffic Control Devices (MUTCD) – the set of standards that all DOTs in the USA follow."

integration at the WTI explains more. "The One-Stop-Shop (OSS) web application provides information for travelers in California, Oregon, Nevada and Washington and features comprehensive real-time data for when you're planning a trip," he explains. "Part of the genesis of the OSS was a nod to the fact that sometimes we need information for a larger area than just one state. In the main, traveler information is handled by the individual DOTs or even jurisdictions smaller than that. If you cross borders – which you're much more likely to do in rural areas – you end up having to transition between one system and the next."

The project first started in Northern California, where Ian Turnbull is chief of the Office of ITS Engineering for Caltrans District 2. "Travel doesn't stop at political boundaries so travel information shouldn't either," he maintains. "Before OSS, you'd have to look at a variety of different sources to plan a journey." What was required was a seamless, borderless, traveler information resource. "The focus was more on rural because that's where you're more likely to be traveling longer distances."

Currently, the OSS allows you to look at CCTV images, DMS, weather information and weather stations that are along the route. "We are going to be expanding it into highway advisory radio messages, incident information from the different state police departments, accident information as well as details on construction."

Down to the planning

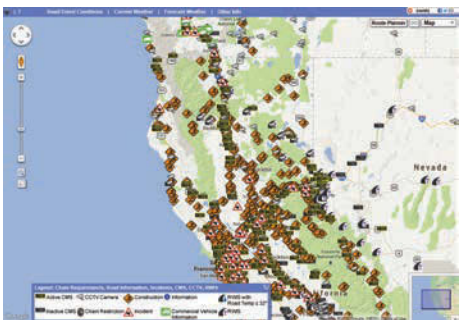
What's clear is that there is great scope for rolling out ITS in rural areas, given the availability of the right systems and the will to succeed. But Bob Scott says it's important to do your groundwork, as underlined by his National Rural ITS Conference presentation about ITS planning and implementation on a rural freeway corridor. "Nothing in terms of ITS works without good communications," emphasizes the principal of SRF Consulting when asked to distill the different approaches required for rural and urban areas.

Generally the aim is to deploy fiber optic along the freeway corridor although in some cases you might need to look at alternatives: "We may tie into the fiber optic backbone that goes throughout a state, for instance, and then use wireless and local hotspots to connect up to the freeway corridor," reveals Scott. Spread-spectrum radio tends to be used to communicate along key corridors. "You need to do a signal strength test and look at the type of interference because generally you're working with the unlicensed spectrum," he adds. "The licensed spectrum is always an option but you need to work with each state's frequency coordinator for that. Another path for communications is cellular. "We test with various cellular providers to ensure that the coverage is good. Satellite is sometimes an option, but due to the cost isn't something we generally recommend."

To help further still, Scott says SRF has developed a GIS tool that maps out all of the device locations. "It finds the best source of communications for a particular device, whether that be fiber, spread-spectrum radio or cellular." This was particularly useful for a large statewide planning project that Scott worked on recently. "We input all of the different device and plant locations where the DOT wanted them and used the GIS tool to take the first cut of recommendations for communications technology and then refined things from there."

When it comes to the gathering of rural traffic data, non-intrusive technologies such as radar are en vogue and enable volume, occupancy and speed data to be collected. A centralized system will often be used in tandem to collect and process the data, apply the algorithms, etc. Bluetooth is increasingly being used also, particularly where the cost of other detection technologies is prohibitive. "It's a great way to collect travel-time data."

Whatever the apparent barriers to deploying and managing ITS in rural areas – from how to power field devices, ensuring reliable and effective communications to keeping systems maintained and fully operational – what's clear from speaking with people is that there are always ways to resolve most of the issues.



The OSS web application provides travelers in California, Oregon, Nevada and Washington with comprehensive, real-time data that can be employed in planning their long-distance trips

Citizen reporters

The Citizen Reporter Program is a groundbreaking rural program developed in Utah. The basic idea is that members of the public will be trained up to submit road and weather reports to Utah DOT via their smartphones. "Rural roads are very important to our network but they don't get a lot of volume," say Lisa Miller, traveler information manager. "It's vital to have more eyes out there so we see this as really beneficial."

A pilot involved around 50 UDOT volunteers. "We're launching it to the public in the next few months," Miller says. "Our goal is 800-1,000 reporters over the course of the program." Groups being targeted as potential volunteers include the Utah Trucking Association as well as the Highway Patrol.

Plow crews, roadside stations and in-house meteorologists also provide weather information to UDOT.

For the purposes of road weather data, Miller says the state is split into 145 segments with the status of the road highlighted on the UDOT traffic app, the website and 511 system. On the wider ITS deployment front, Utah is in a strong position compared with many other states as it can call upon its fiber network of more than 1,800 miles: "This has been developed through UDOT installs as well as trades with private sector agencies that are keen to get their communications networks from one place to another, which lets us piggyback on them."

> We may tie into the fiber backbone that goes throughout a state and then use wireless and local hotspots to connect up to the freeway corridor
>
> **Bob Scott, principal, SRF Consulting, USA**

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Brimming with success stories, V3.0 of the FHWA's *Best Practices for Road Weather Management* can guide you through whatever Mother Nature throws in your way. **Nick Bradley** provides an update on nine of the featured projects

Illustration courtesy of Tim Ellis

The *Best Practices for Road Weather Management* has in the words of Paul Pisano, team leader of the FHWA's Road Weather Management Program, been an invaluable resource for agencies wanting to deploy solutions to alleviate the impacts of adverse weather. And if the highly subscribed webinar that coincided with the launch of V3.0 last year is anything by which to judge, the international road weather community clearly agrees. "Version 3.0 captures the state-of-the-art and presents 27 all-new practices that build upon previous successes," says Ray Murphy, ITS specialist with the FHWA's Office of Technical Services.

A great threat to surface transportation

There remains an acute need for such solutions. According to the FHWA, in 2011 there were 7,130 fatalities and 629,000 injuries as a result of adverse weather, which are astounding statistics when you consider some of the tools that are available and the positive results they're delivering. But as you will read over the next five pages, with the increasing convergence of ITS and meteorological techniques, roadway authorities are stepping up to the plate.

Systems are being deployed that not only address blackspot areas but mitigate risk in the event of severe, widescale weather events. Arizona's DUST and Florida DOT's bridge windspeed sensor project are great examples of the latter, while a life-saving, ice-warning system deployed in Colorado's Snowmass Canyon confirms what can be achieved with a bit of smart thinking. And with support from systems such as MDSS, maintenance teams can look at the bigger picture, make more informed decisions, maximize efficiencies and do what their constrained budgets often force them to do – much more with much less. There will be ups and down, of course, but road weather managers have never had it so good… >

Automated warnings for Caltrans travelers

In response to heavy fog along SR 99, a cutting-edge detection and warning system is now in place

Fog of the severity that led to an 81-vehicle pile-up on SR 99 in Fresno in November 2007 hasn't been seen since, says a relieved John Liu, deputy district director, Caltrans District 6, division of maintenance and operations. But he knows it may return in the next few weeks.

And should it do so, the right technology – a fog detection and warning system (FDWS) – is in place to help prevent a repeat of that 2007 tragedy, which led to two deaths and 68 injuries.

California's Central Valley – which extends from Bakersfield north to Redding – is one of the USA's largest agricultural regions.

> "Motorists often drive at speeds unsafe for the visibility and that's a recipe for disaster" *John Liu, Caltrans*

It is also a major transportation corridor, with I-5 and SR 99 connecting major population centers between southern and northern California. "In Fresno, SR 99 carries more than 100,000 vehicles a day," Liu reveals. "But the region is also subject to what is known locally as 'tule fog' [from the tule grass wetlands], which typically forms after recent rains and when winds are calm and there is cooling at night."

During the fog season – which runs roughly from November 1 to March 31 – visibility can be reduced to less than 100ft and in some cases nearly zero. "Motorists often drive at speeds unsafe for the visibility and in such conditions, that's a recipe for disaster," Liu laments. And that's exactly what happened in 2007.

Designed to prevent this from occurring again, the FDWS was implemented in phases from October 2008 over a 12-mile stretch on SR 99. Phase 1 was completed in February 2009 and Phase 2 with full functionality on November 1, 2009, just before that year's fog season.

The system is a cocktail of California's first multicolor changeable message signs (CMS), Vaisala PWD10 forward-scatter visibility sensors, SmartSensor HD radar spot-speed sensors from Wavetronix and cameras from FLIR. "It alerts motorists automatically through intelligence built into the ICx Cameleon ITS transportation management software," Liu explains. "Speed detectors are deployed every 0.25 miles and visibility sensors and CMS every 0.5 miles.

"The PWD10s are installed at driver eye level to ensure the system is reporting the current conditions as seen by drivers. Meanwhile, the Wavetronix sensors are capable of measuring traffic volume, classification, speed, lane occupancy and presence in both directions of travel. The data from both sensors is used to assess visibility conditions and – equally important for travelers and traffic managers – the speed differential at downstream locations."

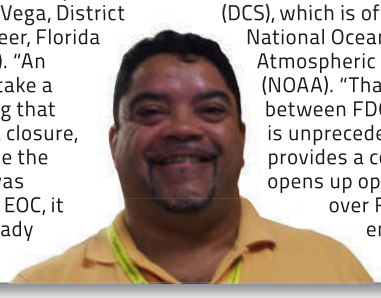
As with many installations in such rural locations, dedicated hard-wired communications weren't available. "Everything is wireless, in this case using Proxim devices to communicate between the technologies in the corridor," Liu says. Backhaul communications to the TMC is achieved using Verizon Wireless EVDO modems. "And due to the

Bridge-wind sensors offer certainty and safety

An efficient, safe and more accurate method to collect and disseminate wind speed

Whenever a severe weather event such as a hurricane sweeps into Florida, law enforcement officers are deployed to the state's bridges to take wind-speed measurements with handheld anenometers, from which decisions are made about bridge closures. That was unacceptable to Florida Highway Patrol Chief Grady Carrick, who was not only concerned officers were being put in harm's way but that it was also an inefficient use of resources at a time when they could be needed elsewhere.

"Frequent communication missteps were also leading to inconsistent information being disseminated to the public," reports Peter Vega, District Two ITS engineer, Florida DOT (pictured). "An officer might take a 40mph reading that would mean a closure, but by the time the information was relayed to the EOC, it may have already reopened."



As part of a 2011 pilot project, a high-wind speed alert system was deployed on 20 critical bridges and interchange flyovers in the Jacksonville area.

Each installation cost just US$10,000, although that wasn't only down to the low cost of the WindSonic sensor itself (from Gill Instruments in the UK). The solar-powered GPS transmitters utilize a free telemetry service, the Data Collection System (DCS), which is offered by the National Oceanographic and Atmospheric Administration (NOAA). "That partnership between FDOT and NOAA is unprecedented and provides a conduit that opens up opportunities all over Florida," Vega enthuses. "The most expensive part of any ITS is communication and NOAA has assisted in reducing costs substantially. Similarly, there can be redundant paths for this data due to the satellite capabilities, hence flexibility and multiple 'home runs' are possible."

"NOAA has told us that this is the first time the DCS

scarcity of fixed infrastructure, 35% of the devices run on solar."

"No major fog-related crash has occurred within the project boundaries since it was constructed," says Liu, although he concedes the amount of fog has been much lower in recent years due to drought.

Maintenance has been a particular challenge however, due in part to DOT staffing and budgetary limitations. "The visibility sensors require yearly calibration and cleaning, while the speed sensors require annual calibration. We've also experienced a high failure rate with the PV panels and batteries as well as theft; the former also require periodic cleaning.

"There have been issues with the communications, too, with high failure rates, recurring costs and lack of plug-and-play for the wireless point-to-point system. And as there are more objects at the roadside along this stretch, vehicles have collided with the equipment from time to time.

"The system message is currently specific to fog conditions only," says Liu. "If we had to do things all over, we would make the message sets generic to all types of visibility restrictions, such as dust, rain and fog. The messages in the system are currently hardcoded, fixed, and not easily configurable. The system is also closed loop and doesn't allow for easy data sharing with other traveler information systems such as QuickMap, PeMS, 511, etc."

Would a smartphone- or in-vehicle-based variant solve such issues? "We did think about that, but given the limited timeframe to get a system in place, a more traditional roadside system was used," Liu says. "But with continued advances in auto technologies and the ubiquity of smartphones, there is much more potential now for a system without as many field elements."

> "We're obtaining better accuracy, tracking and greater efficiency" *Peter Vega, Florida DOT*

has been used for a real-time public safety-related project," adds Randy Pierce, specialist in telecommunications with FDOT.

So other than a rethink as to how the sensors could be better mounted to the bridges – at some locations, maintenance-of-traffic (MOT) setup was necessary – Vega wouldn't have done anything differently. The system started to pay straight away. "In June 2012, an early season tropical storm was bearing down on us and the EOC had to deploy law enforcement to multiple bridges," he recalls. "But due to unforeseen circumstances, the amount of resources needed for bridge closures wasn't available; the EOC requested utilization of these bridge wind sensors, even though the software package release was a month away.

"To overcome this challenge we accessed North Florida's data on NOAA's website to monitor and deploy units. A few more high-wind events during the 2012 hurricane season enabled us to realign field personnel so that only the vulnerable bridges which 'could' have suffered were addressed. In other words, as a result of the deployment, we're obtaining better accuracy, tracking and greater efficiency."

Real-time response to standing water

An Active Traffic Management scheme on I-35W adds a crucial safety warning system

Minnesota's Smart Lanes on I-35W have never featured in these pages in a road weather management context before, so why now? "When we converted the existing HOV lanes to HOT lanes, we added a 2ft buffer between the HOT lane and the general-purpose lane," explains Brian Kary, freeway operations engineer at Minnesota DOT. To accommodate the buffer, the HOT lane was shifted to the left, onto the inside shoulder. "This was originally designed to allow for ponding during heavy rain, meaning vehicles using the HOT lane could be driving in standing water," says Kary.

A danger, standing water has the potential to unexpectedly hydroplane light- to medium-sized vehicles moving at speeds of 50mph or higher. "So our options were to either add extra catch basins – which would have required rebuilding the inside median barrier – or actually utilize the Active Traffic Management (ATM) aspect of the Smart Lanes to warn drivers of the potential danger."

Rain gauge sensors were therefore installed to track the rainfall intensity, while a recently completed University of Minnesota study developed recommendations for when a message would be displayed on the overhead Intelligent Lane Control Signals (ILCS). "The next step is to program these recommendations into our Intelligent Roadway Information System (IRIS) software," Kary reveals. "An algorithm would have to be coded within IRIS to have the ILCS messages automatically displayed when the rain sensor reached the thresholds for the ponding."

Although there haven't been any crashes as a result of ponding in the project area, Kary and his colleagues in the RTMC have witnessed drivers slowing down during heavy rainfall. "One of our big challenges is determining whether there's actually a need for the system. The heavy rainfall seems to have a pretty good effect of slowing drivers down anyway."

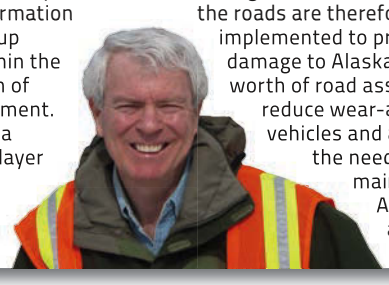
> The next step is to actually program these recommendations into IRIS *Brian Kary, Minnesota DOT*

Another component of the ATM system is an advisory variable speed limit system that warns motorists of congestion downstream. This system currently uses a constant deceleration rate to determine advisory speed limit values, which may differ during different types of weather. "We are working to develop new techniques for the advisory VSL system that would adjust the deceleration rate and the maximum speed value automatically, based on real-time weather conditions," Kary says.

Alaska's TDP program for weight restrictions

Decisions about weight restrictions on Alaska's roads are aided by a network of temperature sensors

If Alaska's big freeze isn't enough to contend with, the springtime thaw – which affects pavement integrity – is also a source of consternation for the state's Department of Transportation and Public Facilities (ADOTP&F). "This thawing occurs from the surface of the road down through the sublayers," reveals Jack Stickel from the transportation information group within the DOT's Division of Program Development. "You end up with a water-saturated layer of soil developing between the pavement surface and the still-frozen subgrade beneath." And when heavy trucks press down on this constrained system, the thaw zone's pore pressure increases dramatically and can lead to 'quick' foundation conditions.



> "This automated, real-time temperature profile visualization is invaluable" *Jack Stickel, ADOT&PF*

Weight restrictions on the roads are therefore implemented to prevent costly damage to Alaska's US$10bn worth of road assets, reduce wear-and-tear on vehicles and also reduce the need for road maintenance. And to help assess when these should be enacted, a Temperature Data Probe (TDP) program has been developed. This incorporates two statewide networks, one for TDPs co-located with RWIS sites and one that comprises standalone installations. "The Measurement Research Corporation (MRC) probes consist of a lead-in data cable and a 6ft, 1in-diameter thermistor string (16 per probe), which is installed vertically at the road shoulder," Stickel says.

The standalone sites are polling data three times an hour, which is uploaded into an Oracle regional database and becomes available under Alaska's RWIS and TDP Profiles for M&O on the ADOTP&F intranet page, as well as the RWIS public website. Before decisions are made, site observations, past experience, NWS forecasts, roadway pavement structure, etc, are also factored in.

Depending on the quality of the roadway's structural regime and moisture content, restrictions are usually completely lifted as the thaw depth exceeds 48in.

Stickel feels the automated, real-time temperature profile visualization is invaluable in setting the weight restrictions. "But it also enables commercial trucking to plan work schedules and minimize impacts of hauling less than full loads," he says.

Performance measures in winter operations

Improving safety and mobility for the traveling public and minimizing 'ice-up' time for maintenance crews

Statewide implementation of the Idaho Transportation Department's (ITD) Winter Maintenance Performance Measures System (WPM) began in 2011. The goal was to examine in much finer detail whether or not practices could be altered to enhance operational efficiencies. "I wanted to develop a way to give maintenance crews real-time feedback on the effectiveness of their practices," reveals Ed Bala, District 5 engineer from ITD. "I knew it would be difficult to prevent icing but I wanted to minimize it."

With that concept in mind, Bala developed the storm index, which measures ice duration per unit of storm severity. "This is modeled in an equation using wind velocity, snow depth and pavement temperature," Bala explains. As the program has evolved, Bala's colleague, Dennis Jensen, winter maintenance coordinator, developed the mobility index to measure the percentage of ice-free time when snow falls on freezing pavement.

"It's the revolution in remote sensing that has made all of this possible," contends Bala. "We have non-invasive pavement sensors from Vaisala that communicate via cell phones and run on solar power, enabling them to be placed virtually anywhere. There are 96 sites in total but 100 polling locations as some sites poll more than one surface location. In addition to the atmospheric sensors, each RWIS site will typically have a DSC111 to measure the road's grip coefficient and a DST111 to measure surface temperature. Most DOTs have used the technology, but only in a passive sense. I think our WPM are the first of their kind, especially as they offer real-time feedback."

> We have established much more continuity in winter operations than prior to the WPM *Dennis Jensen, Idaho TD*

"When we implemented the performance measures statewide back in 2011, there was a great deal of apprehension about ITS devices monitoring winter operations," recalls Jensen. "Two seasons on and the majority of operators, supervisors and managers are not only accepting WPM through RWIS but are requesting additional sites across the state!"

"In the storm index, a smaller number indicates a better score," Bala says. "In the winter of 2009, our overall index was 0.7 but in 2012-2013 it was 0.07. Also, our crash rate here in District 5 has been reduced about 40%."

"We have established much more continuity in winter operations than existed prior to the WPM," adds Jensen, who says he is still in the process of evaluating the ROI.

Ahead of the curve to protect drivers

Motorists driving on dry roads needed notification for a potential icy curve ahead in Snowmass Canyon

Completed in October 2004, the US$100m Snowmass Canyon Widening project on Colorado State Highway 82 is a marvel of modern road engineering. "It involved the building of two roadways – one virtually on top of the other – along steep, geologically unstable slopes using a terraced system of retaining walls and bridges," says Michael Curtis, project manager, Region 3 Traffic, Colorado DOT.

But shortly after the new road opened, accidents started to happen at one specific location – the result of snow melt on a curve draining across the roadway and sometimes freezing to create a sheet of black ice. With a posted limit of 50mph and a curve advisory of 45mph, many drivers were lulled into a false sense of security by the dry conditions before the curve and if going too fast would simply spin out of control on the wet or ice. "Five accidents in 2005, 15 in 2006, five in 2007, 14 in 2008, five more in 2009 and another five in 2010," Curtis says of the consequences.

The technological response to this? A combination of a non-invasive RWIS featuring Vaisala's DST111 road surface temperature sensor and DSC111 road surface condition sensor, VSL signs and a VMS.

The rural area did pose a few challenges. As there were no telephone lines at the location of the RWIS or the VMS, communication to the RWIS was achieved via a cell modem, while a wireless spread-spectrum system was set up to communicate with the VMS.

> That data is enabling us to warn motorists in plenty of time about the real conditions *Michael Curtis, Colorado DOT*

And what of the results so far? "The system was fully installed by February 2011 and cost US$290,000," Curtis reveals. "We had seven accidents during the 2011 winter – four of which were after the system became operational – and in the winter of 2012 we had just three. CDOT maintenance personnel have been impressed with the accuracy of the real-time road surface condition data and that is enabling us to warn motorists in plenty of time about conditions up ahead. It's up to them whether or not they heed that advice!"

The VSL part of the project has now been removed though. "We were adjusting the regulatory limit based on the actual conditions, as communicated via the wireless spread-spectrum, but we didn't get this approved by traffic personnel at our HQ so had to take the VSL out; an advisory sign would have been okay."

Michigan DOT's measurement of regain time

A performance metric has been developed to determine the effectiveness of winter maintenance

The economic costs of disruption from a snow storm can be huge – between US$66m-US$700m a day in some states; a one-day shutdown due to impassible roads in Michigan has a US$251m impact. But winter maintenance doesn't come cheap, costing Michigan DOT something in the region of US$100m a season. "That's around 40% of our total maintenance budget," reveals Will Thompson, associate region engineer – University Region. "With such levels, it's important that we have the right performance measures in place to evaluate the effectiveness of changes to our operations and to communicate this to the public.

"Speed is one of the best indicators when it comes to analyzing the success or otherwise of our winter maintenance operations," Thompson continues. To obtain this information, during the winters of 2009-2012, MDOT collected speed information along I-96, from Ionia County to the Oakland County line.

> Speed is one of the best indicators when it comes to analyzing the success of operations *Will Thompson, Michigan DOT*

I-96 is a six-lane freeway near Brighton (14 miles) and a four-lane rural freeway near Lansing (35 miles). "We're using portable trailers with microwave sensors attached to detect speed before, during and after a winter storm event," Thompson says. "They're spaced such that each is collecting information from a segment of Interstate maintained by different MDOT road maintenance garages – in Grand Ledge, Williamston and Brighton. This data is then downloaded and graphs are prepared to show the average speeds over time." Additionally, storm start and end times are recorded by maintenance staff along with other information about the intensity and temperatures during the storm. "The data is then used to illustrate 'regain time' – i.e. the time needed after a winter storm event until vehicle speeds return to normal operating speeds."

In the future, when MDOT begins using speed data from cell phones as well as other sources, much more and widespread information will enhance the metric further still and in doing so will help to finetune MDOT's winter maintenance operations performance as a result.

Arizona's DUST warning system

Dust storms lead to poor visibility and potentially dangerous conditions on Arizona's highways

Haboobs (from the Arabic for 'blast') are common in Arizona around springtime and in the summer, and from a traffic management perspective wreak havoc on I-10 especially. So along a 60-mile stretch where the most severe dust-related traffic incidents have been concentrated, Arizona DOT (ADOT) has deployed the Dual Use Safety Technology (DUST) Warning System. It features a series of sensors to record visibility, weather stations to monitor wind speed and soil-moisture sensors to provide clues as to the condition on the ground, all of which is linked to a suite of ITS systems.

"Dust-storm accidents make up a small percentage of the state's traffic fatalities, but they tend to be large and dramatic," suggests Bill Harmon, ADOT engineer for the Safford district. In actual fact, between 2000-2011, blowing dust was responsible for 1,207 collisions, 40 fatalities and 1,136 injuries, according to DOT figures.

> "Dust-storm accidents make up a small percentage of the state's traffic fatalities, but they tend to be large and dramatic" *Bill Harmon, Arizona DOT*

Deployed on I-10 between the communities of Bowie and San Simon in Cochise County, DUST also helps with unexpected snow and ice in the Texas Canyon area of the Interstate.

"It's not a new technology, rather a second-generation system that expands the capabilities of an older, smaller system," Harmon reveals. Anenometers, forward-scatter visibility sensors, wireless Ethernet networks based on the WiMAX IEEE 802.16 standard, PV cells for power, LED-based traffic beacons and CCTV cameras are among the gadgets that make up the overall system. The sensors detect high winds and low visibility and the CCTV provides a visual confirmation to enable ADOT and the Department of Public Safety to make informed decisions as to roadway closures and detours.

So has it been worth the investment? "Weather events and crashes are highly random in nature and it can take years for enough data to be collected to make a meaningful assessment," Harmon says. "But a single fatality has a very high emotional as well as a financial cost to society, so if we can reduce the number of crashes, the cost could be justified in a traditional business sense."

But as the Arizona DOT engineer concludes, technology cannot resolve all the challenges traffic managers are presented with. "You're always going to get a certain portion of the traveling public being confused by the warning messages, or sadly even choosing to ignore them and attempting to pass through an area experiencing bad weather just hoping for the best."

Decision support for winter maintenance

How MDSS recommendations can deliver cost savings running into millions of dollars

From treatment types and timing to rates and locations, Maintenance Decision Support Systems (MDSS) have undoubtedly revolutionized how agencies approach road weather operations. And having led the multistate Pooled Fund Study that developed and deployed MDSS between 2002-2012, South Dakota DOT (SDDOT) knows more than most the benefits that can be reaped.

"Winter weather can be a major barrier to travel here," reports SDDOT's David L Huft, research program manager. "Our surveys also reveal travelers regard winter weather as their greatest highway safety threat.

"We typically experience several major Interstate highway closures each winter that completely halt movement of passenger and freight traffic," continues Huft. "And we spend millions of dollars during these events as well as other more routine winter events, such as freezing rain, ice, snow, blowing snow, near-zero visibility, etc.

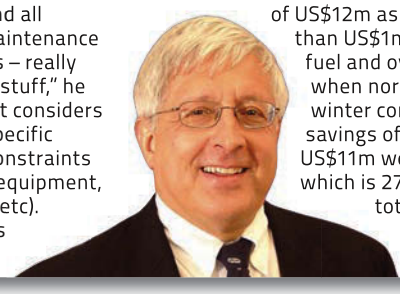
"With MDSS, we benefit from high spatial and temporal resolution weather forecasts, numerical modeling of the pavement structure to predict response to forecasted weather and all feasible maintenance treatments – really innovative stuff," he explains. "It considers location-specific resource constraints (schedule, equipment, chemicals, etc). It considers maintenance that has already been applied as well as the material type and application rate. The treatment choices recommended are those that optimally satisfy defined levels of service requirements."

Yet despite the benefits that MDSS has brought to Huft, his colleagues and DOTs around the USA, resistance to change has been a challenge. "It involves sophisticated technology and requires a profound change in the approach to winter maintenance, if its benefits are to be realized," he says.

> "Our surveys also reveal travelers regard winter weather as their greatest highway safety threat" *David Huft, South Dakota DOT*

"We have experienced significant savings, but because we switched from using salt/sand mixes to nearly 100% salt as our deicing material during the same time period, we have been unable to separate savings resulting from MDSS from those from the deicer change."

But there are concrete figures elsewhere that highlight the value of MDSS. Indiana's statewide deployment of it during the winter of 2008-2009 resulted in reduced salt costs of US$12m as well as more than US$1m savings in fuel and overtime. "Even when normalizing for winter conditions, total savings of more than US$11m were estimated, which is 27% of its normal total winter budget."



Tolling's highest good

Funded through an innovative partnership between the community and the CTRMA, the MoPac express lanes, writes **Heather Reavey**, will also fund Texas's first Regional Infrastructure Fund and help to deliver critical transportation projects faster than ever before

Photographs courtesy of HNTB

When a US toll facility can sustain itself without public subsidy, it is considered highly successful. When it can sustain itself and help pay for other transportation projects in the region, it rises to a new level of social benefit. "And that's tolling's ultimate goal," believes Mike Heiligenstein, executive director of the Central Texas Regional Mobility Authority (CTRMA). Anticipated to open in late 2015, Central Texas's MoPac Express Lanes will be such a facility and will also help to fund the state's first regional infrastructure bank.

Carrying more than 180,000 vehicles each day, MoPac is a key route to downtown Austin and a primary commuter alternative to

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Interstate 35. "Since congestion is a growing problem on MoPac, high-occupancy vehicle lanes – or express lanes – have been part of the Capital Area Metropolitan Planning Organization's (CAMPO) Long Range Transportation Plan since 1994," explains Heiligenstein, who joined the CTRMA in 2003 just months after its creation and oversaw the successful financing and construction of 183A, the agency's first toll road.

CAMPO's mission is to coordinate regional transportation planning with counties, cities, local transportation agencies and the Texas Department of Transportation (TxDOT) and to approve the use of federal transportation funds within the region. In 2012, the organization received an unexpected allocation of US$130 million from TxDOT and the MPO Policy Board was subsequently charged with distributing the money to a shovel-ready project in a congested area. The only project the region had fitting the criteria was the MoPac Improvement Project.

"With CAMPO's funding and a US$69m grant from TxDOT, the CTRMA is adding an 11-mile express lane in each direction from downtown Austin north to Parmer Lane," Heiligenstein adds. "Located in the center of the corridor, the MoPac Express Lanes will be the first variably priced toll facility in Central Texas and the first express project in a planned network for Central Texas. "The US$200m project includes the construction of sound walls, the enhancement of bicycle and pedestrian facilities as well as upgrading the corridor's visual appearance," he says.

Scheduled to begin construction in the fall of 2013, the project offers all the benefits any well-planned toll facility should, such as better reliability, congestion management, an express transit route, reduced travel times, improved emergency response and more.

> Even those citizens who choose not to use the facility will benefit from future projects the express lanes will fund
>
> **Mike Heiligenstein, executive director, CTRMA, USA**

The CTRMA uses toll revenues to fund other improvements that benefit all road users

The ins and outs

"Tolls will vary depending on traffic demand," Heiligenstein says, when asked to detail some of the specifics surrounding toll policies and practices. "Once in the express lanes, the minimum trip length will be fives miles with no additional entering or exiting permitted.

"Changeable electronic signs will display the current rates in real time, so drivers will know the current toll rates before deciding whether to enter the lanes, with tolls collected electronically via TxTag. Drivers who don't have a tag account will use the lanes via video tolling.

"There will be no maximum toll and no HOV component," the CTRMA executive director highlights. "Toll-free travel will be restricted to registered vanpools of nine persons or more, emergency vehicles, military convoys and Capital Metro buses (Austin's public transit service). In actual fact, this will be the first time in Austin's history that buses will have the opportunity to use an express lane."

According to Heiligenstein, the Mobility Authority will evaluate the need to waive tolls on a case-by-case basis. "If an incident in the express lanes creates a backup, causing a degradation of the driver experience, the time of the incident can be isolated and tolls levied during that period be waived or modified," he says. The Mobility Authority will also be able to manually override the pricing software.

The landmark agreement

Part of the RMA's agreement with the MPO calls for the creation of the state's first Regional Infrastructure Fund. Beginning in 2017 – and for the next 25 years – the CTRMA will deposit a total of US$230m from toll revenues into the fund. This financial commitment will be based on a schedule that provides upfront flexibility of payment, with the largest deposits being scheduled near the end of the term when cashflow is expected to generate more of a surplus. "Once the infrastructure fund

A transportation tattoo

The MoPac Improvement Project would not be possible without a solid partnership. CAMPO contributed most of the funding and provided the strategic vision, while TxDOT contributed funding, guided the Mobility Authority through the National Environmental Policy Act (NEPA) process and participated as a member of the evaluation team during procurement. The CTRMA, in turn, will construct, operate and maintain the facility.

Being a good partner requires commitment, flexibility and rigidity: *Commitment*: Express lanes are different from a regular highway project as they require a permanent commitment. That's why the CTRMA encouraged each of its partners – and its own staff – to think of the MoPac Improvement Project as a transportation tattoo – something only a Texas tornado could remove! *Flexibility*: A project such as this is a group effort. Lead agencies must solicit and incorporate the ideas and goals of others, so that all the participants – TxDOT, CAMPO or a resident at a public hearing – achieve their goals. *Rigidity*: At the same time, the lead organization must be steadfastly dedicated to achieving the end goal. It can't let individual agendas change the trajectory of the project. The lead agency is the keeper of the dream, the vision. Its job is to realize that vision, no matter what.

Tolling is just one component of the CTRMA's goal to provide improved transportation services

has accumulated to a substantial amount, CAMPO can use the funds for other transportation infrastructure projects in Central Texas, including bike lanes, transit service, truck lanes or improvements to I-35's general-purpose lanes," states Heiligenstein. The CTRMA can also use and bond against any revenues exceeding its US$230m commitment, which is anticipated to be substantial.

"The Regional Infrastructure Fund is one of those ideas that makes sense," he suggests. "Texas already has a State Infrastructure Bank so why not adopt the same concept at the regional level as one more way the Mobility Authority can keep its promise to reconnect the region and create local sources of funding for needed mobility improvements? It's a win-win for everyone." In what ways? "The Mobility Authority gets its project jump-started," Heiligenstein responds. "The Regional Infrastructure Fund supports our mission to implement innovative solutions (tolled or non-tolled) that reduce congestion and create transportation choices that enhance quality of life and economic vitality. Furthermore, by avoiding a bond sale, we save more than US$314m in interest and principal payments that would have been due over the next 35 years. That means it will be easier for us to finance future projects. Even citizens who choose not to use the facility will benefit from the projects the express lanes will fund."

> This public-public partnership is truly an innovative response to the transportation funding crisis and will pay off for Central Texas for years to come
>
> **Will Conley, Policy Board chairman, CAMPO, USA**

CAMPO's Policy Board chairman Will Conley is equally enthused and says the fund is an incredible opportunity for the region. "Central Texas has some of the worst traffic in the USA and we desperately need more money to improve mobility in critical corridors such as MoPac and I-35," he says. "This public-public partnership is truly an innovative response to the transportation funding crisis and will pay off for Central Texas for years to come."

An out-of-the-box solution

Ultimately, the Mobility Authority's commitment to create the Regional Infrastructure Fund represents an unprecedented regional partnership for mobility solutions. "Rather than using toll revenue from the MoPac Express Lanes to pay back bond investors, the Mobility Authority will be able to allocate that money to critical transportation projects in Central Texas," Heiligenstein concludes. At a time of tremendous uncertainty regarding future transportation funding, the local community is thinking out of the box and leading the way in the USA when it comes to innovative ways to address local mobility challenges. The MoPac Express Lanes will not only contribute to the quality of life of its customers, but also to the good of the general public.

• *Heather Reavey is vice president at HNTB. For more information about the CTRMA, please email mstein@ctrma.org*

Inside the CTRMA

The Central Texas Regional Mobility Authority is a local, independent government agency created to improve the regional transportation system. Its mission is to implement innovative solutions that reduce congestion and create transport choices that enhance quality of life and economic vitality. The CTRMA was created in October 2002 to serve Travis and Williamson counties. It runs the 183A toll road in Williamson County, the Manor Expressway in Travis County, and has several more in the construction and development phases. The Mobility Authority is as dynamic as the region it serves.

MoPac best practices

Some of the best practices implemented in the course of the MoPac Improvement Project proved so successful that they will be carried forward and applied to future endeavors:
Delegating: Empower mid-level staff to solve problems instead of escalating every issue to the executive level.
Addressing conflict: Get all issues on the table – fast – while they are small and manageable, and have a regularly scheduled time and place in which to address them.
Anticipating roadblocks: The Mobility Authority strives to see things from its partners' perspectives. What would CAMPO perceive as an obstacle if x, y or z were suggested? Can the obstacle be overcome? And if so, how?
Sharing goals: The Mobility Authority tries to avoid miscommunication and misunderstanding by asking all its partnering agencies to express their goals and missions for the project. The more each partner understands the other, the better all will be.
Placing transparency and accountability above all else: The Mobility Authority will ensure it stays engaged with its partners to ensure surprises are kept to a minimum. To that end, it holds monthly meetings with other transportation agencies to vet issues of importance.

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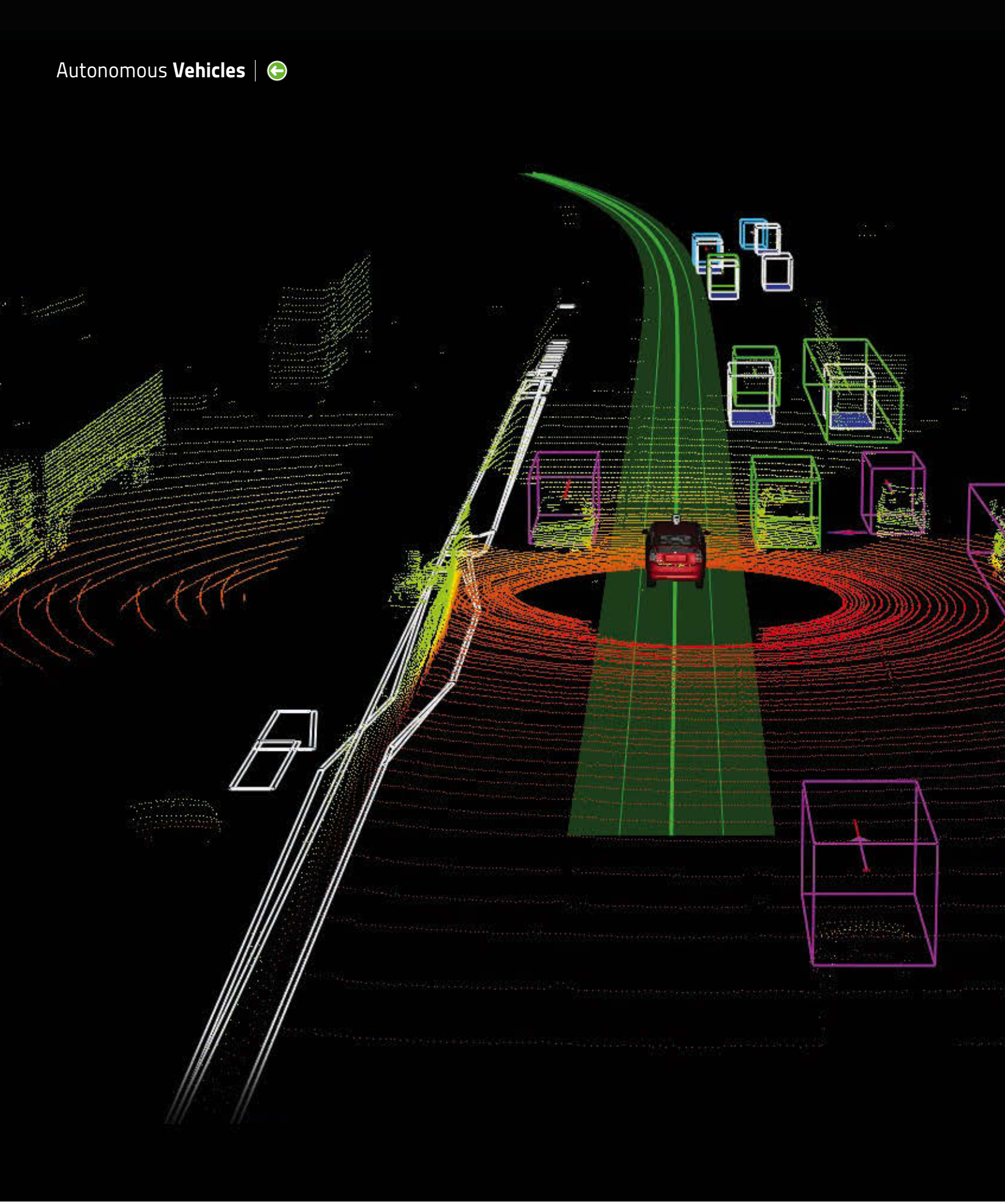
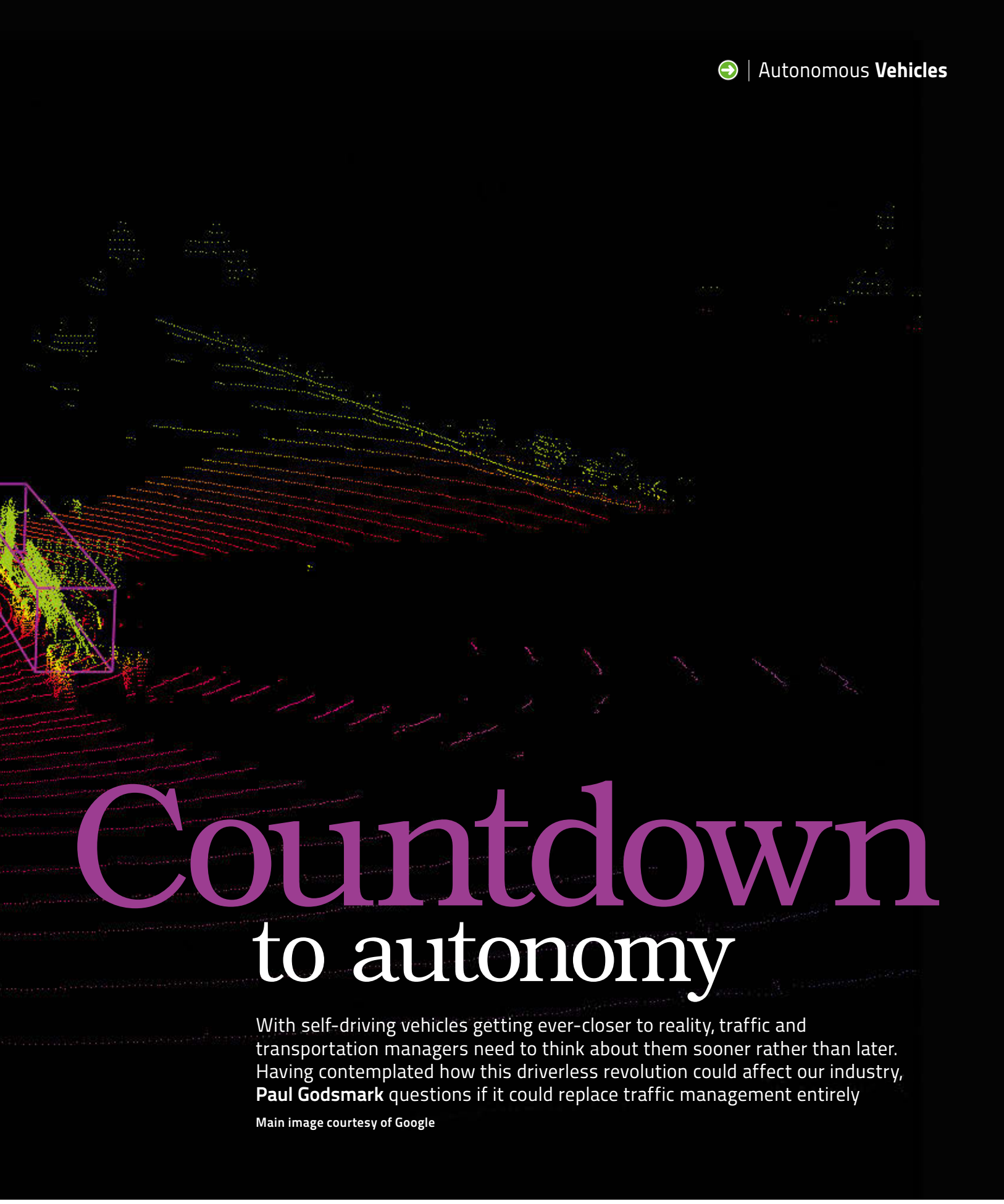




Countdown to autonomy

With self-driving vehicles getting ever-closer to reality, traffic and transportation managers need to think about them sooner rather than later. Having contemplated how this driverless revolution could affect our industry, **Paul Godsmark** questions if it could replace traffic management entirely

Main image courtesy of Google

Technology is advancing rapidly and an increasing number of people seem to be taking the possibility of self-driving vehicles seriously. But what should that mean to people working in traffic engineering and ITS? That's a question I started pondering myself back in September 2011 when I was looking at developing new work in the ITS area. And as that research progressed, my estimate for when this technology might arrive on our roads tumbled down from several decades to only five years – or 2017 – as indicated by Google at the California SB1298 autonomous vehicle bill signing ceremony on September 25, 2012.

Photograph courtesy of Google

Governor Jerry Brown signed the legislation last year that could pave the way for driverless cars in California. He was actually driven to Google's HQ in the now famous, autonomous Toyota Prius

> If Google is correct with its aspiration for unmanned capability by 2017, then the consequences of not being ready for what may then happen could be very significant indeed

Auto makers have been much less clear with their timelines, most probably because they know only too well that with fully automated (NHTSA Level 4 – Full Self-Driving Automation) vehicles that are capable of unmanned operation, automated shared mobility fleets are inevitable, so they'll no longer be able to sell as many cars. Hence, with the recent announcements from Volvo, Nissan and Daimler of automated vehicles by 2020, maybe it is worth reading between the lines to see if they are specifically talking about NHTSA Level 4 automation? (Which they are not.) Auto makers have in fact suggested they will achieve full Level 4 automation by 2025, which still sounds far too optimistic for some.

Disruptive influence

So why should we take particular notice of Google when it has its sights set on 2017? At the recent TRB Workshop on Road Vehicle Automation (Stanford University, July 2013), Ron Medford of Google (formerly second-in-command at NHTSA) explicitly stated for the first time that Google aspires to bring a NHTSA Level 4 technology product to market as its first offering. That's some statement – extraordinary, in fact, when you consider the technical and engineering challenges that must still be overcome to achieve that.

Prepared for the revolution?

Some think driverless vehicles will revolutionize society, while others say they'll have only a limited impact. But they'll definitely have an effect on road and traffic authorities. And here's how…

1. If there is great interest in autonomous vehicles from businesses – and the premium for the technology is as low as expected – many OEMs will have advance orders for Level 4 vehicles several years before deployment. Also, if one Level 4 automated taxi can replace, say, six private vehicles, the effective market penetration will be leveraged up – i.e. if 1% of the vehicle fleet are automated taxis, they could replace 6% of the private car fleet.

2. Once Level 4 vehicles have been deployed then transit services could be affected, especially peripheral routes and services that already have low ridership levels at off-peak times.

3. DOT staff will need training in how to accommodate or deal with Level 4-capable vehicles. This may involve a cultural shift to think around the implications of current and future laws, regulations, standards and practices if they aren't already in place or fully understood.

4. Operational, business and revenue models may need to be reviewed to determine their robustness. Long-term transportation plans should be updated now, rather than waiting several years for the scheduled update.

5. Transit-orientated developments, car parking, park-and-rides, tolling and PPP projects and operations could be particularly affected.

6. If the Transport as a Service model takes hold as A-taxi fleets grow, the public sector will need to review its role in all forms of transit, and plot an appropriate course through this complex surface transportation revolution.

7. All transportation-related infrastructure projects should be reviewed for robustness against the deployment of Level 4 vehicles. How much parking is required and

2017 vision

The cost of Level 4 vehicles is often quoted as a reason for slow deployment. But Google has stated that it expects the additional cost of its technology on an existing vehicle with numerous sensors to be only a couple of thousand dollars.

Lidar sensor costs are falling all the time and technological advances are occurring on a regular basis.

It is also assumed that NHTSA will have the capability to carry out safety testing and certification by 2017.

Not only that, major issues such as laws, liability, insurance, security and trust will have been sufficiently addressed by 2017 so as not to delay deployment.

Personally I am swayed by my research over the past two years, and find the Google aspiration both credible and probable, but fully appreciate that to reach such a position requires numerous assumptions and expectations (see *2017 vision*, above).

So each agency and organization will need to come to its own assessment of when Level 4 vehicles capable of unmanned operation might arrive. Most will not be as optimistic as I am, but it is important to make that decision as 2025 is 12 years away and really doesn't require road authorities and municipalities to do anything more for the time being, other than watch and wait.

Some words of warning. If Google is correct with its aspiration for unmanned capability by 2017 – and it is an 'if' – then the consequences of not being ready for what may then happen could be very significant indeed. Perhaps we should assume the 2017 date is credible, and if it's missed then there's more time to prepare.

where? As roundabouts are the most safe and efficient of intersections for automated vehicles, should they be considered as the standard intersection form? As land values could change with people willing to commute for longer periods of time, will this affect planned development zoning and project locations? Are the traffic projections robust enough to justify widening?

8 Large employment displacement is bound to occur around a disruptive technology. It would be best to recognize this early and pay attention to the unionized roles that might be affected!

9 Road vehicle fleets operating in the public sector will be able to utilize Level 4 technology. Fleet-replacement strategies should be developed to take advantage of the benefits.

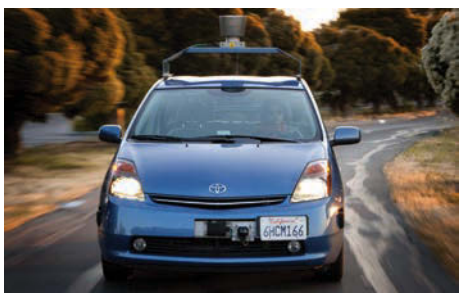
10 Start to think from the perspective of the new paradigm. Automated snow plow competitions exist already. How beneficial would an unmanned Level 4 vehicle be as a probe in traffic streams? Or delivering specific sensors to where they are required on the network?

So back to the original question: What should autonomous vehicles mean to traffic engineers and ITS professionals? A great deal. The fact that a vehicle will be able to reposition itself to a point of need and perform duties by moving people and goods without the cost of an onboard driver means we are going to experience the first paradigm shift on our roads since the modern motor car was invented.

Why a paradigm shift?

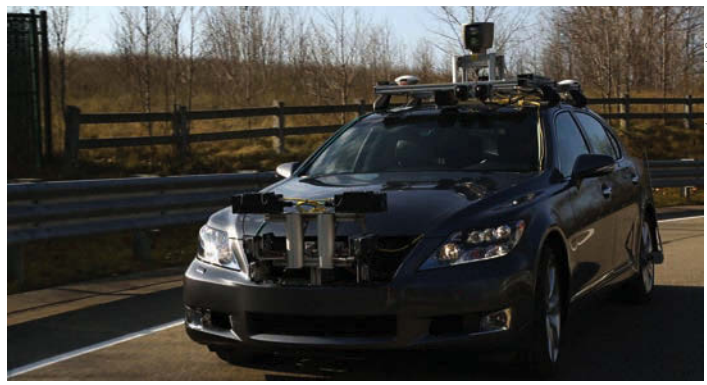
With the introduction of Level 4 automated vehicles, a lot of things will start to happen all at once. Safety will improve for the users of these vehicles, as hopefully we'll remove most of the human error that is widely known to be a factor in 93% of all traffic collisions. The 'driver' will then be free to use that time productively. A substantial proportion of people who didn't have easy access to road transportation – including those with impaired mobility, seniors, the medically at risk, people who are too poor or simply don't have licenses, etc – will now find it much easier to get around. Many businesses operating fleets will want to utilize the technology as it removes driver costs, results in lower fuel and maintenance costs (Google honed in on this in several live presentations), avoids working-time regulations, improves efficiency and makes their business model more competitive.

The crucial difference is that the car is no longer a 'dumb' technology, but a tool that simply needs an instruction for it to go and perform work on our behalf. And



Photograph courtesy of Google

(Right) **Car makers such as Toyota, Audi, BMW, Ford and Volvo and Tier 1 suppliers such as Continental have been working on autonomous car technology for years**
(Below) **With the Google Self-driving Car, computers, sensors and other technologies enable it to operate independently, although a human driver can override the autopilot function and take control of the vehicle at any time**



Photograph courtesy of Lexus

combine that with the differences described above and you now have a robot that frees up people's time from the driving task, which could change where and how we live and work just as the first motor cars did some 130 years ago.

According to research from the Earth Institute at New York's Columbia University, these automated taxis – or 'A-taxis' – are expected to reduce the cost of transportation for the average person by around 40%. So by relinquishing ownership of our private

> As this technology shows all of the hallmarks of being 'disruptive', in order to stay ahead we need our policies to precede the technology

vehicles, we can just hire the type of vehicle we need, when we need it. No more driving around looking for a parking space or worrying about fuel, tires and maintenance. No more using an SUV or a 4x4 pickup when there is a single occupant and no luggage in the vehicle. Just hire the right vehicle for the right job: a lightweight, possibly electric one- or two-seater for work and most trips around town, and something bigger for times when you need it.

For road authorities, municipalities, planners, traffic managers, transit organizations, etc, this begins to create a whole new set of problems to overcome. If we don't plan properly, we can also anticipate a host of unexpected and unintended consequences. As this technology shows all the hallmarks of being 'disruptive', in order to stay ahead we need our policies to precede the technology. Some thoughts as to how this might affect traffic and road authorities appear in *How prepared are you?* on the previous pages.

What's fascinating is that the deployment of Level 4 might be only four years away and yet none of our planning, standards or best practices take any cognizance of what that may mean. In some ways it may be similar to the golden age in civil engineering in the 1800s when roads, railways, bridges, etc, were being built. The engineers had to develop the standards and the codes as they went along, based on a sound understanding of first principles and a willingness to get the job done in the face of adversity.

And as for maximizing the benefits of Level 4 technology, to do that we need to remove the suboptimal human element from behind the driving wheel altogether – which could arrive much sooner than people realize if the municipalities are willing to embrace the challenge. And in itself, that's food for thought for a future article.

• *Paul Godsmark is a chartered civil engineer (UK) residing in Alberta, Canada. He is a co-manager of the DriverlessCarHQ Facebook page and has a personal blog at http://autonomous-vehicle-impacts.blogspot.ca/. Feel free to contact him by emailing pgodsmark@gmail.com*

They're inevitable…

Many existing business models would benefit from Level 4 vehicles, especially taxi, car rental, car share, ride share and peer-to-peer (P2P) companies. Once they have Level 4 technology then their business models will become almost indiscernible and reflect the A-taxi TaaS model. There is an argument that the auto makers will operate their own fleets as Daimler is doing with Car2Go.

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Charge ahead

The Dartford Crossing is the bane of many people's lives in Southeast England. But as the HA's Nigel Gray reveals to **John Challen**, with free-flow measures on the way all that could soon change

Photographs courtesy of the Highways Agency

With average daily volumes in the region of 150,000 vehicles, the Dartford Crossing is one of the most trafficked sections of road in England. And whether you're traveling northbound through the tunnel or southbound across the Queen Elizabeth II Bridge, it's often one of the most loathed stretches of road in England.

So in an attempt to drastically reduce congestion and improve journey times for people traveling over or under the River Thames, authorities have proposed a free-flow system that will see cash payments become a thing of the past and automatic payments for all. The project will result in the removal of the infamous booths, an introduction of automatic license plate recognition (ALPR) technology and a complete overhaul of the road layout.

The costs of the upgrade are estimated at between £68m (US$109m) and £84m (US$135m), which form part of a total contract worth between £237m (US$380m) and £478m (US$766m). "These figures include the set-up and operational costs over a 7-to-10-year period," explains Nigel Gray, project lead at the Highways Agency, before adding the actual amounts are set to be finalized by the end of the year.

"The greater estimate includes new customer charging and enforcement management services to administer the operation, infrastructure works to provide open traffic lanes northbound and southbound, the safe removal of the plaza and barriers, and new traffic control measures to ensure continued safety and integrity of the tunnels," Gray reveals.

Improvements to the Dartford-Thurrock section of road also include the installation of what Gray refers to as "roadside technology and communication links", namely ALPR and beacon equipment to capture vehicle license plates and tags.

"The Crossing was designed to handle 135,000 vehicle movements a day but it is not uncommon to reach 160,000," continues Gray. "On top of that, traffic flows are expected to increase by a fifth over the next 30 years as a result of the anticipated development in the Thames Gateway. The Dartford Crossing sees more than 50 million vehicle crossings each year, which exceeds its design capacity and leads to the congestion that gives it a bad name.

"The new charging system is part of a package of measures to improve crossing

The infamous toll barriers will soon be removed from the Dartford Crossing as the new free-flow system goes live

capacity," Gray adds. "Currently the charge can be suspended in the event of an emergency causing severe congestion at the crossing, and this will continue to be the case when the new crossing is fully operational. So in the medium term, the barriers will be removed and remote payment introduced and in the long term there are plans for a Lower Thames Crossing."

Equipment and enforcement

Although the technology provider for the ALPR and tag-and-beacon system has yet to be selected, Gray is keen to stress that it is an area that will be subject to careful scrutiny. The more effective the system, the more chance there is of greater revenues as well as traffic running smoother in both directions. And he insists the HA will take a hard line in the name of free-flow traffic. "Tackling drivers who try to evade the congestion charge will be a key component of the remote payment scheme," he explains. "Enforcement regulations have been drafted and include the provision to impose penalty charges with maximum permissible values and to instigate debt-recovery processes."

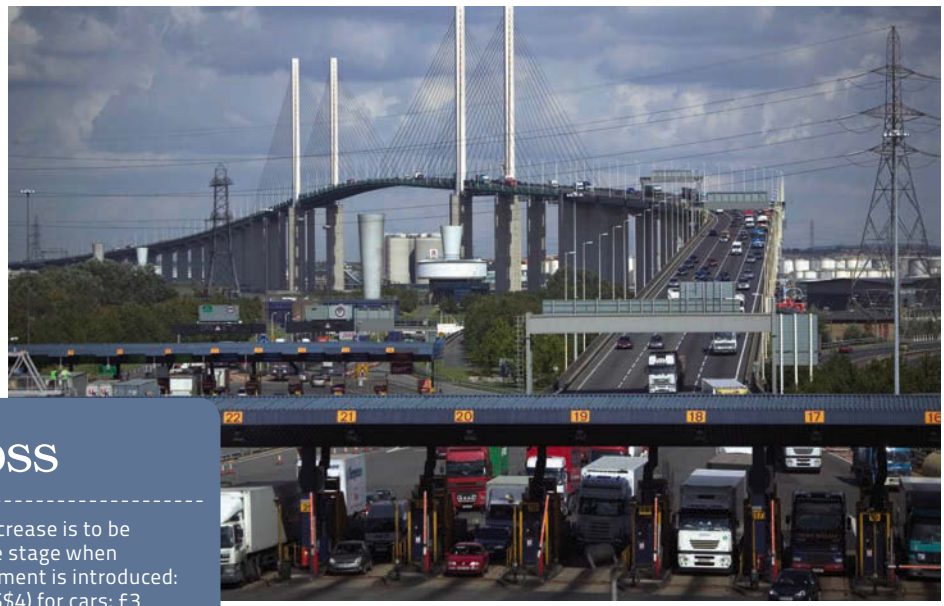
Tough talk on non-compliance, then, but there is a great deal of work to be done before the project team even reach that stage. To date, work has included the progression of two new pieces of legislation to support a free-flow charging arrangement at the Crossing, and preparation of the engineering and road infrastructure design. Installation of the hardware is now approaching fast.

"The on-road vehicle detection technology required for the free-flow charging project will be in place in summer 2014, while the removal of the plazas and road infrastructure work will start from October 2014," Gray confirms. This initial development work will be followed by testing and validation of the equipment and systems, in anticipation for the remote payment arrangement to be introduced in October 2014. "The actual road layout changes – including removal of the existing booths – cannot happen until the new arrangement is in operation," says Gray. On-road improvements will be carried out overnight and at weekends and are expected to be completed by early 2015.

"Road users will see improvements in journey times very quickly but to remove the existing barriers and plaza will take time," Gray believes. "Safety remains a top priority. We need to ensure the ongoing safe operation of the crossing during this time. A system will monitor and control the northbound traffic entering the tunnels, to ensure that overheight vehicles and those with abnormal or dangerous loads continue to be managed correctly." Under a separate project, the tunnel's safety systems are already being upgrading to the latest standards.

The preferred method of payment will be advanced charging, with Gray providing assurance that discounts will be available for those who set up an account and keep it topped up. "These discounts will vary by vehicle class – 33% for cars and between 12-13% for goods vehicles," he details. "Drivers choosing not to set up an account will have up to midnight on the day after they cross to pay the standard charge. The penalty charge for non-payment will be £70 (US$112), with a reduced rate of £35 (US$66) if paid within 14 days. If the penalty is not paid within 28 days it will increase to £105 (US$168)."

Until the identity of the technology provider is revealed it will be difficult to gauge the potential effectiveness of the systems and their impact on fighting congestion and moving road charging in the UK forwards. Gray, though, is confident that the scheme will be a success and is drawing from results achieved in England's capital. "The system is similar to the London congestion charge and lessons have been learned from this and similar schemes."



The bridge at the Dartford Crossing currently exceeds its designed capacity, but free-flow measures will ease the strain

> The actual road layout changes – including removal of the existing booths – cannot happen until the new arrangement is in operation
>
> **Nigel Gray, project lead, Highways Agency, England**

The cost to cross

Charges for the use of the Dartford Crossing have always been a bone of contention for UK road users, and this looks set to continue with the forthcoming changes. Officially called a 'congestion charge', the cost of using the tunnel (anti-clockwise) and bridge (clockwise) will be based on a two-stage increase.

The first stage came into effect in October 2012 but a further increase is to be made at the stage when remote payment is introduced: to £2.50 (US$4) for cars; £3 (US$4.80) for two-axle vehicles; and £6 (US$9.50) for trucks. Local residents will benefit from a £20 (US$32) a year discount.

In the current discount scheme local drivers are charged £10 (US$16) a year for 50 free journeys and 20p (US$0.32) per journey after that.

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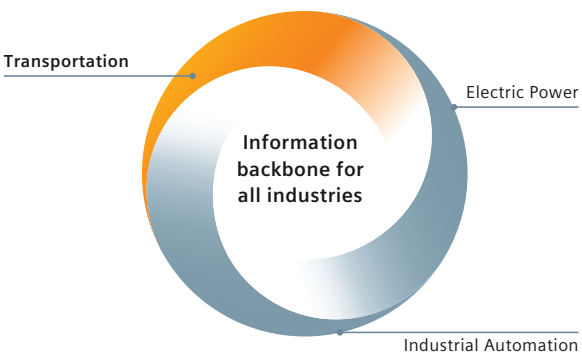


Answers for industry.

Centers of attention

TOCs are the nerve centers of an ongoing intelligent traffic management revolution. It's therefore not surprising, finds **Timothy Compston**, that increasing attention is being paid to design features to ramp-up their operational capabilities

Technologically, ergonomically, collaboratively and as a consequence operationally, the traffic management centers at the hearts of our communities have altered beyond all recognition in the past decade, with increasingly sophisticated systems being integrated to help TOC staff manage how they operate our road traffic networks.

High-definition videowalls are just one such example of a must-have TOC accessory and now very much in evidence. In practice, when these powerful new visualization technologies and display solutions are combined with fiber and wireless backbones for higher data flows, they offer the prospect of unparalleled real-time and multiple-camera views of incidents, interactive mapping to highlight congestion and traffic flows, road weather reports and broadcast, web and social media updates.

But for every shiny new TMC or multi-million-dollar refurb, there's also the harsh economic reality that many budgets are still constrained, so more cost-effective ways of running and upgrading centers are also much sought after. The sharing of facilities and equipment with other agencies is a noticeable trend, for example, while the outsourcing of day-to-day operations to third-party providers has also surfaced as an option for DOTs.

Photograph courtesy of Virginia DOT

Power of Scotland

Traffic Scotland's new TOC is, reveals **Scott Lees**, a great example of partnership working and sharing resources to provide the best possible response to incidents on the road network

There's been something of a TOC revolution going on in Scotland recently, with one of the year's most impressive projects from a design and technology standpoint coming to fruition in April. Close to the Forth Road Bridge in South Queensferry, the new purpose-built Traffic Scotland Control Centre has been developed to support a more joined-up response during major incidents. It is also hoped that the new center will improve the coordination and communication of real-time traffic information and help reduce journey times across the 3,500km of the Scottish trunk road network.

> "This was the best use of public money and allowed us to have an input into the design from the very outset

Scott Lees, head of network operations at Transport Scotland – an executive agency of the Scottish government – is enthusiastic about the transformation the center represents for his organization's ITS capability. "It's a far cry from the interim temporary office accommodation the service was working out of before, with its limited single-story height," Lees laughs. So when the opportunity arose to change things for the better, Traffic Scotland grabbed it with both hands. "The first real managed motorway system in Scotland with an ITS corridor was happening on our doorstep and at the same time there was the potential to co-locate the center in a building that was required for the Forth Replacement Crossing," Lees explains. The result is a modern, dual-function solution hosting both the Traffic Scotland Control Centre and the Forth Replacement Crossing – Contact & Education Centre. "This was the best use of public money and allowed us to have an input into the design from the very outset."

One of the key requirements from a design and ergonomics perspective was

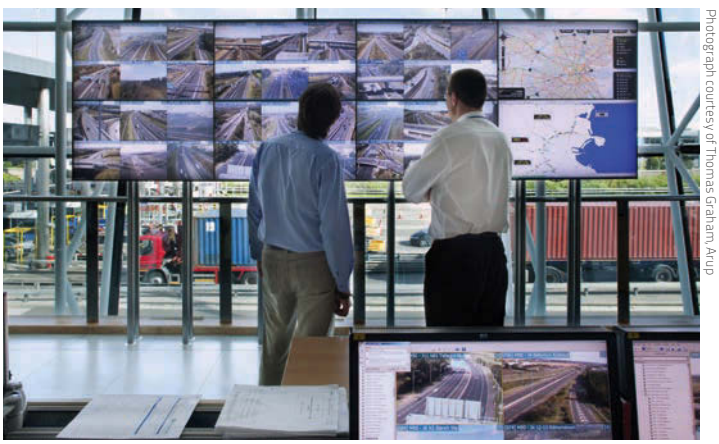
Human factors

Kevin O'Sullivan is the manager of the Motorway Traffic Control Centre (MTCC) in Dublin, which is run by Egis Road & Tunnel Operation Ireland on behalf of the country's National Roads Authority. When it comes to designing and/or operating a modern TOC and the technology within, he maintains the human factor is most critical. Systems have to be intuitive and straightforward. "If you complicate things too much, you're leaving yourself open to potential errors – which is the last thing anybody wants," O'Sullivan says. "We ideally want solutions that lead operators logically through an incident-response process; the number of systems should also be kept to a minimum."

One option is to move away from proprietary products – which O'Sullivan feels can be slow to integrate with other systems – to more open solutions. "This might enable you to streamline your processes," he continues. "If all your systems are integrated, the upshot is you don't necessarily have to employ different systems to perform different tasks."

Another element O'Sullivan thinks deserves more attention is how you handle the interface with your peripheral systems. "There's all the external devices in the field such as VMS, CCTV, loops, RWIS and other monitoring tools to consider, so it's not just the systems in the control centers that have to be managed effectively."

The MTCC manager also stresses the perennial problem of ensuring adequate control center staffing levels for when problems occur. "Traffic control centers, by their nature, can be quiet at times but can ramp up suddenly in the event of a major incident."



Photograph courtesy of Thomas Graham, Arup

Egis Road & Tunnel Operation Ireland runs not only the Dublin Port Tunnel and control room (right) **but also the adjacent Motorway Traffic Control Centre, so staff are trained to work across both facilities to enhance efficiencies**

the high ceiling. "It's a comfortable place for the workforce with space for a large-scale videowall comprising 40 screens. This is a powerful operational tool at the heart of the center, which is more than you can say for the display in our previous control room. Now we can subdivide the wall and show multiple CCTV streams from across the country, bring up website feeds, pull up TV news channels, highlight what Traffic Scotland signs are displaying and even spotlight journey time and congestion data."

Another important operational addition is the purpose-built Transport Scotland Resilience Room adjoining the main control room: "In times of emergency this is where our resilience team congregates. People can walk in and out to share information or, if needed, glass sliding doors can be closed for a degree of privacy. We also have a four-screen mini version of the videowall in the main control room to show cameras and other 'live' information and support conference calls at the same time as the video images."

(Far left) **Although Traffic Scotland's new center will principally oversee the Scottish trunk road network, it will also act as a center of collaboration and innovation to deliver improved performance** (Left) **Scotland's deputy first minister Nicola Sturgeon officially opened the new TOC** (Above) **Weigh-in-motion systems on the Forth Road Bridge recorded almost 24 million crossings in 2012**

A path being taken by O'Sullivan and his colleagues to respond to these fluctuating workloads involves the cross-training of his staff. At a practical level this means training operators from the MTCC and the adjacent Dublin Tunnel Control Room – which Egis is also contracted to run – to be interchangeable, and in doing so providing much greater operational flexibility.

Consultancy matters

"Although we have long-standing experience in operating traffic management centers, it's something we've moved away from in recent years," reports Fraser Sommerville, divisional director, highways and transportation at Atkins. "We now work very much in an advisory capacity in the field of TOCs."

That said, in the past decade Atkins did help to establish and run Traffic Wales's Coryton TOC. "This was initially set up as a very small operation within our offices but the Welsh government then decided it wanted its own dedicated building," Sommerville recalls. "We helped with the design of the building and arranged the seamless migration of transport and telecommunications systems from the previous building near Newport."

What is perhaps more indicative of Atkins' TOC activities these days is the contract it has with the Highways Agency in England to help develop the HA's Regional Control Centres. "In this case we are mapping out how to transfer the systems from 32 police control offices into seven regional centers and providing strategic technology support advice on new systems," Sommerville says.

> "We ideally want solutions that lead operators logically through an incident response process; the number of systems should also be kept to a minimum"
>
> **Kevin O'Sullivan, manager, Motorway Traffic Control Centre, Ireland**

When quizzed as to the relative importance of the individual elements when reconfiguring or designing a new TOC, Sommerville says it all depends on your starting point. "Most of the clients we work with have legacy systems in place," he states. "Where control centers want to retain some of their older systems, an option might be some type of middleware to bring systems together. What we've got in many of the HA control centers, for example, is a plethora of different screens for different systems, which can potentially become an issue when you've got four or five screens on an operator's desk. How you sensibly manage that is a big issue, so an important aspect to consider is how best to streamline all those feeds through one common interface."

As to the wider TOC trends that Sommerville is noting, all roads would appear to lead to integration – greater integration of systems around the information that is coming in, the integration of data and, interestingly, more integration between various stakeholders.

The way ahead for disaster recovery

Such a joined-up approach is guiding traffic management in Christchurch, New Zealand, which in July inaugurated its new Transport Operations Center. This smart new building signifies a collaborative effort that has emerged out of adversity, however,

Photograph courtesy of the Highways Agency

The South Mimms Regional Control Centre in England, which is one of two Highways Agency TOCs controlling operations on the M25 motorway

Media moguls

In Baltimore, Maryland, T J Bathras (above left) is running a TOC that's already been subject to an impressive technology makeover, with an open IP-based solution incorporated into management operations.

Following conversations with Bathras and his colleague Raj Sharma (above right), both of whom played a vital role in the construction and ongoing development of the TOC, it's clear that there's a constant search for new ways to enhance the quality of service offered by the center.

One trend Bathras says is having a dramatic impact on the day-to-day work of TOC staff is the rise of social media. "We're finding ourselves using Twitter and Facebook more and more to get notifications out there in real-time," he says. "This means our role is changing – and increasingly fluid – because we are receiving a much larger amount of real-time data yet simultaneously we're having to distill it all down and push it out to the motoring public."

As far as future TMC enhancements go, within the next six months Bathras and his colleagues will be able to access cameras from other agencies based in Baltimore. "They'll all now be incorporated into one common operating platform for any type of video feed, meaning we can select the police department and other agency cameras to provide us with extra real-time traffic information, which will allow us to do our jobs more effectively and efficiently in the TMC.

"The beauty of the platform we're planning to use is that it's web-based, so it doesn't require a load of infrastructure additions. We believe that's a win-win for each agency as everyone is sharing cameras and video systems."

following the series of devastating earthquakes that struck the city in February 2011, starting off with one of magnitude 6.3.

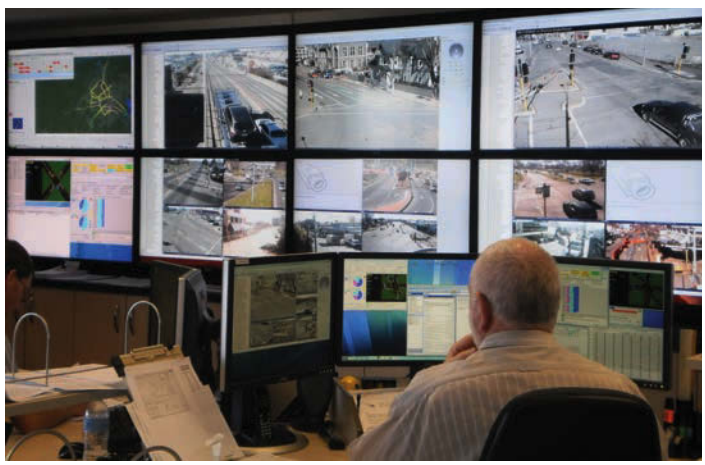
The multimillion-dollar facility builds on the strong links that were established between Christchurch City Council, New Zealand Transport Agency (NTZA) and Environment Canterbury in the days, weeks and months following the quake. And for the first time, all these agencies are now together under one roof – a not uncommon trend when it comes to TOC operations.

For John Mackie, transport and green space manager for Christchurch City Council and the TOC's spokesperson, the new traffic hub represents what he calls a structural realignment. "It takes what we had in Christchurch with our existing control center managing all the traffic lights and traffic cameras and substantially expands this through the NTZA and Environment Canterbury integration to pick up responsibility for the entire 2,300km network, including state highways and local roads," he says.

There are several key parts to the center's operations, as Mackie reveals further. "As well as monitoring the network, optimizing the traffic lights to improve traffic flow and informing the public of interruptions and real-time events on our roads, our TOC handles all the approvals for temporary traffic management plans."

While this might seem a fairly mundane role at first glance, following the catastrophic events of 2011 Mackie says it's actually an essential capability given the huge levels of damage in Christchurch that had to be put right. "In addition to the roads infrastructure, beneath the surface we had the water, waste-water pipelines and utilities," he adds. And more than two years on from the earthquake, there's still something in the region of 130-140 active worksites in the city dealing with the water situation alone. So as part of the ongoing strategy to cope with such a large volume of temporary traffic management plans, Mackie says it made sense at a strategic level for the new Christchurch TOC to take a wider view of the impact of such sites on the efficiency of the overall network.

A new app was unveiled at the same time as the TOC and includes a temporary traffic management map, news articles and live streams from CCTV cameras on state highways. "It arrived in time for a busy period in the repair and rebuild work in the city and enables users to keep up with planned events on the network – from roadwork sites through to weight



Christchurch's new TOC is looking to improve traffic flow on local roads and state highways, and in particular key commuter, public transport and freight routes

> As well as monitoring the network, our TOC handles all the approvals for temporary traffic management plans
>
> **John Mackie, transport and green space manager/TOC spokesperson, Christchurch City Council, New Zealand**

Wonder wall for District 7

More than 400 cameras monitor the highways of Los Angeles and Ventura counties, images that are then fed into the Caltrans District 7 TOC – featuring a new videowall from AV specialist Electrosonic.

Comprising a 12-screen center unit in a 4 x 3 configuration and flanked by a pair of six-screen 3 x 2 units, the giant wall features 80in diagonal screens in the center and 52in screens at the sides.

The standard wall format has single-camera feeds on the side screens and 2 x 2 graphic traffic patterns on the center, with single-camera feeds surrounding them. "They monitor locations with heavy traffic and can bring any of those feeds up on the larger display as needed," says Guy Fronte, project manager.

"We couldn't take the wall down during rush-hours, so we swapped out one projector at a time to enable continuous operation," says Fronte of the installation process.

Control of the new videowall is achieved using a Quantum processor previously installed by Electrosonic. The Crestron touchscreen control system that operates the wall, turns the system on and off and also monitors lamp life, was modified to accommodate the new projector engines. Christie one-chip SXGA displays are integrated to take advantage of improved projector quality, while Christie RPMSP-D132U displays were selected for the center screen and RPMX-D132U displays for the side screens.

Photograph courtesy of Virginia DOT

> Interoperability among the TOCs and a statewide ATMS platform will enable us to provide a consistency of service across Virginia
>
> **Dean Gustafson, state operations engineer/division administrator, operations division, Virginia DOT, USA**

restrictions and road closures," says Mackie. "It's a major step forward for us and recognizes the importance of mobile communications. It not only provides travel information en route but will one day open up the possibility of proactively pushing information out to our users."

A new road for outsourcing

Virginia's DOT (VDOT) is often lauded for its own innovative practices, so the news that it had decided to outsource TOC operations generated a great deal of interest. The six-year, US$355m contract (plus three two-year option periods) to integrate and operate all of VDOT's transport operation centers as well as manage its Safety Service Patrol and implement a statewide ATMS went to Serco earlier this year.

"We historically ran our TOCs using a mixture of state forces and contractors, so for us here in Virginia outsourcing isn't an alien concept," suggests Dean Gustafson, state operations engineer for VDOT and division administrator for its operations division. In general, Gustafson goes on to say, there was a belief that VDOT's existing set-up was becoming unwieldy, having developed piecemeal with 11 separate contracts to operate and maintain the state's five TOCs (in Salem, Stanton, Richmond, Hampton Roads and Northern Virginia), each with their own requirements and standards. "We didn't really have the type of commonality you would want between contracts and, at a practical level, only the Stanton and Salem TOCs were interoperable. Because of that, there simply wasn't the ability to deploy ATMS statewide."

Photograph courtesy of Virginia DOT

(Above left) **VDOT is outsourcing the management of control room operations at five of its TOCs** (Right) **VDOT is moving away from its existing traffic management systems to a single advanced, real-time, statewide solution that oversees its 57,000 miles of roadway**

The answer to this dilemma was for Virginia DOT to move to a single, consolidated, statewide contract. "We can now focus on improving our operations rather than just managing contracts," Gustafson says. "Interoperability among the TOCs across the five regions and a statewide ATMS platform will also enable us to provide a consistency of service across Virginia." Perhaps of more relevance in still choppy economical waters, this outsourcing revolution will help to deliver innovation and protect the value of the investment already made by VDOT in its TOCs – as well as in the thousands of ITS devices deployed in the field.

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Defying the laws of physics?

Brian Ceccarelli and **Joseph Shovlin** think we're blind to the 'fact' that red light cameras are profiting from enforcing ordinances that prohibit the laws of physics. Although their arguments may fly in the face of the status quo, is there any substance to what they have to say?

Main illustration courtesy of Ben White

There continues to be a great deal of debate surrounding the effectiveness of red light cameras – on TV news bulletins, in the mainstream press, within the corridors of academia and even within these pages. Do they prevent or do they incite crashes? It's not hard to find data supporting both cases. So in light of these inconsistent results, asking whether or not red light cameras prevent crashes isn't necessarily the right question.

Red light cameras are intended to moderate driver behavior and cause drivers to run fewer red lights. But can drivers be trained in this way? There are some people who believe that their immediate goal is to catch red light violators, in doing so leading to billions of dollars of revenue. So the purpose here is to ask (and answer) why the industry is so profitable, why crash data is inconsistent and why drivers run red lights – the latter answering the former.

Down to the formulae

Underpinning the support of the red light camera lobbyists and government legislators – and beneath the pro-camera front

organizations and anti-camera activists – there is a single physical formula that models the behavior of vehicles as they interact with traffic lights. But it's a formula that we're convinced has been simplified and misapplied by traffic engineers and as a result it induces motorists to run red lights inadvertently and consequently break the local ordinances.

Red light cameras catch these inadvertent violations and send out citations. Is driving ability thus irrelevant? Is the ability to stop before the light turns red irrelevant? Good or bad driver, everyone must obey the laws of physics (see the *It's physics!* sidebar).

Mathematically speaking

The first of the three formulae that determine the length of a yellow light, Formula 1 ('the Formula') applies to all traffic movements. Formula 2 narrows Formula 1's scope by applying only to traffic decelerating at a constant rate into an intersection – for example, turning traffic. Formula 3 narrows the scope even further and applies only to traffic that doesn't slow down when the light turns from green to yellow. Formula 3 only applies to unimpeded traffic moving straight.

But with traffic engineers universally applying Formula 3, are they actually forcing drivers in many situations to run red lights?

Formula 1 expresses the meaning of the yellow light duration for the general case for all traffic movements. The yellow light duration equals the time that it takes for a vehicle to traverse the critical distance. If a vehicle is farther from the intersection than the critical distance when the light turns from green to yellow, the vehicle has the distance to stop – and then yellow means stop. If the vehicle is closer to the intersection than the critical distance, then yellow means go. In order for the vehicle to legally enter the intersection, the light must remain yellow for long enough to reach the intersection. The Formula is a basic rate x time = distance formula.

It's physics!

There are three related physics formulae[1] that determine the length of a yellow light duration. First there's the general formula (Formula 1):

$$Y \geq \frac{t_p v_0 + \frac{v_0^2}{2[a+Gg]}}{v_{avg}}$$

The second (Formula 2) rearranges the terms and uses a constant deceleration:

$$Y \geq \frac{2\left[t_p + \frac{v_0}{2(a+Gg)}\right]}{(1+v_i/v_0)}$$

And the third (Formula 3), the simplified form for straight-through traffic, is the ITE yellow change interval formula:

$$Y \geq t_p + \frac{v_0}{2[a+Gg]}$$

Where

$$v_0 \geq \begin{cases} v_l, & v_l = \textit{speed limit} \\ v_{85}, & v_{85} > v_l \end{cases}$$

Y = the yellow change interval;

t_p = perception/reaction time (P&R time);

v_0 = the velocity of the vehicle at the safe and comfortable stopping distance (critical distance;

v_i = the velocity of the vehicle at the intersection stop bar;

v_{avg} = average velocity of the vehicle as it traverses the critical distance

v_{85} = the 85th percentile speed of free flowing traffic. When $v_{85} > v_i$, use v_{85}

a = the safe and comfortable decelerate rate of the vehicle

G = the earth's gravitational constant

g = the grade of the road

Traffic signals: 1868-2013

1868: The two-way red-green traffic signal is invented in London

1920: William Potts, a Detroit police officer, invents the amber light. First signal head with amber light erected at Woodward and Michigan Avenue

1930: Institute of Traffic Engineers founded in 1930 in the USA

1959: Physicists Denos Gazis, Robert Herman and Alexei Maradudin (GHM) develop amber light duration formula. They restrict use of the formula to vehicles that approach the intersection from the critical distance at a constant speed v_0, which is the maximum allowable speed. The formula includes the all-red clearance interval

1965: Institute of Traffic Engineers adopts GHM's formula, which ITE writes into the *Traffic Engineering Handbook* 3rd edition. ITE omits GHM's restrictions and omits the 'naught' in v_0, leaving v subject to future misunderstanding. From then on, this formula is known as the ITE yellow change interval formula

1975: Institute of Traffic Engineers changes its name to Institute of Transportation Engineers

1982: The *Transportation and Traffic Engineering Handbook* from the ITE describes that the formula requires some drivers to beat the light

1983: ITE introduces gravity's effects into the formula. Many jurisdictions adopt new formula. Surprisingly California with hilly San Francisco does not

1997: Herman, co-inventor of the original amber light formula, dies

2002: Dr Chiu Liu, physicist and civil engineer for Caltrans, and Dr Lei Yu publish paper in ASCE Journal of Transportation Engineering. Liu

> We are not trying to justify all red light violators. We are looking at the vast majority of cases where red light camera violations are caused by the underlying physics
>
> **Brian Ceccarelli , science and engineering software consultant, North Carolina, USA**

(Above left) **The yellow light duration is a critical component within the issue of red light running**

The numerator expresses the distance:

$$critical\ distance = t_p v_0 + \frac{v_0^2}{2[a + Gg]}$$

The critical distance is the distance needed to stop – i.e. the distance the driver travels while reacting to change from a green to yellow light and then braking to a stop. If you divide this distance by the average velocity the driver traverses this distance, the result will be the time that it takes to reach the intersection. That's the minimum time required for the light to be yellow.

In its unsimplified form, the Formula allows all drivers in all situations to enter an intersection legally. It covers situations when drivers slow down at different rates, when drivers slow down at a constant rate as in preparing to execute turns, or when drivers go straight without being hindered by other traffic. Traffic engineers never use this Formula in its unsimplified form.

Formula 2 represents a specialized case[2] of the Formula and applies to drivers decelerating at a constant rate into the intersection. Movements that fit this formula are vehicles approaching the intersection with intent to turn left, right or perform a U-turn, who are not in a queue waiting to turn. The average velocity is the average of the driver's velocities at the beginning of the critical distance and at the intersection stop bar.

Formula 3 represents an even more specialized case. This is the Institute of Transportation Engineers' (ITE) yellow change interval formula. By setting v_i to v_0, this formula assumes drivers travel at their initial speed unimpededly though the critical distance. Once inside the critical distance, drivers must proceed at the speed limit or accelerate[3] in order to enter the intersection before the light changes to red.

Because the yellow time is half the time that it takes to stop, the yellow light forces the driver to make a judgment between stop and go. At the critical distance upstream from the intersection, this decision is most vital because at this distance it is the most difficult for the driver to choose correctly. Without knowledge of the exact location of the critical distance, some drivers guess wrong and run red lights unintentionally – some slam on the brakes while others try to beat the light. Although this formula works only for the singular case, traffic engineers have actually been applying it to all types of traffic movement.

Going back in time...

Formula 3, the classic yellow change interval formula, first appeared in 1959 in a white paper written by physicists Denos Gazis, Robert Herman and Alexei Maradudin (GHM).[4] In 1965, the ITE appears to have miscopied Formula 9 from GHM's paper into ITE's *Traffic Engineering Handbook*.[5] From there it became known as the ITE yellow change interval formula (see *There's been a misunderstanding* sidebar).

There are many rationalizations that traffic engineers devise to justify blanket

concludes that turn yellows must be longer than the ITE formula. Liu defines the formula that allows all traffic to proceed legally into the intersection

2003: Dr Lei Yu, co-author to Dr Liu paper, writes TxDOT report *0-4273-2*. Yu takes poll of traffic engineers, which shows that goal of legal motion of traffic does not make top 10 considerations for a yellow light duration. Traffic flow takes precedence. Accordingly, Yu plugs in numbers into new formula which meet traffic flow goals but simultaneously create illegal movement (Yu contradicts his previous paper)

2004: Gazis, primary inventor of the original amber light formula, dies.

2012: McGee, Moriarty, Eccles, M Liu, Gates and Retting write Transportation Research Board *NCHRP-731*. Authors make an acceptable guess where to measure v but still do not realize that v's measurement location is exact. The formula continues to be misapplied to turning movements. Cases where drivers decelerate en route into the intersection continue to be ignored

2013: Dr Alexei Maradudin, sole surviving inventor of ITE formula, writes letter to Caltrans enumerating the improper uses of his formula

2013: ITE has spread to more than 90 countries

There's been a misunderstanding

Of all the authors of *The Problem of the Amber Signal Light in Traffic Flow* white paper, only Alexei Maradudin, a physics professor at the University of California at Irvine, remains alive to this day. Just a few months ago, Jay Beeber, the executive director of the grassroots organization Safer Streets LA asked Maradudin to set the record straight. And in a letter dated July 23, 2013 to California's Traffic Devices Committee, Maradudin enumerated the don'ts of his formula "...in the hope that our work not be misunderstood and therefore misused". In his letter, he wrote[6], "Applying the formula to circumstances where a driver must decelerate within the critical distance into the intersection results in a minimum amber time which is shorter than what is necessary to eliminate the dilemma zone."

Maradudin also emphasized some of these specific circumstances that did not apply. They include 1) Turning traffic where the speed limit is greater than the intersection entry velocity; 2) Traffic approaching two close-by intersections: traffic may have to slow down for the second light (or traffic waiting for the second light) before arriving at the first light; 3) Traffic going straight that slows down for vehicles entering and exiting the highway to and from business entrances and sidestreets near the intersection; 4) Traffic slowing down before entering the intersection as a result of traffic density, traffic turning in the lane and traffic changing lanes; 5) Traffic where the speed limit decreases on the far side of the intersection; and 6) Traffic slowing down due to pedestrians, railroad tracks and potholes and other hazards.

use of the simplified formula and it's not within the scope of this article to elaborate on them. But engineering judgment starts with the proper application – not the misapplication – of the physical sciences. The definition of engineering is the application of physics, chemistry and earth science. The mandate of every state's statutes for professional engineers is that they comply with the laws of physics. Although signal head visibility, intersection geometry and human factors are important to computing proper perception/reaction times and comfortable deceleration rates, these considerations cannot come at the sacrifice of the laws of physics.

To traffic engineers who rationalize shorter yellow times using traffic flow goals or 'drivers disrespecting the yellow' arguments, we dismiss those arguments, just as Gazis, Herman and Maradudin did. We must provide the driver a solvable decision problem.

Understanding the physics

As long as all-red clearance times were sufficient for drivers to enter the intersection late but exit it before conflicting traffic gets the right-of-way, the problem was masked. But it became readily apparent when red light cameras – running 24-7 and catching every violation – exposed its magnitude.

We have no problem with the cameras in themselves. As a matter of fact, without them these underlying engineering errors wouldn't have been discovered. And we are not trying to justify all red light violators. Everyone has seen drivers who, with plenty of stopping distance, speed up and enter intersections many seconds after a light turns red. These are the violators the cameras should be catching. Instead we are looking at the vast majority of cases where camera violations are caused by the underlying physics.

(Left) **Anti-camera protestors take to the streets in Port Richey, Florida**

> Engineering judgment starts with the proper application – not the misapplication – of the physical sciences

Dr Joseph Shovlin, research scientist at Cree Labs, Research Triangle Park, North Carolina, USA

Using the simplified formula with common speed limits leads to 3- to 5-second yellow change intervals; the unsimplified Formula requires 2 to 3 seconds more than those. Without understanding the physics, some jurisdictions try to appease the outcry by reluctantly adding a small grace time to the yellow. In Florida, for example, FDOT is currently transferring 0.4 seconds from the all-red clearance interval to the yellow change interval at some of its red light camera intersections.

Anti-camera organizations such as the National Motorists Association lobby governments to add one second to the yellow. Many organizations such as the FHWA and NTSB want engineers to use the 85th percentile velocity rather than the posted speed limit in the calculation. Attempts such as these add at most one second to the yellow. But this just skims the surface.

The New Orleans Regional Traffic Safety Coalition led by Steven Strength – a P.E. for

the Louisiana DOTD – set up a test course to measure the yellow duration needs for right-turning drivers. They measured about 6.2 seconds for several 40mph vehicles.[7] But by conforming to Formula 3, Louisiana grants such vehicles only 4 seconds. Some jurisdictions ignore the formulae altogether (see *Against the grain* sidebar).

The case of Cary

Actual red light running data is hard to come by. Is this because the companies and municipalities involved don't want the magnitude of the problem to come out? If driver behavior was modulating red light violations, you'd expect similar intersections would have similar violation rates. But this wasn't the case in Cary, North Carolina, where the difference was the yellow change interval – in fact huge differences existed from intersection to intersection.[8]

At specific intersections we were able to track changes in yellow change interval based on changes in the violation rates. For example, a 600% increase of violations for a solitary left turn lane was due to the NCDOT decreasing the yellow change interval from four to three seconds. We saw a 50% increase of violations for straight-through movements on a different intersection due to the NCDOT decreasing the yellow interval from 4.5 to 4.4 seconds. Even a 0.10-second change has radical consequences.

Because engineers have been systematically introducing error, one finds the most red light runners where there are the most turning lanes, nearby business entrances, or other intersections near a traffic signal. Indeed it is in these locations where the ITE formula fails the most. Is it therefore a coincidence that it is at these locations where most cameras take vigil?

Against the grain?

New York City and Winnipeg are two cities seemingly ignoring the ITE formulae entirely, setting the yellow to arbitrary durations below even that of the ITE formula. One has to accept that the ITE formula is still physics; yellows cannot get shorter than it. The ITE formula also represents the shortest yellow times and those are for the quickest traffic movements. You cannot invent new laws of nature and expect drivers to conform. Any duration below ITE's formula guarantees a high-volume steady stream of unintentional red light runners.

> If one wants to increase safety yet cause more drivers to run red lights, one increases the all-red interval while decreasing the yellow change interval

Camera-equipped intersections tend to be at locations where the ITE formula doesn't stand up

Physics is an open book, so it's doubtful that nobody is aware of the exact same statistics that we have, a pattern that is especially evident in Cary, Raleigh and Knightdale, North Carolina.

Crash course?

Intersections ripe for revenue can also be ripe for crashes but that is not a given. Crashes are a function of the combined yellow and all-red intervals. Red light running is a function of the yellow interval alone. Lengthening the all-red clearance interval reduces crashes without affecting the number of red light runners. If one wants to increase safety yet cause more drivers to run red lights, one increases the all-red interval while decreasing the yellow change interval.

This practice is par for the course for some transportation agencies. And because we're striving for honesty, some of those DOTs do not decrease the yellows with the intention to cause more red light running. They decrease the yellows to increase traffic flow, but the result is the same – a sustained increase of red light runners. The goals of traffic flow and safety compete, a fascinating topic with a long history and in itself perhaps the subject of a future article.

• *Brian Ceccarelli is a science and engineering software consultant in Cary, North Carolina, who has a B.S. in physics. Joseph Shovlin, meanwhile, is a research scientist at Cree Labs in Research Triangle Park, North Carolina and also has a Ph.D. in physics.*

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IRF MEMBER

Troubled times

Traditional methods for forecasting future traffic levels may no longer hold weight in a post-global-financial-crisis era. **Charles Russell** and **Serbjeet Kohli** detail the ways in which we can now obtain a more accurate picture when the economy is up and down

Images courtesy of Lisa S/Shutterstock & Steer Davies Gleave

We've always been able to say with a degree of confidence that – regardless of the economic climate – road traffic never falls. And until around the middle of the last decade (and for the previous three-and-a-half decades), that might have held. But no longer! There has of course been the odd hiccup: when OPEC cut the flow of fuel in the early 1970s and in 1991 when the last big recession hit Europe, although the picture then was clearer. As Figure 1 shows, now it is anything but!

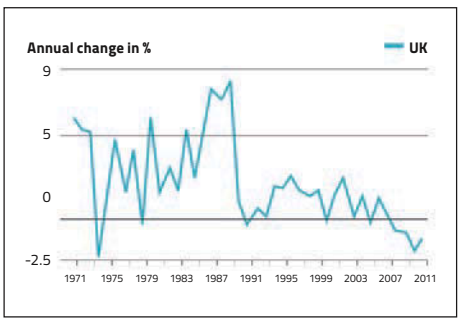
Changing picture

In some countries, there were hints that the apparently iron relationship between economic and traffic growth was actually beginning to look shaky in the early part of the past decade. Since 2007, with the financial crisis and the ongoing subsequent recession, the picture has changed dramatically. Traffic levels on our motorways – for both private and commercial vehicles – have stagnated and often fallen. So our clients – the owners, investors and lenders for tolled roads across Europe – have been asking lots of questions. What's going to happen next? How far can traffic fall – and what (Figure 1) will happen when even the most stricken economy begins its climb back to health?

To try to answer these questions, in our different projects we have sought to understand what drove the rise and fall of traffic across this period. In the past, we have relied heavily on gross domestic product (GDP) as an indicator of performance. Does the evidence suggest that this remains a reliable proxy?

Aggregate forecasts of traffic volumes are possible as changes in volumes are assumed to be driven largely by macroeconomic trends. The overall volumes of travel respond to industrial production, increases in unemployment, recessionary contractions of GDP and various other factors. In a period of economic growth, however, when most macroeconomic indicators tend to move in the same direction, it may be difficult to quantify the effect of each individual indicator (GDP per capita, employment, etc) on aggregate traffic volumes, which are also in a growth phase. Due to the low amount of variation within these indicators in the growth phase, the overall effect of an economic recession on traffic volumes cannot be established with certainty.

(Figure 1) **The graph illustrates the change in vehicle kilometers (UK)**



French resistance?

At least on the Autoroutes Paris-Rhin-Rhône (APRR) network in France (covering around 2,000km of autoroute in the east and south east of the country), this looks unlikely (Figure 3). After a first reaction

to the fuel price hike across the spring/summer of 2008, light vehicle traffic initially remained buoyant. But as the economy dipped for a second time, traffic dropped and hasn't yet shown much recovery.

The picture is more striking for trucks. Almost immediately, and as the recession hit, truck traffic fell dramatically – well ahead of the fall in GDP (Figure 4). But after that, traffic grew through 2010, only to fall away again in 2011 and 2012.

We have examined the relationship between a set of macroeconomic indicators in four European countries over the period 2001-2011 and found – as expected – that overall traffic volumes grew until the global financial crisis (GFC or 'the crisis') in 2008 and slumped after this point of inflexion.

In studying the correlation between various macroeconomic indicators and traffic volumes, we noticed two emerging trends. The first is that the relationship between some of these indicators and traffic volumes changed with the onset of the financial crisis in 2008. While traffic growth tracked GDP growth or the Index of Industrial Production (IIP) fairly accurately prior to 2008, for example, these variables were not very useful in explaining the decline in traffic volumes after the GFC.

The second noticeable trend was that the volumes of light vehicles (which were predominantly cars) and heavy goods vehicles are influenced in different ways by these indicators. Although the impact of the crisis on light vehicles was relatively mild, the volumes of heavy goods vehicles (HGVs) slumped drastically in some cases.

Personal disposable income

It is clear from the analysis that we now have to look elsewhere to understand how traffic rises and falls. For cars, it seems as if measures of personal disposable income (PDI) provide a more powerful explanation. For many years, until perhaps 2005, PDI appeared more or less to track GDP. But

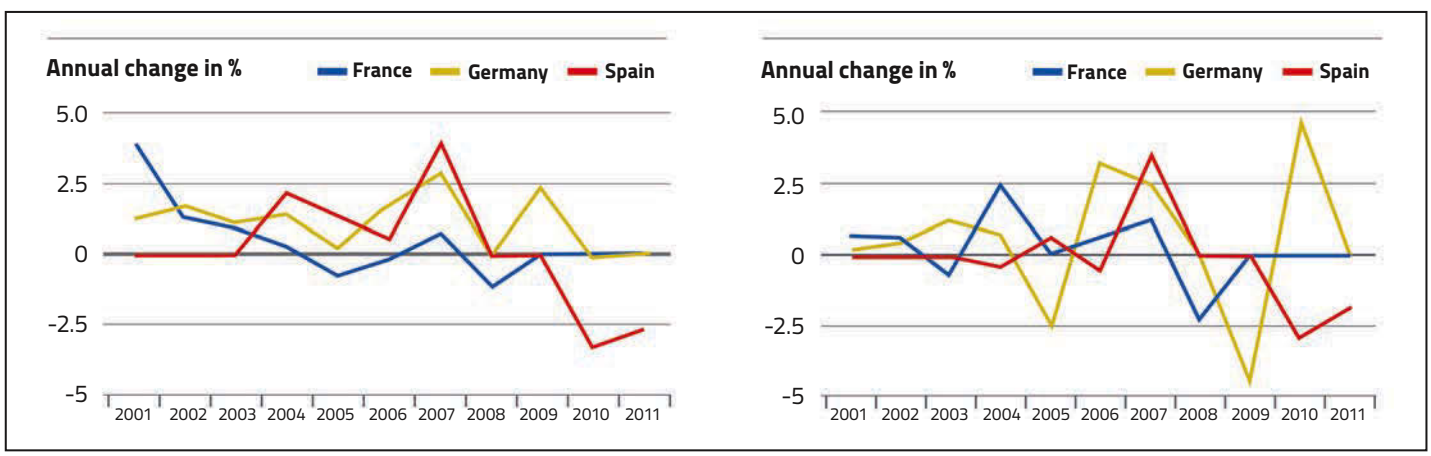
> It is clear from the analysis that we now have to look elsewhere to understand how traffic rises and falls

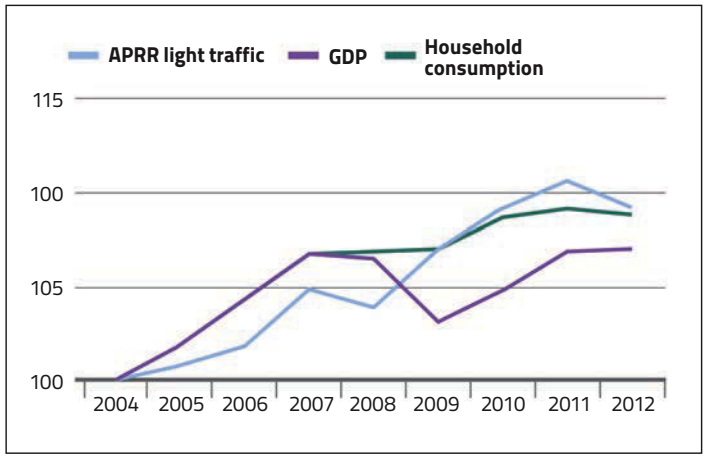
(Right) **Accurate traffic forecasts are integral in building the economic case for a particular investment, such as a tolled road**
(Figure 2, bottom) **Annual change in light vehicle kilometers (left); annual change in heavy vehicle kilometers (right)**

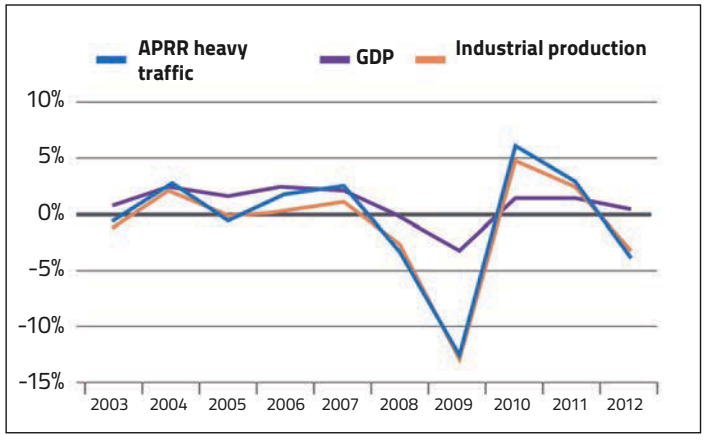
through the credit boom and contraction, and on into the recession, PDI is clearly following a different path. Perhaps this provides a better indicator? And for trucks? Certainly, measures of industrial production have more closely tracked levels of truck movement. At the outset of the recession, production fell dramatically – seemingly as a response to an equal reduction in the levels of stock held as inventory. Since then, the fall has been far less – and traffic levels have stabilized and even grown. In 2012, however, it seems that as confidence in a speedy recovery dwindled, there was a further fall in inventory and a drop in volumes of traffic moved.

Are these the indicators for growth over the next years? And as the economy finally recovers, do we expect traffic to reach the levels we saw before the great financial crisis? If so, would the normal relationships between traffic growth and economic growth then be re-established?

To answer these questions, it is first important to understand what changed during the global financial crisis. The dramatic response noted in the industry during that time where the depletion of inventories (de-stocking) results from an attempt to conserve cash flow in a tightening credit environment. This, in turn, is seen to have resulted in drastic drop in truck flows on the road network.







(Figure 3, top) **Light traffic and GDP and PDI in France** (Figure 4, above) **APRR heavy traffic, GDP, industrial production**

On the private user side, the unprecedented drop in interest rates by central banks is considered to have buffeted the household income levels, even when unemployment was rising and real wages were falling during the initial phases of the crisis. This, in turn, has been noted as a possible cause for resilience in car traffic. In fact, light vehicle traffic rose slightly or remained stable in 2009 (as shown in Figure 2) before falling away between 2010-12. Clearly the exact trend in different countries and parts of the road network was very different.

This indicates that there are more micro issues at play, which are generally not well accounted for in traditional forecasting techniques. We have a lot to learn from the emerging trends of traffic growth in low or stop-start economic growth conditions that lie ahead of us. What does seem to be clear is that traffic forecasting is not going to be as straightforward as it used to be prior to the economic events of 2008. ○

• *Charles Russell is a director with Steer Davies Gleave, one of the world's leading transportation consultants, while Serbjeet Kohli is an associate with the company. For more information, please email charles.russell@sdgworld.net or serbjeet.kohli@sdgworld.net*

IBM's **Eric-Mark Huitema** reveals how an era of connected vehicles could revolutionize how traffic is managed

Interviewed by Nick Bradley/Portraits courtesy of Alexis Kembery

> This 'internet of cars' will spearhead what I think will be the most important innovation phase since the dawn of the automobile itself

Eric-Mark Huitema has just 30 minutes to spare before he boards Lufthansa flight 2305 bound for Turin, Italy, and the Smart Mobility World conference, at which he'll be delivering a presentation on the subject of smarter connected cars. With the Big Blue's prominence in big data and cloud computing, you'd expect it to be influential in this high-tech field. But IBM's Smarter Transportation leader, Europe, doesn't want to talk about the connected vehicle *per se*; he'd much rather discuss how they're going to impact roadway authorities.

Connected vehicles: our only hope?

"Current traffic management technologies and practices won't have a hope in dealing with what's around the corner," warns the affable Dutchman. "It took pretty much the entire history of mankind for the global population to reach two billion people, yet in only a generation that has surged to seven billion," Huitema says. "And most of these people will be living in cities, which are getting bigger by the day."

In 1950, there were just 83 urban areas with a population of at least one million people and in 2010 there were 476 – an increase of 573%. "There are currently something in the region of one billion cars on the world's roads – a number that will double by 2020. That's what we're facing."

However, despite this burgeoning population growth – and increasing urbanization and motorization – there is hope in connected technologies. We're living in an increasingly instrumented, interconnected and intelligent world – three amigos that IBM refers to as the "three Is" that are driving its Smarter Planet initiative.

"Every aspect of life can benefit from the three Is," Huitema advises. "And you can see this happening already in traffic management to assist TMC managers. Loop detectors are being replaced by smart sensors with numerous functions all on the same sensor. Vision-based systems are reaching levels of intelligence we could only have dreamed about a few years ago. Our vehicles are becoming mobile sensors. And we're also now doing a lot of social sentiment analysis around traffic and transportation, with people connected to Twitter and Facebook essentially becoming a new breed of incident detector – and sometimes they're more accurate and faster than traditional methods, too."

Once you have established the three Is environment, Huitema says you can move to what he labels as the three As – awareness, anticipate and act. "If you're aware and have visibility of all city data sources, you can anticipate and proactively manage the problems and mitigate the

impacts – or even prevent the problems occurring in the first place," he explains. "And that's when you have to act – and when TMCs really propel into the future."

Action, Huitema goes on to say, is based not only on the experience of a traffic manager – vital as that may be – but on computer-aided decision-making tools that are based on specific real-world scenarios. "If there's an incident, our intelligent systems may shortlist three courses of action and they'll be calculating exactly what will happen 30 minutes, an hour, two hours, etc, into the future in each scenario, so that decisions can be made based on accurate models and predictions. Such a process is unique in the world of traffic management; it will be real mindshift."

But is it too much of a mindshift for an industry that is sometimes hesitant to change? "In the Netherlands, we have a saying – *wet van de remmende voorsprong* – which translates as the 'law of the handicap of a headstart'," Huitema laughs. "In other words, a headstart may not always be a good thing in the long run. We are finding that our new markets in China, Asia, the Middle East, Brazil and Latin America are more willing to embrace the possibilities of these new technologies, and although they arguably have the bigger transportation problems, they will reap the rewards. In the more mature markets, though, such as in the USA and in Europe, in some cases there's more of a feeling that if something is working fine, then why change it?"

But change will have to come eventually as connected vehicles are here already, here to stay and will penetrate at a lightning pace. "Over the next five years, there will be an almost sevenfold increase in the number of new cars equipped with factory-fitted mobile connectivity," Huitema predicts. "Already you're seeing wireless technologies such as cellular, NFC and 802.11p on new cars, making it possible to communicate with the traffic infrastructure and with other cars. These are the enabling technologies for cars to develop a situational awareness to avoid accidents – the backbone of future autonomous driving functionality.

"I can envisage connected vehicles developing in a similar vein to cookies on your web browser – your car will alert you to local services and offers that are tailored especially for you, but at the same time because the information is individualized to you in your vehicle, governments could relay information relevant only to you based on your location – ghost driver alerts, ice warnings, etc. This 'internet of cars' will spearhead what I think will be the most important innovation phase since the dawn of the automobile itself, and that will have a similarly significant impact on how we manage traffic on our roads."

Huitema puts forward an extremely convincing case, but what makes him so certain this is the path we're on? "The technology has come so far in such a short time," he responds. "The same technologies we implemented at an experimental stage four or five years ago for our road pricing trials in Eindhoven are soon to be standard in cars as a result of eCall being mandated," he says. "This could be potentially disruptive for today's tolling best practices, as eventually you won't need tags and gantries, video tolling, etc – everything you'll need to calculate location, time, distance traveled and so on will be built into the car already, so theoretically you could just download a tolling app from the cloud as a value-added service, much in the same way you download a software to your smartphone. Eventually we'll be paying for road usage by the mile and the enabling force will be connected vehicle technologies. Bolted onto that, though, the same technology will enable information to be conveyed about things like road collisions, potholes, slippery roads and traffic jams."

The Eindhoven trial

As to further evidence of how connected vehicles could assist traffic managers, Huitema points to the Eindhoven trial with NXP, which reached another milestone in early 2013. Around 300 connected cars automatically shared braking, acceleration and location data that was analyzed by the central traffic authority, RWS, to identify and resolve road network issues. "We showed them how to link the information and combine it into a smart information stream," explains Huitema, "which then becomes of value to report the state of the road, for example, or as safety information to better inform drivers and help road maintenance managers increase safety.

"If we can extract all possible data from vehicles and then combine it into valuable information to increase traffic safety and achieve a better flow, we will all profit," Huitema insists. But how much penetration is required in order for the data to be operationally effective across much larger networks? "They're achieving some pretty good results with just 300 vehicles in Eindhoven," says the IBM man. "But a 5% penetration really gives you a good view on the current traffic patterns; with 10% you can predict what will happen next.

"We'll find out what larger penetration rates will lead to when eCall is rolled out. We're on the verge of some big changes, some exciting changes. As a consequence, our cities will become more pleasant to live in, regions will be more efficient and economies can keep on growing."

And just as Huitema issues those predictions, an alert on his smartphone indicates that our time is up. "I have a flight to catch," he says. "Where would you be without your smartphone? We'll soon be saying the same about smart cars!"

Onboard analytics

In the Eindhoven trial, IBM analytics was used. Raw data from the vehicles highlighted 48,000 incidents over a six-month period, from 1.8 billion sensor signals, according to Eric-Mark Huitema. Incidents included heavy rain, blackspots, switching on hazard lights and fog. The disparate data from thousands of sensors was managed and analyzed through the IBM SmartCloud Enterprise service, which made it possible to dynamically manage the needed capacity, which varies greatly depending on whether it is a peak traffic period or an unexpected event occurs. "The data enabled officials to act in near-real time on dangerous road conditions, accidents or rising traffic density," says Huitema. "It also informed drivers in the vicinity of an incident through smartphone or built-in navigation device."

Flying the flag for the UK, TRL's **Alan Stevens** offers his thoughts on the future of intelligent transportation

Interviewed by Max Glaskin

When your staff tell you it would be good to give an interview at short notice to a magazine that'll be seen by your peers and rivals around the world, the less than confident would decline. The fact that Dr Alan Stevens, chief scientist and research director at TRL, accepted *Traffic Technology International*'s request at less than 24 hours' notice reflects the fact that, having just celebrated 25 years at the UK's transport research laboratory, he knows his stuff and trusts that his calm, composed opinions will be given due consideration.

Reader interest

He prefaces our conversation with a truly British sentiment. "Whether I'm an interesting person to talk with, you'll have to work out," he says. Readers can judge for themselves as he dissects issues pivotal to road transport and the application of new technologies – including driverless cars, road pricing, the intelligent highway, electric vehicles (EVs) and, er, the curiously distinct habits of people in different parts of a small and populous island.

> "Individual autonomous vehicles are almost there, having evolved through ACC, lane support, collision avoidance and that sort of thing"

First though, who is he? "I started by taking things apart and putting them back together again. I'm an engineer," explains Stevens. "I did a physics degree and a PhD in medical imaging but 9 out of 10 people at TRL will tell you I'm a psychologist or human factors specialist as I'm very interested in how people relate to a technology, how they use or misuse it."

This expertise evolved through early work on license plate readers, route guidance and mapping digitization. He's editor-in-chief of the *IET Intelligent Transport Systems* journal and co-chair of Europe's iMobility working group on human factors, which is reviewing the guidelines for in-vehicle interfaces. His staff at TRL focus on research, which is either funded by clients, grants or by TRL itself from any surplus that it might accrue.

So having compressed half a lifetime into two paragraphs, Stevens is eager to predict the future for autonomous vehicles. "Yes, yes, it's a very interesting question," he enthuses. "It's almost come from nowhere over the past couple of years." With the logical approach of someone who's taken many things apart and put them back together, he immediately breaks the issue into two. "I would make a distinction in my mind between individual vehicles and platoons. The former are almost there, having slowly evolved through automatic cruise control, lane support, collision avoidance, etc. Step by step we're getting to where there'll be

> The UK is good at making decisions that include cost-benefit analysis. We've got a lot to offer, particularly on infrastructure

completely autonomous vehicles in certain situations, such as on motorways. Yes, I can see them by 2020. I think that's quite likely."

Coming from a man talking cautiously to a stranger, that's a strong statement. But he's less certain about platooning (Volvo's experiment is pictured right). "We're doing modeling ourselves on some of the traffic implications, to see what the benefits really are and how others react with platoons. My PhD student has been doing her thesis on this and she shows that drivers not in a platoon adjust their behavior as a result. Driving is a social act and the norms are that people copy. Even if you know logically that you should leave a two-second gap, when you see a lot of other vehicles in a platoon not doing that, there seems to be an unconscious pull to behave like them and reduce your headway," he explains.

The potential for a platoon to block views of exit ramps and questions about apportioning legal responsibilities among drivers in a platoon are other important aspects yet to be resolved. "I can't see us getting to the deployment of platoons for a while," says Stevens, before putting it up for discussion. "But that's my view. Am I right? Who knows?"

The prospect of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies being implemented widely elicits more thoughts. "From a vehicle perspective, V2V communications will go ahead in the automotive sector. V2I is more interesting and, to some extent, more difficult," Stevens concedes. "I did some work for the European Commission, taking the infrastructure owner's view of what cooperative technologies can do. They can be deployed either by installing beacons or by using the existing cellular networks. Personally I think non-infrastructure cellular is the right way but we'll see how it pans out. Cellular uses what's there already. On the other hand, there is the cost of transmitting data and some issues regarding latency."

For Stevens, the main question about V2I is, are there functions that might work better? "There can be interaction at traffic lights in urban settings, which would provide a small local benefit at the junction, by reducing emissions to improve the immediate environment, for example. But the local authority will still want to control traffic in a much more strategic sense, to balance the flow of vehicles, pedestrians and cyclists. I can see greater benefits in terms of safety to be had from V2V."

Give road pricing a chance

Perhaps fortunately, there is no such job as secretary of state for global transport. Nevertheless, it didn't stop us asking Dr Alan Stevens what he would do if he awoke one morning to find he had the job – and the resources to implement his wishes. Even if the prospect was daunting, he wasn't put off.

"I would take another serious look at road pricing, using time, distance and place charging to bring about a more rational use of the roads. It's technically feasible, although there are issues surrounding acceptability," says the temporary global transportmeister. He'd have to harness his department's hefty information section to convince people that the technology is fair and works – and that the necessary support systems for legal and administrative needs are also fair and reasonable.

"Then everyone can make much more sensible travel-choice decisions since the cost of the journey will be reflected in the price."

Photograph courtesy of Volvo

The UK's place in the bigger picture

Whether or not worthwhile V2I applications are developed and deployed, the need for traffic technology around the world has never been higher. Certainly there's a lot of competition out there battling to meet that need. Can the UK, a country that hosts many plants owned by overseas car makers, really stake a sizeable claim in the traffic technology market? The devil's advocate question prompts a staunch response from the vice-chair of ITS-UK. "Yes, we have limited national vehicle interests but we have lots of roads intelligence," Stevens responds. "The UK is good at making decisions that include cost-benefit analysis. We've got a lot to offer, particularly on infrastructure. ITS-UK has more than 150 members, including lots of big players, and it's become increasingly confident and influential in recent years. We can call upon good consultants, researchers at universities and software providers."

Such resources will undoubtedly take Stevens' native country forward – but which way? Where, in his opinion, are the best transport networks today? Who might others aspire to copy? "We tend to look to the Swedes and the Dutch as being pioneers," he reveals. "The Dutch make their public transport join up so travelers can make journeys easily using several modes. At TRL we're also interested in what the Dutch have in their designs of roundabouts and we're looking at that to help cyclists. Our Highways Agency is working with Dutch authorities and looking into joint procurement, which is an interesting way of getting some standards and new technologies into the infrastructure side of things."

Meanwhile, TRL is conducting a lot of work with EVs. "They'll be part of the mix and there's increasing interest now models are appearing from the manufacturers," Stevens says. "Their range means they are most likely to be suitable for fleet owners or as second cars, but modeling shows their take-up depends very much on government incentives. The recharging infrastructure also needs to be sorted out. There's an interesting contrast in that respect here in England. In the northeast they're used heavily; people park their car and plug it in. But people in the southeast don't seem to want to leave their EVs plugged in on the street. There are always implications for technologies from the human factor."

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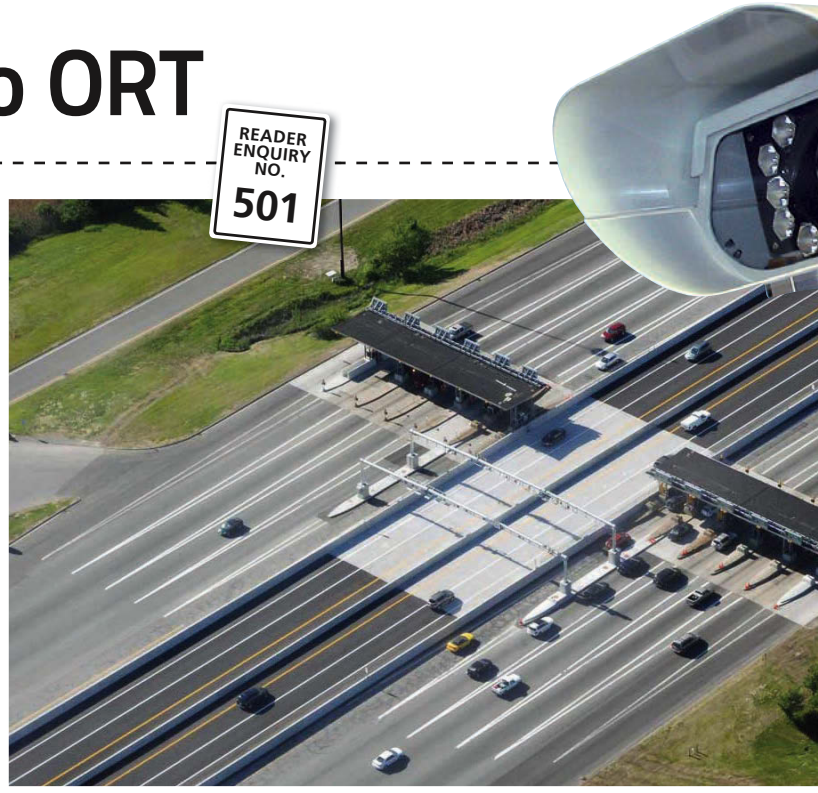
The quicker route to ORT

READER ENQUIRY NO. 501



There is no denying the shift toward free-flow toll collection. Everywhere you look, toll authorities and operators are switching to open-road tolling (ORT), all-electronic tolling (AET), high occupancy toll (HOT) lanes, and other free-flow methods. This movement is being driven by clear benefits, including better utilization of road capacity, reduced fuel consumption, reduced emissions and an improved experience for patrons.

For these agencies, the issue isn't whether they should convert existing toll roads to ORT or AET. Rather, it's finding the fastest, easiest and most efficient way to make this conversion happen.

That was the mindset of the New Hampshire Department of Transportation (NHDOT) in late 2012 as it considered an upgrade to the busy Hooksett toll plaza on the I-93 turnpike. For NHDOT, upgrading the Hooksett toll plaza represented a major opportunity to reduce congestion and increase customer satisfaction.

"We needed to increase the capacity of this key tolling location by 40% to better handle the 80,000 vehicles per day that pass through it during peak periods," explains Chris Waszczuk from NHDOT's Bureau of Turnpikes. "We needed this to be done on schedule and on budget, using a process that wouldn't compromise the customer experience during construction."

To meet these goals, 14 old toll-booth lanes needed to be converted into a new 16-lane configuration with four ORT lanes in the middle (two in each direction) and six cash/mixed lanes on either side. Schneider Electric, the company responsible for the ORT lane conversion, drew upon experience gained in a similar NHDOT project at the Hampton toll plaza in 2010, incorporating configurations and test protocols with only minor modifications.

This type of 'fast track duplication' process reduced the complexity of the overall project while enabling NHDOT to continue to capture revenue from the site. Most importantly, it enabled the project to be completed a full three weeks ahead of schedule, allowing the opening to occur prior to the critical Memorial Day weekend and the start of the summer travel season

Schneider's program modifications involved an upgrade to the latest technologies that constitute a best-in-class ORT solution, including advanced vehicle imaging systems, new laser technologies and a redundant dual-data-path lane control design. Employing backward-compatible systems provided an easy path to higher performance without the need to completely re-validate the design. This translated into cost efficiency for the project and NHDOT.

Need to know?

How New Hampshire DOT has taken a shortcut to open road tolling (ORT)

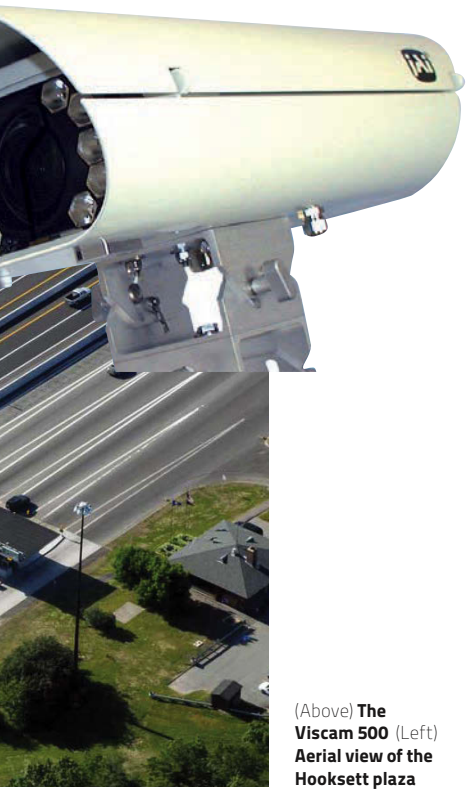
- Converting an existing toll system to an open-road one is not as complex as you may think: a little innovation goes a long way
- Using a 'lessons learned from past experience' approach helps to shave a considerable amount of time off system changeover

Toll gantry at the Hooksett plaza with a sign emphasizing that drivers do not need to stop to pay tolls

The importance of imaging

"A high-quality vehicle imaging system was a critical piece of the project," says Darby Swank, program manager at Schneider. "Good images are needed both for confirmation of transponder data and (of particular importance) for enforcement of violators."

Building on the Hampton project, Schneider installed high-resolution Viscam 500 imaging systems from JAI above the free-flowing lanes to capture front and back images of license plates and the associated vehicles. Each 3.6-megapixel camera provides a 15-17ft-wide field of view (FOV), which enables coverage of the wider ORT lanes at full highway speeds. The wide FOV also provides overlapping views of neighboring lanes to make sure that vehicles making



(Above) **The Viscam 500** (Left) **Aerial view of the Hooksett plaza**

lane changes are easily captured for the back office.

High-speed flash illuminators were included in the Viscam configuration to provide 24-hour, year-round capability. Additional systems are now being installed at the cash/mixed lanes in order to capture plate images of any vehicles passing through the toll gates without paying.

The success of the Hooksett project has NHDOT considering where the next conversion can be made. Swank believes that other agencies should be doing the same. "The ability to provide extremely high performance while maintaining a cost-efficient process shows what can be achieved in these types of retrofit projects," he says. "With all the benefits of free-flow tolling schemes, there's really no reason to put off implementing these changeovers."

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The NTSB recently released a proposal that calls for all US vehicles to be equipped with technology that will essentially let them talk to each other. This announcement is a vital step toward truly revolutionizing road transport with what the automotive industry is calling the 'connected vehicle'.

There are two main applications of connectivity with road vehicles – vehicle to vehicle communication (V2V) and vehicle-to-infrastructure (V2I) communication. Together, they combine to create the connected vehicle and will change the way we think about road transport in the coming years.

The benefits of a connected road network cannot be overstated. With regard to safety, V2V/V2I technology can help drivers by augmenting their awareness of their surroundings. The technology can not only inform drivers of any impending hazards, but can also take measures to prevent accidents happening in the first place. Poor visibility, blind spots, driver distraction and even fatigue could all be compensated for with a V2V/V2I system. In fact, a USDOT report recently estimated that a V2V/V2I system could potentially address 81% of all-vehicle crashes, translating into a considerable reduction of vehicle-related injuries and deaths.

In terms of mobility, V2V/V2I technology can reduce traffic congestion through a number of means. For one, having vehicles communicate to a central hub gives transportation agencies true real-time traffic data, enabling them to better manage their facilities to maximize efficiency and minimize congestion. A V2V/V2I system could also enable vehicles to work together by driving much closer on the freeway and platooning with other vehicles heading to the same destination. As a result, roads gain more capacity by fitting more vehicles into the same amount of space.

Although we're still a long way from realizing a road transport system of connected vehicles, there are technologies today that attempt to bridge the gap between existing and V2V/V2I technologies. Adaptive cruise control can track nearby vehicles by using radar and adjust its speed accordingly. Lane departure warning systems seen in some luxury cars can notify you if your car is drifting out of its lane. Both of these high-tech features give drivers a greater awareness of their surroundings.

The next step toward a connected transport system is the development of true V2V/V2I technology. The underlying technology exists, but it's still very much in its early stages. The University of Michigan Transportation Research Institute is currently running a connected vehicle pilot program in its home state. The experiment, involving nearly 3,000 vehicles equipped with various V2V/V2I technologies, seeks to collect real-world data in a concentrated connected vehicle environment. Using the results of the program, NHTSA is expected to issue a ruling later this year on whether or not V2V/V2I devices should be required in all vehicles in the future.

A few issues still need to be addressed before a connected-vehicle transport system can be fully realized. All road vehicles need to be equipped with the technology, laws need to be written at several levels, and the question of liability with automated systems needs to be resolved. However, there's no doubt in my mind that a connected vehicle system will be part of our future, where vehicles and the roads they travel on will be linked in ways we've never seen before. The real potential for safer and more efficient roads is too great for us to pass up.

> There's no doubt in my mind that a connected vehicle system will be part of our future
>
> **Sam Schwartz, Sam Schwartz Engineering, USA**

Novel reflective road markings for pedestrian crossings

READER ENQUIRY NO. 502

Although the Austrian Road Safety Board, Kuratorium für Verkehrssicherheit (KfV), has praised the positive trend of declining road accident figures over the past year, the annual number of accidents involving pedestrians on zebra crossings has actually remained pretty constant. And in Austria, that's where 30% of all accidents involving pedestrians occur, many of which prove fatal. The KfV believes this is an issue that needs to be better addressed and tackled, so welcomes with open arms any solutions that could reverse this statistic.

Of course improved safety at zebra crossings can be achieved via multiple methods. Mutual respect between motorists and pedestrians and clear behavior from both parties at these conflict points are a prerequisite. A pedestrian suddenly stepping out onto a zebra crossing (sometimes distracted by a cell phone call) is a scenario many drivers will have experienced.

A key measure to help pedestrians and motorists is to invest in improving the illumination of the crossing so that pedestrians can always be well identified against the background, without becoming 'invisible' in shadowy zones.

Another possibility is to focus on the road markings at zebra crossings, which is an approach that the Austrian city of Graz, the capital of Styria, opted for a few years back. For many years, road authorities there had been applying the same material to mark zebra crossings – a coldplastic applied with a spatula. But spreading the material over the road surface was uncomfortable for stripers as they had to apply it while on their knees. And when the municipal road maintenance department evaluated the stripings only a few weeks after they had been applied, they often found them with little brilliance and poor retroreflectivity. Hence why the officers in charge of road maintenance in Graz have been eager to look at innovative alternatives as well as testing novel marking systems.

(Main) **Improving road markings at zebra crossings helps increase safety for all road users** (Left) **The Solidplus glass beads are both highly reflective and durable**

Need to know?

The city of Graz is content with the results of long-term tests of reflective road markings

- The Solidplus beads are made of titanium-aluminum silicate glass
- The beads have a refractive index of >1.6 (Class-A bead according to EN 1423)
- Bead gradings are from 100-850μ
- Anti-skid particles can be added to the Solidplus beads according to the end customer's specifications

Improved marking criteria

The main criteria for new types of stripings were the improvement of pedestrian crossing markings in terms of skid resistance and night-time visibility. The striping should have a higher durability – i.e. the need for restriping should be less frequent, which also reduces obstructions for traffic caused by road marking works. Also, the stripers should have a more comfortable working position when applying the

paint. And last but not least, it is Graz's objective to sustainably increase road safety for all.

Holding Graz, responsible for the city's road maintenance, initiated a cooperation with Amstetten-based glass bead manufacturer and road marking systems specialist, Swarco. Twenty-one intersections in Graz's city center were included in the tests of new marking solutions from Swarco. The daily traffic over the pedestrian crossings in the test field ranges from 15,000-18,000 vehicles (Petersgasse) and between 16,000-22,000 vehicles (Opernring). Approximately 10% are heavy goods vehicles.

Tests and findings

With the aims of enhancing road safety for pedestrians, cars, trucks and single-track vehicles – and finding a marking system for zebra crossings that is easier to apply and more durable – a number of marking systems have been applied in Graz and tested under real traffic conditions since August 2011.

The glass beads are embedded into a roll plastic material

There were two main improvements required of the new systems deployed: that their retroreflectivity was augmented and prolonged; and that their anti-skid properties were increased. Before the tests, the zebra crossings had been equipped with standard glass beads and a 20% anti-skid particle share.

In the course of the tests, Swarco's innovative Solidplus reflective glass beads were used, which are characterized by very high retroreflectivity and durability over long periods. A further feature of the beads is that a substantial increase of anti-skid material doesn't negatively affect the night-time visibility of the striping.

The tests also resulted in the development of a novel marking material into which the Solidplus beads are embedded – a so-called roll plastic. Roll plastic has been used successfully for bicycle lane coatings for some time, predominantly in a red color.

The roll plastic material has the advantage that its coarse fillers enhance skid resistance on a long-term basis. In addition, the method of its application (spreading with a roller, which is more comfortable for the stripers) creates a rough structure on the striping's surface, which also helps to increase its night-time visibility.

Both the roll plastic and the coldplastic that was previously used (which was applied with a trowel) were tested with various gradings of Solidplus glass beads (100-850μ) and with different proportions of anti-skid aggregates (30-50%). Special emphasis was put on the comparison with standard glass beads and aggregate mixes.

The measurements over a period of two years show that a marking system consisting of roll plastic and Solidplus 100 212-850 T18 M35 glass beads leads to a considerably better result regarding night-time visibility and grip, and therefore effectively contributes to an increase in traffic safety.

A further conclusion is that the higher ratio of anti-skid aggregates (35% instead of the usual 20%) does not have a negative influence on the degree of soiling of the marking.

The superior durability and performance of this form of marking is particularly evident at locations where the zebra crossing markings are subject to shearing forces caused by turning vehicles.

At the test locations in Graz, where the markings have been in place and subjected to traffic load for two years, the retroreflectivity values of the markings with Solidplus are still on a level that conventional beads would only have at the beginning of their life.

Martin Stampfl, director of street maintenance region south at Holding Graz, is pleased with the results of the study. "In view of the daily urban traffic, we are very content with the test results," he says. "The measurements show that the new system with improved anti-skid properties contributes to increased traffic safety even two years after installation, by providing better visibility of the zebra crossing, especially at night. At the same time, the simplified application method of the marking system makes life a lot easier for our road marking team."

Hans Jesacher from Swarco is also delighted about the fruitful cooperation and regards the project as an impressive confirmation of the successful R&D work of the past years. "Road marking remains the most economic way to provide good orientation and road safety," he comments. "Our research team at Swarco's Competence Center for Glass Technology in Amstetten has proved there is an innovation potential for glass beads from which all road users benefit."

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Traffic management with floating car data

READER ENQUIRY NO. 503

Using the actual locations of driving vehicles is becoming a widespread method of monitoring network-wide traffic information. Floating car data (FCD) systems, for example, are already being used in many parts of the world for delivering traffic information as a service to the navigation and media market.

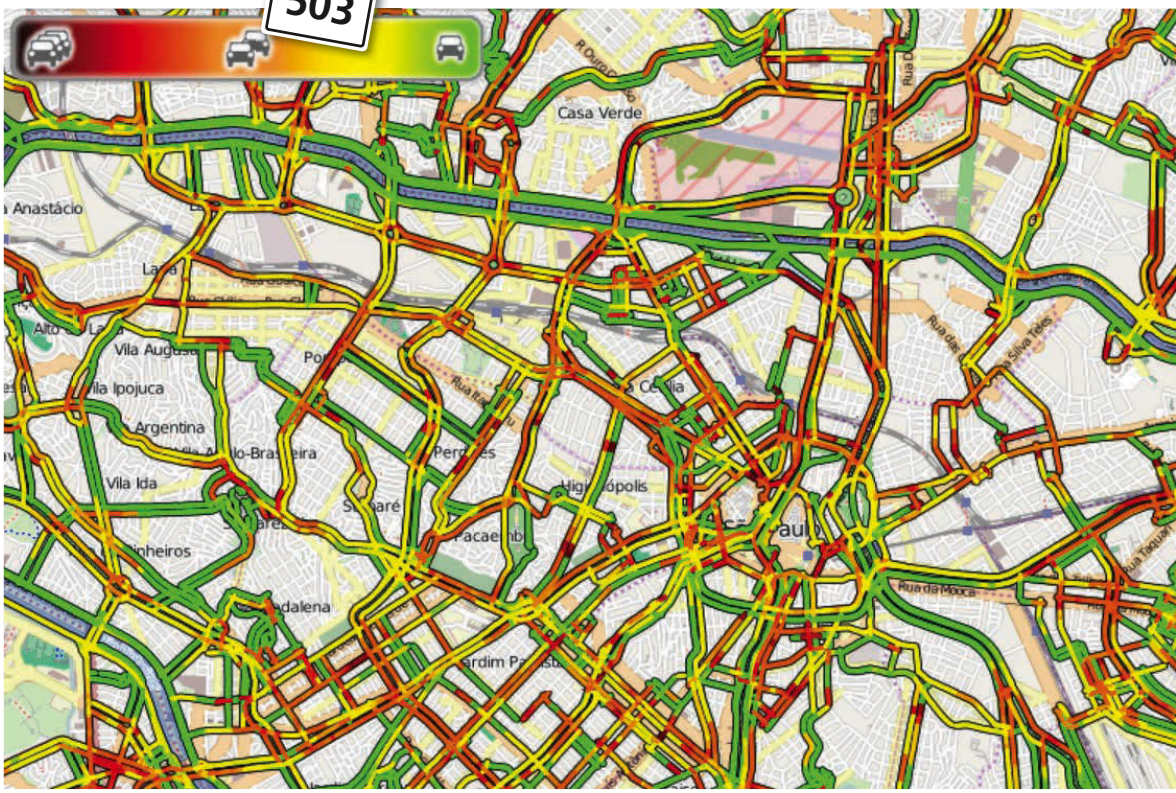
Traffic management can also take advantage of FCD when the detailed detection of traffic is guaranteed. Be-Mobile, which operates its FCD system in numerous countries, sees two essential conditions for traffic management to benefit from FCD data. Firstly, the incoming positioning data must be numerous and detailed. Secondly, the process must be accurate and based on traffic engineering principles.

Positioning data

The positioning data that FCD systems use must be accurate to guarantee good detection. Only vehicles that are actually in motion should be used to create the positioning data. Devices sending probe data from moving vehicles are the only ones used in Be-Mobile's system.

The system also works with vehicles that communicate at fixed time intervals. This leads to more positioning data during slow traffic and ensures that the measurement data is more detailed when traffic speeds are low.

FCD can be considered as a real-time survey of the driving population. Having good penetration is the key to making representative measurements. The Be-Mobile system works via real-time processing of GPS positions of driving vehicles. In the example from Brazil shown in Figure 1 above, it has a penetration of about 3% in the studied area.



Need to know?

Experience in FCD shows that traffic managers will gain lots from this relatively new form of data collection

- Be-Mobile operates traffic services in Europe, South America, the Middle East and Asia
- The principle of FCD is relatively simple: retrieve the real-time GPS positions of millions of vehicles (taxis, trucks, vans); calculate the routes and travel times between these positions; then detect any traffic jams

The FCD process

A second necessary step to enable FCD-based traffic management is to have the right process in place to generate the data. The raw data must be processed in a timely, accurate and precise way to achieve detailed traffic detection.

The raw data is filtered and potential false data is removed. New incoming data is processed in an event-based way, which minimizes delay. Positions are matched to a representative description of the road network to generate samples of travel times. The aggregation of different samples leads to the publication of the real-time speed and travel-time values.

The system is designed to contain the basic traffic flow engineering principles. Jams are caused by incidents or bottlenecks and the type of congestion depends on the encountered capacity reduction. Larger bottlenecks cause zones of low but homogeneous speed, while smaller bottlenecks and local disturbances trigger traffic shockwaves.

Due to the evolving traffic, mixing up different traffic conditions on a road link will affect the quality of detection. As a result of that, the system works on road segments that are no longer than 50m, which assures that traffic on a segment can be considered as homogeneous during a period of one minute. It also makes it possible to

have detailed end-of queue detection and monitoring of traffic shockwaves.

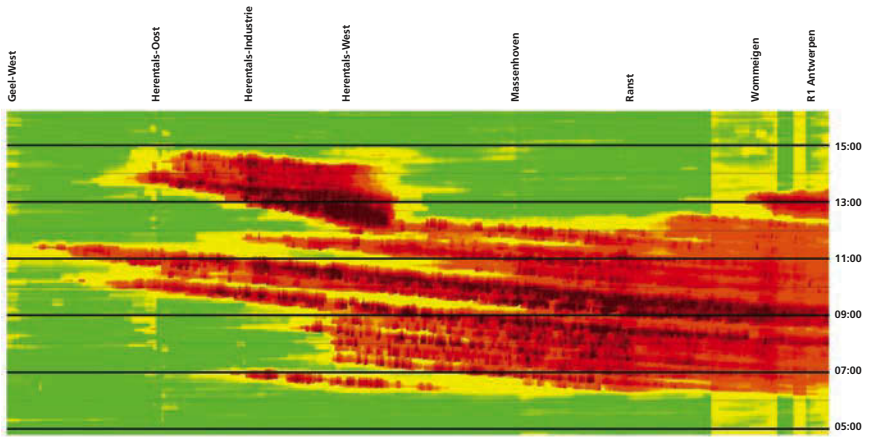
Validation

The ability of FCD to monitor accurate travel times can be shown by comparing it with road-based reference measurements such as BlueTooth. Figure 3 below shows the travel time in seconds measured with BlueTooth and FCD for a trajectory of 1.2km. The morning and evening peak is monitored in both systems. The impact of an incident around 12:00pm is also picked up by both systems.

Congestion evolves over location and time. Looking at only the most recent traffic situation is not an effective way of getting a full insight. A TX diagram, also known as a 'time distance' diagram, gives a detailed representation of traffic evolution over a trajectory by showing measured traffic speed over time and place. Traffic bottlenecks, congestion waves and the effect of incidents can all be identified.

To illustrate this approach, Figure 2 above represents a stretch of road on the Belgian motorway E313 between Geel and the junction on the Antwerp ring road. This 40km-long stretchhas two lanes between Geel and Ranst and three lanes further on.

The horizontal axis represents the distance; the vertical axis shows the time. The various colors represent the speed measured by the Be-Mobile FCD system. Speeds of 90km/h and more are green, 70km/h is yellow, 50km/h orange, 30km/h red and speeds around 10km/h are dark brown. An individual driver travels from the bottom left to the upper right in the diagram.



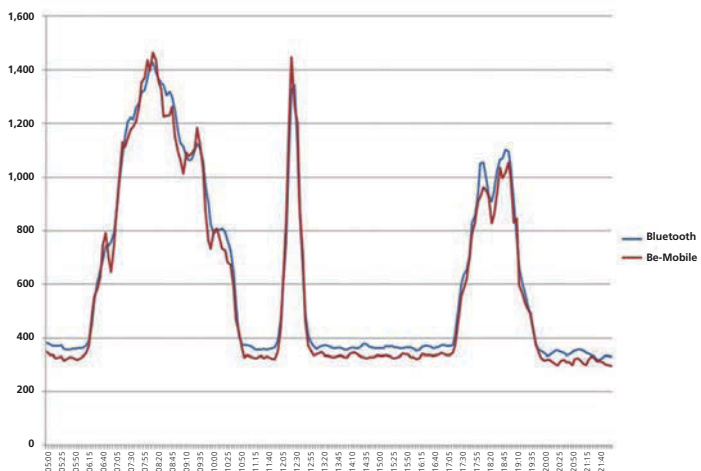
(Figure 1, far left) **Be-Mobile's monitored system in Brazil** (Figure 2, left) **Measured speeds gathered via FCD on a stretch of highway in Belgium** (Figure 3, below) **Travel times over 1.2km measured by Bluetooth and FCD**

The morning congestion starts simultaneously around 6:15am at the Antwerp ring connection and between Herentals West as well as Massenhoven. Near Antwerp, on the three-lane road, traffic is more homogeneous and a constant slow speed is detected. Further from the bottleneck, in the left part of the diagram, traffic fluctuates and traffic shockwaves are detected.

An incident at the Antwerp ring caused even slower traffic between 8:40am and 9:10am, as indicated on the right-hand side of the diagram. This leads to a shockwave that moves on against the driving direction and spills back to Geel-West around 11:30am.

At 12:00pm an incident happens in the end of a jam just past Herenthals West. A lane is blocked for 45 minutes, which results in congestion in Herentals East. The limited throughput at this incident location alleviates the congestion near Antwerp.

The use of these TX diagrams for live traffic management results in a better understanding and judgment of how traffic evolves on the road. The bottlenecks and incidents are picked up more quickly due to the complete coverage of the road with accurate traffic detection. Analyzing and evaluating the traffic conditions afterward is easier.



Data fusion and prediction

FCD provides a detailed view of speed and travel-time evolution. Adding data from road-based traffic detection sensors and fusing the various sources results in a complete estimation of the state of the traffic. Information about the traffic density and the amount of passing vehicles is also generated through this process.

Forecasting the traffic situation and predicting the impact of different scenarios is the next step in making FCD an asset in traffic management, in doing so leading to easier integration and roll-out of new applications to control traffic by the road administrator.

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ALPR within the increasingly demanding ITS world

READER ENQUIRY NO. 504

(Main) **Tolling is a perfect fit for ALPR**
(Above) **Basler's IP and machine vision cameras complement each other in ALPR applications**

Automatic license plate recognition (ALPR) is a technology that serves a multitude of traffic applications. It is most frequently used for parking or access control solutions, yet it is compatible with traffic monitoring, city tolling and enforcement applications as well. Its most prevalent variant involves high-resolution machine vision or industrial cameras that, coupled with the right sensors, deliver the high levels of sensitivity needed to produce high-quality images. IP cameras often serve as a sensible complement to industrial cameras, providing extra coverage that is especially important in the enforcement sector. To avoid motion blur and unintended rolling shutter effects, IP cameras can be outfitted with high-sensitivity sensors with global shutter and real-time trigger functions, as found, for example, in Basler's IP camera lines.

Other ALPR solutions concentrate on traffic safety applications, including speed and red-light enforcement. Such systems are used more generally as part of traffic flow monitoring for journey time measurement (JTM) and congestion charging, such as the solutions deployed in free-flow tolling, city tolling and access control.

Technology behind ALPR

ALPR applications face numerous technical hurdles, starting with the difficult issue of constantly changing light conditions (night, sunrise, sunset). To master these challenges, a supporting light source, typically designed to cover a small spectrum (such as 760nm or 850nm) is installed. Near-infrared (NIR) solutions are frequently used, as NIR illumination reflects well off license plates – an important factor in automated recognition. Monochrome cameras are usually suitable for image recognition, typically with an IR-pass filter installed to block out the visible spectrum. In this way, pure-IR illumination creates stable lighting conditions for day or night recognition.

Systems intended for China and the Middle East face a special set of challenges. ALPR there requires color cameras, which in turn need the support of white-light illumination. The decision to go with such white-light based ALPR systems may reflect local preferences (color versus monochrome images) or the need for color information for certain applications, such as enforcement (vehicle color, color information on the license plate required for identification).

For this reason many ALPR systems comprise a combination of a monochrome camera with NIR light support (ALPR camera) and a color camera, typically with a larger field of view to capture the larger scene (environment camera). They also work with an integrated illumination system, typically LED-based, and a processor unit for the corresponding ALPR algorithms.

Because license plates vary greatly around the globe (size of numbers, reflectivity), the local requirements deviate greatly in some cases. In Europe a resolution of approximately 800-1,000 pixels is sufficient for the width of one lane of traffic (9-12.3ft), whereas in the USA, lanes are typically 12ft (3.7m) wide, with smaller license plates and smaller symbols – necessitating resolutions of around 2,000 pixels.

Image quality is another decisive factor. Vehicles typically move at high speeds, so special cameras and sensors are required. This includes cameras with high sensitivity to work with short exposure times to avoid blur in moving objects. But it's important to note that only a select range of cameras have the technical characteristics necessary to perform this challenging task.

Need to know?

As part of vision-based solutions, ALPR can fulfill almost any technical requirements

- Industrial cameras deliver uncompressed images in real time and offer various interfaces, such as USB 3.0, GigE, CameraLink and IEEE 1394
- In contrast to industrial cameras, internet protocol (IP) cameras offer features such as DC- or P-iris, day/night modes, image compression and multichannel video streaming
- Using both industrial and IP cameras helps to create the best ALPR systems

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What's next for winter road management?

READER ENQUIRY NO. 505

Winter road management can be an expensive and labor-intensive operation. The removal of snow and treatment of roads during winter months involves staff, vehicles and costly supplies. Plus, a growing number of organizations are facing new regulations and legal requirements to provide detailed reports for winter road management activity. The good news is that technology is making it much easier to measure and manage a winter road management operation.

Mobile data collection systems are at the center of progress for winter road management. These systems have been around in various forms for years, but are getting more advanced, and more cost efficient, as technology continues to evolve.

Once installed, a mobile data collection system enables administrators to collect real-time information on weather and roadway conditions, and can provide operators as well as supervisors with recommendations as weather conditions change. Additionally, many organizations choose to install a mobile data collection system to save money by improving efficiency and streamlining fleet operations that include material application, fuel use and fleet deployment.

Data collection technology

These new winter road management solutions work by installing a mobile data collector (MDC) onto snow plows, patrol vehicles and other fleet equipment. Modern MDCs range from a simple tracking device that plugs into an OBD-II port, to a tabletsized, touchscreen device installed inside the cab.

Mobile data collection systems help road authorities to plan and deliver their winter management solutions more efficiently and effectively

Need to know?

Mobile data collectors are bringing intelligence to winter road management operations

- Activity reports generated by modern MDCs can detail what materials were applied and the location of the trucks as well as provide a 'breadcrumb' trail of the route an operator took
- MDCs can also display maintenance decision information (e.g. local radar, weather forecasts and recommended material application rates) to be communicated to the snow plow operator via an on-board web interface

The MDCs collect key sets of data that are custom defined. This can include primary data from the vehicle such as speed, direction and engine status. More advanced MDCs can also collect data on material application rates, plow blade position, air and road temperatures, camera images, engine codes and more.

On advanced systems, a touchscreen user interface allows operators to input driving conditions and lane treatment information.

Most MDCs today include a cellular modem, which allows information gathered by a unit to be sent to a central system in real time for use in generating activity reports. Some advanced central systems make collected data available to third-party solutions such as accounting, maintenance, time card and work order management, either through direct integration or indirect methods such as secure FTP or web services.

As more regulations come into the winter road management space, reporting is also becoming a key factor in the decision to implement a mobile data collection system. Reports that used to take days can be generated in a few clicks.

Is now the time to implement a comprehensive mobile data collection system? It depends on an agency's unique situation, but increasing numbers are exploring pilot programs to test the new technology and prove its effectiveness to their governing bodies.

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New CMOS sensor technology

READER ENQUIRY NO. 506

Transportation congestion is a common problem shared by cities in both developed and developing countries. Rapid population growth and urbanization have brought about a rise in traffic that has outpaced road capacity, resulting in the loss of productive working hours, environmental pollution, and wasted fuel and precious energy resources. These issues have been compounded in recent years by limited government spending, which has forced policymakers to implement less than ideal road infrastructures. Fortunately, new technologies are greatly improving the solutions available. Each of these new technologies brings its own set of benefits – and of course drawbacks.

Although not a new alternative, road tolling is often seen as a suitable option for the complex problem of how to manage transportation network demand. Tolling has the potential to generate the extra revenue needed to build new road infrastructure, as well as redirect traffic towards under-utilized areas to create a more efficient flow of vehicles and traffic patterns. It is seeing a renewed interest with the evolution of technologies such as RFID-based systems, and video automatic license plate recognition (ALPR). These are a major step forward from the coin-operated toll booths that many of us remember.

RFID versus video

RFID systems require the installation of a transponder in each vehicle, which may not be practical for every user, and they also present an initial setup cost. However, once installed, RFID technology is very efficient and requires little maintenance.

Video ALPR systems are an effective method of electronic toll collection (ETC) on pay-per-use roads and they improve traffic flow by allowing cars to pass through toll gates without stopping. While making it easier for users, the technology behind ALPR is quite complex when you factor in all of the components required to make it work. These include: the need for multiple cameras; a separate trigger system required to detect vehicles; proper illumination to operate under a variety of environmental conditions; rugged embedded computers to serve as the brain of the system; and sophisticated image processing algorithms to localize each license plate and read out the plate numbers. Not only are these systems more complex, they also require extensive maintenance as various components reach the end of their life and frequently need to be replaced.

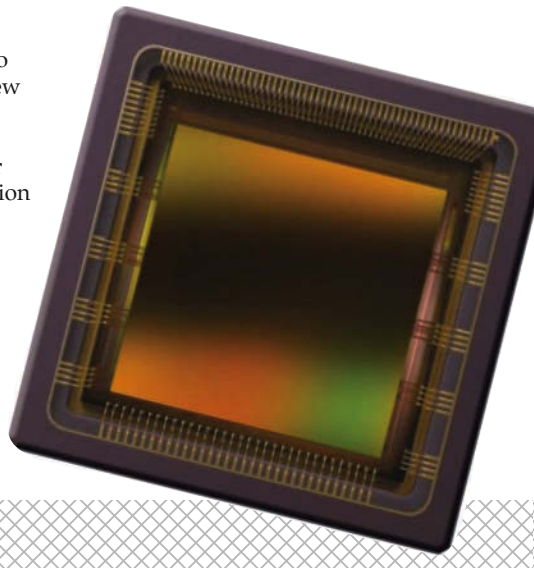
Need to know?

The evolution of the CMOS sensor is enhancing camera-based ITS applications

- CMOS sensors help to capture excellent quality, high-speed images with zero blur
- Applications that CMOS sensors are particularly well suited for include traffic monitoring, ALPR, high-speed inspection and motion control
- Lumenera offers a wide range of advanced cameras that feature CMOS sensors

Next-generation ALPR

Emerging high-speed video technology is enabling a new generation of video-based ALPR that will be more affordable to install and far easier to maintain. Innovation in CMOS image sensor technology has led to the introduction of high-definition sensors (up to 4 megapixel resolution), that can operate at speeds of 100 to 200 frames per second (fps). To put things in perspective, this is about twice the resolution and speed of a high-definition television. These new CMOS sensors offer light sensitivity that is close to that of a CCD sensor, but at a much faster frame rate. They also have the ability to freeze-frame high-speed objects such as moving vehicles, because of a built-in electronic global shutter – an innovation for CMOS sensors. The new image sensors



(Far left) **ALPR can help tackle congestion** (Left) **Lumenera USB 3.0 camera** (Below) **A CMOS sensor**

also eliminate the need for a separate trigger, which is traditionally required to collect snapshots of moving vehicles. Their speed capabilities allow cameras to capture real-time video, which is then automatically processed by software to extract the most suitable image of the moving vehicle for the ALPR engine. The ability to stream and capture this real-time digital video is now much easier to do, as a result of a combination of these new image sensors and high-speed data interfaces such as USB 3.0, which enables the fast and reliable transfer of such large amounts of data.

Ultimately, this new ALPR system architecture reduces installation costs as it relies on a lesser number of components, increases reliability by eliminating points of failure, and simplifies maintenance.

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For the past several years, the tolling industry has been taking baby steps toward interoperability. Just like any great innovation, it started as an idea. What if…? Many would say that little progress has been made. Toll roads seem to plug along without much technological change, but in the shadows many agencies, companies and individuals remain steadfastly on a path to the future.

If you step back and look at tolling as a business that has many unfranchised operators, you can see why it's so hard to get consensus on unified issues such as interoperability. You have to remember that each one of these businesses operates independently with their own budgets, customer needs and unique local and/or regional politics. Added to that is the tens of millions of dollars in investment that existing toll agencies have made in their technologies and business rules. Although the business models may differ greatly, each of these agencies can claim great customer, financial and operational success over many years.

To move forward at all, the old adage, 'if it ain't broke, don't fix it' has to be challenged to the point of progress instead of complacency. Risk has to be assessed. Reality has to sink in. Reward has to be imminent. Decisions on new technology, business rule changes and operational issues need to be addressed by consensus and not by a dozen independent organizations. Questions need to be asked, technology tested, alliances forged. Most of the time it seems you take 10 steps backward to take one step forward.

Five years ago there was no 6C and no accurate video OCR. Multiprotocol readers and tags were not possible due to IP issues. Today we have not only these technologies but also many agreements that have created interoperable regions.

Although it may seem like nothing happened over the past decade, we have moved steadily from 'what if?' to 'we can'.

Now we are here – in the future – and we've gone from a one-lane construction zone to a six-lane highway. Just in the past seven months, look at the analysis that has been performed on the RFID technology by the IBTTA; the advancement of license plate standards by AAMVA; and the recent announcement of an advanced license plate pilot in North Carolina.

Florida and North Carolina are now interoperable and North Carolina is also interoperable with E-ZPass. Oklahoma and Texas have announced that an agreement is pending. Add to that the recent announcement from ATI (Alliance for Toll Europe Interoperability) to provide a North American hub with Egis and Sanef ITS that, when fully deployed, will be capable of providing full customer service, transaction and back-office operations not only for tolling but also for other mobile transactions such as transit, parking, fleets, fast food and rental cars.

So the questions begin. Why should my agency/region change? Why should I give in to some other group? What makes that group think they do things better than I do or that their technology works better or is less expensive? Who is going to govern this consortium, now and in the future? How will that governance work? Who will control it? Will this group force decisions on my agency?

But one thing is certain – although it took some time to get here, we aren't slowing down any time soon.

> Although it may seem like nothing happened over the past decade, we have moved steadily from 'what if?' to 'we can'
>
> **James Eden, director of tolling, AECOM, USA**

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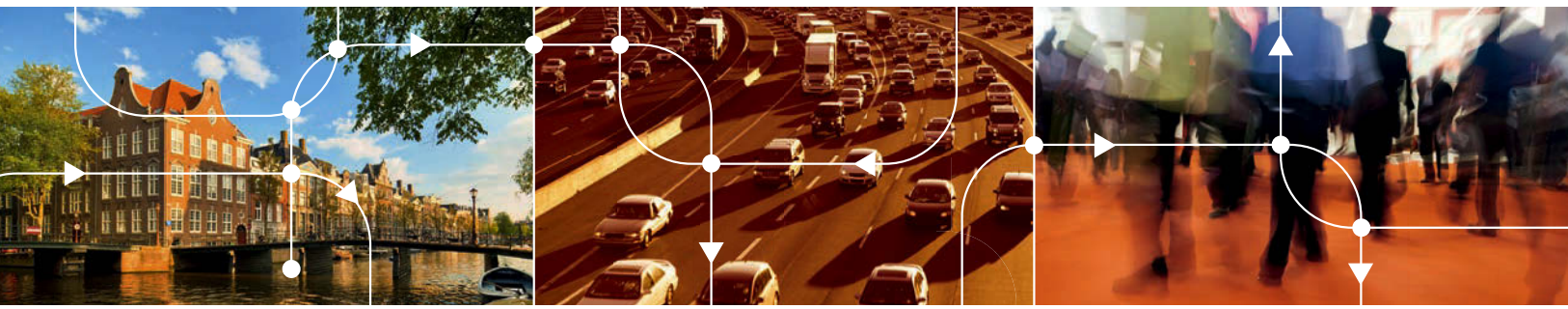

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Taking microsimulation software to a new level

READER ENQUIRY NO. 507

Improving the user experience and responding to industry demands were the main priorities when the team behind a well known traffic simulation software recently gave it a major redesign. In addition to a modern user interface design, PTV's Vissim 6 offers faster network coding and easier data access via lists, quick views and programming interfaces.

By redesigning the basic architecture, the developers have brought Vissim closer to the transport planning software Visum. "These improvements might not be immediately visible, but the users will definitely benefit from faster implementations," says Axel Leonhardt from PTV. "The first thing one notices when opening Vissim 6 is the new user interface with its modern and clear design," he reveals. "Thanks to its flexible window concept, any number of network editors, lists and other windows can be grouped and moved to different positions inside and outside the main window."

Need to know?

A redesign has brought impressive new features to a popular traffic modeling software tool

- Vissim 6 supports modelers in their workflow via several new or improved tools
- It features a new GUI, multiple network windows (each with 2D or 3D view) and faster network coding
- Data can be accessed in lists, quick-view windows and via the Component Object Model interface
- The new software also offers more flexible graphics, result outputs and AVI recordings

Faster network coding

The network editor's new features enable faster network configuration. For example, single objects can be selected and made visible directly via the enhanced network object bar. "Moreover, it provides immediate access to the graphics parameters so that views and color schemes can be edited easily," explains Leonhardt. "Only the elements that the users need are shown in the network."

The redesign of the basic architecture is another factor that contributes to increased efficiency: it means users can access all object data via lists, the quick view and the Component Object Model interface. Changes to properties of one or more selected objects in lists and in the quick view take effect immediately. Another convenient feature is the option to edit the network and the associated data in parallel.

Vissim 6 enables users to replicate traffic situations from the real world (right) **on their computer screens** (above)

Analyzing results

Before now, results were always provided in separate files. In Vissim 6, they can be accessed directly, allowing users to display results of one or more simulation runs in a list. "In addition to lists, it is possible to present the simulation results using different colors or as labels of the corresponding network elements," Leonhardt says. How many vehicles pass a measuring point? What is the speed on a specific stretch of road? Such results can be highlighted in different colors or shown as labels so that black-spots can be quickly identified.

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Thermal imaging cameras prove their worth in ITS applications

READER ENQUIRY NO. 508

Cameras from thermal imaging experts are becoming increasingly common in today's traffic scene, with recent developments on the corporate side aptly illustrating how important the various vendors in this sector regard the ITS market.

In late 2012, FLIR Systems acquired traffic video specialist Traficon. Therefore it comes as no surprise that the company – now known as FLIR ITS – is ready to launch new thermal products for the traffic market. At this year's World Congress on ITS in Tokyo, FLIR is introducing the ThermiCam.

This new product is an integrated thermal camera and detector for vehicle and bike presence detection and counting at signalized intersections. It detects vehicles and bicycles at and near the stop bar. The intelligent sensor transmits its detection information over contact closures or via IP to the traffic light controller, which enables a more dynamic control of traffic lights.

FLIR ITS has a great deal of experience with integrated solutions that combine a traffic camera and the video analytics needed to detect the traffic. In fact, this new variant has the same housing as the well-known TrafiCam and TrafiCam x-stream video sensors, which have been installed all over the world. The main difference between the new solution and its siblings is the camera core; ThermiCam obviously uses a thermal imaging camera instead of a 'traditional' visible camera.

What is thermal imaging?

Thermal imaging sensors use thermal energy emitted from an object. Thermal, or infrared energy, is light that isn't visible by the human eye: it is the part of the electromagnetic spectrum that we perceive as heat. Unlike visible light, in the infrared world everything with a temperature above absolute zero emits heat. Even very cold objects such as ice cubes emit infrared. The higher the object's temperature, the greater the infrared radiation emitted. ThermiCam operates in the long-wave infrared region.

Need to know?

Thermal imaging is now being put to use by a number of detection-based intelligent transport applications

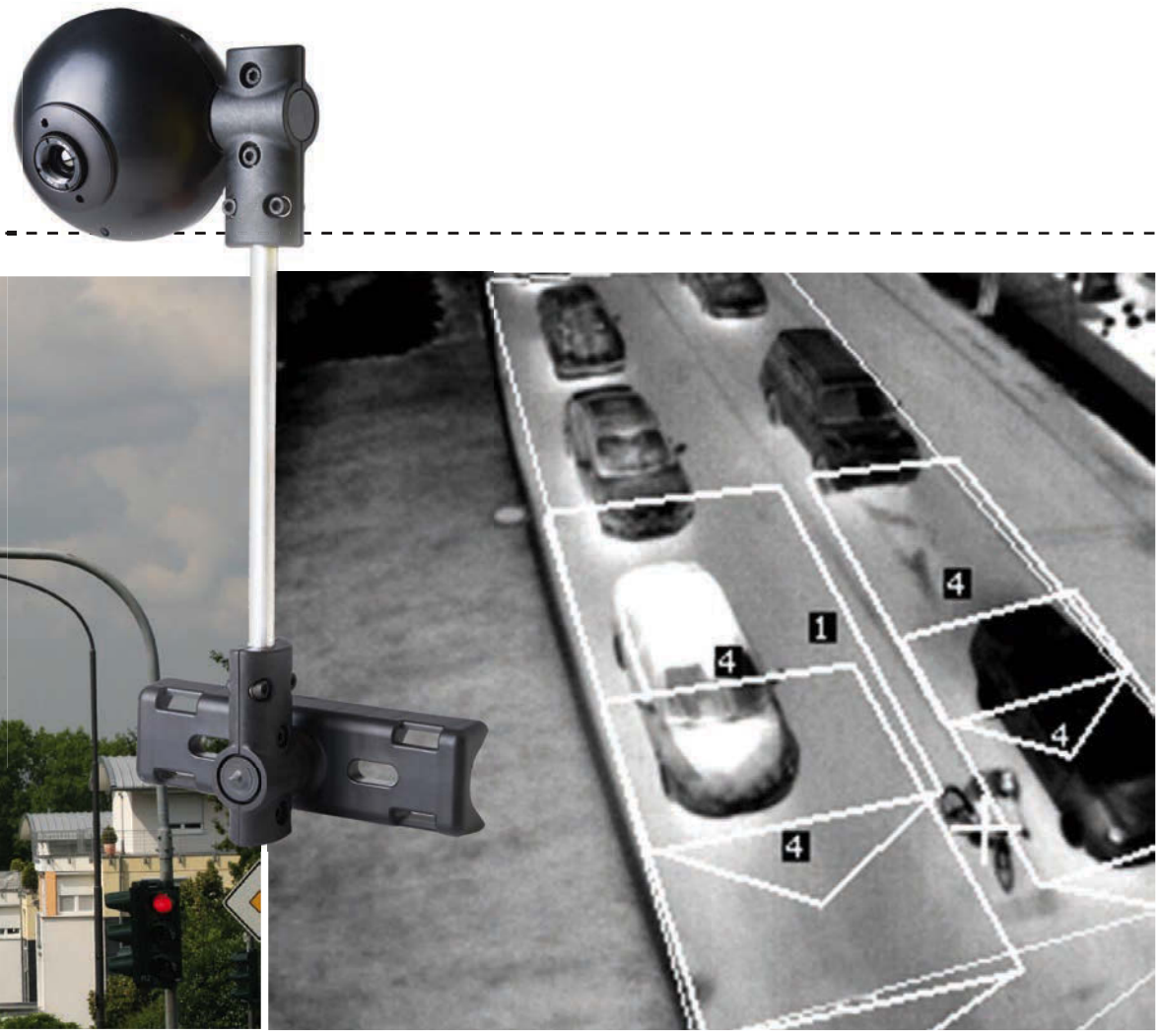
- Originally used in areas such as the security sector, thermal imaging technology is now being introduced to the ITS market
- A detection system based on thermal imaging can successfully make a distinction between bikes and vehicles
- ThermiCam is a new solution from FLIR ITS, to be launched this October

Benefits of thermal imaging technology

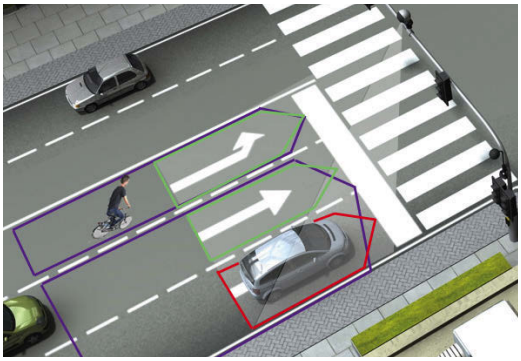
The use of thermal imaging offers a number of undeniable advantages when it comes to traffic detection on signalized intersections. First is the ability to distinguish between vehicles and bikes; ThermiCam uses the thermal energy emitted from vehicles and cyclists to distinguish between them. The sensor can provide the traffic light controller with specific information on vehicle and bike presence, which allows traffic managers to make more intelligent decisions and adapt green times according to the specific road user type (vehicle or bike).

Achieving exactly the same with traditional video cameras and detection algorithms would involve tackling some serious challenges, as CCTV cameras have a hard time detecting cyclists situated close to vehicles or in dark shadows.

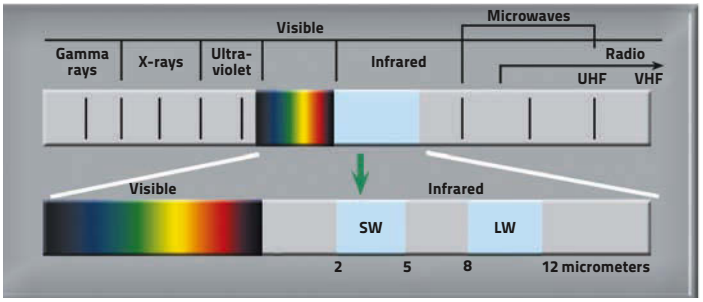
Another benefit of thermal imaging is guaranteed detection, day and night. Unlike traditional CCTV cameras, FLIR ITS's thermal cameras can detect vehicles and bikes in the darkest of nights over a long range. As a result, traffic managers



(Main) **ThermiCam installed at an intersection** (Inset) **Close-up of the ThermiCam** (Left) **Vehicle and bike detection being conducted**



(Left) **ThermiCam can be used for advance detection of bikes and vehicles** (Below) **Infrared energy is the part of the electromagnetic spectrum that we perceive as heat**



are provided with uninterrupted, 24-hour detection of motorized vehicles and cyclists, regardless of the amount of light available.

The other main benefit of thermal cameras is that they provide detection even in difficult weather. Various conditions that are tough for traditional, visible cameras – such as sun glare, wet road surfaces, car headlights, shadows, snow or fog – are no problem for thermal cameras.

Suitable applications

Thermal cameras can be a direct replacement for electromagnetic loops for conducting vehicle and bike detection at the stop bar – a common application being 'green on demand'. This means that the green light is activated only when a bike or vehicle is present in the dedicated detection zone. Both moving and stationary bikes and vehicles can be detected by FLIR ITS's smart sensor. The system is able to handle up to 16 virtual vehicle detection zones and up to four virtual bike detection regions (larger surface compared with a zone).

Another application is advance detection of bikes and vehicles, which is commonly used by traffic managers to lengthen the green time and thereby keep traffic flowing smoothly. For advance detection of vehicles, thermal cameras can effectively replace inductive loops and radar. If there is a vehicle approaching the stop bar when the traffic light is about to turn to amber, the green time can be extended until it has left the area. The same is true for bikes: if a bike is detected at a certain distance from the stop bar, the green time can be extended until it has left the area.

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Smartcard-based solution stops toll leakage in Malaysia

READER ENQUIRY NO. 509

Toll leakage caused by violators is one of the main challenges faced by toll road operators, particularly in closed-toll systems. And that's in addition to the ongoing challenges that come with maintaining the tolling equipment and trying to prevent fraudulent usage of magnetic paper-based toll tickets.

Toll collection systems based on the magnetic paper ticket have come to the end of their era. The mechanical hardware that performs the ticket read/write is slow, prone to failure and needs a fair amount of maintenance. Magnetic paper tickets are also subject to abuse and tampering as a result of their limitations in information storing, which means they can later be manipulated by road users to get a lower toll rate.

Toll road operators have an ongoing focus on improving their ticketing services and reducing both fraud and operational costs. Therefore many operators are looking for a toll ticketing system that could replace the magnetic paper ticket and could collectively enhance fare collection operations, ticketing and payment services, which will, in turn, increase their revenue collection.

Via the use of the standard Mifare Classic 4k card and image-capturing technology, Teras Teknologi has reformed the old magnetic paper-based ticketing system to a smartcard-based one for the toll collection system in Malaysia. It also added more security features to overcome any existing shortcomings. The toll collection system is called TRACE (Toll Revenue Collection & Enforcement), which in general incorporates the toll business practices associated with transit smartcard ticketing, vehicle image capturing and fare collecting. Modernizing a toll fare collection system affects a variety of agency-wide functions and activities, from financial management to customer service operations to service operational planning.

TRACE provides a specification that can be operated with different levels of functionality, from transit card issuance and receiving as well as vehicle image capturing, which can later be used for toll fare and vehicle information validation. A major benefit of the smartcard to individual operators is its memory, which acts as a fare payment medium that can store transaction information. It's an electronic infrastructure that provides an incomparable means of data collection. The information contained in the card can be verified for its legitimacy, which helps to fight fraud. The smartcard ticketing and image-capturing technology is able to control the fraud and fare evasion perpetrated by road users traveling without tickets or with invalid ones.

Need to know?

Implementing a new method of toll collection has produced remarkable operational improvements

- Teras is a leading Malaysian technology services provider for the ETC sector and is a subsidiary of highway operator Plus
- Until recently, paper tickets were a common means of toll payment on Malaysian highways but Teras' smartcard system is proving attractive to toll road operators and users

Primary functions

The main function of the TRACE system is similar to that of a normal closed-toll system (with entry and exit points) that can conduct both cash and electronic payment transactions. At the entry lane, the system provides features to encode the vehicle's image, registration number and other relevant toll information into

(Main) **A smartcard system is replacing magnetic paper tickets in Malaysia** (Far left and below left) **The TRACE system in operation** (Left) **TRACE can be integrated with Malaysia's existing toll systems**

the smartcard ticket. At the same time, the information captured is sent to a centralized server. At the exit lane, the image stored in the smartcard can be displayed for the toll collector's visual verification of vehicle image and registration number as well as other transaction information. The images can also be retrieved from the centralized server whenever information at the entry point is required, therefore any violations or fraudulence can be uncovered at an early stage.

The improvements brought about by the deployment of the TRACE system are numerous. Top of the list of benefits are the accessibility of payment media, support for transit card administration and transparency of toll fare policy. Other benefits include offering road users a choice of payment options, the simplicity of system operations, and the speed of issuing, validating, processing and payment. The Malaysian scheme has also increased the up-time of toll equipment. Finally, it offers accurate and efficient data retrieval in support of attended customer service actions as well as ensuring the security of toll transactions and vehicle information/image and preventing card fraudulence.

Toll operators are able to retrieve transaction information through the centralized server that consolidates all vehicle images and card transaction details. The transaction information can be used to generate statistical reports and road user profiles, provide greater fare data collection activities to make operational decisions, and to assess travel habits and traffic patterns to gain the benefits of secure and meticulous revenue control.

The pilot program

In 2009, pilot runs tested the relevant components and established the goals and objectives of the TRACE system on a highway in the north of Malaysia that was managed by the operator Plus. This included a return-on-investment (ROI) model that can create a compelling business case for full implementation.

An array of test projects and field deployments are beginning to show that the smartcard and image-capturing technology can benefit business operations by creating efficiencies, improving quality control and strengthening security while simultaneously helping the environment by cutting material waste and embracing the culture of recycling.

The implementation demonstrated a decrease in operational expenditures on paper products by almost 70% during the fourth year of the system's deployment, as recyclable smartcards and online paperless reporting replace magnetic paper-based systems. This looks set to increase to 74% in the fifth year of implementation. The system offers a clear ROI for Plus and significantly improves the operator's toll revenue collection operations while being environmentally friendly.

The key selling point is that the system can be integrated with existing toll systems or used for new smartcard-based toll collection schemes. Being flexible, the system can also be enhanced as necessary to suit an individual operator's specific requirements. This would include the addition of other security and audit features, such as vehicle image, registration number and cashless transactions. The success of TRACE's implementation has greatly helped Plus and has influenced other toll operators to go for a full-scale, smartcard-based toll system in Malaysia.

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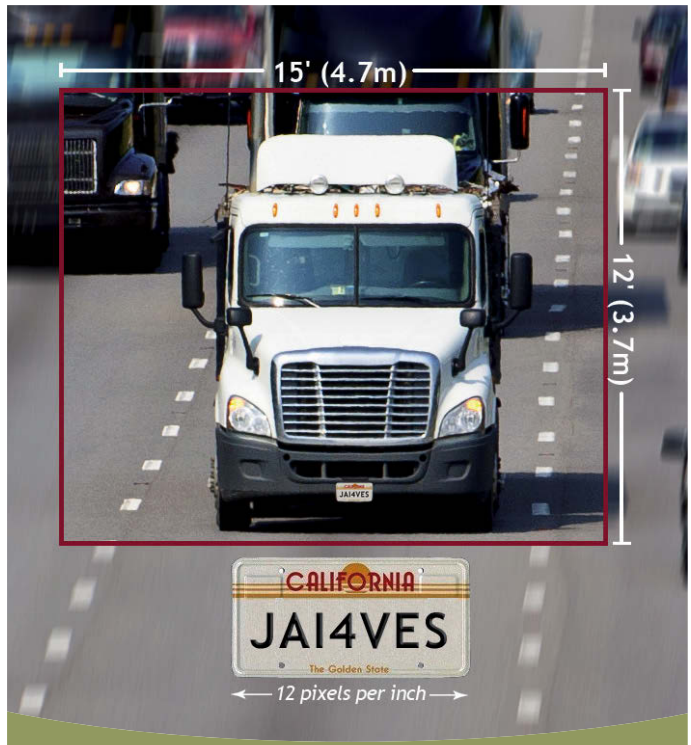

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See the possibilities

ITS drives new TMC visualization demands

READER ENQUIRY NO. 510

With the rapid growth and urbanization of society, traffic is projected to increase to more than 1.7 billion vehicles on the world's roadways in just a few short years. Intelligent transportation systems (ITS) are emerging to handle the increasing number of vehicles, and are generating massive amounts of data to optimize mobility. For example, 'smart' streets will soon be equipped with traffic signals that continuously receive traffic data on density and flows to optimize circulation, while onboard navigation systems direct drivers to the nearest parking spaces.

However, while information is power, it's also a challenge for today's traffic management center (TMC) operators when it comes to turning it into actionable knowledge. Decision makers must have ongoing access to real-time data and the means to quickly view, analyze and act on it to successfully manage traffic flows, incidents and emergencies.

Commonly known as 'big data', the huge volume of information generated by these new intelligent systems is both a blessing and a curse for TMC staff. To effectively manage and interpret the millions of new data points, control room operators need more robust visualization tools that enhance image presentation, versatility and collaboration.

Control rooms must evolve

The very latest networked visualization platforms can empower TMC staff to see the big picture, as well as minute details of their transportation network. The most effective solutions bundle high-resolution videowalls with sophisticated image presentation and collaboration software to substantially boost situational awareness. Those that can generate optimized perspectives (a grouping of any type of sources) to allow operators to create, edit and share views on-the-fly to adapt to changing circumstances, have the potential to vastly improve the decision making process.

(Left) **Videowall composed of 21 LED-lit cubes at a TMC in Frankfurt, Germany** (Below) **A Barco LED videowall helps Virginia DOT manage hundreds of miles of roadways**

Need to know?

Big data challenges TMCs but networked visualization helps them to evolve

- The Barco TransForm N server and CMS-200 control room management software combine to enable operators to capture, control and configure how information is presented on all displays
- Staff can dynamically manipulate video and graphics, flipping image perspectives from the wall to individual workstations
- Screen layouts can be scaled, rearranged, and zoomed in or out

Visualization expert Barco provides a comprehensive array of solutions designed to enable TMC operators to transform big data into meaningful knowledge.

The company's latest LED and LCD videowalls present images and data in crisp color with ultra-high contrast to enable viewing of the smallest details. As a result of the walls' extremely small seams, staff can see an uninterrupted common operational picture.

Inter-agency collaboration enhances public safety

Collaboration is a critical capability, as traffic operations are integrally linked with other public safety agencies as a result of the risks on roadways due to vehicular traffic. The ability to collaborate in real time with police, emergency responders and other entities is an important advantage, especially in crisis situations. The Barco solution facilitates this collaboration by simultaneously displaying video feeds, graphics and data from numerous agencies via a single, common operational picture, enabling real-time sharing of information among all decision makers to facilitate fast, appropriate responses.

Migrating to an optimum control room solution that can handle big data and improve traffic management requires two distinct building blocks: an 'any source, anywhere' networked visualization platform that can dynamically display unlimited sources; and robust image management software that facilitates collaborative decision making across multiple functions and geographies. The goal is to instantly provide information wherever it is needed, not just on the display wall, but where decisions are made.

Armed with this new, robust control room of the future, TMCs can reap the rewards of these new intelligent systems to optimize their operations.

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Weather operations and best practices

READER ENQUIRY NO. 511

Although The Narwhal Group is a relatively new player in the ITS field, the genesis of the company and the motivation for Ralph Patterson, John Grant (ITS engineer), John Amidon (ATMS software engineer) and Jonathan Turner (ITS electrical/communications engineer) to form it in the spring of 2012 stretches back much further. "Ralph was the statewide meteorologist for Utah, whereas myself, John and Jonathan were ITS consultants," reveals John Grant, who works in engineering and business development.

Experience is everything

Having between them been at the coalface for more than 80 years – and freely admitting to feeling "constrained and limited" in previous roles when they attempted to pursue other new innovative ideas and concepts – they opted to go it alone and break away from the 'stovepipe thinking' imposed on them by others. "As a niche company, our products and services are directed in many seemingly different areas," adds Ralph Patterson, road weather operations. "These include smartphone application software development and support; consulting with state DOTs on weather and RWIS operations; offering road weather expertise to the USDOT's FHWA Road Weather Management Program; and helping out small and large weather and engineering firms.

"In a nutshell," Patterson continues, "we focus on merging technology with human intellect – an approach that ensures a well-balanced highway operations program that is not only able to improve efficiency but can also increase its benefit:cost ratio."

(Left) **The Narwhal Group offers help and guidance to improve DOTs' road weather management regimes** (Below, left) **The Narwhal Group's experience is such that it can address and relate to a wide breadth of transportation and road weather-related issues**

Need to know?

The expertise needed to enhance the weather salience of DOTs' O&M programs

- The Narwhal weather team has experience at local, regional and national levels of government to help resolve issues involving complex weather phenomena
- Merging road weather technology with human intellect in a collaborative environment to deploy sustainable solutions that are innovative, cost effective and easy to maintain

Help is at hand

With the advantage of having worked on both sides of the road weather fence, Patterson feels the road weather community is currently in a transition phase, struggling to keep up a balance between new technologies, costs, training and reliability of new and novel products that are available today.

"One of the most important things to do when deploying new technologies is to keep the capability to understand it as well as maintain and operate it," he says. "The road weather community is also working to understand how and whether climate change will require costly changes in O&M in the coming years."

And having worked with them for more than 17 years, Patterson has a great deal of sympathy with DOT managers when it comes to the challenges presented to them by advances in technology. "Technology always comes with a steep learning curve for those who are expected to be intimate in its use and increase levels of service while keeping costs down," he concedes. "This takes a lot of training time and resources, all of which are at a premium in an operational environment. Most DOTs simply want something that works – they're not afraid of hard work to get there – but again they don't have wriggle room regarding time and resources. Winter is either here right now or it's just around the corner!"

Something Patterson thinks is definitely around the corner is the use of mobile data for road weather purposes. "The aviation and maritime sectors have been using it for years and surface transportation is on the cusp of that technology, but there are cost and privacy concerns to overcome first," he says.

Do more with less

Costs in the present, though, remain a constant source of concern for DOTs facing budgetary cutbacks, so how can Patterson and his colleagues help them to do more with less? "The key is to understand how a DOT operates," he suggests. "While they may have some similarities, each DOT is unique in the way it is structured and operates. If we understand how they work, we have the experience and talent to help them optimize their workloads."

Sometimes this might just be a case of developing a software solution or integrating disparate ITS infrastructure. At other times it might be as simple – although Patterson emphasizes "not easy" – as outlining new

policy or procedures for changing the way they use weather and RWIS information to handle a storm.

Once you start to understand these challenges and problems fully, Patterson says that's when you can really start to push the boundaries of what can be achieved. "I think the states that are really starting to get a hold of these issues are the ones that bring meteorologists into the loop – and there are quite a few of them," he says. "This is by no means the end goal but rather a sign that DOTs realize they need to expand their quiver of solutions. Much like a DOT has traffic engineers, construction engineers, geo techs, mechanics and planners, etc, when a DOT brings in additional skillsets and knowledge they can start merging technological solutions with human intellect to really get the full use out of existing and emerging technologies."

Positive influence

The other side of this, Patterson says, is that road weather is no longer just a maintenance issue. "More and more DOTs are realizing how weather affects traffic and that with good traffic management and timely traveler information you really can change the traveling public's behavior," he says. "If we can keep them from going out at the worst times – or maybe simply have them change the timing of their travel plans – it has been shown that we can reduce weather-induced delays and let the plow drivers have a clear shot at clearing the roads."

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It's been 20 years since E-ZPass collected the first electronic toll. And in those 20 years it's grown to become the largest ITS application in the world, with millions of customers and hundreds of millions of transactions. Its real age is closer to 22, because the first few years enabled us to go from an idea to a true regional coalition. I'm very proud of my role in creating it and nurturing it through the first few formative years, but I don't want to write about that part and will instead focus on what we have learned. Maybe I'll tell some war stories about the good old days another time, but for now I'll only refer back insofar as it informs our actions today.

My most compelling memory is the dedication of the public officials who worked tirelessly to serve their customers and the region. People who work for government don't usually receive much praise, but for E-ZPass, within a few months of inception we had more than 100 people working on half a dozen committees. They didn't have to do it; they volunteered.

This was encapsulated for me in an argument I had with another leader of the coalition one evening in New Jersey. I said that we had to do the right thing for the region; he insisted that we had to do the right thing for his agency.

For the longest time I thought that he was narrow-minded and flat-out wrong, but I finally came to understand that both of us were in fundamental agreement on doing what was right. We disagreed on how widely to define it, but it was a public policy goal not a personal one that drove us, and the process.

That led to a lot of compromise to make the system work: what procurement method to employ; read/write instead of read-only tags; where to place the tag on the windshield; when to settle financially between agencies; how to format a transaction; what tag technology to use; and what the name of the system should be. Every one of these issues, with the exception of tag placement, was a big deal and involved months of discussion. Only tag placement was settled in 20 minutes at a meeting with three state DMVs.

On all issues I was more intent on managing progress than getting it done my way. As far as the name was concerned, we should all be grateful. The choice was between E-ZPass and By Pass; I preferred the latter but its association with coronary heart disease doomed it. We are all better off!

If we learned anything through E-ZPass it's that it's all about the customer. If this service had not offered real value to drivers, then it would have died 20 years ago. There was no need for expensive advertising because everybody knew instantly that not having to stop at a crowded toll plaza was a good thing. And you know what? Millions of satisfied customers can't be wrong.

> It's been 20 years since E-ZPass collected the first electronic toll. I'm very proud of my role in creating it and nurturing it through the first few formative years
>
> **Larry Yermack, Wendover Consult, USA**

New winter road management hardware and software

READER ENQUIRY NO. 512

The budget for winter road maintenance surpasses €250m (US$333m) each year in Sweden alone. Substantial economic cost aside, the environment also pays a hefty price. Several studies and research papers highlight the great opportunities for improvements to the economy and ecosystem that would be possible with more effective winter maintenance operations.

It is clear that there is room for improvement in many elements of winter maintenance, especially in measurement technology and decision support. Much of the technology available on the market today is simply a rehash and rebranding of ideas put forward in the 1970s and 1980s. To bring winter maintenance up to date, the latest university research must be applied to both hardware and software, and all the pieces put together to achieve the best possible results. With this in mind, MetSense was founded in Gothenburg, Sweden.

MetSense is launching a range of products in 2014

New kid on the block

Even though it was established in 2009, MetSense is considered a newcomer on the market for winter road maintenance technology. However, the company is borne from more than 30 years of university research in road weather climatology and more than 20 years of sensor research and production experience. Therefore the know-how within MetSense easily matches that of established companies on the market. What's more, as it is a new player, the company has a greater level of freedom and the opportunity to 'think outside the box' far more than a company with a set image.

New sensor hardware will improve winter road maintenance

Need to know?

Applying the latest research to build a complete solution for winter maintenance

- A new player in the winter road maintenance arena is set to shake up the market when it launches a range of new hardware and software products
- A key part of MetSense's offerings will be MDSS, which are tools to help road managers make the right decisions with regard to when and where to perform maintenance activity – such as where to salt and how much salt to use

From the very outset, the company's goal has been to offer a complete line of innovative products to make life easier for winter maintenance professionals. This is achieved by combining the most up-to-date knowledge in road weather science with technical advances in hardware, all of which are soon to be unveiled.

Throughout 2014, MetSense will launch a full range of products, from RWIS sensor hardware to maintenance decision support systems (MDSS). This will establish the company as a provider of tools for all levels of winter road information systems.

"I am confident that MetSense will make a big difference," says the company's Johan Edblad. "We will provide decision makers with new tools for monitoring and forecasting severe road weather and driving conditions. Our sensors and MDSS will make it easy for users to decide the best action to take with regard to their maintenance strategies."

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Sensors for detecting fog and icy roads

READER ENQUIRY NO. 513

Swedish inventor Sten Löfving passionately believes that his visibility and road-state sensors can save lives. Löfving owns a small company in Gothenburg that manufactures sensors capable of identifying dangerously foggy conditions and slippery roads.

He has been developing his sensors – which he refers to as his 'babies' – since the early 1990s and his company, Optical Sensors, now has lots of happy customers around the world. His main market is in Korea, where road authorities have been using the technology for 10 years. Nearby Taiwan is his next largest source of sales.

The Netherlands and Spain also provide him with regular business, but other markets in the West have proved harder to crack. "Perhaps it's because we are a small company, but the reality is that my sensors predict safety-relevant quantities far better than conventional road weather stations. Therefore they have the potential to make roads much safer.

"They provide automatic and accurate readings of visibility and slippery road dangers," Löfving explains. "Road authorities can react straight away by changing speed limits or issuing traffic warnings. It's a far more reliable process than relying on the naked eye to determine when poor visibility becomes dangerous."

(Main) **The vehicle-mounted Road Eye sensor being tested** (Below) **The compact, low-price fog sensor MiniOFS**

Need to know?

Technically advanced road weather sensors to detect two frequent causes of accidents

- A Swedish inventor has created a range of effective and cost-efficient road weather sensors
- These sensors rely on back-scattering technology, which has enabled Sten Löfving to keep the prices down
- The majority of visibility sensors use forward-scattering techniques; using back-scatter instead means the devices are cheaper to manufacture and more compact

Two sensor types

Optical Sensors manufactures two categories of sensor, the Fog Sensor and the Road Eye. With the Fog Sensor, a laser beam is fired out of the unit to detect fog particles in the air. If particles are present, light is back-scattered to an artificial 'eye' housed in the sensor. Conversely, if the air contains no fog particles, the receiver doesn't 'see' any laser light.

The Road Eye, which detects slippery conditions, operates on similar principles to the Fog Sensor but is a more sophisticated device. The road surface is illuminated by light from three separate IR laser wavelengths, which makes it possible to identify various conditions. "At least four separate road states can be identified: dry, wet, icy and snowy," Löfving adds.

Two versions of the system are available. The Road Eye Short Distance (SD) is attached to vehicles, enabling it to monitor road surfaces during journeys, whereas the Road Eye Long Distance (LD) is positioned in one location and monitors a user-defined area of the road surface.

The Road Eye sensors have attracted a lot of interest in recent years, which means that Löfving could be on the cusp of a commercial breakthrough. A research team from Luleå University of Technology recently teamed up with a car manufacturer to investigate the sensors' technical abilities in a project that was monitored by Vägverket, the Swedish government's road authority.

"The sensors impressed everyone in the trials and there's a chance that the government could use them to reduce accidents on the roads, but the biggest breakthrough would be if the car maker decided to install them in hundreds of thousands of cars. They are considering it," he reveals.

Löfving is now 63 years old and nearing retirement, but he dreams of his 'babies' being used worldwide. "People have wanted to install weather sensors to increase road safety for a long time. But the products used have been expensive and inefficient," he concludes. "My sensors will enable safety to be improved in the most direct, cost-effective way possible."

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Vast improvement in travel times on the A89 from Bordeaux to Lyon

READER ENQUIRY NO. 514

Vacationers whose journeys to the French Atlantic coast or Spain were frustratingly interrupted by bottlenecks on the French highways in and around Lyon should have a much easier time of it when they next drive the route. With the commissioning of a new road section from Balbigny to La Tour-de-Salvagny, the 500km cross connection between Bordeaux and Lyon is now entirely navigable.

More than €1.5bn was invested by the motorway operator Autoroutes du Sud de la France (ASF) – an enterprise of the Vinci Group – for the implementation of this project, which had been planned for 30 years. The last 53km involved four years of construction alone and an investment of €1.5bn from Vinci Autoroutes.

During planning and construction, special focus was placed on minimizing the burden on the environment and on the preservation of the biological diversity in the affected region.

And from looking at some of the project's vital statistics, it is clear why it took more than nine years after ASF received the contract from the French Ministry of Transport until the opening of the last section on January 21, 2013.

First, the new artery features a 50km, 2 x 2 lane motorway (that can be widened to 2 x 3 lanes between Tarare East and La Tour de Salvagny). It has five interchanges and one junction, as well as 108 standard bridges and tunnels, 20 small and six large wildlife crossings, 47 watercourse restorations and 35 structures carrying local and agricultural roads.

The project also involved 16,000,000m^3 of earthworks. There are eight viaducts (2,150m total length). On the new stretch of road between Balbingy and La Tour de Salbagny there are three road tunnels (5,700m total length, equating to 11.45% of the A89).

Forty-one permanent multipurpose basins had to be created to limit the risk of river overflow, while 120 substitution ponds were created to replace those destroyed along the motorway realignment (all the frogs from the existing ponds were captured and released into the new ponds). Two bat shelters and two bat crossings were also constructed.

Security conscious

In the planning and realization of the project, security was of course a key concern and was especially important when it came to the road tunnels. Deploying the most advanced technology in surveillance and traffic management was of particular importance for Vinci. To meet this demand, at an early point in proceedings, Vinci drafted in Eyevis's French subsidiary as a reliable partner for the planning of the project's new highway section.

In Tarare, just before the entrance of the three tunnels, a new operations building was constructed for members of ASF and the traffic police responsible for highway security. The traffic control room was designed and supported until its opening by Michael Zerdoun of Eyevis France. As well as planning the large-scale video technology to be used, the design process also included the furnishing and ergonomic organization of the control room, as well as the equipment of several crisis rooms and the entire IT structure of the control center.

As a result of Eyevis France's comprehensive planning of

The videowall is composed of a mix of rear-projection cubes and LCD screens

Need to know?

At the heart of a prestigious new road project in France is a state-of-the-art traffic control center

- Sixty employees work in shifts in the new control center
- Fourteen operators are in charge of the surveillance of the highway section and the coordination of security and maintenance services
- Around 300 cameras on the 50km section between Balbigny and La Tour de Salvagny send their signals to the control center

(Main and left) **The videowall forms the heart of the TMC** (Above) **The entrance to one of the three road tunnels on the A89**

the control room project, the final installation serves as a model for similar installations with regard to the latest technical components and ergonomics in the control room.

The central element of the control room is a large-scale videowall, consisting of six LED rear-projection cubes featuring 60in diagonal screens and full-HD resolution. The cubes are flanked by two 2 x 2 arrangements of 46in LCD screens. Two display technologies were selected because the middle part – the cubes – is primarily intended to display static image contents of the traffic management systems, which could lead to image retention effects for LCD screens. The LCDs on the right- and left-hand side of the cubes have the advantage when it comes to depicting moving images from surveillance cameras along the highway.

At the core of the visual display, a Netpix controller system serves as the connection to all incoming signal sources and guarantees their reliable display on the videowall. The source administration is realized through Eyevis's wall management software, Eyecon. Through this, the sources can easily be managed and displayed on the large-scale display system in the control room, but also on the displays and projectors in the crisis rooms. To guarantee complete security in the event of system failure, two Netpix systems are in operation.

Systems integration

The integration of complex IT components and the inclusion of a number of customer-provided systems into the overall structure was performed by Rémi Durand of Eyevis France's IT department, in close cooperation with operators of the control room. As a key part of this process, the functionality of the Eyecon software was adjusted to the operators' specific needs. Incoming alarms from the different traffic management systems such as incident detection and traffic flow evaluations are now coupled with their corresponding reactions on the large-scale image system. In addition, various predefined source arrangements can be presented on the displays via configured hotkeys. Due to the ease of use of the system (despite the complex structures in the background) and the fact that all operators were well trained as they had come from other ASF control centers, the control center could be put into operation without a lengthy training period.

Michel Tournebis, project manager at ASF, accompanied the construction of the control center from the beginning and he details a highly positive outcome of the overall project. "The topology of the landscape between and the resulting route with tunnels and numerous slopes, means this section must be well monitored, especially in winter. With Eyevis France we found the ideal partner to maintain safety on this route."

As this was such an important project, it underwent a high-profile opening ceremony on January 19, 2013. In the presence of nearly 2,000 invited guests and Frédéric Cuvillier, Secretary of Traffic, Maritime Affairs and Fishery, as well as Pierre Coppey, president of Vinci Autoroutes, the new highway connection was put into operation.

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Low-cost, passive sticker tags drive higher ETC adoption

READER ENQUIRY NO. 515

Passive ISO 18000-6C sticker tags are available to drivers at little or even no cost. At a fraction of the price of tags used in traditional electronic tolling technologies (infrared, 2.4GHz, 5.8GHz, etc), passive sticker tags pave the way to deliver the promise of efficient electronic toll collection (ETC) and all-electronic tolling(AET).

Increasing the efficiency of transportation networks and implementing road pricing schemes keeps traffic moving and reduces pollution. However, one barrier prevents these benefits from being fully realized – low user adoption of tags. The cost of traditional tags ranges from US$10 to US$50 – a price that is too high for many drivers, especially in developing countries. Low-cost, passive sticker tags solve this problem.

In Taiwan, the recent success of passive sticker tags deployed on a large scale removes all doubt about the use of passive RFID technology in AET. Driver adoption of ETC in Taiwan jumped from under 50% to more than 85% in less than a year once the toll operator decided to provide ISO 18000-6C sticker tags (known as eTags) at no cost to vehicle owners. Previously, drivers had to buy an expensive onboard unit (OBU) for ETC. Now, with the majority of drivers using ETC, future plans to implement multi-lane free flow (MLFF) tolling and distance-based pricing schemes can easily be achieved.

These sticker tags will soon hit the streets of India too. India's Ministry of Road Transport and Highways (MoRTH) has mandated that all domestic automobile manufacturers affix a passive ISO 18000-6C sticker tag on the windshield of all new vehicles, beginning in October 2013. This is the first step toward a national ETC system for India, as envisioned by the National Highways Authority of India (NHAI). The low-cost tags are a key enabler of the NHAI vision for a single, nationwide tolling system in the country.

Passive ISO 18000-6C sticker tag applied to a vehicle headlamp

Why use open standards?

ETC systems based on these tags and readers also enjoy the cost advantages of an international open standard. Rather than being locked in with a proprietary electronic tolling solution, toll operators will be free to choose from manufacturers and system integrators that offer multiple hardware and solutions based on the ISO 18000-6C standard. The healthy competition sustained by an open standard ensures a robust ETC system by keeping operational costs low and driver adoption high.

In most cases, ETC solutions based on ISO 18000-6C are simple to interface with existing systems, which makes it easy for toll operators to switch from a traditional system to one based on the new tags and readers. In addition, many readers are now available that support a large number of communication protocols, enabling a smooth transition and interoperability with legacy systems.

An open standard-based solution using a sticker tag can also enable new applications. For example, the same tags can be used for electronic vehicle registration, access control and vehicle commercial solutions such as parking and payments.

The benefits of such tags have been proved in implementations around the world. When the tags are installed in the majority of vehicles, transport planners and policy makers will be able to realize the full benefits of ETC/AET on their highways.

Need to know?

Low-cost ISO 18000-6C sticker tags can encourage a broader take-up of ETC

- Offering a range of RFID tags, readers and antenna, Star Systems International is a new presence on the global ETC technology scene
- Based in Hong Kong, the Star Systems team is comprised of experts with a long history in the ETC market
- The company's Venus windshield tag has recently been certified for use in India's national electronic tolling program

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Electronic eyes for crime-fighting

READER ENQUIRY NO. 516

Introducing innovative technology is a common practice among police and public security forces in their efforts to tackle crime. The most advanced modern systems, such as license plate readers installed on police vehicles, represent a valid support to surveillance and defense activities. Such tools function as tireless, scrutinizing eyes, capable of identifying wanted and ill-intentioned individuals.

A recent survey conducted by the American trade association, NetChoice, and involving more than 500 members of police forces, showed a decisive preference for license plate reading systems and confirmed the efficiency of using such technology.

To support police forces in their efforts, the Italian ITS company Tattile has launched a novel, new solution. Equipped with megapixel sensors, it is able to scan more than 100 license plates per second, front and rear, in any light conditions. One of the family of Tattile automatic license plate recognition (ALPR) products, it is a compact system featuring several components: camera, IR lighting and embedded OCR reader for ALPR. These instruments are able to read license plates from a constantly updated list, including plates from more than 80 countries.

Easy to install and with low energy consumption, the new system needs neither embedded processing units nor physical connection between the cameras and the vehicle's onboard computer/tablet. Recognition is performed on-board the cameras, which can be installed on the car's roof, hood or in the trunk. Plate numbers are transmitted via wi-fi.

For law enforcement agencies, ALPR has proved to be a force multiplier, enabling them to do more with less

Need to know?

A new license plate recognition solution is being embraced by police forces

- Overall, the process of ALPR is complicated because factors such as dazzling lights can prevent the identification of plates at night
- Because it is such a challenging application, special cameras are required to conduct ALPR
- Cameras used in ALPR need to be designed for that purpose and developed with application-specific features

Installation is simple and fast, and the system is easily transported from one vehicle to another. As a consequence, costs are naturally reduced. The new solution is provided with sophisticated software that allows image acquisition both in greyscale and color. With an automatic multiple exposure, the sophisticated selection of acquisition criteria occurs automatically.

"The added value of our mobile ALPR resides in the fact that it enables users to monitor their roads constantly," explains Massimiliano Cominelli from Tattile. "It is an invaluable help for security forces.

"Moreover, these new-generation mobile systems ensure not only vehicle identification, but also a correct contextualization of the event, which is provided by content images or video," he adds. "Our embedded GPS gives the exact location of the event. Also, the transmitted images are of an extremely high definition."

Control and access

The control console runs on PCs, tablets and Android-based smartphones, and enables data reception from several devices; data can be read as images or texts and can be viewed as blacklists and whitelists.

Access via the web interface is the easiest way to set up the camera and allows users to control and program the device, supervise what the machine is reading and update the software.

"It goes without saying that such instruments are useful not only for patrolling an area but also for juridical enquiries," Cominelli continues. "These systems allow police authorities to track and identify the journeys of blacklisted vehicles."

Statistical enquiries have been conducted in the field by specialized agencies in the Italian police force. Results show a positive response toward using ALPR technology for investigating crimes. As well as vehicular crime, these tools have been used to solve violent crimes, including murder, kidnapping, human trafficking and drug dealing.

There are countless cases of stolen cars that have been recovered via ALPR, but most important is the huge number of suspect individuals that have been tracked by these tireless electronic eyes.

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Wireless parking sensors for smart cities

READER ENQUIRY NO. 517

Pretty much everything in our cities will one day be smart and connected – from the electricity grid, buildings and vehicles to the roads on which they drive. The role that parking will play in this future – in which cities will ultimately adapt to citizens' needs – cannot be overstated either. And that's something authorities have come to accept, attracted especially in many cases by the solid business case presented by more intelligent parking strategies. Smarter parking has a direct impact on traffic flow optimization, emissions reductions and consequently also on quality of life and visitor satisfaction. The numerous knock-on effects of addressing a city's parking problems through smart parking solutions can be huge.

Need to know?

Wireless parking sensors are helping to create smarter parking systems for cities

- In Nedap's system, every time a vehicle parks in a bay, an event with timestamps is generated
- The sensor not only measures whether or not a car is parked in a bay; it also monitors the duration of time any cars spend in that bay
- Nedap's sensor is battery powered and is the only dual technology (infrared and magnetic) sensor on the market
- Sensit is a sophisticated self-healing wireless network with bidirectional communication

(Above) **The Sensit units are battery operated and completely wireless** (Left) **The sensors in the ground constantly communicate with each other and also with relay nodes**

Parking data from on-street sensors is considered a prominent part of this effort, the information from which makes it easy to guide visitors, delivery drivers, taxis, workers and residents quickly to available parking spaces, which reduces congestion caused by drivers searching for spaces.

One key player in the smart parking sector is the Dutch company Nedap AVI, which has been marketing its Sensit system since 2006. Maarten Mijwaart, Nedap's general manager, North and South America, describes Sensit as "a robust wireless sensor system that is especially designed for parking in challenging on-street environments.

"We have designed Sensit to be easily integrated with third-party systems for parking guidance and traffic management, wayfinding applications as well as enforcement," he reveals.

Technical requirements

On-street parking is an integral part of a city's public infrastructure, which results in a number of very specific requirements when it comes to deploying a sensor-based parking system. Firstly, city streets cannot be closed off (or barely accessible) for many days while a sensor network is installed, since this would badly affect traffic flow. Any system to be deployed in a city must therefore be easy to install and set up.

There are also a number of demands to be made on the technology that goes into the system itself, as Mijwaart explains further. "As a result of busy streets and high-volume traffic movements, thousands and thousands of events are generated in the wireless sensor network. Smart filtering and efficient communication protocols should be used to keep the system running – even under the most challenging of circumstances.

"In addition, street-mounted sensors are continuously exposed to a variety of extreme conditions. The sensor must remain operational in snow, wet and dusty conditions, in a range of temperatures. Also, the physical pressure from all types of vehicles driving over the sensors must not lead to failures of the sensor units."

Mijwaart also observes that a system is only as good as the data it generates. "Good-quality parking data is the core of any effort to optimize parking management. Occupancy data from on-street parking sensors has to be set up in a transparent way, should be available in real time and must support common standards for data integration."

To achieve a city's smart ambition, an integrated approach to traffic and parking is needed. "This requires an open and scalable sensor network that integrates seamlessly into other systems for parking and traffic guidance, as well as parking enforcement systems," Mijwaart states. "It is fair to say that on-street parking in cities can sometimes be remarkably challenging," he concludes, "but the potential impact of wireless sensor networks is enormous."

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Self-funding speed enforcement relies on automated back-office system

READER ENQUIRY NO. 518

In early 2010, under the UK's 95 Alive strategic road safety partnership banner, North Yorkshire County Council (NYCC), City of York Council (NYC) and North Yorkshire Police (NYP) collaborated to assess the feasibility of camera enforcement in line with the government's directive to reduce casualties.

The trial was across an area spanning 8,000m² that had 28 identified collision sites. Covering the area with only one camera van proved to be logistically challenging and only enabled the van to be deployed once a day.

The pilot, which was originally planned for six months, was twice extended for the same period to enable further assessment of the impact on road traffic collisions at the test sites. The results after 18 months were impressive: NYP captured more than 26,000 offenses and reduced speed-related collisions at the test sites by up to 59%.

However, there were still too many collisions in the area. So, following a business case submission, NYP progressed to deploying three vans, twice a day, to increase the benefits by trying to reduce the number of speed-related collisions even further. This potentially meant that NYP could capture up to six times the number of offenses that were captured during the pilot, which posed two main challenges.

The administration of the more than 26,000 offenses from one van, which equates on average to 1,444 offenses per month, proved very time consuming as the team had to manually fast-forward to each offense on the film clip, grab a still image of the offense and validate the evidence. July 2012 proved to be the busiest month during the pilot program and saw NYP's five-person strong central ticket office (CTO) processing more than 2,100 traffic violations. An analysis of the pilot recorded a 50% reduction in speed-related fatal collisions during 2011 and a 59% reduction in speed-related fatal and serious injury collisions across the first 12 months of the pilot program. The longer the speed enforcement pilot ran, the more apparent the effect on road safety became.

Removing the CTO's bottleneck

The timely processing of all violations captured by just one van proved challenging and re-allocating some of the enforcement staff to the back-office team was not an alternative. So the idea of an automated back-office system was born.

After comprehensive research and visits to other police forces across the UK to obtain a better understanding of the capabilities of various systems, NYP completed its requirements document and issued the tender for an automated back-office application. The decision to proceed with StarTraq Dome was a direct result of the application's convincing functionality.

The simplicity of the software and the speed at which offenses can be verified are key selling points. The ability to read offenses from flash cards and the ease of processing a range of vehicle classes and offense types are also popular features among Dome users. Fast-forward functionality enables users to spot violations quickly and easily. Finally, the option to upload and/or verify offenses directly from the patrol vans through the cloud is highly appealing.

Three months after the contract was awarded, StarTraq Dome was in operation at NYP, which saw the six administrators process more than 2,760 offenses in April and 3,900 in May. In June, NYP processed more than 5,000 traffic violations, which is

NYP already has plans in place to expand its system beyond speed enforcement

Need to know?

NYP overcame backlog issues and devised an exceptional speed enforcement program

- NYP increased its speed enforcement coverage from one van to three vans; naturally, the number of offenses to be processed shot up
- An automated back-office system means that administration staff can process far more offenses than they did previously and not fall behind in their many other duties – such as dealing with phone calls and post

Dome enables traffic violations to be processed far faster than via manual processing

more than double the volume of the busiest month during the pilot program.

Still, NYP currently only operates at 60-70% of its overall capacity, providing extra bandwidth for further road safety projects, as NYP's safety camera manager, Dave Brown reveals. "The efficiencies achieved through StarTraq's automated back-office enforcement system are enormous and with the majority of offenders opting for driver education courses, NYP's program fully funds itself."

He also says that NYP is already planning to expand the system: "We even have spare capacity and will be looking at enforcing other offense types, such as mobile phone and seatbelt violations in coming months – all of which can be processed by StarTraq Dome."

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Emergency response vehicles – police cars, ambulances and fire trucks – are, of course, a smart idea. The lights and sirens tell us to move over as they speed to complete their mission. By appearance, they are also quite smart. They are bristling with communications. Police cruisers are often outfitted to accelerate and speed beyond the capability of the cars you and I own, and fire trucks and ambulances are specialized and engineering marvels.

But are they indeed smart? To begin with, they belong to different agencies, with different procurement practices, levels of funding and sophistication. Often their radio communication systems are proprietary with no guarantee of interoperability. In the USA, until the advent of Next Generation 9-1-1, their dispatchers will receive emergency notification by voice only. No data streams. No digital images. So they don't necessarily begin their missions smart and well informed.

These vehicles also present a great many devices for their drivers. Emergency responders – often operating under high stress and workload – must cope with a myriad of potentially complicated inputs and outputs. This endangers the operators, because no matter how cat-like their reflexes, they are really a specifically trained version of you and me: a driver who can get distracted and tired and therefore a driver who can crash when distracted from driving.

At issue, really, is that public safety and first responders are by and large not able to take advantage of advances in telematics. They don't benefit from the nearly ubiquitous digital communications of near real-time information, which provides the rest of us with personal mobility. And they are not mainstreamed in alluring future concepts of cooperative systems and the concomitant safety, mobility and environmental benefits.

It can be argued that of all participants and stakeholders in telematics, emergency responders need to receive the full benefit the most. A prime example that may even have affected your commute to work today is that incidents or crashes cause congestion. An emergency crew would have responded to injuries. Then a road operator crew – working in coordination with the emergency responder – would have had to clear the incident. Until they completed their task, you were stuck in traffic. Undoubtedly your boss wasn't pleased.

Funding for this community is piecemeal. Moreover, public safety is a relatively small market, with intermittent local purchases *de rigueur*. National and international standards for interoperability would help. Spectrum allocation could help. Widespread awareness and a set of helping hands from those of us who are part of the smart car ecosystem, from the gamut of policy makers to technology and system developers, will certainly help. Therefore I hope this column will pique each reader to consider how such a helping hand could be individually or collectively offered, then extend it to the public safety and emergency response community, who are in dire need of their own smart vehicles and systems.

> Extend it [a helping hand] to the public safety and emergency response community, who are in dire need of their own smart vehicles and systems
>
> **Jim Misener, transportation and technology consultant, USA**

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How European ATM success stories can be replicated in North America

READER ENQUIRY NO. 519

Active traffic management (ATM) is a widespread ITS solution for freeways in Europe. In North America, there are at present several ATM systems in the planning and implementation phases. But there are two major questions that need to be addressed. Can the impressive results seen with ATM in Europe be duplicated in North America? And how should an effective ATM system be designed for such a different environment?

With new vehicle-to-vehicle (V2V) as well as vehicle-to-infrastructure (V2I) advances generating a host of new data, it will be a major challenge to implement features based on this new data in ATM systems. Heusch/Boesefeldt, however, has devised a way to provide an integrated, straight path from an ATM simulation lab incorporating an automated operation control software suite to a fully cooperative traffic control center.

The concept of testing new ATM strategies and algorithms in a traffic modeling environment is often referred to as a laboratory or test bed. Following this test bed concept, Heusch/Boesefeldt in conjunction with its North American subsidiary, Traffic Technology Solutions, has developed the ATM Lab by integrating the ATM control and management software GeoDyn2-Control with the microscopic traffic simulation tool Vissim. The ATM Lab allows users to interactively test various traffic and incident scenarios in microsimulation, observe their impact on the whole network through Vissim, and determine the most promising ATM control strategies. Furthermore, the ATM Lab provides realistic 2D and 3D animation capabilities for communication of the strategies and their impacts on a wide range of audiences.

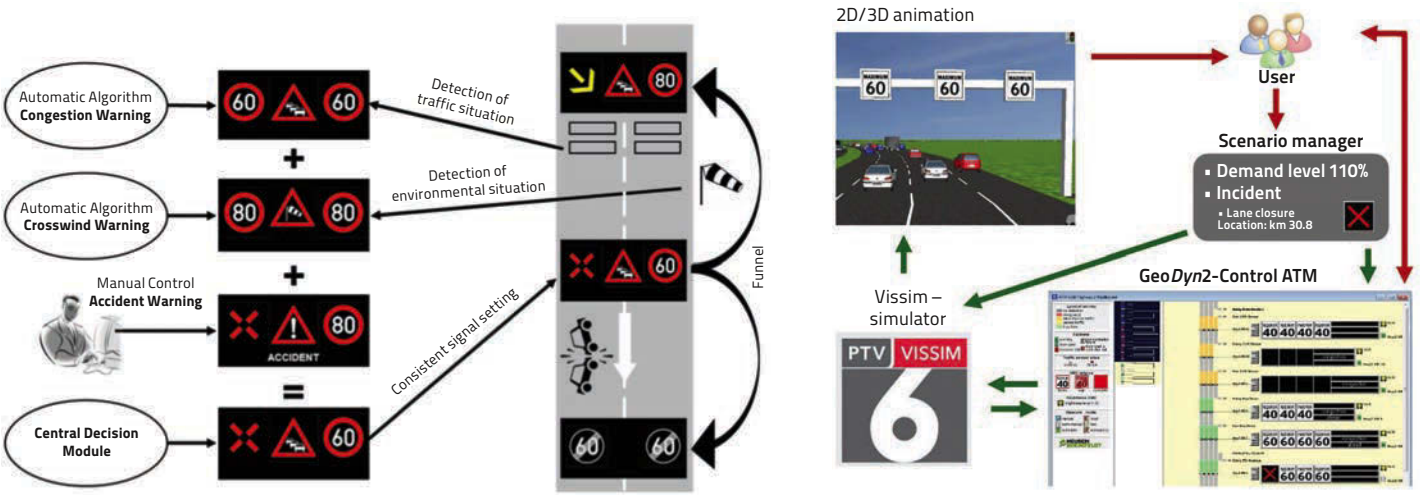
Such an integrated system far exceeds the capabilities of traditional traffic simulation modeling techniques. For instance, it can provide consultants, operators and decision makers with a powerful tool to evaluate the performance of different control programs in conjunction with physical design alternatives

Need to know?

A straightforward path to a cooperative TMC for active traffic management based on European experience

- ATM strategies optimize traffic flow and increase safety
- A popular strategy is speed harmonization, where individual vehicle speeds are harmonized to increase density and thus overall flow rate
- Other strategies include hard-shoulder running, wrong-way driver warning and weather warning

German ATM system with VMS (highway A5 near Frankfurt)



(Above left) **Priority and consistency rule-based generation of control measures** (Above right) **Functional principle of the ATM Lab**

(e.g. distance between road gantries). It therefore creates a new paradigm for planning, evaluation, optimization and operator staff training of ATM control systems.

The ATM control and management component of the ATM Lab is based on Heusch/Boesefeldt's GeoDyn2-Control, software that comes from more than 30 years of experience in freeway traffic control. The process logic and user interface resembles the proven operator interface of sub-centers and traffic control centers in Germany and Austria.

Automated ATM control

GeoDyn2-Control incorporates the operational experience from approximately 70 deployed systems in Central Europe. This freeway control software supports ATM strategies that focus either on traffic flow optimization or safety.

ATM strategies usually have their own control mechanism that contains an algorithm to determine the situation (either traffic or environmental). As a result, each application derives a recommendation (typically a combination of dynamic speed limit, lane closure and warning sign/text) for each dynamic message sign (DMS). At the core of the solution is a central decision-making module that develops the overall information message that is harmonized in both longitudinal as well as latitudinal direction from sometimes conflicting recommendations from the individual strategies. The module is able to take priorities and consistency rules into account. However, the operator is still in charge and there is also the option for manual control. Although typically about 90% of the derived messages and dynamic speed limits are based on the automated control system, the ability for manual operator intervention is a vitally important feature of ATM.

Cooperative TMC

The data required to operate ATM systems is typically gathered and processed in a traffic management center (TMC), using information from many sources, including traffic sensors, environmental sensors, incident alert messages and planned roadwork information.

Emerging new technologies such as V2V and V2I have been the focus of research around the globe for many years and are now on the verge of large-scale deployment. These cooperative systems can greatly improve the quality and reliability of information via data from individual vehicles, including their location, speed and environment. A new and extremely valuable data source will therefore soon be available, which should result in a substantial quality improvement for traffic control. However, for that to become a reality, TMCs need to be 'V2I ready'.

The newest GeoDyn2-Control system provides solutions for handling these emerging cooperative services. Based on new approaches in system architecture, the software suite fuses information from many data sources and provides harmonized, real-time information to the individual vehicle via numerous potential communication channels.

As a crucial task, location referencing has to be solved for individual vehicle-based dynamic traffic data. Therefore, a service has been introduced performing on-the-fly map matching to process individual probe vehicle traces. The architecture is based on standardized techniques such as AGORA-C (ISO Standard 17572-3) or OpenLR, allowing for continued improvement of the location referencing.

V2I creates high-performance processing requirements due to the large amount of input data. A hybrid architecture adding a high-performance data processing subsystem to the service-oriented architecture (SOA) was chosen to cope with this and could be successfully proved in the recent large-scale field trial of the sim^{TD} project.

Additionally, the architecture is such that it provides open service interfaces to enable easy integration with existing TMCs. Thus, a straight path can be offered from planning and evaluation to a fully operational and cooperative TMC.

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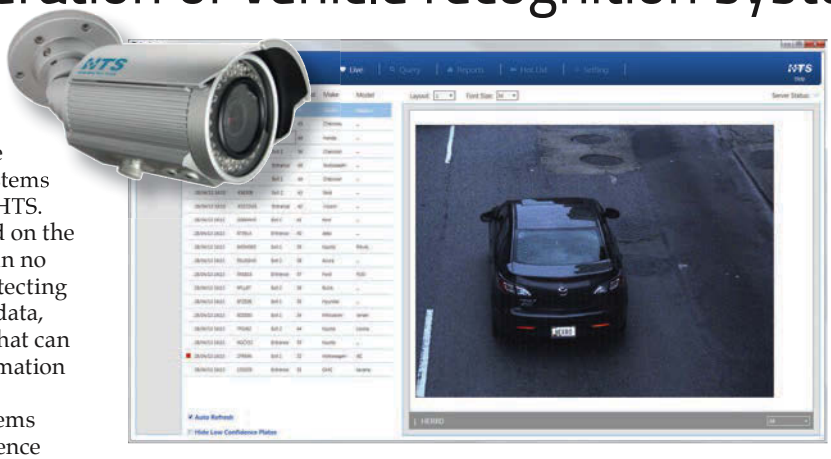
New generation of vehicle recognition systems

READER ENQUIRY NO. **520**



A new range of advanced automatic license plate recognition (ALPR) systems has been launched by HTS. The solutions are based on the approach that ALPR can no longer be just about detecting and collecting vehicle data, but rather it is about what can be done with the information a system receives.

The company's systems offer advanced intelligence capabilities, providing users with valuable data in real time. The new range is called VRS (Vehicle Recognition Solutions), which is a line of IP cameras combined with a management software solution that transforms vehicle and license plate data into valuable information for fast, effective decision-making.

An intelligent vehicle management platform called SeeControl helps users monitor and respond to vehicle-driven events and strategically plan via real-time vehicle identification and assessment as well as retrospective forensic analysis.

In addition, HTS's solutions help to create a complete vehicle profile, including various other parameters in addition to its license plate number. Such parameters include: vehicle manufacturer (car make); model; plate colors; country or state jurisdiction; and special icons on the plate itself (such as a disabled driver symbol).

The system analyzes and reports on vehicle data captured and tracked by HTS imaging units using the company's intelligence engine, which powers functionality with a distinct user advantage. It instantly recognizes targeted vehicles of interest, and provides essential insights by analyzing license plate data, vehicle characteristics, movement, time, speed and location.

"These abilities are a valuable contribution to users, helping them to detect vehicles with false license plates," comments Meta Rotenberg from HTS. "In controlled areas such as airports, license plate recognition systems with the vehicle recognition feature can be installed at access lanes, automatically monitoring the vehicles entering and exiting the area, in doing so detecting any discrepancies between the vehicle type and its license plate number."

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The latest in non-intrusive enforcement technology

READER ENQUIRY NO. **521**

The secret of any activities with high technological value is to be able to combine reliability and innovation. At DT srl, the company focuses on building a consolidated skillset from its technicians to its management to create innovative solutions, with two key areas of expertise being parking and automated traffic management.

For the parking sector the company offers a complete range of products, including: entry/exit gates; manual and automatic cash devices; and parking management software.

In the traffic management sphere it develops solutions in a number of different areas. For road pricing, DT srl offers vehicle classification technologies for motorway toll systems. It also produces detection and classification systems, based on infrared technology, for determining the type of vehicle (freight or passenger) via axle counting.

For all of the above scenarios, security is of paramount importance. DT srl offers its customers CCTV-based security solutions to control parking areas or roads, combined with OCR technology for processing images of license plates.

In addition to these established markets, the company also works on a variety of custom projects for customers who cannot find 'off-the-shelf' solutions. One notable example of this work involved conducting truck length measurement for loading such vehicles onto a ferry boat. DT srl developed a system able to classify a vehicle into six categories (based on pattern analysis) and to determine its length.

This project solved many problems as it offered a high-tech approach to the traditional method of an operator having to manually classify vehicles. Today, the companies using this automatic classification technology have the twin benefits of accurate measurements and large economic savings. The original system has been in operation for three years without a fault so DT srl is now ready to offer the technology on a larger scale.

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What types of weather data does your traffic management center collect and use – and how are these information sources utilized in your operations?

Answer the Burning Question via our LinkedIn group page at www.trafficTechnologyToday.com

A "We have installed wind-speed sensors on some of our bridges (see page 22) to provide more accurate updates about conditions during high-wind events, which not only helps law enforcement make more informed decisions about bridge closures but also enables more timely information to be disseminated to the media and the public. Bridge closures in North Florida due to high winds can result in major delays to travelers, hence being able to forewarn them provides huge benefits as motorists can at least be ready for unexpected gusts. As for FDOT TMCs, they benefit from more accurate data as they assess traffic conditions and evacuation efforts during a severe weather event. At the backend of this bridge project is a pair of redundant satellite earth stations (in Lake City and Tallahassee), which receive wind monitoring data from the NOAA GOES satellite and database it. Using a web server, the data is then made available to a browser on any TMC computer on the network, anywhere in the state. It can be viewed in graphical form (with small direction arrows) or in tabular form, in both cases showing multiple area bridges – and their associated wind conditions – on the same screen."

Randy Pierce
telecommunications administrator, ITS section, Florida DOT, USA

A "Many of Utah's critical highway routes are in rural areas and can be prone to flooding, snow drifts, landslides, high winds or low visibility due to wild fire smoke. UDOT's RWIS network currently has nearly 80 deployments throughout the state. The RWIS feature several weather sensors that calculate wind speed, precipitation type, roadway temperature and more – some have a traffic camera as well. Utah has had an active winter and spring with several large storms, flooding and landslides. In June 2013, we deployed a portable RWIS unit near Monument Peak on SR 31, a site adjacent to an area that was burned in a forest fire and was at risk of landslides (a portable RWIS can be relocated at a later date for other uses). The RWIS sends alerts to the UDOT TOC meteorologists who can then contact UDOT crews and UDOT management working in a specific area and alert them to any danger of landslides or flooding. The alert information is also shared with the National Weather Service, the National Forest Service, the US Geological Survey, Utah Highway Patrol and other agencies. Utah DOT contracts with Northwest Weathernet for meteorological services and RWIS installation."

Lisa Miller
traveler information manager/public information officer, Utah DOT, USA

A "Forecast weather is provided by the Met Office in the form of regional forecasts and provides a general forecast for the whole region. We pass this information to customers via our website, Traffic Scotland Radio, Twitter and by using the VMS throughout the country. Weather forecast information from the Met Office is also supplemented by notifications using the public weather service, which the Met Office utilizes to output to many organizations for weather warnings and alerts. Transport Scotland's maintenance agents responsible for the maintenance of Scotland's trunk road network also have contracted other sources of weather forecast, which provide detailed route-specific information that permits the operating companies to plan treatment of the roads on a 24-hour basis. During the times when Transport Scotland and Police Scotland call in the Multi-Agency Response Team (MART), all this information is available within the control center. In winter, Transport Scotland has regular conference calls with the Met Office and receives detailed advice through the long-, medium- and short-range forecasts. These conference calls are attended by control room management, operating companies and Police Scotland. The control center also has access to the information provided by the numerous weather stations throughout the trunk road network. RWIS data provides localized real-time information specific to that weather station location on a regular basis. It is therefore possible that local RWIS conditions may at times be different to the regional forecasts."

Stein M Connelly
Traffic Scotland Operator Manager, UK

A "Real-time road weather conditions collected by the National Roads Authority (NRA) RWIS provide all road users with current road conditions. But the data also provides third parties and local authorities with real-time weather data for their area and road weather forecasts to assist them in making informed decisions about salting. We have 54 RWIS on the network collecting local meteorological data such as humidity, air, road surface and sub-surface temperatures and salt concentration on the road surface. We use this data in our ATMS, which produces weather alerts for the NRA. This information is then used to issue appropriate warnings to the road user in that area by notifications and through VMS. It is also displayed to users via our website and app."

Kevin O'Sullivan
manager, Motorway Traffic Control Centre, Ireland

Readers are invited to answer the Burning Question for the January 2014 issue:

As *Traffic Technology International* moves into its 20th anniversary year (1994-2014), how do you predict our roads will be managed in 2034?

email answers to:
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