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TECHNOLOGY INTERNATIONAL

January 2016

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IS IT ALL UBER FOR TAXIS? JOIN THE BIG DEBATE!

EXCLUSIVE INTERVIEW

PLUS

Predicting potholes
A new geographic information system can predict where road damage will occur, 30 years into the future

Intertraffic preview
The build-up to 2016's Intertraffic Amsterdam – the global biennial trade fair for the traffic industry – begins

Malcolm Dougherty
The director of Caltrans, the USA's biggest DOT, talks about leading the world in autonomous vehicle research

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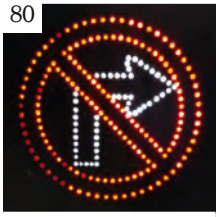
Cover story

44 Surface dangers

Technology that predicts and reacts to adverse weather and saves lives

Max Glaskin finds out how the latest ITS is making our roads safer in wind, rain, snow and ice



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Editor's letter

Polarized debate is one of the signs of a vibrant, rapidly evolving industry, where disruptive technologies are changing not just the game, but the rules of the game – and the players fight it out to decide where the new limits should be set. This phenomenon is particularly apparent in the world of transportation, where we find ourselves on the brink of not just a connected and autonomous vehicle revolution but an ownership one.

In the October/November issue, our cover story looked at a possible future where private car ownership falls away as people take out mobility-as-a-service subscriptions. Such all-encompassing services are still in their infancy, but when it comes to getting around by taxi, Uber and its imitators are already ripping up the rulebook and changing the way people think about not just riding in taxis but vehicle ownership itself, at least in big cities. In this issue's Big Debate (page 10) software engineer and futurist Mike Hearn takes the Uber model one stage further and asks what it will look like when such vehicles are self-driving – he even develops a radical new concept of taxis running completely autonomously as 'AI cars'. Such vehicles would manage themselves as independent businesses, collecting fares and spending them on fuel and repairs, without any human intervention.

It's fun to dream. But on the other side of the debate, there's a healthy dose of reality from our former columnist 'Gridlock' Sam Schwartz, who asks if it is sensible to throw out carefully planned regulation just because someone's come up with a cool app. He also points to the very real, but easily overlooked, problem: whether taxis are traditionally hailed or summoned via an app. Driven by a human or a robot, they're all going to have to share the same roads, and there is only so much space to go around, so some regulation may be essential. The debate is certain to go on and on – join it in our online poll.

Elsewhere in the issue there's plenty on other groundbreaking transportation technologies, from machine vision in 3D (page 54), to a GIS system that can predict where potholes will occur in 30 years' time (page 28). If only every aspect of our industry were as easy to forecast.

Tom Stone
Editor

Editor
Tom Stone
tom.stone@ukipme.com

Deputy editor
Lauren Dyson
lauren.dyson@ukipme.com

Production editor
Alex Bradley
Chief sub editor
Andrew Pickering
Deputy production editor
Nick Shepherd
Senior sub editor
Christine Velarde
Sub editor
Alasdair Morton

Art director
James Sutcliffe
Art editor
Ben White
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Head of production and logistics
Ian Donovan
Deputy production manager
Lewis Hopkins
Production team
Carole Doran, Cassie Inns, Frank Millard, Robyn Skalsky
Circulation
Adam Frost

Publication director
Mike Robinson
mike.robinson@ukipme.com
Publication manager
Godfrey Hooper
godfrey.hooper@ukipme.com
Australasia business manager
Chris Richardson
chris.richardson@ukipme.com

CEO
Tony Robinson
Managing director
Graham Johnson
Editorial director
Anthony James

Traffic Technology International
UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey RH4 1DF, UK
Tel: +44 1306 743744 • Fax: +44 1306 742525
Email: traffic@ukipme.com • www.ukipme.com

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Progressive action?

Lloyd Fuller takes a look at the recently approved Surface Transportation Reauthorization and Reform (STRR) Act

Fostering innovation

The STRR Act is said to promote innovation by encouraging private investment in the US surface transportation system. According to the Transportation and Infrastructure Committee, the act: promotes the deployment of transportation technologies and congestion management tools that support an efficient and safe transportation system; updates federal research and standards development to reflect the growth of technology in transportation; encourages the installation of vehicle-to-infrastructure equipment to reduce congestion and improve safety; and enhances truck and bus safety by accelerating the introduction of new transportation technologies.

In November, the US House of Representatives approved The Surface Transportation Reauthorization and Reform (STRR) Act, 2015 – a bipartisan, multiyear surface transportation bill to reauthorize and reform federal highway, transit and highway safety programs. After 10 years of short-term fixes and extensions, the bill authorizes federal spending on transportation projects for six years and guarantees funding for three years.

"The House voted to give our infrastructure and our economy a much-needed shot in the arm," said Bill Shuster, Transportation and Infrastructure Committee chairman, following the announcement. "The STRR Act provides strong reforms and policies to help us improve America's transportation system, and now we can get to work on resolving the differences with the Senate bill and carry a final measure over the goal line."

The guaranteed funding equates to approximately US$339 billion

> "The act provides critical funding for research and development of next-generation innovations, while accelerating the adoption of new and existing technologies
>
> *Regina Hopper, president and CEO, ITS America*

The bill aims to provide financial certainty for state and local governments so that they can undertake large-scale, complex projects; and also to provide the financial flexibility needed for states to invest in bridge rehabilitation and replacement. Ultimately, the goal is to eliminate the red tape that has slowed down infrastructure improvements in the past.

"It has been 10 years since Congress last passed a long-term transportation bill," said ITS America's president and CEO, Regina Hopper, in response to the positive vote. "[At that time] iPhone and Android phones were not part of everyday life. Mobile apps providing real-time traffic information, adaptive traffic signals, smart parking systems and big data analytics were futuristic concepts. The act provides critical funding for research and development of next-generation innovations, while accelerating the adoption of new and existing technologies that are making our roads and vehicles safer, reducing traffic congestion, enabling new mobility options and modernizing our transportation network to meet current and future demands."

The STRR Act promises to fund projects supporting critical bridge infrastructure, among many others

However, not everyone agrees that the bill is the long-term solution the USA has been waiting for. "This is just another patch, albeit on a larger scale," says Michael Sargent, a research associate at Thomas A Roe Institute for Economic Policy Studies at The Heritage Foundation, in a post on The Heritage Foundation's news platform, *The Daily Signal*. "While there are some parts of the bill that are small steps in the right direction, the bottom line is that it does nothing to fix the current problems that plague the trust fund and require perennial congressional attention. Congress will be back in the same spot in a few years' time, but with an even larger hole in the trust fund's finances to deal with."

Is this bill the answer to the USA's transportation funding problems? Tell us what you think by joining our LinkedIn discussion at: **tinyurl.com/linkedinSTRR**

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Cities of lights

Lloyd Fuller looks at how new lighting technologies are being used to improve transportation infrastructure

Street smart

Intelligent lighting on LA streets enhances the city's connectivity

The City of Los Angeles (LA) is in the process of installing intelligent, connected LED street lighting. LA will deploy 100 Philips SmartPoles – a connected LED street lighting solution that incorporates fully integrated 4G LTE wireless telecommunications technology from Ericsson. The SmartPoles will provide LA with high-quality, energy-efficient public lighting, as well as improved network performance in dense urban areas.

According to the *Ericsson Mobility Report*, cellular data traffic is expected to grow ninefold by 2020. Philips SmartPoles will meet this demand by enabling seamless mobile wireless

4G/LTE connectivity via small cell technology that facilitates increased data capacity in the telecoms network. Earlier this year, LA became the first city in North America to monitor and control its street lighting through Philips CityTouch, an advanced streetlight management system that uses mobile and cloud-based technologies.

International advantage

A lighting upgrade on an important bridge promises enhanced visibility and safety

The international bridge linking the USA and Canada between the twin cities both named Sault Ste. Marie in Michigan and Ontario, is getting a major lighting upgrade, which will provide a 20% increase in illumination, increasing visibility and safety. The tolled crossing is controlled by the Sault Ste. Marie Bridge Authority – a partnership between the Michigan Department of Transportation and Canada's Federal Bridge Corporation, but day-to-day operations are carried out by the International Bridge Administration (IBA).

The IBA will replace the existing 96 white high-pressure sodium bulbs that run along the top of the twin-arch spans, with new, more energy-efficient LED units. As well as the increase in illumination, the IBA expects a 55% reduction in energy use, which will result in savings of US$44,310 in energy costs and US$30,330 in maintenance costs over the life of the fixtures.

The US$55,100 estimated cost of the project includes rebates from energy-saving programs from each country's grids, which provide power to each half of the bridge, with the investment expected to pay for itself within six years.

Safe vision

Ford's lighting technologies will improve visibility at night

Ford is developing 'smart' lighting technologies that will enable drivers to more easily identify potential hazards when driving at night. The company's camera-based Advanced Front Lighting System can widen the beam at junctions and roundabouts to better illuminate hazards that are not in the direction of travel.

The system builds on Ford's Adaptive Front Lighting System and Traffic Sign Recognition, which are already available in Ford vehicles, to provide drivers with improved visibility at roundabouts, stop, and give way or yield signs. The new system also uses GPS information to better illuminate bends and dips on a chosen route.

Freeway focus

A dedicated public-private partnership will improve lighting infrastructure in Michigan

The Michigan Department of Transportation has entered into a P3 agreement to upgrade and maintain the freeway lights in Detroit's tri-county area. Of the approximately 15,000 freeway lights in the Detroit metropolitan area, 87% are now high-pressure sodium or metal halide fixtures. The P3 contract will replace the outdated lights with energy-efficient LED lights in the first two years. Only about 70% of the existing

freeway lights are currently working, with much of this due to fiscal constraints and multiple instances of copper theft. The P3 contract mandates that 90% of the lights be operational after the first year, and 98% after the second year.

13,587
Number of official yellow taxi medallions in New York City
Source: Taxi and Limousine Commission (TLC)

24,854
Number of Uber-affiliated cars in New York City
Source: Uber

410,831
Average number of daily yellow cab trips in New York City in July 2015. (a 10.8% decrease from the previous year)
Source: Wall Street Journal

93,897
Average number of Uber daily trips in New York City in July 2015 (a 324% increase on the previous year)
Source: Wall Street Journal

Does Uber mean time's up for taxi regulation?

Mike Hearn is a software engineer who currently works developing Bitcoin systems. Previously he was a senior software engineer and tech lead at Google, where he worked on Maps/Earth among other projects

A few weeks ago I got to the airport and discovered I'd had a brain fault – somehow I had walked out of the door without my luggage. Luckily I had enough buffer time that I could get a taxi home and back and still catch my flight. Unluckily, as I live in Switzerland, that ride cost about half as much as the flight itself, despite going 0.2% as far.

Can things be better? Much ink has been spilled on the relationship between Uber, the taxi industry, and its regulators. But I think focusing on the current state of things is a distraction – in its current form Uber is little more than a traditional taxi firm with a slick hailing app. Uber itself acts a regulator, gathering data on bad drivers in ways that traditional regulators cannot, but circumvents traditional licensing. It acts the way it does not because it's run by anarchists who believe all rules are bad, but because it feels many taxi regulations exist merely due to bureaucratic inertia and thus have no moral legitimacy. Many of their users agree!

But a much more interesting question is how will the taxi industry be affected by self-driving cars? Last year, the lead engineer on Google's robotic car program demonstrated current progress. The vehicles can now read hand signals from cyclists and policemen. They can avoid accidents even when there's another car going through a red light. The progress is impressive.

> "Eliminating the human and doing management via the internet makes many taxi regulations, and therefore the regulators, obsolete"

The first thing to understand about self-driving cars is that you will probably not be able to buy one. There are only two companies credibly developing driverless technology: Google and Uber. Both are service companies. Neither have showrooms, factories or the sales staff needed to sell cars. The vehicles need both laser-scanned maps and often law changes, meaning it takes effort to enable them in each new region. The huge R&D investment means such vehicles would start out incredibly expensive if sold straight into the market. And the developers will continue to evolve the technology rapidly even after going to market, so they'll want tight control – at least in the early years.

It makes much more sense for the vehicles to be run exclusively as an automated taxi service. Then the vehicles can run 24/7, be continuously tuned, offered affordably, and people are already used to taxi services being region-specific.

This has several implications. For starters, it will trigger a showdown between the tech industry and regulators that will make the current scuffles over Uber a forgotten sidenote. Eliminating the human and doing management via the internet makes many regulations obsolete, and therefore, makes the regulators obsolete. Yet the existence of these services requires the blessing of those same regulators in order to be legal. The coming fights will quickly identify governments that prioritize technological progress over special interests.

Another implication is that once costs are low enough, it won't make financial sense to own your own car anymore. In regions well served by the vehicles and served poorly by public transport, the US-based providers may quickly end up with a transport oligopoly. This, in turn, will mean the economic welfare of the region is controlled not only by a small number of companies, but more worryingly, by Congress. Individuals who discover they have violated US law, but not their own local laws, may discover

Could autonomous taxis be paid for by Bitcoin? Mike Hearn is now lead platform engineer at R3 CEV, looking at how to apply Bitcoin's underlying principles of decentralized finance to the banking system

View a simulation of autonomous vehicles negotiating a traffic-signal-free four-way intersection here: trafficTechnology today.com/aim

that they become specifically blacklisted. Such things already happen in the financial system. The implications for civil liberties are profound.

Via Edward Snowden, Silicon Valley learned it was being routinely deceived by governments. They are now responding to the political pressure put upon them by designing encryption that they cannot themselves control. How might this trend affect robotic taxis? Is it possible that to avoid their companies being turned into political weapons, the designers will grant the robots they build autonomy, so they operate independent of any human intervention at all? For example, the vehicles could collect their own fares using a digital currency such as Bitcoin that bypasses banks, directly hire humans to repair and refuel them, and find customers in peer-to-peer markets – with their numbers regulated by supply and demand, like a natural ecosystem.

But it's not all about politics. There will be more everyday benefits as well.

Combining vastly lower costs and modern artificial intelligence will yield dramatically better speculative execution. While cabbies of today may make rough guesses about where to find customers based on experience, tech firms will be able to accurately predict demand by blending public data about news, events and search traffic with (when given permission) private location and conversation data. People will get used to stepping out of their home or the home of a friend to find a self-driving taxi already waiting for them, even though they never requested one. Existing taxi firms will call it unfair competition – everyone else will love it. This better utilization will help control congestion, enable higher density cities due to less need for parking, and when manually driven cars are kept in their own lanes or banned entirely, eliminate the need for traffic lights – even at four-way intersections. Prepare yourself for some heart-stopping but entirely safe maneuvers!

Turn the page for a defense of taxi regulation

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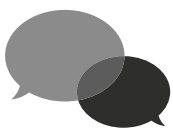
NO!

Taxi services need proper regulation

Samuel I Schwartz is a transportation engineer who started his career as a New York cab driver, going on to become the city's Traffic Commissioner (1982-1986) and coining the term 'gridlock'



JOIN THE DEBATE!

Can the traditional taxi-service model survive the Uber onslaught?

Log on to trafficTechnology today.com/uber to vote in our poll

If the goal is to improve mobility for city dwellers – to replace automobile dependency with active and multimodal transportation options – then it's difficult to see how ride-matching can ever be more than a small part of the solution. That's because the defining characteristic of the Ubers and Lyfts of this world (and of their very vocal cheerleaders) is hostility to regulation.

For decades now, regulation has been getting a very bad press, and not just from conservative politicians and libertarian economists. Everyone has a list of silly bureaucratic rules that have long outlived their usefulness, and I'm no exception. One of my favorites is the requirement that a car's registration sticker must be to the left of the inspection sticker or you'll get a ticket. Wait, I think it might be the other way around. Actually, I'm not sure whether it applies when you're in the car or facing the car. But, after spending a lifetime studying the subject, one of the few inarguably true things I've learned about transportation networks is that access to them can't be efficiently allocated by an unregulated free market.

The first problem with eliminating, or strictly limiting, regulation of these new and exciting services is consumer protection. Because Uber isn't a regulated business, the relationship between drivers and riders – all that 'sharing' – is governed by contract law.

When you download an app and take a trip in a car you summoned, the contract you accepted is between you and your driver, not with the company that created the app. Uber isn't responsible, for example, if one of its drivers attacks you, or runs you down. That's why it insists that the drivers carry liability insurance of US$1m. The company's terms and conditions take great pains to spell out very clearly that it has no responsibility for services provided by third parties – i.e. the drivers.

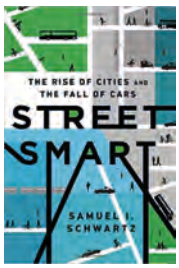
But the real problem with an unregulated market where the number of smartphone-dispatched cars is limited only by the number of willing drivers isn't a lack of liability. It's a surplus of VIM: vehicles in motion.

The VIM problem isn't a new one, but then, once you strip away the GPS and smartphone apps from ride-matching services, they're not entirely new either. What they resemble, more than anything else, are old-fashioned radio-dispatched limousines, a subject with which I have some history.

Back in 1982, when the number of taxi medallions in New York City (11,787) seemed inadequate to meet demand, a guy named Bill Fugazy, who owned the Fugazy Limousine Company, announced that he was prepared to put 6,000 limos on the streets, each of them just a phone call away from anyone with a credit card. The number actually didn't sound too daunting. More than 30,000 vehicles enter midtown Manhattan each hour –or roughly 200,000 a day. Manhattan's bridges and tunnels were handling more than one million daily. What could be so difficult about handling another 6,000? The mayor was for it. The city council was for it. The voting public was for it. The only people who saw any red flags were cranky transportation engineers. Such as me.

What we knew was this: at that time, the number of vehicles in Manhattan's central business district at any one time was between 139,000 and 181,000. But we also knew that not all

> "The real problem with an unregulated market isn't a lack of liability. It's a surplus of VIM – vehicles in motion"



Sam Schwartz's opinion is an edited extract from his new book Street Smart: *The Rise of Cities and The Fall of Cars*, available now from all good retailers

of them were actually moving. Many, if not most, were parked. By taking the number of miles traveled during an hour and dividing it by the speed, in miles per hour, I was able to calculate that, between 8:00am and 9:00am, only a few more than 5,200 vehicles in the core were in motion, and the maximum number that would allow any movement at all was fewer than 9,000. Which meant that if only a third of those radio-controlled limos-of-the-future were to operate in the most desirable part of New York at any given time, they would increase traffic density by at least 20%. The result? Total gridlock.

It's not just a New York problem. Every city on the planet has a measurable VIM maximum. It's a different number for each city. Each car above that critical number on the streets results in fewer total miles traveled. Nor is it like an on/off switch. Mobility starts to degrade long before complete gridlock occurs.

This doesn't mean that there's no place for ride-matching services. Not only are they hugely convenient; they also make the decision to live without a personal car possible, even attractive. I applaud the technology that created them, and expect they will continue to supplant existing taxis, or to convert them to a service that looks a lot like Uber: cabs that can be summoned and paid for using smartphones.

But to the degree that their appeal depends on increasing the supply of cars to the point that no one is ever more than a few minutes away from a roving driver waiting for a smartphone to put driver and rider together, the model is fundamentally unsustainable. Long before enough smartphone-carrying drivers hit the streets, the VIM tipping point will be reached. Beyond that point – that is, beyond the maximum carrying capacity of a particular city's streets – the numbers won't add up to more mobility, but less.

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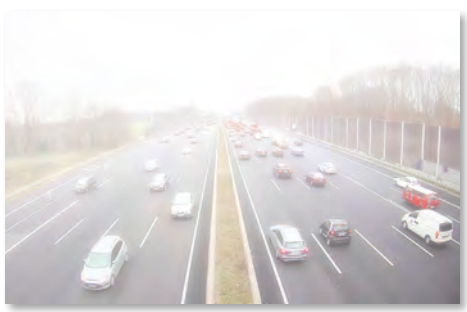

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New eyes for industry

One morning you wake and realize you're responsible for an US$11bn organization with 20,000 employees and you have to facilitate the mobility of 40 million citizens over 50 million miles of lanes. Either you've been dreaming or you're Malcolm Dougherty, director of Caltrans, California's Department of Transportation. He's been having mornings like that since being appointed in May 2012 and seems fairly cheerful about it. I buttonhole him right after he has talked delegates through his vision for the near future of intelligent transportation at the ITS World Congress 2015 in Bordeaux.

We talk first about autonomous vehicles. Immediately it's clear that safety is the keystone in Dougherty's bridge to the future. "The automotive companies just want to go out there and do what they want to do," he says. "As a government agency, we need to make sure it's going to be safe. The track record of autonomous vehicles may be much better than that of human drivers, but as soon as there's an accident people are going to look at the government and say 'Why didn't you prevent this from happening?' It's important to make sure the technology advances around that safety conversation."

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Addressing auto manufacturers

Is it difficult to have the safety conversation with the automotive sector? "Not necessarily," says Dougherty. "What they are most concerned about is over-regulation slowing them down. They certainly think that their technology is safe, but I cannot simply accept statements like, 'Trust me, the technology is safe.' I need them to prove it to me with real-life demonstrations, and on top

Caltrans director **Malcolm Dougherty** reveals his plans to keep California at the forefront of connected and autonomous vehicle research, while maintaining safety

Interviewed by Max Glaskin

> Auto manufacturers think their technology is safe, but I can't accept 'Trust me, the technology is safe.' I need them to prove it to me

> A black box in your car that theoretically talks to a signal some time in the future? Not too many people are going to buy that

of that, I need data from them showing me that it is safe."

Dougherty got some real-life proof of self-driving safety when he was taken for test drive in a Google car around the streets of Sacramento. "I was watching the computer screen when we got to a signal and the car stopped on its own. The screen showed it was already mapped to turn left onto a one-way street, but when the light turned green a pedestrian stepped out," says Dougherty. "The Google car tracked the pedestrian and waited until he had moved out of the way, and then it made a left turn all on its own. So it knew that the pedestrian was there." A perfect, reassuring result, although tempered by another tale.

Clearly Dougherty sees it is important for Caltrans to be involved in this research. "We want to take an active part in furthering both automated car technology and connected vehicles. California is well suited, with Silicon Valley and a lot of the technology companies to help lead the way."

Does that mean California is under pressure to host autonomous vehicle trials, exposing its citizens to new hazards? "I don't think we're taking unreasonable risks. What I don't want to do is be too conservative and expect perfection in the autonomous vehicle," he says. "If we're not even going to accept a fender bender, we're going to slow progress down. I want to take the appropriate measures."

A life on the road

Do you own a car? is perhaps one of the dumbest questions to ask a Californian, let alone the director of Caltrans. Dougherty is civil enough to give a straight answer. "I have a car. I bought a very fuel-efficient car because I actually drive a lot of miles in my commute," he says. "And about the time my son got his driver's license, he got my big car, the pickup, and I switched, so I could rack up the miles and reduce my impact on the environment."

Dougherty has worked for Caltrans for 23 years, from project design through to chief engineer and director. "I have gotten increasingly involved in ITS because I saw first-hand what the traffic and mobility challenges were," he says. "We weren't going to be able to simply keep doing things the old way – building more lanes and more highways. We were going to have to use technology to accomplish our objectives."

"There was a time when a vehicle came by with emergency lights flashing and the car got confused. The operator had to take back control and he navigated out of the situation. So it's always learning and it's going to come across different situations that are new to it," says Dougherty. The incident confirms the necessity of the regulation, from the Department of Motor Vehicles, for there to be a trained operator and a steering wheel in any autonomous car being tested on the highways of California. They must also have insurance of US$5m.

Today, 10 operators satisfy those regulations and are allowed to drive autonomous vehicles on the Golden State's roads, making it one of the busiest testbeds for public highway running in the world.

Getting connected

As for connectivity, Dougherty is similarly earnest. "I do think, as an operator of a road network, the first place we're going to get involved is at signalized intersections. First, because there are a lot of safety concerns around intersections. Second, we've got a lot of equipment there and it's a logical place for the vehicles to be talking to the infrastructure," he says. "If the car now knows what the timing of the intersection is, and if it knows what the timing of the next six signals are, it's advantageous not only to the vehicle owner but also to the road operator. The more vehicles I have connected to the signal, the more I know where traffic is, and we can start setting signal timing in series to maximize throughput."

With its fair share of congestion, Caltrans would welcome such advances. It's had a V2I testbed in Palo Alto for a couple of years using DSRC, although it's unlikely that similar automatic systems based on cellular communication would be acceptable to Dougherty in its present form. "I don't think that technology is there yet," he says. "There's a delay. At intersections, the signals need to be communicating with cars and reacting in fractions of a second. Cellular communications are not fast enough. When multiple vehicles are approaching an intersection, there have to be very rapid and accurate communications between the signal and the vehicles. We're talking about cars going at 40mph toward each other."

For him, the best thing would be for connectivity and vehicle autonomy technologies to merge and advance together. "I'm a firm believer that the two technologies have to come together. That's when you'll maximize the effectiveness of both."

Until then, he believes it will be difficult for people to buy into connectivity alone. "The technology for V2V and V2I is not really marketable right now because if you buy it, there's nobody for it to talk to. And there's no infrastructure to talk to because we haven't deployed that equipment. So I think we're going to have to encourage the implementation of V2V in vehicles, or we're going to have to put some of the infrastructure communication points out there so that it can be marketed. A black box in your car that theoretically talks to a signal some time in the future? Not too many people are going to buy that."

Why doesn't Caltrans lead the way by investing in infrastructure connectivity? "We do want to be a leader in connectivity as well as autonomous technology. It is a challenge to make such investments in new technology when you're not addressing all your potholes," says Dougherty, touching on one of the many things he must consider each morning when he wakes. "It is difficult to prioritize scarce resources, but we must find a way to move forward with new technology because there are great opportunities to improve safety and mobility."

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Sophisticated digital billboards use vehicle-recognition systems to target advertising directly at individual drivers. Is road safety compromised? And, if not, should the advent of full-color VMS be prompting road authorities to cash in on valuable ad space? **David W Smith** investigates

Anton Sterkhov / Shutterstock.com

FOUR

The number of US states that prohibit all billboards: Maine, Vermont, Alaska and Hawaii. Cities with prohibitions on new billboards include Houston, Los Angeles, Saint Paul and Kansas City. Montana prohibits digital billboards

Advances in technology are transforming the world of roadway signage. Sophisticated car recognition technology is helping to display targeted advertisements to individual models and colors of cars, and variable message signs (VMS) are replacing the more basic static signs used by road authorities in the USA and elsewhere. But the speed of changes has thrown up a host of debates around safety and appropriate usage. Are the new digital billboard adverts so distracting that they cause accidents? Can color VMS signs that use images rather than words confuse drivers? Meanwhile, there are ongoing arguments about whether VMS has any future at all in a world of vehicle-to-vehicle technology and smartphones.

The most striking advances are being used to advertise on digital billboards alongside major roads. Car recognition technology, such as that supplied by US company Worknet, determines the model of passing cars and sends out targeted adverts to drivers. Worknet's system uses commercially available Axis cameras and the company's own Vehcio technology to perform its dazzling tricks.

"This type of technology triggers the message relevant to that make and model on the billboard's carousel," says Mike Maziarka, Worknet's president. "It can be used to target Porsche, or Lexus, drivers with ads telling them how great their cars are. But it's also used for the opposite purpose – to tell drivers of other luxury brands that they should be driving a Lexus. It might say, 'Hey white Audi driver, it's time to cross over to the new Lexus NX'. This type of advertising is legal because it's not using license plate recognition to pick out individual drivers, but only the model of car."

(Above and right) **Worknet's system sends out targeted messages to drivers**

> This type of advertising is legal because it's not using license plate recognition to pick out individual drivers, but only the model of car
>
> **Mike Maziarka, president, Worknet, USA**

A striking use of recognition technology came at the end of 2013 when British Airways launched a London-based ad campaign that had a child on a giant billboard pointing at a BA airplane every time one went overhead. The ruse, which bamboozled motorists, relied on a 'virtual tripwire' in the sky that was triggered at a precise moment.

This type of advertising wasn't possible until very recently. Connectivity costs were prohibitive because of the amount of internet bandwidth required to stream video messages and there were too many latency issues. But it's now possible to use a server-based app with a high level of computing power. Within one second, the software can do the computing and send a message to the digital billboard saying a red Porsche Cayenne is passing by. It will flip up the relevant sign.

Driven to distraction?

Digital billboard advertising, however, has thrown up questions about driver distraction. Does the projection of increasingly sophisticated messages take the driver's attention off the road and cause accidents? The Swedish National Road and Transport Research Institute (VTI) conducted a widely publicized study of this

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Photograph: Highways England

US$2.5m

The price Google paid to rent the world's largest digital billboard, in Times Square, New York City, for four weeks. It is the size of a football field

question. They hired motorists to drive an instrumented vehicle past four electronic billboards and used eye-tracking technology to track the drivers' gaze. A driver was considered visually distracted when looking at a billboard continuously for more than two seconds. The results were published in 2012 in the journal *Traffic Injury Prevention*.

Although the authors drew no definite conclusions, their data showed that drivers gazed for significantly longer periods at electronic billboards compared with normal signs. The authors say this wasn't surprising – billboards are brighter, visible from greater distances, and display a constantly-changing series of advertisements. The authors concluded that they "have the potential ability to keep up the driver's curiosity over an extended period of time". But they stopped short of saying digital billboards should be banned.

Co-author Christer Ahlström, a researcher for VTI in human-vehicle-transport system interaction, says it is difficult to say if drivers look at the billboards too much: "Although adding a visual display will attract a driver's attention, billboard-related distraction appears to be minor and regulated by drivers as the demands of the driving task change. Most of the time, drivers have 'spare visual capacity' that can be spent looking at billboards, or executing other tasks."

Ahlström says academic studies (Antin et al. in 1990 and Birrell, Fowkes et al. in 2014) estimate that about one-third of a driver's visual attention could be allocated to activities unrelated to driving.

"The Swedish guidelines for digital billboards are that the message should be short and simple, with no videos or animations. Luminance is adjusted based on surrounding light, and there is a maximum of one message change while driving past the sign," he says.

"With these limitations, I believe drivers are able to adapt their glance behavior safely. If the commercials include continuously changing information such as video, or if the signs start displaying personalized ads, like Google does on your computer, it will be more attention-grabbing and this is something I personally don't want to see in the vicinity of the road."

> Although adding a visual display will attract a driver's attention, billboard-related distraction appears to be minor and regulated by drivers as the demands of the driving task change
>
> **Christer Ahlström, human-vehicle-transport system interaction researcher, VTI, Sweden**

(Above) **Adding color to VMS can help to improve readability**
(Left) **Bright video billboards attract attention in Piccadilly Circus, London**

Recognition of safety

The uses of the car-recognition technology are not restricted to advertising. For example, in Dubai, UAE, road authorities are hoping to link car recognition technology to VMS to inform trucks when they will be unable to navigate under upcoming bridges.

More controversially, Maziarka argues that state DOTs (Departments of Transportation) in the USA could take advantage of developments in

780,000

The highest estimated number of billboards on federal aid roads in the USA in December 2013 (Source: Scenic America)

technology to begin selling advertisements on VMS.

"The boards with high pixelation and the ability to target individual cars would be more attractive to advertisers and might extend the life of VMS," he says.

Neil Hoose, an expert on intelligent transportation systems and MD of Bittern Consulting, says the issue of whether DOTs could use VMS to advertise has been debated long and hard. "One problem is that lots of people are turned off by adverts, so if they think the VMS will always show adverts, they won't be looking when it shows important information," he says. "If DOTs were going to advertise, it would probably have happened by now."

For the moment, there is a vast difference in the quality of the VMS signs used for digital billboards and the more rudimentary ones employed by DOTs. But there has been some convergence. Many new VMS used in the USA, and increasingly in the UK, use color and graphics rather than text. "The more basic VMS will gradually disappear," says Hoose. "The new MS4 signs on the UK's motorway network use LED screens with multiple colors. They reduce ambiguity and say far more than the old signs with their limited text space."

But there are issues around using the new signs to communicate with drivers. "Consistency and coherence is vital," says Hoose. "A sign on the M5 in Somerset has to be the same as one on the A1 in Durham, even if the manufacturers are different. On occasions, the signs make more sense to traffic people than to average motorists."

Consistent progress

Suppliers of VMS or DMS (dynamic message signs), as they are sometime now called, all around the world need to be aware of the need for commonality between signs. In the US, DOTs generally look at what other states have done and make an effort to copy them to keep designs simple. For this reason sizes and shapes tend to be similar across the USA. However, the trend toward using more color is accelerating. Psychological studies have show that using an image of a person instead of text means it communicates more directly with the brain. It can also express a wider range of messages.

But Hoose says transportation authorities have to think hard about how much sophistication is desirable. Using color brings advantages, but if VMS become too complex, drivers can't absorb information. Another issue, he says, is that 'requirements creep'. "If the signs are capable of providing more information, people will naturally want to use them for more things. They will have to be more reliable, so components will be more expensive and testing costs will rise. There could also be security issues. The ability to hack in and put in unpleasant images becomes possible and more money has to be spent on security."

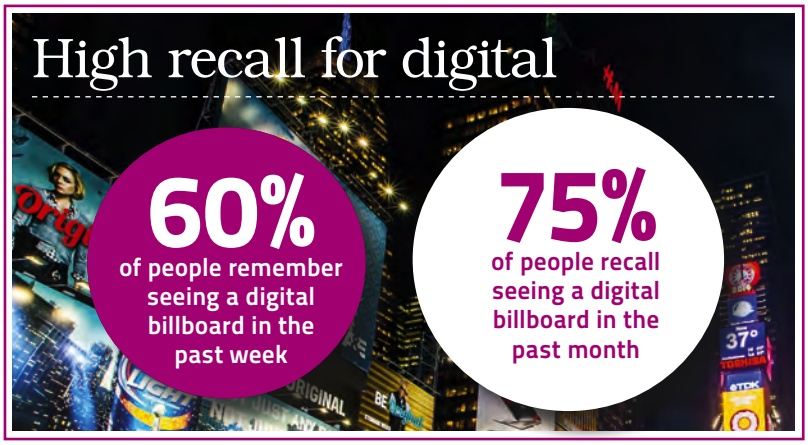
(Below) **Dynamic, full-color signs assist highway drivers in the USA**

VMS forever?

Although many commentators have predicted the demise of VMS signs in the era of smartphones and vehicle-to-vehicle communication, Hoose is less certain. "It's hard to confidently predict the future of VMS," he says. "Road authorities would love to get rid of this expensive infrastructure, but governments would have to mandate retrofitting millions of cars to have a 7in display screen always connected to 4G.

"Drivers would resent having to pay for it and manufacturers would need time to bring products to market. Even then, the technology would need to be foolproof. VMS speaks to every driver on the network and DOTs would have to be certain that all messages got through to every car. That's a real challenge."

Hoose thinks it could be more appropriate to divide messages up into 'strategic' and 'tactical'. "Tactical information would involve controlling the road ahead and would appear on VMS," he says. "Strategic advice would be about optimal routes and traffic conditions. Operators might think that's best sent to satnavs and smartphones."



Source: Nielsen survey

> If the signs are capable of providing more information, people will naturally want to use them for more things. But they will have to be more reliable, so components will be more expensive
>
> **Neil Hoose, managing director, Bittern Consulting, UK**

250

The number of VMS used, over 50 gantries, to manage speed limits on a 10-mile stretch of 'smart motorway' introduced in 2006 on the UK's M42

(Source: Automobile Association)

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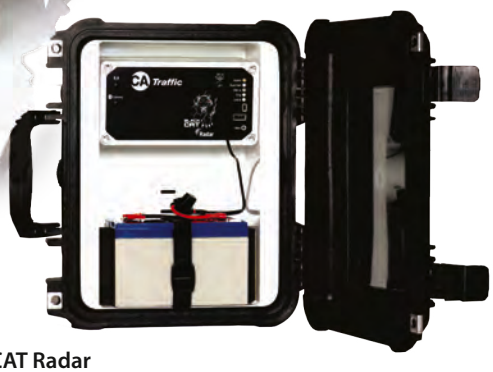

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The Black CAT Radar unit allows for the collection of traffic data without the need for in-road traffic sensors. This newly developed radar product has the ability to detect the lane position of vehicles, thus allowing the device to monitor two lanes of traffic travelling in the same direction. Furthermore, improvements with the on-board algorithms ensure that the vehicle length measurement is more accurate, allowing for VBV classification.

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Revealing the future

What if you could predict where a pothole is going to occur? Now imagine you can do this 30 years into the future. **Tom Stone** finds out more about the GIS system that reveals the fate of our roads

Illustration: Spooky Pooka at Debut Art

Nobody likes a pothole. Motorist rail against them, the media feeds the fire with inflammatory stories about poorly maintained highways, and road authorities are left with the expensive and seemingly never-ending task of filling them in. It's a problem as old as the roads themselves, with solutions that are traditionally no more high-tech than a wheelbarrow full of gravel and a dollop of blacktop. But now researchers from Cranfield University in the UK have developed a geographic information system (GIS) that can make huge savings on repair costs by identifying exactly where potholes are likely to occur, not only in the short term, but as far into the future as 2050.

The team at Cranfield used GIS to merge three different data sets. Focusing on the county of Lincolnshire, they overlaid the map of the minor road network on top of their soil data map, which in turn sat

GIS enables layering of geographic data to reveal previously undetected patterns

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on top of a map showing the moisture saturation levels in the ground. The minor road network was the focus of this work because major roads have stronger foundations and are therefore they are far less susceptible to subsidence.

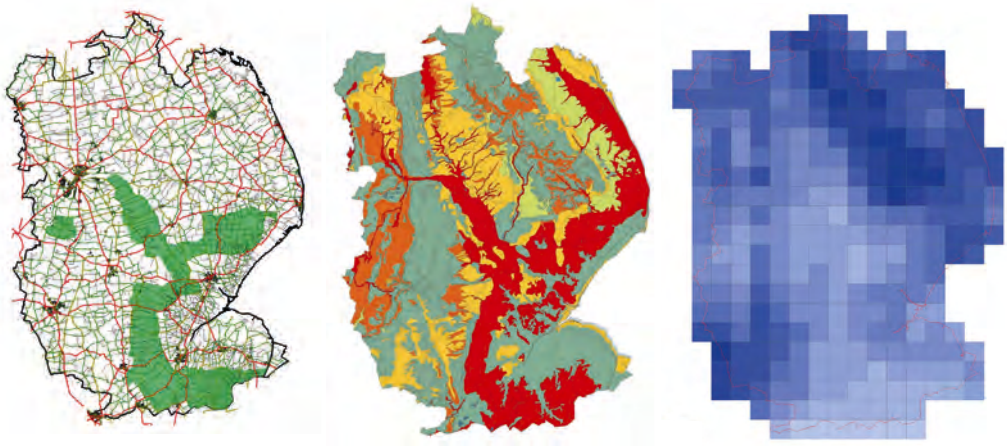
Stephen Hallett, principal research fellow in environmental informatics at Cranfield, worked extensively on the project – which was funded by the Engineering and Physical Sciences Research Council (EPSRC) – alongside Dr Timothy Farewell, and PhD student Oliver Pritchard.

"The cost of drought damage is really a very significant problem in Lincolnshire," says Hallett "They are head and shoulders above all other counties when it comes to this type of damage. We were tasked with helping the council to understand the relationship between different soil types and the conditions they were experiencing in the roads."

Using GIS, Hallett and his team were able to show a very close visual correlation between a certain type of clay soil, low moisture levels, and the roads prone to damage. "This clay has the potential to shrink and swell and it's only when the soils dry out that the problem manifests. So the perfect storm is a combination of prolonged dry conditions with shrinking and swelling soils."

Uniquely, the Cranfield research is taking this whole process further, so it doesn't just show what has happened in the past, or what is happening now; the system is able to predict what will happen to the road network in the future.

"We can swap out the past and present climate and swap back, in its place, climate change projections for the future," says Hallett. "So we are looking at the time period 2030 to 2050 and trying to understand what is going to happen in this area. If you understand those past and present conditions, and have confidence in that, then you can start to look to the future and we can use our climate modeling data sets that predict patterns of rainfall to help."

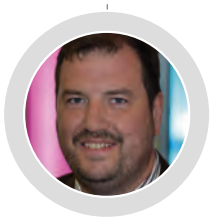


(Above) **The three key data maps in Cranfield's GIS** (left to right) **high-risk local roads, soil type, and moisture saturation in Lincolnshire, UK**

Managing the problem

The research has been of huge benefit to the local council, which is now using this geohazard mapping in its survey vehicles. They have also changed the way in which they repair roads that are at high risk of subsidence and potholes.

> We are looking at the time period 2030 to 2050 and trying to understand what is going to happen in this area
>
> **Stephen Hallett, principal research fellow in environmental informatics, Cranfield University, UK**

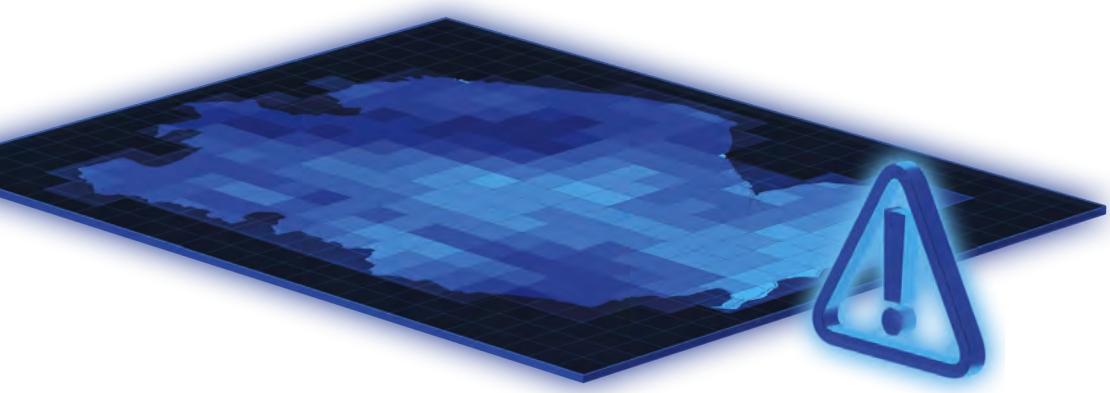


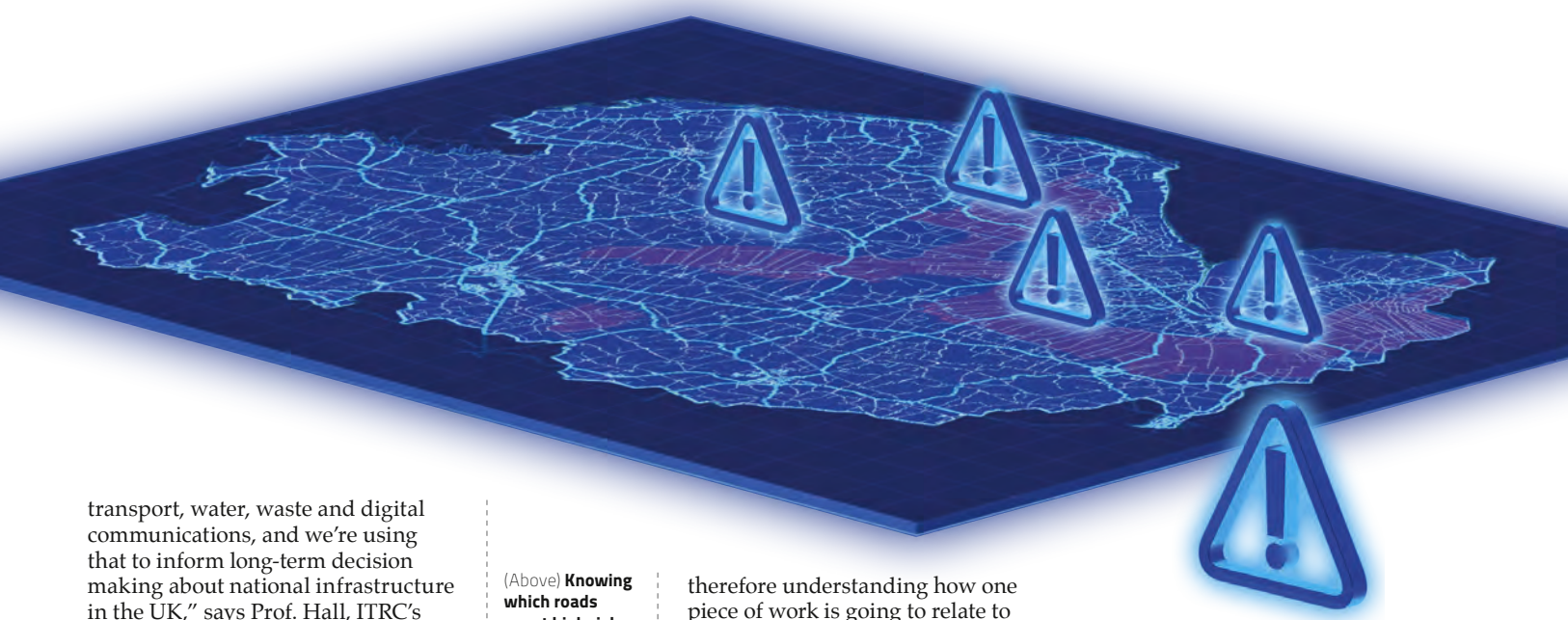
"They use a scoring matrix to prioritize which roads need to be dealt with and that matrix informs them about the likely duration of any solution," says Hallett. This has led to the idea of 'in-situ recycling' for high-risk areas – essentially combining materials that would otherwise go into a landfill and rebinding them into the pavement surface. "This is a cheaper approach for dealing with high-risk roads, because whatever they do, they know the road will be damaged again within a short period of time," explains Hallett. "Then in lower-risk areas where they still happen to have problems, they can take the road apart and resurface it more thoroughly.

"What we're trying to do is give the council the information they need in order to apply a rational approach to prioritizing areas and to use appropriate techniques in each of those areas. They're extremely pleased with what we've done. And it enables them to have an evidence base for presentations to the Department for Transport for the funding they receive – some £31m (US$47m) a year, which they have to allocate wisely across their 950 miles (1,500km) of drought-affected roads within the 5,500 miles (8,800km) of total road network that they are responsible for."

Part of the bigger picture

The work at Cranfield University is part of a larger project – the UK Infrastructure Transitions Research Consortium (ITRC) – which draws together leading British academics, under the leadership of Prof. Jim Hall from Oxford University, in an attempt to predict the future of the UK's infrastructure and advise where investment should be focused. GIS is one of the many tools used by the ITRC when modeling alternative futures of interconnected infrastructure systems. "The ITRC has built the world's first 'system of systems' modeling capability, which goes all the way across energy,





transport, water, waste and digital communications, and we're using that to inform long-term decision making about national infrastructure in the UK," says Prof. Hall, ITRC's principal investigator.

The ITRC's National Infrastructure Systems Model (NISMOD) has four branches: LP, looking at long-term performance; RV, looking at risks and vulnerability; RD, which is concerned with regional development; and DB, which is the database and the foundation of the ITRC's modeling suite, featuring hundreds of layers of data on the UK's interconnected infrastructure systems.

"All the major projects and programs are together in one plan," says Dr Matt Ives, leader of NISMOD-LP development. "Underpinning that is the pipeline, which is about £460bn (US$693bn) of investment in infrastructure. With the NISMOD-LP tool, we are able to project into the future alternative worlds of different demographics, climate change scenarios, and see how well the pipeline does."

"We are able to look in particular at the multimodal nature of transport," says Dr Raghav Pant, leader of NISMOD-RV development. "We are trying to understand how failures in roads, railways, boats and airports affect each other and hence we are working with the Department for Transport."

"The work of ITRC in creating NISMOD will potentially be extremely helpful to infrastructure planners and designers in the future," says Sir John Armitt, president of the UK's Institution of Civil Engineers (ICE). "The impact of one system on another – and therefore understanding how one piece of work is going to relate to another, and realizing the need to develop other systems in parallel, is very important."

(Above) **Knowing which roads are at high risk of subsidence can help inform decisions about how they are repaired**

Expanding the system

Returning to the part of the ITRC project that has been looking at road surfaces in Lincolnshire, there is now scope to expand it across the whole of the UK. "We applied for some follow-on support from the EPSRC's Impact Acceleration Account (IAA) on the basis that if what we are doing worked in Lincolnshire, then we should be able to apply it elsewhere," says Hallett. "And we've actually now run our modeling for the entire country. We hold a massive database that's 50TB in size. It holds 5km climate data projections for the whole of the UK – for now, for 2030 and for 2050. So we can now draw upon that body of data – big data if you like – together with our national soils information that we hold at Cranfield, in order to undertake a similar exercise for other councils."

> The ITRC has built the world's first 'system of systems' modeling capability, which goes all the way across energy, transport, water, waste and digital communications
>
> **Professor Jim Hall, principal investigator, Infrastructure Transitions Research Consortium, UK**

Furthermore, Hallett envisages being able to use the same system to assess other infrastructure. "Slope stability is definitely an issue, and there is considerable interest here at Cranfield in geotextiles that can be used to stabilize slopes, and how you identify when road embankments need attention. Quite a bit of research has gone on here in the past, with experiments being run on the sides of roads to look at this. What we have now is some of the information resources that underpin this, to allow regional risk assessments to be undertaken and provided to local authorities."

A happy ending to the most recent stage of this project is that the PhD student involved, Oliver Pritchard, secured an industrial placement at Arup, because of his work and thanks to an EPSRC Impact Acceleration Account Secondment Award. "One of the things he'll be looking at is some of the transport network tools for modeling resilience and interdependencies of various infrastructure types. Arup is also very interested in the work being done by the ITRC as it has progressed through the years," says Hallett.

The work has also led to another project for the university itself. Cranfield recently won a bid to become a Centre For Doctoral Training in big data and environmental risk, partnering with Cambridge, Newcastle and Birmingham universities in supporting doctoral researchers looking at environmental issues, from land degradation and flood risk, to urban pollution and the effects of trees on road networks.

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Show business

Ahead of the much anticipated Intertraffic Amsterdam 2016 exhibition, which will take place on April 5-8, 2016, **Lauren Dyson** talks to the organizers about what makes the biennial event such a huge success

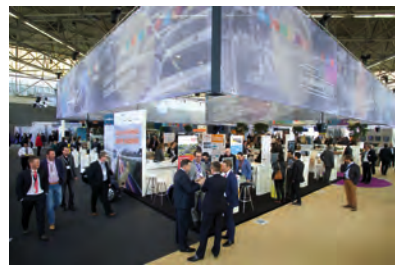
It has been almost two years since the last Intertraffic Amsterdam – and excitement surrounding the 2016 event is building. Since the first show in 1972, Intertraffic Amsterdam has established itself as a leading event for industry professionals wanting to keep up with the latest trends and developments in the traffic and mobility sectors.

Over the years, Intertraffic has become well-positioned to provide a comprehensive overview of the industry through its extensive network of exhibitors – the number of which is expected to exceed 800 in 2016. Exhibitors include importers, manufacturers and local agents for products in the fields of smart mobility, traffic management, infrastructure, safety and parking. They also include national, regional and local authorities, cross-sector trade associations and research organizations. Intertraffic Amsterdam is well known as an ideal platform for product launches, so visitors can expect to discover products and innovations at the exhibition that have never been seen before.

"The Intertraffic Amsterdam events are always a success because not only do we have all the market leaders present, but we also connect traditional industries with future technology," says Carola Jansen-Young, senior marketing communications manager at

Come and meet the *ITI* team at **Booth 10.001**

5.6.7.8 APRIL 2016 Intertraffic AMSTERDAM



the RAI Amsterdam. "We have an international senior visitor base and are able to facilitate matchmaking at various levels."

Indeed, Intertraffic Amsterdam continues to attract high-profile visitors from all over the world, including final decision makers, co-decision makers and advisors from private ventures, contractors, and local, national and international authorities. The 2014 show welcomed almost 27,000 visitors from 128 countries worldwide – and similar numbers are expected this year.

Progress and innovation

Innovation is an essential theme at Intertraffic Amsterdam and is named as the number-one reason for people to visit the show. One of the highlights of the 2014 event was the introduction of the InnovationLAB – a central stage used to showcase Innovation Award nominees and to host seminars, workshops, debates and presentations. Following its successful launch, a 2.0 version will take place at the 2016 show.

In fact, the April event will focus on innovation more than ever before. "One exhibition hall will be designed and equipped to show innovations off to their full extent," reveals Richard Butter, Intertraffic's domain manager for worldwide events. "It will have a Start-up Pavilion and an Experience Lab. The hall will also focus on smart urban-mobility solutions with a massive daily conference program on the show floor. The layout and conference program will be based on the themes of transportation and traffic efficiency; customized mobility; ecomobility; and safety."

> One exhibition hall will be designed and equipped to show innovations off to their full extent
>
> **Richard Butter, Intertraffic's domain manager for worldwide events**

There has been notable progress in all areas of the industry over the past two years, but nowhere more so than in the smart mobility sector. "Intertraffic 2016 will cover the continuous development of smart mobility, the importance of big data, and the transition from traditional infrastructure solutions to those that connect with cooperative and autonomous driving and communication," says Butter. "We are noticing a shift from managing traffic to managing mobility."

Forward thinking

Fans of the Intertraffic brand will be pleased to know that the Amsterdam show isn't the only event on the horizon. "Following Intertraffic Amsterdam, we will have Intertraffic China, which runs concurrently with ChinaTranspo, from May 23-25," says Jansen-Young. "It's our ninth edition in China." There is also a brand-new Mexico event to look forward to. "Although we have only recently launched this with our partner E J Krause, it has kicked off with a bang," Jansen-Young adds. "The market is very promising and we are looking forward to a great show in November."

But before all that, Intertraffic Amsterdam will take place on April 5-8, 2016, at the RAI Amsterdam Convention Centre. "It is always a great experience to gather so many exhibitors and visitors together," says Jansen-Young. "With the event having been in existence for so many years, it always feels like an industry friends' reunion where we share the latest developments and innovations with each other."

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Intelligent operations

Jenny Simonsen,
Q-Free, Norway
Booth 11.309

Can you tell us about a recent innovative project?

The car park management system (CPMS) at Stockholm's Ericsson Globe, which went live in March 2015, demonstrates how barrier-less parking could be implemented in the future. It showcases how Q-Free is cross-fertilizing previously discrete sectors of traffic management with innovative new solutions. Here, automatic license plate recognition (ALPR) expertise from the free-flow, cashless tolling environment is being used to create a cashless, barrier-free and user-friendly solution for parking.

How does the system work?

The highly flexible Q-Free CPMS interfaces with ALPR at the front end and various back-end systems, including those for electronic pricing, accounting and invoicing, which are operated by the customer, APCOA.

A state-of-the-art parking guidance system monitors and controls 1,400 single-space sensors. These are mounted overhead and trigger colored LEDs to show occupancy as

well as pushing information to the back office.

A total of 18 cameras cover nine entrances and exits. Inside, there are 21 touchscreen payment kiosks. To pay, all a visitor has to do is type in his or her license plate details and, once an image of the correct vehicle is displayed on the screen, confirm and pay. The first two hours of parking are free, but there is also the facility to leave without paying and then do so online within 72 hours. It is an example of how intelligence built into a system improves user convenience and satisfaction by helping to reduce waiting times and congestion.

5.6.7.8 APRIL 2016 Intertraffic AMSTERDAM

Smart camera for ITS

David Shi, Roseek, China
Booth 11.234

What trends are you noticing in the industry?

Front-end image processing is a big trend. The resolution of cameras is increasing all the time, but at the same time the transmission of large amounts of high-resolution image data causes problems. Smart cameras make it possible to analyze real-time images in the front end and transfer

only the necessary data to the center for statistics. This frees the back-end PC from heavy image processing and decreases the bandwidth of data transmission.

How are your cameras used in ITS applications?

As a smart camera provider, Roseek has many customers in the ITS sector. Users can develop their own algorithm and software based on our smart camera platform. There are now more than 100,000 Roseek ITS smart cameras running on roads in China, Korea, Brazil and many other countries.

How do you see your products developing?

Roseek will keep working on more powerful ITS smart cameras, camera housing and integrated control platforms. We are becoming a one-stop ITS hardware provider.

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Weight watchers

Daniel Kneubühl, Haenni Instruments, Switzerland
Booth 01.322

What are the current trends in the vehicle weighing sector?
The vehicle weighing sector is witnessing an increasing amount of weight measurement solutions that are automatic, but do not provide the required accuracy. They are being installed for statistical reasons and to feed the big data machine. More accurate, sustainable systems are needed. This is what we provide

Where have your products recently been implemented?
This year, Romania added 58 Haenni scales to its official weight-enforcement operation.

Signs of the times

Pascal Conte, Lacroix Traffic, France
Booth 11.609

What is your latest news?
On October 1, the Lacroix Group announced the creation of Lacroix City, comprising Lacroix Signalisation, Lacroix Sogexi and Lacroix Traffic. This new international brand offers a comprehensive range of signage for informing, monitoring, managing and lighting cities and highways. Lacroix City responds to the current issues of global cities: guiding, optimizing and securing the flow of vehicles and people, when energy management is a recognized obligation.

Where have your VMS been installed?
Lacroix Traffic has installed more than 100 VMS in Mexico, the majority being solar powered. We strive to engineer low power, full color matrix signs, including new-generation LED technology, to provide highly reliable, easy-to-use and long-life technical solutions requiring little maintenance.

Is the demand for full color VMS increasing?
We foresee a great future for the deployment of full color, LED, matrix VMS, which are not only capable of displaying various character heights but also many types of traffic symbols. Some European countries seem to have fallen behind in this field, but, at the same time, demand is picking up in many areas of the world such as Mexico, Russia, the Middle East and the USA.

The future of traffic management

Marc Rummeny, RTB, Germany
Booth 11.301

How are new technologies impacting the traffic sector?
Smartphone technology is becoming increasingly common in traffic applications, for example for navigation or to reserve a parking space. RTB has developed a system for visually impaired pedestrians that works with a smartphone app. Signals are transmitted via Bluetooth. If a person running the app approaches a traffic light, an acoustic orientation signal increases. This makes it possible to easily locate the mast. During the approach, the sound increases step-by-step and reaches its final output volume when the person reaches the traffic light. If the person remains in the direct environment of the signal group, the blind requirements function is activated.

How do you see the industry developing?
Increasing street traffic and dense traffic infrastructure not only cause problems for drivers and pedestrians, but also for those that manage traffic flow. RTB develops products to support every participant in street traffic: traffic light equipment for pedestrians; dialog displays as a communication medium for drivers; classification systems for cities and municipalities; and products that make it easier to find a parking space. Managing traffic flow will become increasingly important over the next 20 years.

What is your latest company news?
In late 2014, we took over three pay-and-display machine models from Siemens. In addition, we have recently developed a new parking sensor for single-space detection that features easy installation and advanced detection capabilities.

Model behavior

Miller Crockart, PTV Group, Germany
Booth 11.401

How is our industry changing?
Everything is becoming connected. 'Shared economy' is the buzz-phrase at the moment. This doesn't only mean wi-fi space or shared licenses for software, it also impacts traffic on the road, in relation to shared vehicles, for example, or shared data. Autonomous vehicles are another popular topic. In the future you will not own a vehicle, but will have access to one.

Have you had any recent product developments?
Recently PTV Group launched mesoscopic simulation in PTV Vissim 8, combining multimodal microsimulation with mesoscopic simulation in a single hybrid modeling solution. This combines the high speed of mesoscopic simulation with the level of detail provided by microscopic simulation.

How is PTV Vissim being used by road authorities?
Major UK cities such as London, Birmingham and Edinburgh and world cities such as Atlanta, Beijing, Dubai, Hong Kong, Moscow, Munich, Paris and many others are using PTV Vissim. Some use it to develop strategic models that support the forecasting of future multimodal transportation demand and the development of infrastructure policy and planning. Others use it to develop operational models that support the management of the road network, improving performance and reliability. With the advent of autonomous vehicles fast approaching PTV Vissim is now also being used to address and assess the impacts of changing travel behavior choices and patterns that will almost certainly alter the way cities are planned.

PTV Visum also underpins our PTV Optima real-time solution, so this has evolved into not only a long term planning tool but also an operational planning tool that supports real-time decision making.

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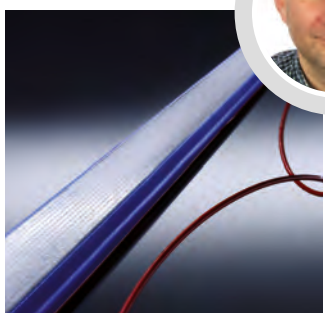
High-speed success

Tomas Pospisek, Kistler Instrumente, Switzerland
Booth 10.315

What was your biggest success story in 2015?
Kistler became the first WIM manufacturer to receive the OIML R-134 certificate for vehicle weighing with strip sensors from 3-65km/h (2-40mph). Supported by this certificate, Kistler WIM systems, based on maintenance-free Lineas quartz WIM sensors and the Kistler WIM Data Logger, can now be used for legal weighing in traffic-related applications such as tolling and automatic weight enforcement.

What is happening in the WIM field?
WIM has become a very interesting market and it will continue to have strong growth potential thanks to improvements in the reliability and accuracy of weight and traffic data provided in a high-speed environment. We are now seeing more projects that employ WIM data, not only for traffic data collection and pre-selection, but also for legal enforcement. Automatic weight control enabling direct prosecution of overloaded vehicles, tolling based on weight, or quick determination of load in industrial applications are trends that are visible in many countries worldwide.



How will the industry change over the next 20 years?
Besides further improvement in WIM systems accuracy, and more measurement reliability, we will also see interoperability and real-time exchange of data among roadside technology and sensors, vehicles and central management systems. We will also observe an expansion of WIM add-on functions, such as speed measurement, dimensions control, and dangerous goods monitoring. This will transform WIM stations into complex measurement checkpoints that directly communicate with onboard sensors in vehicles.

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Surface dangers

When extreme weather hits roads, safety and journey times can be severely affected. That's why transportation professionals and meteorological scientists are pooling their resources to develop new road weather information systems, as **Max Glaskin** discovers

959,760
Total number of road traffic accidents in the USA from 2002-2012 attributed to wet pavements, causing **4,789** fatalities

(Source: FHWA)

The fact that weather is crucial to road traffic was made clear by the trepidation with which a legal challenge against road-weather system intolerability was treated, in a keynote speech at the end of the ITS World Congress 2015 in October. Among the conventional thanks and praises, Fotis Karamitsos, acting deputy director general of DG MOVE at the European Commission, mentioned a ruling that the European Court had made only the day before.

He told delegates in the Palais de Congrés in Bordeaux that the Czech Republic had challenged an EC directive that requires road weather information services, among others, to be interoperable across Europe. The court dismissed the challenge, Karamitsos was visibly relieved to report to the gathered tansportation professionals.

Policy makers like Karamitsos are eager to promote services that benefit road weather management because they will improve safety and reduce chaos. For example, bad weather and slippery roads are blamed for 15% of fatal accidents in France and around 20% in Finland. In the USA, the FHWA has gone so far as to publish a 134-page compendium showing transportation departments how to save dollars through road weather management.

Even relatively minor weather events, such as heavy rain, can

> I have found that there is a correlation between the intensity of rainfall and the length of congestion. It's the first time this relationship has been quantified
>
> **Toshitaka Azuma, VICS, Japan**

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(Right) **Wet road conditions in Tokyo, Japan**
(Below right) **The Finnish Meteorological Institute's road weather alert system, part of the European Field Operational Test on Safe, Intelligent and Sustainable Road Operation (FOTsis)**

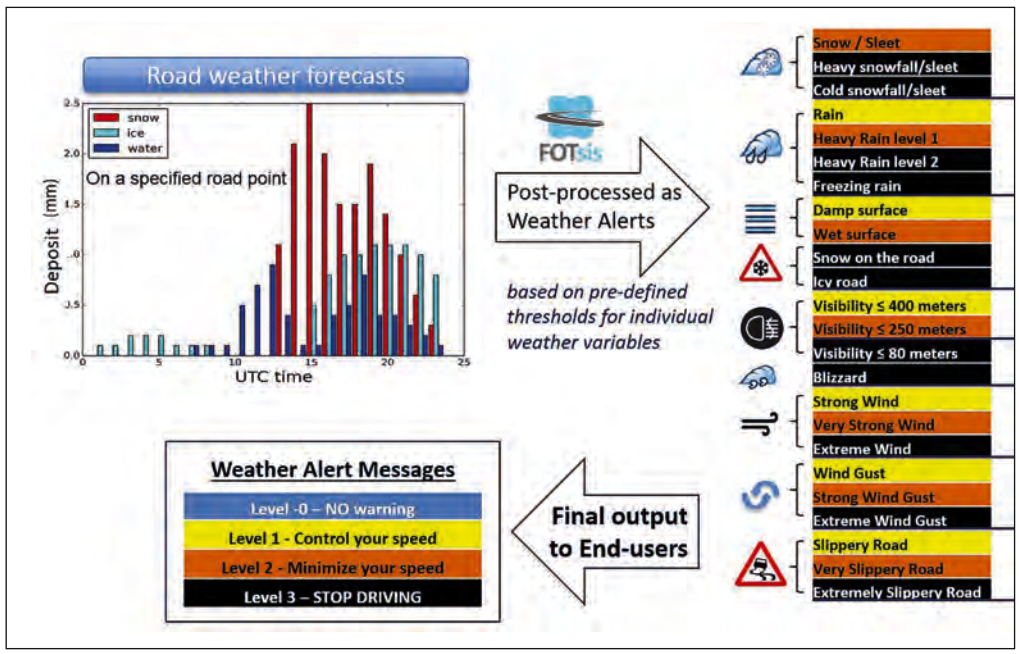
76%
The increase in your chance of having an accident if you are driving in the rain in Japan

(Source: MEX/Japan Weather Association)

trigger congestion. Everybody knows this almost intuitively. Drivers slow down when they recognize hazardous conditions and, in heavily used urban areas, the queues back up quickly. If traffic management centers (TMCs) know exactly the degree of weather severity that will tip a network into chaos, they can use forecasts to plan ahead and mitigate the consequences. Gathering such knowledge has been the goal of Toshitaka Azuma of the Vehicle Information and Communication System Center (VICS) in Japan.

He has been studying rainfall intensity in Tokyo and its impact on congestion. He is particularly interested in the fact that there has been a 50% increase in heavy downpours since 1975 and is attempting to predict what impact this might have on the 2020 Olympic Games, which will be held in Tokyo during the storm season. VICS alerts drivers to traffic events and is set to tell them when at least 50mm (2in) of rain is expected to fall in an hour, but Azuma's analysis of city center jams suggests this should now be refined.

"I have found a correlation between the intensity of rainfall and the length of congestion. It's the first time this relationship has been quantified," Azuma says. Analysis through a 150-minute storm of increasing intensity shows that the total length of tailbacks in Tokyo rises from 13 miles (20km), to almost 30 miles (50km).



> We can get fine detail down to 100m and produce forecasts for specified road points
>
> **Pertti Nurmi, head of meteorological research applications, Finnish Meteorological Institute**

This represented an 80% increase compared with the same time period one week earlier when there was no storm. What's more, his study reveals that traffic chaos in Tokyo is triggered when rain falls at just 25mm (1in) per hour – half the intensity that VICS currently regards as worthy of alerts. Azuma suggests that forecasts of rain intensity will help TMCs estimate the impacts and help mitigate them more reliably, by sharing information with road users.

Connected vehicle system

Intelligent road weather forecasting similar to that being undertaken in Tokyo has been an element of FOTsis, Europe's four-year field test of seven close-to-market cooperative V2I technologies on nine highways, which ended in March 2015. A system developed by the Finnish Meteorological Institute (FMI) for Finland's roads was exported to

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€20.8bn
The average annual estimated cost of weather-related road accidents across the EU (US$22.7bn)
(Source: VTT Technology)

several European sites – in Spain, Germany, Greece and Portugal – for assessment.

"We have a general large-scale atmosphere forecast model and on top of this we have a localized one-dimensional energy balance model, using local observations so we can get fine detail down to 100m, and produce forecasts for specified road points," says Pertti Nurmi, head of meteorological research applications at FMI. Rather than giving drivers data about temperature, road surface temperature and precipitation, the system outputs one of four simplified alerts, from 'No warning' to 'Stop driving', as shown in the table on the previous page.

Now that FOTsis has ended, FMI is waiting to learn if it will get funding to implement a full-scale system. Highway operators in the Netherlands, Estonia, Belgium, Japan and Korea all wish to become partners. "We try to see beyond our own playground," says Nurmi, "We tuned and tested our road weather forecasting system during the Sochi 2014 Winter Olympics for the 25-mile (40km) road from the Black Sea to the mountain location of the outdoor sports, making use of six road weather stations. We're also working with the highways administration of Sweden and Volvo cars to assess the potential of the vehicles to measure various ambient variables."

(Above) **Onboard weather display being tested in Finland** (Above right) **Roadside weather camera**

Positive feedback

Delivering local road weather information to vehicles is being tested at Sodankylä in arctic Finland by another FMI team. It's part of the Cooperative Mobility Services of the Future (CoMoSeF) project, in which roadside units are not only V2I communication nodes but also host a road weather station. "We want to measure as much as possible and have the ability to support all wireless devices," says Dr Timo Sukuvaara, senior research scientist at FMI. So communication protocols including 802.11p, 802.11n/g wi-fi and 3G cellular are included and can link to an in-vehicle PC, laptop, Android tablet or Android phone. Systems to link to an iPad and the Jolla open platform phone are in the pipeline.

The station makes typical road weather measurements of road and

> We can send information to vehicles using the hotspot roadside unit but that's not the whole story. We also want something back – the vehicle's own observations of the road. If we can get this really local information then it will complete the circle
>
> **Dr Timo Sukuvaara, senior research scientist, Finnish Meteorological Institute**

(Right) **A road weather station installed by the Finnish Meteorological Institute**

€2m to €4m
The estimated annual cost of extreme weather borne by road commuters, in terms of wasted time, in Helsinki (US$2.1-4.3m)

(Source: VTT Technology)

air temperatures, wind speed and wind direction, and has a weather camera. For research, it has extra capabilities including visibility and snowdrift measurement, frost depth and underground temperatures, road surface sensors for temperature and condition, an infrared camera and an optical system for analyzing road friction. In FMI's station nearby there is equipment that analyzes snow and water particles, snow depth and weather radar.

"We can send this information to the vehicles using the hotspot roadside unit, but that's not the whole story," says Sukuvaara, "We also want something back – the vehicle's own observations of the road. If we can get this really local information then it will complete the circle." In other words, as there is a communications link, why not use it to collect road weather data from moving vehicles nearby and combine it with data from the static sensors?

"This is our vision, so we have equipped three of our vehicles with sensors," says Sukuvaara. "Of course,

(Top and above right) **Signs display current chain conditions on Interstate 5 in Yreka, California** (Above) **Hazardous conditions on the entrance road to Interstate 5**

a car's own CANbus onboard unit could send us relevant data, related to road-surface temperature, air temperature, road-surface condition and wiper activity, but no car manufacturers have yet given us access." So the three FMI vehicles have been proving it's feasible for them to be mobile road weather observatories and transmit useful data for processing.

The next step is for FMI to work with a telematics systems provider so that it can compare the quality and reliability of the data it gathers through its standard methods with what can be acquired using vehicles. Meanwhile, the truck carrying the equipment of the Finnish ski team between major European sports contests during winter 2015/16 has been fitted with sensors to monitor the road surfaces it travels on and communicate their status to FMI.

A unit on the truck will use a laser radar to measure the water, snow or ice on the asphalt and the temperature of the road surface. The FMI will interpret the data and share its assessment of road – and ski – conditions with the team. The skiers will then be able to refine their journey plans to each venue – as well as their strategies for competing on the piste.

Signs of the times

Getting information about hazardous road weather to drivers is not always so simple. On Interstate 5 in Yreka, California, signs that tell drivers when they should fit chains to their tires to improve grip are routinely changed during storms. Previously

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20,000
Average number of vehicle crashes annually in the USA attributed to fog, causing around **400** fatalities

(Source: Vizzion)

maintenance workers had to walk across the freeway to the signs on the median whenever a chain control condition changed. This exposed them to three lanes of traffic in conditions of icy, snow or poor visibility with each traverse. In response, a team in Caltrans District 2 developed a semi-automated system that enables the signs to be controlled remotely from a roadside cabinet or cell phone.

"With four sets of signs to be turned manually, workers had to traverse the highway eight times," says Keith Koeppen, who provides ITS engineering and support to Caltrans District 2. The solution for

(Above and below) **VMS provide real-time information about traffic conditions on Interstate 5, California**

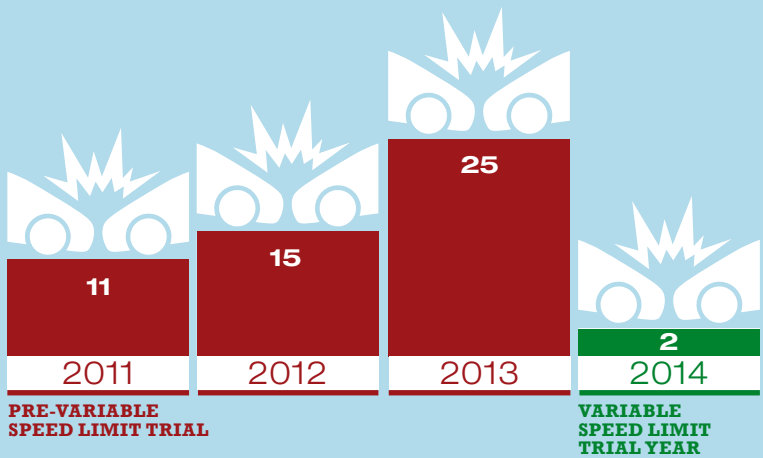
> With four sets of [chains required] signs to be turned manually, workers have had to traverse the highway eight times
>
> **Keith Koeppen, ITS engineer, Caltrans, USA**

Variable success

To make roads safer in extreme weather, a small corner of Texas has gone against its usual stance on variable speed limits

Trials with variable speed limits (VSLs) triggered by road weather conditions have had a dramatic result on road safety in Texas. VSLs are not normally allowed in the Lone Star state, but the legislature approved and required a pilot program using them that was completed in February 2015. In the trial an Envirotech Sentry visibility sensor and an IceSight friction sensor were set up by TxDOT at Ranger Hill on the IH-20. It is a steep hill with a curve and a history of ice and fog.

With a short lead time for the trial, standard portable message signs to display the limit in numerals were used, with a mask overlaid to make it look like a regular speed-limit sign. Algorithms analyzed the incoming sensor data over three months and changed the VSL when road weather conditions changed, and with the approval of staff.



The crash rate for Ranger Hill, IH-20, in Texas was steadily rising before the weather-based variable speed limit trial. In the trial year there were just two crashes, neither of which was fatal or caused serious injury

eliminating such risks was to use electronics, with drivers' attention being drawn to specific advisory signs by attached flashing beacons. The signs are illuminated at night. A variable speed limit sign close by displays the appropriate maximum speed for the current conditions. All can be controlled without a worker having to step onto the freeway.

While the new setup eliminates the hazards for workers, it's not yet clear how drivers will react to the new signage, because last year's mild winter on the affected Anderson grade meant there was no call for chain control. That's the trouble with weather – long-term predictions are all but impossible. Nevertheless, with the continued judicious application of ITS, managing roads according to short-term forecasts, and reacting in real time to current weather conditions will become increasingly effective, which in turn will make travel times more predictable and improve safety when the weather turns against us.

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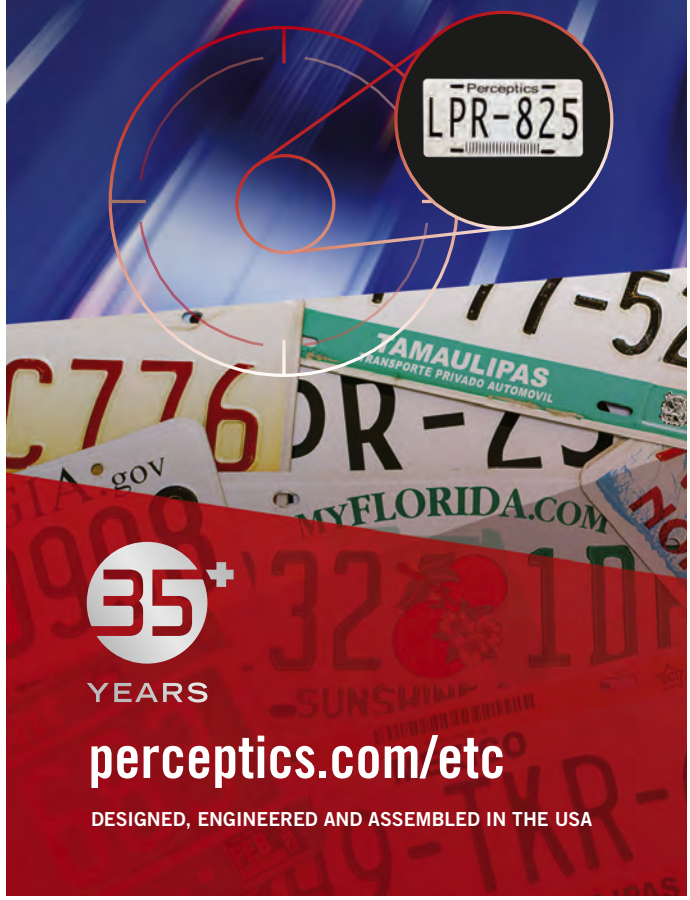

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Into the next dimension

Lidar 3D-imaging technology is one of the cornerstones of autonomous vehicle development, but as **Max Glaskin** discovers, this new type of machine vision also has applications in speed enforcement, active safety and asset surveys

Illustration: Artemenko Valentyn

Lidar adds an entire dimension to machine vision: depth. Software can generate 3D images by analyzing data from other sensors, but lidar (laser image detection and ranging) creates a pop-up world, instantly. Ever since the first DARPA autonomous vehicle challenge a decade ago, lidar has enabled vehicles to map their surroundings and avoid obstacles.

Without lidar, Google's self-driving car would be a battered wreck. Lidar will be key to Volvo's Drive Me automated cars when 100 ordinary customers receive them in Gothenburg in 2017. Seven of the top 13 OEMs are working with lidar for advanced driver assistance systems (ADAS) and more than a quarter of lidar units (by value) are set to find their way onto autonomous vehicle projects. Like the models it builds, the interest in lidar seems solid – the annual market for lidar on passenger vehicles will grow from last year's US$51.1m to US$141m by 2021, says consultancy Frost & Sullivan.

"Lidar is more robust, has better resolution, gives better 3D range information, and is not dependent on lighting, compared with traditional vision systems," says Jesse G Hurdus, autonomy lead at TORC Robotics in Blacksburg, Virginia, USA, which has been building self-driving vehicles for a decade. He recently led a research team that demonstrated a new system that enables a blind person to drive a car.

Like so much solid-state technology, lidar is being miniaturized repeatedly, without reducing the field-of-view and resolution, says Hurdus. The latest unit from Velodyne scans in 16 planes, yet is smaller than previous single-plane units for the same price. Nevertheless they're still not cheap, especially compared with the average price of US$30,000 for a new car.

"I think US$50,000 to US$70,000 is a realistic price for a complete lidar system on an R&D autonomous vehicle," says Hurdus, "That price will fall, of course, when you get into volume production."

Smaller sensors are available for less than US$10,000 each, but more than one may be needed to give the

vehicle a wide enough view of its environment. "Lidar is more costly than a camera because it's an active sensor that has to emit pulses itself," says Hurdus. "So it requires extra electronics and they have to be calibrated more finely."

Being active, it can gather information that thwarts standard vision systems – with its infrared wavelengths it can effectively see in the dark.

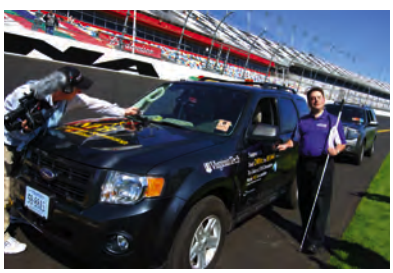
"It does have shortcomings; particulates in the air such as dust and water reflect or refract the beam," says Hurdus. "Longer wavelengths are being considered in order to attempt to overcome these problems, as are higher powers, but that has safety implications."

Software solutions

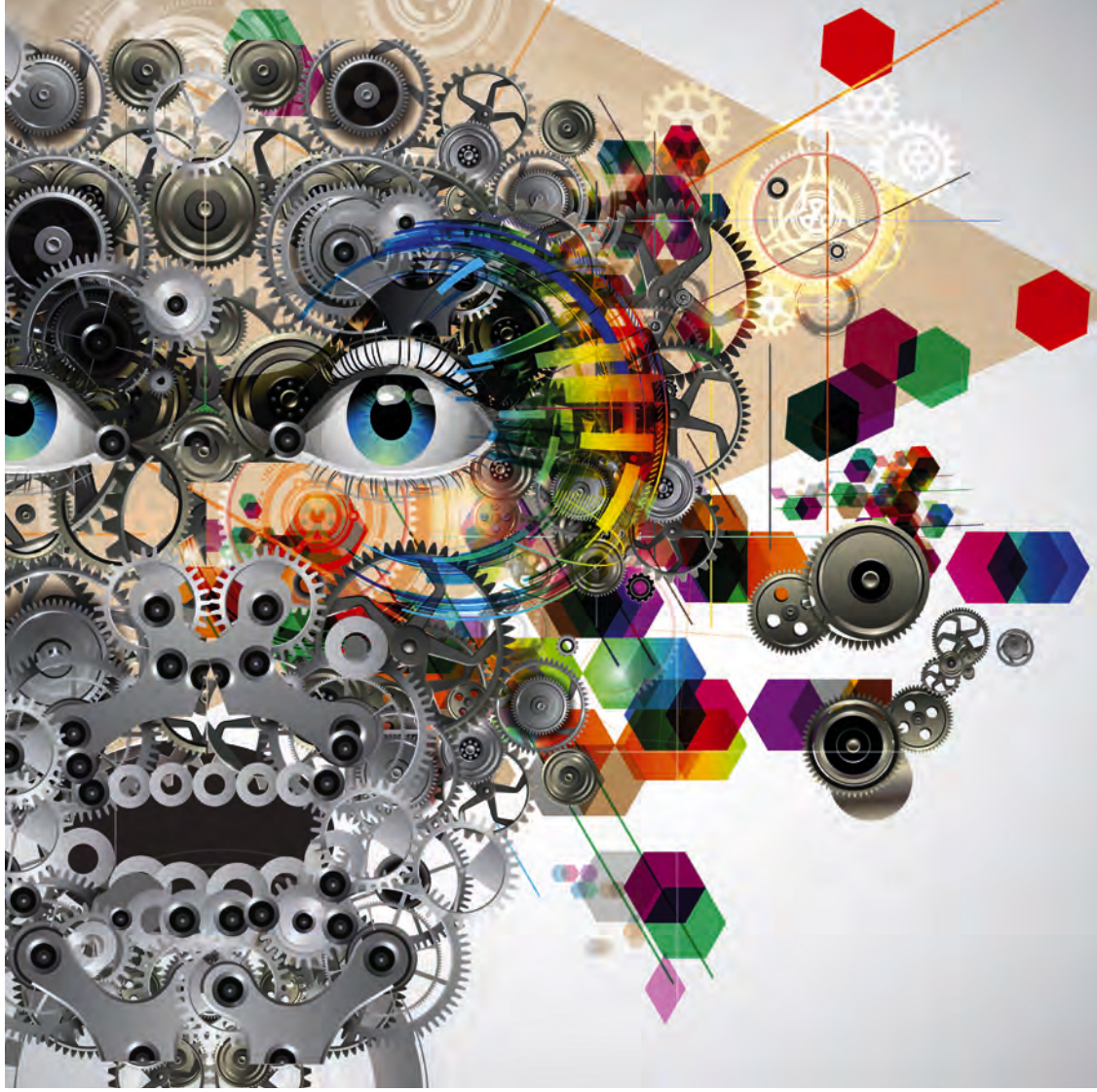
Good software is key to interpreting the returned signals. A uniform surface with mirror-like qualities, such as water, could be a problem, but software can help identify it and even use the information to aid the detection of hazards such as ice.

"It's all about the software," Hurdus stresses. "When you're getting three, four or five sensors on a single vehicle, the amount of processing grows, so the goal is to simplify the actionable information. Fundamentally lidar will give you shape and range and, by combining that with data from other sensors, the software can answer questions such as 'Is that a car, a bike, a person or a wall? Is it moving? Which way and at what speed?'"

As lidar and other sensors rapidly improve and become capable of gathering more information, the demands placed on processing



software and hardware to fuse that data has also grown at a similar rate. "Graphics processing units for parallel processing can help, with specific software," says Hurdus. "Nvidia is currently developing a hardware computing platform that is dedicated to self-driving cars."



> Lidar does have shortcomings; particulates in the air such as dust and water reflect or refract the beam. Longer wavelengths are being considered to overcome these problems
>
> **Jesse G Hurdus, autonomy lead, TORC Robotics, Virginia**

Real-world applications

But lidar is no longer simply the preserve of expensive autonomous prototypes and research vehicles; Toyota is using an integrated sensor module that includes a lidar camera in its Safety Sense C active safety system – which is already available in the 2016 versions of its RAV4 and

(Left and right) **Virginia-based TORC Robotics has developed a system that enables a blind person to drive a car**

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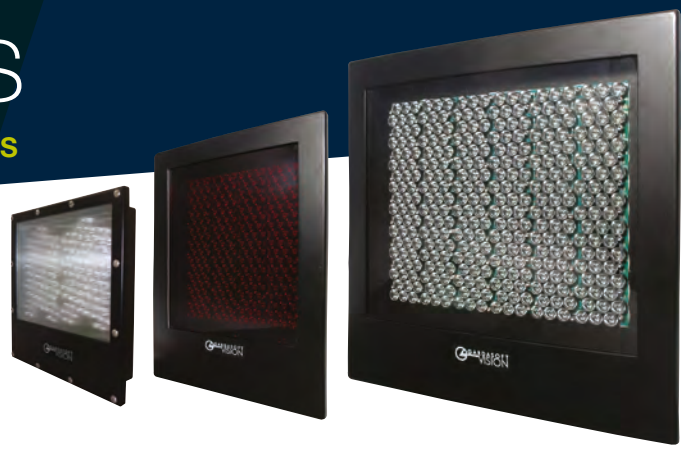

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Unsure shooters

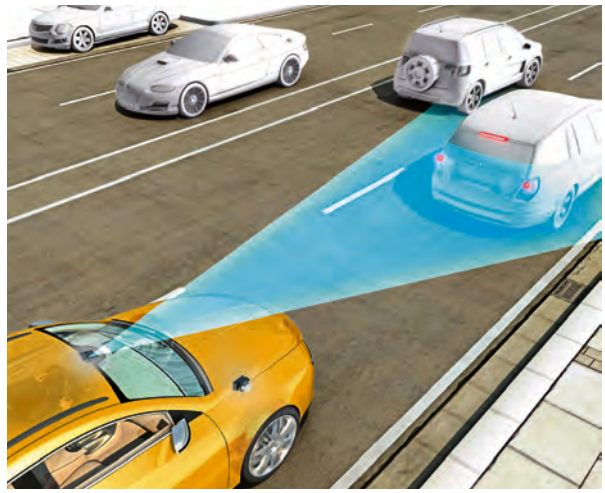
It used to be said cameras never lie, but when it comes to lidar, university researchers have managed to fool the lens

Every system that receives signals is vulnerable to attack and Dr Jonathan Petit has shown that lidar is no different. He and his Masters students at the University of Twente, Netherlands, showed how to trick a lidar unit into 'seeing' another object. The implications could be significant for ADAS and autonomous vehicles in particular.

Put simply, they were able to generate 905nm laser pulses and beamed them at an IBEO LUX 3 unit installed in their lab to create fake objects on the lidar visualization.

Not surprisingly, their discovery in September 2015 caused shockwaves, with pundits fearing the worst for vehicle 3D sensor systems. Yet Petit, now a principal scientist at Security Innovation, is satisfied that his hack is making lidar more robust.

"I'm really pleased by the reaction of the industry," he tells *TTI* from the Black Hat Europe security conference in Amsterdam. "We had worked closely with IBEO during this project. They helped us and have since developed countermeasures. Then others, including Velodyne and some Tier 1 suppliers, called me because they want to make even more robust sensors, improve validation tests and have security by design at the sensor level. It shows they are being responsible and proactive."



(Above) **Automated braking assistance is integrated into new Toyota cars**

Avalon models, and will be rolled out to more models in 2017. If a collision is imminent the Continental-designed unit prompts the driver to brake and, if the driver doesn't react, the vehicle applies the brakes automatically. A CMOS camera categorizes objects and a 905nm lidar monitors 33ft (10m) ahead, calculating the distance to any object with an accuracy better than 4in (10cm).

"In the Multi Function Camera with Lidar (MFL), we have integrated two particularly competitive sensor technologies," says Soeren Pinkow of Continental's chassis and safety division. "By specifically combining the strengths of a camera with those of an infrared lidar, the new sensor module is able to detect objects ahead of the vehicle and, when there is a possibility of collision, it prompts the driver to brake with an audio and visual alert. Up to a speed of approximately 50mph (80km/h), a crash can be completely avoided if the relative speed to the detected object is less than 31mph (50km/h). If the speed differences are greater, emergency braking will considerably reduce the force of the impact."

> By specifically combining the strengths of a camera with those of an infrared lidar, the new sensor module is able to detect objects ahead of the vehicle
>
> **Soeren Pinkow, chassis and safety division, Continental**

(Left) **The building blocks of advanced driver assistance systems (ADAS)**

Hyundai is assessing how lidar fused with camera data can trigger automatic braking. Pioneer, the Japanese electronics giant best known for its in-car infotainment

units, is developing low-cost lidar for ADAS and automated driving, with commercialization due in 2017.

Lidar beyond cars

As costs fall, drivers may not be the only road users to benefit from lidar. A US$115 unit from PulsedLight, said to have a range of 40m, accurate to 2.5cm, has been tested on a bicycle, alerting the rider to the distance of vehicles approaching from behind.

Road workers can also benefit from lidar. A system to safeguard them from being hit by vehicles is going mainstream in France. The first mobile enforcement trailer, containing Vitronic's PoliScan Speed lidar equipment, has been deployed at a workzone by the French Interior Ministry. By the end of 2016 there will be 150 of the movable units protecting workzones across the country. "The trailer is autonomous, so it doesn't require mains power or telecoms to work," says Paul-Emmanuel Caillard, head of the ministry's automated control department. "And the lidar solutions offer good performance, which helps to enforce speed limits."

Traffic management could be the next advance. Researchers working at Purdue University in Indiana, USA, aim to process data from lidar units at intersections to get highly accurate 'microscopic' 3D information about all the traffic passing by, including not only cars and trucks, but bicycles and pedestrians, too.

Even though the boss of Tesla, Elon Musk, said in October that he cannot see a role for lidar on autonomous cars, his view is in the minority. From its current and planned applications for looking out from vehicles, looking at traffic and assessing infrastructure, it's clear that 3D lidar will eventually be as ubiquitous in all areas as video cameras are today. How quickly it develops will be measured in the fourth dimension – time.

Enhanced assessments

Lidar can build accurate 3D models of streets, which include everything from buildings and roads, right down to street furniture

Photograph: Bluesky

Automated surveys of highway assets can be improved with lidar when the right software is used. The UK's Transport Research Laboratory (TRL) has run a vehicle equipped with lidar at traffic speeds along the M25, London's orbital motorway, and used an algorithm to slice the large data sets into manageable lengths without losing vital information.

It automatically identified steel and concrete roadside barriers. For 80% of them, it estimated their heights to within 5cm. A different algorithm was used to identify bridges, footbridges and gantries from the data – it spotted 25 out of 26 and correctly classified the eight road bridges among them, together with an accurate estimate of their height.

Other assets have been identified with lidar aerial surveys, by companies such as the UK's Bluesky, which uses lidar and thermal mapping to generate data sets that can be used for planning, mapping, terrain modeling and asset management.

"High point density lidar can also be used for street furniture inventories, especially when combined with simultaneous aerial photography. The level of detail achievable means that most assets will be visible and can be spatially mapped with a high degree of confidence," says Ralph Coleman of Bluesky. Reflective road markings can also be detected and mapped.

A lidar-generated 3D inventory of infrastructure objects could benefit a highways operator in more ways than just asset management. The information could be a revenue stream if it's incorporated into the databases for commercial ADAS.

Illustration: Artemenko Valentyn/shutterstock.com

> "Lidar solutions offer good performance, which helps to enforce speed limits. Our lidar trailer is autonomous, so it doesn't require mains power or telecoms to work"
>
> **Paul-Emmanuel Caillard, head of the automated control department, French Interior Ministry**

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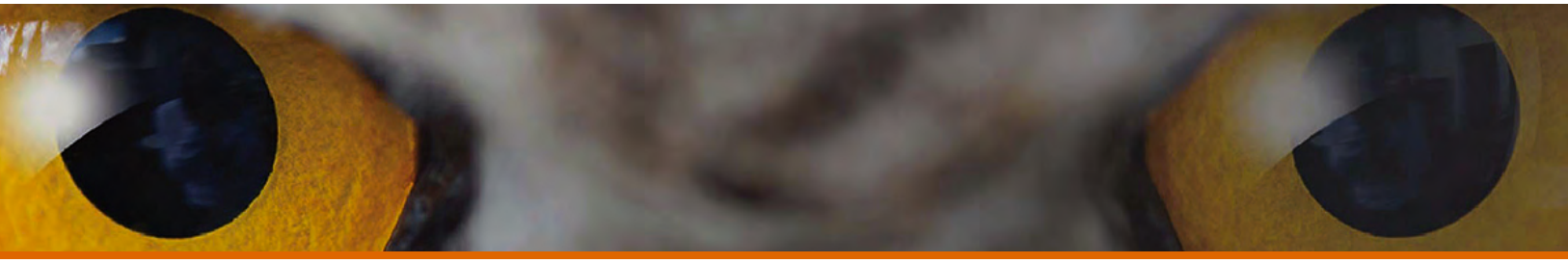

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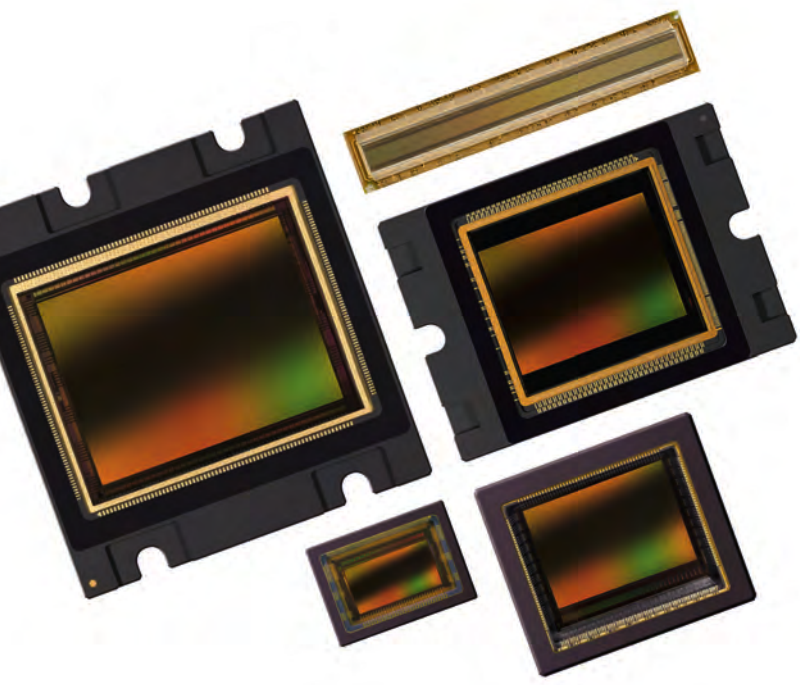

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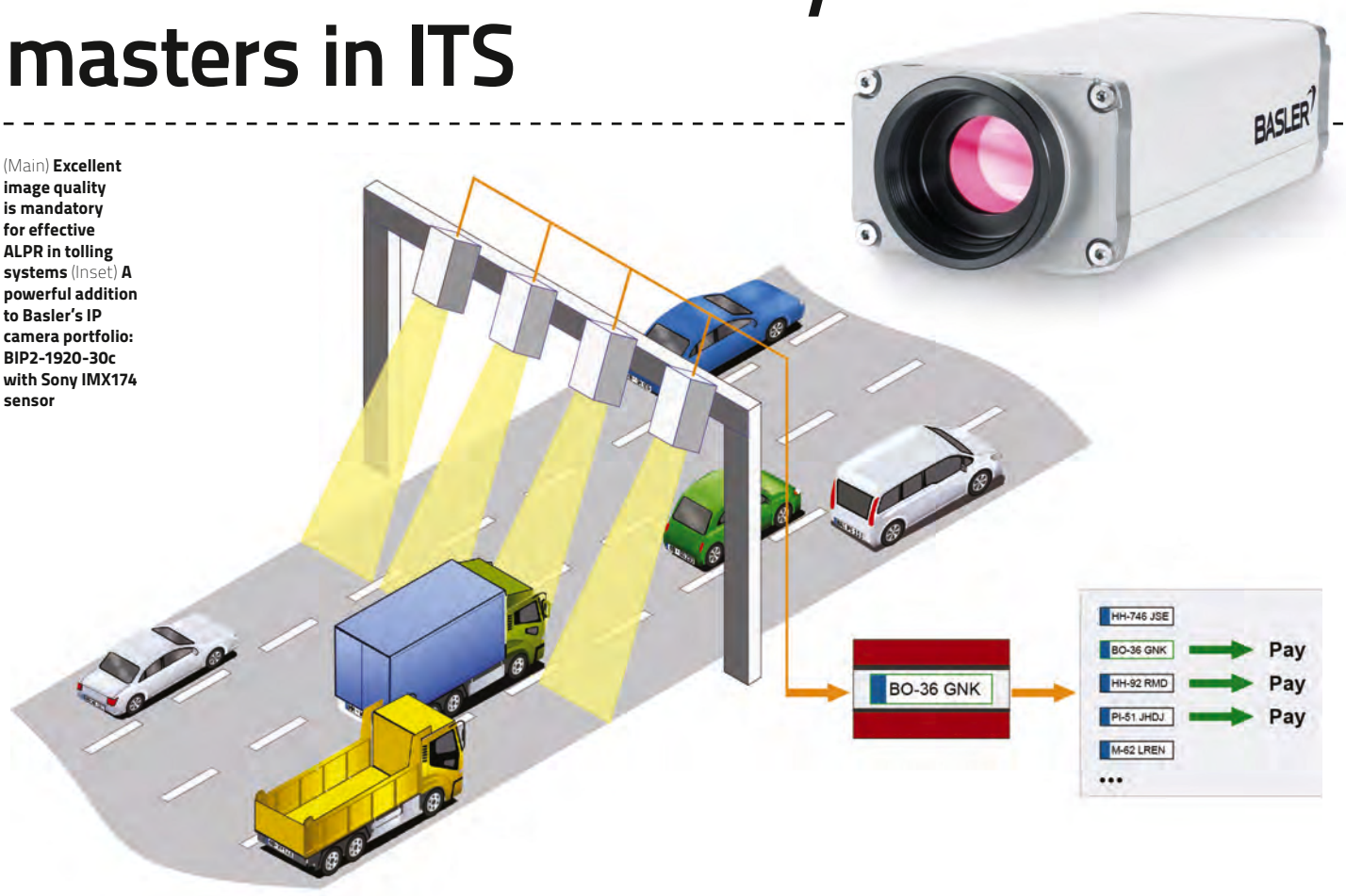
IP cameras serve many masters in ITS



(Main) **Excellent image quality is mandatory for effective ALPR in tolling systems** (Inset) **A powerful addition to Basler's IP camera portfolio: BIP2-1920-30c with Sony IMX174 sensor**

Traffic safety laws are not easy to enforce. Drivers dominate the streets, and the lives of unprotected road users, such as pedestrians, cyclists and motorcyclists, are often endangered. Enforcement solutions exist not just to catch offenders, but also to raise public awareness about rules, and promote greater compliance with road safety standards and regulations. The main goal is always to prevent serious traffic accidents and to save lives.

Detailed image and video material is mandatory for use as legally admissible evidence. For this reason, red light enforcement systems with multiple cameras are used to document the violation completely, with a separate image for the license plate and driver, as well as an accompanying video stream.

Strong feature sets and flexibility are also a must, as the systems must be ready to accommodate the regional and application-specific customizations that come with global deployment. For many projects, the infrastructure predetermines the camera type. For example, access controls for parking lots tend to need IP cameras so that they can be integrated directly into existing security systems.

Traditional, basic IP cameras are often used in simple traffic applications like traffic surveillance, traffic flow analysis, or incident detection systems. For these applications, video streams with limited resolution will do the job.

More sophisticated traffic applications, such as enforcement or tolling, however, require crisp single shots to enable automatic license plate recognition (ALPR) algorithms to read the license plate reliably.

That's where Basler IP cameras come into play: they provide video streaming as well as real-time triggered single shots (JPG/YUV) on highly sensitive sensors such as Sony's IMX174.

With this feature set, Basler's IP camera enables integrators to reduce the number of cameras in some multi-camera setups.

Flexible enforcement

ALPR is a versatile technology that is currently used in many different traffic applications. With its rise as a technological cornerstone of modern traffic systems, the importance of image quality is essential. The high speeds inherent to the traffic field necessitate sensors with global shutter technology and high sensitivity, typically built around large pixels that allow for clear images despite short exposure times. This includes, for example, access control systems, high-speed applications such as free-flow tolling, enforcement and dragnet-style investigation.

Enforcement systems offer a wide range of potential applications for IP cameras. For example, law enforcement may potentially be looking for speed and red light enforcement or lane-violation detection. Other typical areas of application include the detection of illegal

(Above) **Basler IP camera**

(Above) **IP cameras complement existing security systems and can be easily integrated**

use of bus and carpool lanes, or vehicles passing stopped school buses.

Many tolling systems incorporate transponder technology. Both RFID (radio-frequency identification) and DSRC (dedicated short range communication) have grown into standard technologies for electronic tolling, and are used worldwide.

Regardless of their specific tasks, all of these systems have one thing in common: they all require cameras for security reasons and to identify toll evaders. In some cases these cameras are still analog, or more often IP cameras with small sensors, leading to long exposure times and blurry video streams. The Basler IP camera with its large pixels provides the necessary image quality to identify license plates automatically by ALPR algorithms.

A growing number of IP cameras are being used to assist police investigations by providing images and parallel video recordings for in-vehicle applications. This includes recording of license plates of passing vehicles, detected using ALPR algorithms, and comparing them against a database of criminal activity associated with those plates.

In the rail sector, IP cameras also support the identification and filling of rail cars. The automation of these control system processes plays a huge role for the manufacturing industry. The numbers on the railroad cars allow for a unique identification and assignment. The data is combined with the results of a weighing system to determine the consumed raw materials and fill level, allowing for clear, fully automated identification of the individual railroad cars and tanks.

Road and rail inspection systems help with the timely initiation of maintenance and repair measures. Other applications such as train driver assistance systems and train inspections are intended to promote greater safety, such as by supporting the driver in detecting train signals and by monitoring the technical state of pantographs during normal driving operations.

Optimized imaging

With its portfolio of IP boxed models, camera manufacturer Basler offers a broad range of possible options with either CCD or CMOS sensor technology, resolutions from VGA to 5MP, and frame rates of 12.5 - 95fps. All models provide multistreaming (MJPEG/MPEG-4/H.264) functionality, while all global shutter models are additionally equipped with a real-time trigger for parallel capture of individual still images (MJPEG/YUV) and videos. They are outfitted with global shutters and offer high sensitivity for detecting even the minutest details for effective image analysis.

Need to know

Sophisticated traffic applictaions require real-time image capture with sensitive sensors

- The field of monitoring in transportation encompasses a broad spectrum of applications in which IP cameras are primarily used
- Typical applications include weigh in motion (WIM), vehicle identification and traffic monitoring
- Systems are most frequently tasked with monitoring traffic flows; detecting accidents to ensure rapid reaction by the authorities; and synchronized switching of traffic lights to promote a smooth traffic flow

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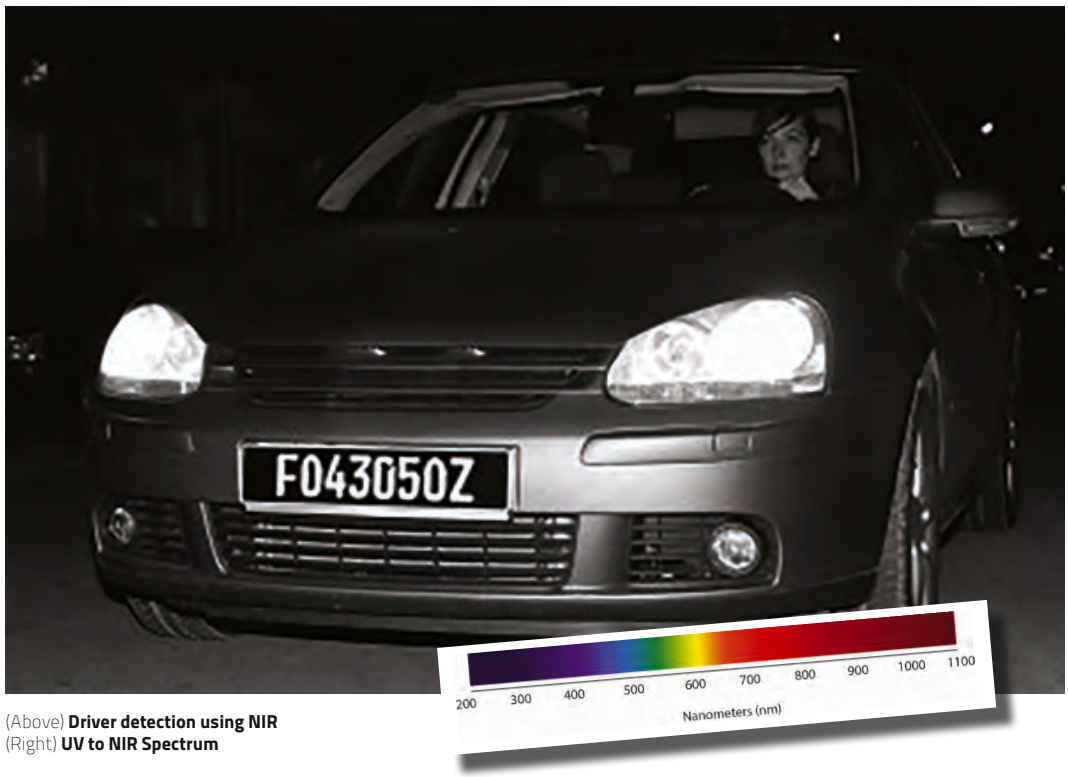
The untapped potential of near infrared imaging for ITS applications

The adoption of near infrared (NIR) for imaging is still not being fully realized for many ITS applications. This can mainly be explained by the fact that in some applications, a technology upgrade is not necessary. For example, if the use of high-power flashes to capture night images (with color) is required and is compliant with local regulations, then there is no need to change. But what about applications where using only the visible spectrum of light does not produce the required results or optimize the accuracy for positive identifications? NIR might be the answer.



(Above) **Driver detection using NIR**
(Right) **UV to NIR Spectrum**

Need to know

NIR provides benefits for established and emerging ITS applications

- The International Commission on Illumination defines NIR to be IR-A: 700-1,400nm (0.7-1.4µm, 215-430THz)
- If we consider the limit of cameras built with silicon-based sensors, NIR is typically limited to a realistic threshold of 1,000nm
- The visible spectrum is typically defined as 380 - 760nm. Using the 760 - 1,000nm non-visible spectrum has benefits for many applications, especially for imaging at night where a system is built with an LED illuminator at 850nm and a monochrome camera is used to capture images due to its higher responsivity in the NIR domain

In many enforcement and tolling applications today, NIR is being used to illuminate vehicles and drivers at night as an alternative to high-power flashes (visible range illuminators) since the strong visible light from a flash can distract drivers and cause traffic accidents. In some regions, regulations prevent the use of visible range illuminators. NIR light is invisible to human eyes, so there is no risk of distraction to drivers during daytime and night-time operation.

In some regions, the driver of the vehicle must be identifiable in the image capturing the infraction. NIR has proven to perform well for penetration of the windshield to capture the details required to identify the driver without glare.

Emerging ITS applications such as automated enforcement of high-occupancy vehicle (HOV) and high-occupancy tolling (HOT) lanes can also benefit from NIR imaging as it is one of the best tools available today for 'seeing' into the vehicle. Within these applications, the requirement is to count the number of occupants inside the vehicle and then validate against the requirements.

Governments and ITS companies may choose to add other new enforcement options that could also use NIR technology. For example, in many regions of the world, cell phone use while driving a vehicle is prohibited. Automated detection and enforcement for this application is not yet readily available, but could use the same NIR imaging techniques and camera positioning as HOV or HOT enforcement systems, thus increasing the enforcement rate for more infractions.

Imaging and innovation

At the recent ITS World Congress 2015 in Bordeaux, France, many of the speaker sessions and demonstrations covered advanced driver assistance systems (ADAS) and technologies, from the research and development to pilot programs. Imaging is critical to many of the applications where automation relies on the proper detection of objects and does not require lidar, which can be cost prohibitive.

At the event in Bordeaux there were demonstrations

of imaging systems, with algorithms used to detect roadside borders for ADAS used on open road conditions (no technology part of the road). These algorithms could identify the road boundaries.

"At the ITS World Congress, I had the opportunity to chat with a senior engineer working in an automotive systems group for a large company," says Eric Ramsden, director of product management, Lumenera. "When discussing the algorithms and technologies used to do 'curb' detection, I asked why they didn't consider NIR imaging to improve the contrasts between vegetation and concrete/asphalt. It was not previously considered, but after some discussion, he was interested in the fact that with NIR lighting and a high-performance monochrome camera with good NIR responsivity, there could be additional data in the images that would further improve the accuracy of their algorithm. Sometimes, translation of technology and ideas from one domain can benefit another domain."

Imaging in intelligent transportation systems is growing at a rapid pace and the uses for this technology vary considerably, whether employed for capturing images inside or outside the vehicle, or for the many ITS infrastructures. The industry is finally starting to use the light spectrum outside the visible range to solve some of the unique challenges that the ITS industry faces today.

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by **Mike Schagrin**

How can a synergy between connectivity and automation benefit electric vehicles?

When it comes to charging an electric vehicle, there are several options available. There's the traditional plug-it-in version, the up-and-coming static wireless charging (park and charge), and the future dynamic wireless charging (charging while driving). So, where does the connected vehicle feature fit?

Previously, I've discussed the synergy between connectivity and automation and how this can create greater capability and benefits than both operating in isolation. Now I want this discussion to include vehicle electrification.

Electric vehicle consumers are on the rise, and as this industry grows, there will be an expanding interest in how the recharging of batteries can be more accommodating. In addition, there needs to be a way of addressing one of the biggest issues people have with battery powered vehicles – range anxiety.

Dynamic wireless charging can address the range-anxiety issue and additionally, provide a means by which automated vehicles can run more efficiently (e.g. continuously running transit vehicles on a fixed loop).

If there were charging loops along segments of roadway, electric vehicle owners could charge their vehicle as they travel toward their destination. The concern about running out of power decreases, which in turn makes battery-powered vehicles much more attractive.

Likewise, if there are charging loops along a fixed transit loop, then battery-powered vehicles could travel for greater periods of time, essentially continuously, and would only need to stop occasionally.

However, dynamic wireless charging requires the other technologies of connectivity and automation to be in place. Connectivity is needed so that the vehicle can communicate with the charging infrastructure to exchange the required information, to enable the power transfer to take place. Because of the speed at which the vehicle is moving, DSRC is currently the likely technology of choice. Additionally, vehicles need to be tightly aligned with the charging coils, which means automation is needed to achieve this alignment precision. Otherwise, the efficiencies of the power transfer would not be achieved and there would be too much power loss to make this approach cost-effective.

> Connected vehicle technology is clearly a building block to the future

The concept of dynamic wireless transfer is not without its challenges; there are costs and practicality issues of installing the necessary infrastructure in the road network, and of course, safety and performance issues as well. The International Transportation Innovation Center in South Carolina, USA, and the Transport Research Laboratory in the UK are both trying to advance the research to the point of commercial viability.

While it may be several years before in-motion wireless charging becomes commercially available, connected vehicle technology is clearly a building block to the future. Not only for automation and electrification, but undoubtedly for many other capabilities as well.

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

New perspectives for mobile monitoring

Sometimes safety and security are all about size – and when talking about mobile surveillance or in-car security, 'smaller' is almost always better. Tamron is pioneering this emerging concept with its new advanced, small-size camera module block, MP1010M-VC. With Full HD resolution and in-built vibration compensation, the Japanese manufacturer's tiny camera module offers a range of new possibilities across different applications.

In fact, the increase in the demand for high-performance video cameras that are small, yet provide all the benefits of larger installations, has been one of the most visible recent trends in traffic safety. Questions about dash-cam equipment, drones, driverless cars and public transportation security were one of the most important elements of recent industry events such as IFSEC 2015 and Intertraffic, where Tamron's new high-tech imaging application aroused great interest among visitors.

For the new module, Tamron has combined the strengths of its two main business divisions. "We already have an extensive portfolio in high-performance lenses for IP/CCTV and machine vision," says Thomas Osburg, European sales manager, Industrial Optics, at Tamron Europe. "But Tamron is also widely known as one of the leading producers of photographic lenses."

While photographers around the world already enjoy Tamron's original vibration compensation (VC) function, the advanced technology now finds new ways into the traffic safety and security market.

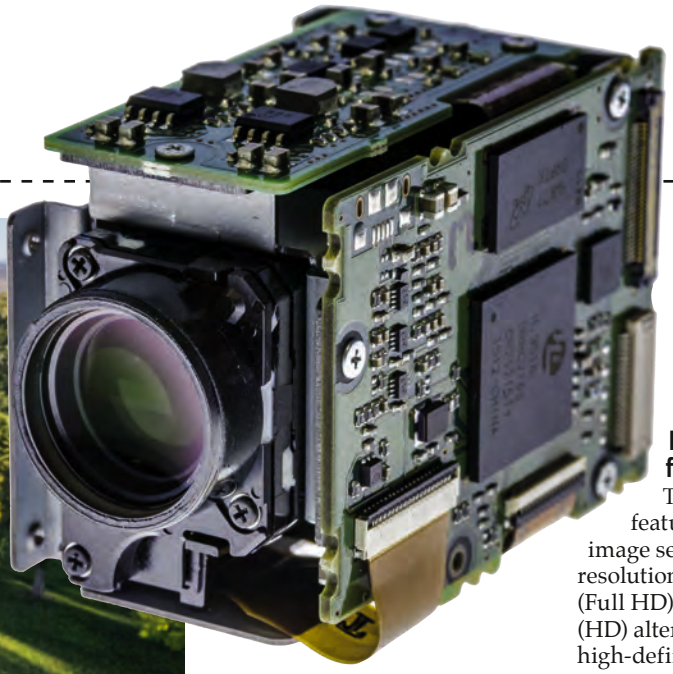
"Thanks to the VC function and its intelligent defog and noise-reduction capabilities, the new ultra-small camera module produces crystal clear and detailed images, even under the most challenging conditions," says Osburg. "With its tiny dimensions of 28.8 x 38.9 x 61.8mm and light weight of approximately 70g, this multipurpose camera module fits into many application areas such as police in-car camera systems and border patrol vehicles."

Other intended uses include drones or remotely piloted aircraft, marine surveillance, construction machinery and public transportation.

Tamron's ultra-small camera module is suitable for drones (above) **and traffic monitoring operations** (left)

Intelligent VC technology

Based on professional SLR camera technology, the VC



(Left) **Tamron's MP10101M-VC multipurpose camera system**

mechanism ensures an efficient compensation of camera vibrations and thus an image reproduction without shake, e.g. during a high-speed chase, regardless of the vehicle velocity and the road condition.

The VC mechanism includes a VC lens element that moves in parallel to the image plane via electronic control. In the control unit, two gyro sensors are installed, which grasp the horizontal and vertical vibrations and report them to the microprocessor. This calculates the rotation angle and passes on the respective control commands to the driving unit that in turn shifts the VC element to counter the direction of the vibration. The system works at a frequency of 4kHz, meaning that a correction is performed 4,000 times per second. Since the VC compensating lens element is held in place, smooth, virtually frictionless movement is assured, providing stabilized images and excellent tracking performance.

Need to know

A new, advanced camera module is ideal for drones and in-vehicle applications

- Additional features of the MP10101M-VC camera include a temperature readout that displays changes in temperatures, an electronic flip to switch the image right-side-up when tracking moving targets below the camera, and an LR reverse to show the image mirror reversed
- The module delivers Y/Cb/Cr 4:2:2 video output via high-speed LVDS and is controlled by Sony's VISCA protocol

Powerful functionality

The MP10101M-VC features a 1/3in CMOS image sensor with a high resolution of 1920x1080 pixels (Full HD) or 1280x720 pixels (HD) alternatively. "This enables high-definition images with 2MP resolution and offers the user the possibility to magnify an image section of particular interest," explains Osburg.

The camera also features a progressive high frame rate of 60fps (frames per second), which many high-end HDTV systems use. Its 60 frames per second are optimal for recording fast-moving objects, which look in fluid motion when replayed. Furthermore, it allows for fluid slow-motion playback. You can slow the recording down two times and still end up with a 'normal' frame rate.

With a 62° wide angle and a fast 10.5x optical zoom lens, the MP1010M-VC offers a broad focusing range (f=3.2mm to 33.6mm). This enables the operator to zoom in even on monitoring objects that are far away from the camera. The zoom function features an internal design, which means that the lens tube does not extend. The maximum optical aperture is F/1.8 at wide-angle and F/3.4 at tele, so even dark scenes can be recorded without disturbing image noise. The minimum illumination required is 0.5 lux when the shutter speed is fixed to 1/30 of a second (target). Image noise is further reduced, thanks to the integrated 2D/3D noise reduction feature.

The MP1010M-VC has a powerful defog function to improve the camera's ability to see through moderate-to-heavy atmospheric disturbances such as fog, haze, dust or smoke. Visibility and video quality (contrast, sharpness) are greatly improved by this feature, thus leading to a higher situational awareness and enabling faster incident detection.

Privacy zone masking enables the user to create a designated area that is blurred or completely blocked by the camera. This way, sensitive material is excluded from the recording. The slow automatic exposure (AE) response is ideal for monitoring areas with abrupt changes in lighting conditions, which pose a challenge in many mobile surveillance scenarios. The function slows the rate at which exposure levels change, enabling users in situations of oncoming night-time traffic, for example, to identify crucial parts of the image, such as license plates or drivers' faces.

Conclusion

Tamron's MP1010M-VC is not only a compact multipurpose camera system, it also offers many high-performance features. The excellent vibration compensation uses SLR camera technology to deliver crystal-clear images, helping customers to improve security and safety in many operational areas.

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Advanced image sensing for difficult lighting conditions

Advanced traffic management systems (ATMS) have become ubiquitous in (sub-)urban agglomerations. Although they are not always popular with many of us, as they are perceived as surveillance apparatus for infractions such as red-light running or speeding, ATMS are essential for ensuring efficient traffic flow and optimizing the safety of drivers and pedestrians, particularly with the ever-increasing number of vehicles in operation.

ATMS also play an important role in toll collection and air pollution control regimes. Next-generation systems are on the horizon: data-centric, behavior-based, real-time networking, with vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, will facilitate a quantum leap to wide-area, self-regulating intelligent transportation systems (ITS).

The key enablers of the leap in performance are new observation tools that make sure these automated traffic systems function as intended. High-resolution cameras equipped with CMOS (complementary metal oxide semiconductor) sensors extending to the near infrared (NIR) will play a crucial role in future traffic infrastructure.

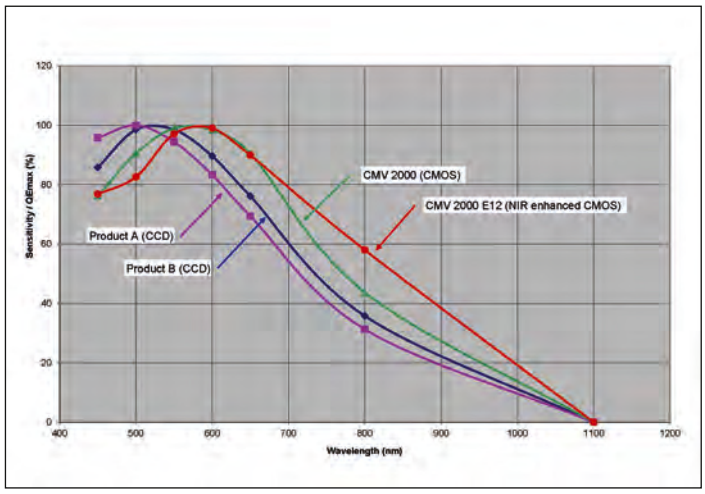
Reliable recognition

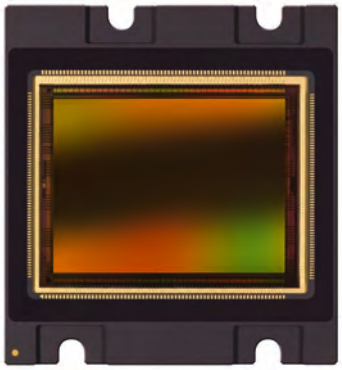
Automatic license plate recognition (ALPR) systems are a key component in advanced traffic management. They are enabled by area and line scan CMOS image sensors operating at high frame rates, with a global shutter. The CMV and Dragster Series developed by CMOSIS, for example, work at various resolution levels ranging from VGA to 20MP for area scan sensors and 2k to 24k for line scan sensors. A low-noise global shutter can expose a full image, without the distorting artifacts created by rolling shutters, and operates at very high frame rates, offering fast windowing capabilities at a wide dynamic range.

(Top) **Sensor windowing centered on license plate**
(Above right) **GATSO GT20 traffic camera with LED illumination unit mounted underneath**
(Above) **ATMS on a busy highway**

ALPR must work day and night, reliably identifying all kinds of license plates, even those that are not self-illuminated. A new way to do this is to illuminate the scene with an infrared (IR) LED array, which is usually mounted underneath the camera. This allows for safe (and invisible) infrared lighting of a road section up to 20m in front of the camera, which doesn't hinder drivers with a flash of visible light. One complication is that image sensors based on silicon – CCD (charge-coupled devices) as well as CMOS – are reaching their sensitivity limits at wavelengths of approximately 1,100nm. To facilitate NIR illumination, CMOSIS has developed an NIR-enhanced version of its CMOS sensors.

One NIR-enhanced product is the CMV2000 E12 image sensor. This is an enhanced version of the standard CMV2000. Its epitaxial layer measures 12μm, instead of the standard 5μm, to improve its sensitivity in the NIR. This 2MP (2,048x1,088 pixels) sensor is used inside Spanish camera maker Imagsa's Atalaya ALPR camera. Atalaya captures license plate information from vehicles on roadways up to 7.5m wide, with simultaneous detection of several vehicles in both lanes. How reliably a license plate is recognized depends on the resolution of the image sensor and the optical character recognition (OCR) algorithms that the surveillance system is built on. OCR software vendors recommend a minimum coverage of three pixels per centimeter of object area to achieve recognition rates of 95% and better. European car license plate letterings come with line widths of about 1cm. Thus an optical sensor featuring 1,200 horizontal pixels is appropriate





(Far left) **Wavelength extension of CMOS sensors compared to near infrared (NIR)**
(Left) **CMOSIS CMV20000 image sensor**

for roads up to 4m wide (3.5m for traffic lanes, plus an additional 0.5m of lane overlap).

Another well-known camera manufacturer which uses a very high-resolution CMOS sensor is Gatso, based in the Netherlands. Gatso uses the CMOSIS 20MP CMV20000 sensor, which was designed exclusively for its widely-used GT20 traffic camera.

The CMV20000 offers a resolution of 5,120x3,840 pixels at a pixel grid layout of 6.4μm². The active sensor area is 32.8 x 24.6mm, which equals the optical format of a 35mm camera. Like all CMV sensors, the sensor's global shutter can operate in a 'pipelined' fashion: during read-out of a processed frame, the exposure of the next frame is started. With CMOSIS's patented eight-transistor cell and correlated double sampling (CDS), dark noise is reduced and non-uniformities are mitigated to a degree that the sensor reaches an enlarged dynamic range of 66dB.

A special property of all CMOS image sensors is that they effectively limit the optical deficiencies (blooming) in image areas that are next to overexposed parts. This is important for traffic situations that are subject to unfavorable lighting conditions, which can impair license plate recognition, especially if the license plates are partly masked or covered by other parts of the vehicle or if they have mirror-like surfaces with glistening reflections. If there are wide differences in light intensity, such as bright sunlight, grey skies and rainy weather, the sensor's dynamic range can be enlarged to 90dB.

Road surveillance does not always require a complete image of a vehicle – only the license plate. To facilitate this, the CMV sensors offer a flexible windowing function, which enables operators to select up to eight n-line windows for a fast readout. This will increase the frame rate but may reduce the data volume captured. Subsampling is a good method to get a quick overview of a scene. In the color version, the image sensor captures only complete Bayer patterns, to avoid false color renderings.

Pixel perfect

A new member of the CMV-Series is the CMV8000, an 8MP version (3,360x2,496 pixels) with 5.5μm active pixels using the patented 8T pixel architecture. Row- and column-oriented optical black pixels are implemented, as well as additional noise cancellation techniques. From an electro-optical point of view, the CMV8000 offers the same performance as the CMV2000 and CMV4000 sensors. It is designed to be system-compatible with these to enable migration to other camera designs and close the resolution gap between the CMV4000 and CMV12000 sensors. The full frame rate of 105 frames per second is achieved by using 16 LVDS (low voltage differential signaling) outputs running at 600Mbit/sec each, and by the proven data interfacing of the CMV12000.

Need to know

CMOS sensors provide high resolution, low noise and enhanced NIR sensitivity

- Following the acquisition of Awaiba in 2014, CMOSIS now also offers line scan CMOS sensors for extreme high-speed and high-resolution imaging
- The Dragster family is very advanced in terms of sensitivity, bandwidth, speed and SNR. The various resolution models (2k up to 24k pixels/line) are highly scalable, making them ideal for a variety of applications

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Machine vision lighting solutions benefit ITS applications

The application of vision-based solutions for ITS applications is set to increase as these technologies' capabilities continue to improve and unit costs fall. However, it is frequently the case that 'headline' technology such as cameras attracts the majority of attention and funding, while ancillary systems – though no less important to an overall solution's effectiveness – are neglected. Taking LED strobe lighting as an example, Peter Bhagat, managing director of Gardasoft Vision, believes that substantial performance and cost advantages can be gained from a more structured approach to complete ITS vision system design.

LED lighting is now realizing its long-held potential for transportation applications. In particular, the progression of LED-based systems into mass production has given users a credible, high-performance alternative to older, xenon-based products. In many instances it is the primary choice of ITS system integrators as they strive to meet evolving demands for high luminous intensity, flexibility of installation and operation, and low cost of ownership. It's also important to appreciate that traffic LED pulse lighting, or LED strobes, are specifically designed for purpose, as opposed to continuous DC lighting, as is used in the security CCTV sector, for example, which cannot meet the intensity levels required for ITS applications.

(Above) **Gardasoft standard LED traffic strobes**
(Below) **The Triniti Traffic SDK enables OEMs to build Triniti functionality into their own software**

Simple solution

LEDs score over xenon-based technology because they enable faster pulsing: typically 30Hz versus 2Hz. This enables detection and triggering to be accomplished via the camera, removing the need for an external sensor, such as a loop or laser, for applications such as enforcement or vehicle classification. In fact many systems now trigger the camera continuously and use the images to detect whether a vehicle or other object is present. That greatly reduces costs because there is a much-reduced installation and maintenance burden. In addition LEDs themselves have no consumable parts, resulting in even greater savings.

Nevertheless users and specifiers face some confusing choices, which can be complicated by an absence of agreed standards for LED systems within ITS applications – with the result that suppliers may have differing parameters for describing their products' performance. For example, some state input power

Need to know

LED strobe lighting solutions can optimize the performance and cost-effectiveness of ITS

- Application benefits of intelligent lighting for ITS include: predictable aging of lights; consistency of illumination performance, including auto-correction; auto-IRIS control by camera manufacturers to cope with changing light environments; multi-pulsing (taking different images of one scene); and more repeatable light levels over years
- There are also benefits in terms of networking for setup and maintenance and for applications where there are two requirements for the same scene

(watts) while others quote output light (lumens).

Intelligent lighting

Intelligent lighting technology is also an important development and consideration for ITS. Indeed, Gardasoft is bringing its patented Triniti intelligent lighting platform, which was developed for the machine vision sector, to its series of LED strobe illuminators for traffic applications. This will provide traffic OEMs and systems integrators with a seamless, easy-to-use connection between OEM traffic software, cameras, system hardware and lighting. Typical system functions include: plug-and-play configuration of hardware and software; integration with traffic OEM software via APIs and industry standard protocols; reduced setup time; increased information for remote diagnostics; and consistency of lighting over time.

Traffic applications are fast benefiting from machine vision technology, which provides detailed information about important elements of a system. Also, crucial factors such as consistency of image capture can be guaranteed.

For most projects it is not only a case of users ensuring that they are selecting the most appropriate ITS vision technology, but that they are also working with suppliers who assist them with effective application advice and testing so that they arrive at the right solution for a given project.

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by **J J Eden**

How should we approach customer service and deliver quality for users?

Greater customer satisfaction leads to more business

Bill Gates once said, "Your most unhappy customers are your greatest source of learning." While most people in our business know that may be true, few know what to do about it.

Recent devastating articles in the USA about poor customer service in the cable TV industry have prompted many watercooler conversations about similar bad customer service experiences. We all have at least one. Whether you manufacture a product, delve into politics or provide a service, the 80/20 rule usually applies: 80% of trouble comes from 20% of problems.

The same holds true for toll operators' customer service centers. The majority of our customers open accounts, travel the toll road and replenish their accounts or pay their bills without issue. It's a small percentage of customers who are the most vocal, push customer service representatives (CSRs) over the edge, and include every government official they can find on the internet when emailing their complaint about the "horrible treatment they suffered as a result of using your toll system".

So how do we respond to these complaints? Should we be firefighters waiting for a complaint and then try to fix the issue? Or should we look at what other industries do and be proactive? Compare Apple's customer ratings with those previously mentioned cable companies. Other industries look at customer service from a different perspective. They see that your greatest way to constantly improve can come from objectively looking at your operation with a constant eye for quality improvement. They know that it is not just about customer phone calls and store-front processes, but the attitude within the entire operation. Sure, we all include the measurements of our business operating system or roadside key performance indicators in our contracts. But it is more than that – we need to take our operations from a requirement mentality to a total quality management program.

Often, quality control (QC) and quality management (QM) are seen as one-and-the same. In reality, QC plays an important role in our customer service centers but is reactive, requirement-filling and organization-focused. QM is a customer-focused process based on planning, prevention and being proactive. QM processes should constantly be updated to fulfill your customers' needs.

If you are questioning the value of this, look at the press from those that don't. Greater customer satisfaction and an enhanced reputation lead to more business and greater trust. We all need to treat our customers the way we would like to be treated. We need to recall the last time we phoned a customer service center to complain about a bad billing or product or maybe even called for information and the CSR was having a bad day, then so did you. We need to implement better ways to track our performance without relying solely on our customer service providers.

We need to find a way to track and record performance more independently, consistently and reliably so that we really know how we are doing prior to the phone calls. We need to avoid the fires as an industry, not just scramble to put them out.

J J Eden is the director of tolling at Aecom.
james.eden@aecom.com

New vision for transportation management and control

The world's transportation infrastructure is congested and overused. Inefficient traffic flow, vehicle accidents and freight transportation delays have a substantial economic impact. Plus, ensuring the security of critical transportation systems has become vitally important.

In an effort to manage and control the world's vast network of roads, transportation systems specialists are turning to computer vision. A transportation vision system – including those for traffic monitoring and toll, red light, and speed enforcement – can provide information ranging from overviews of traffic conditions to details on specific vehicles to ensure more efficient traffic monitoring and more effective law enforcement.

Each type of transportation application places different demands on the vision system, and matching the camera to the application's requirements is essential for obtaining the desired performance.

Environmental considerations

Vision systems for transportation will typically require that cameras be installed out in the open where they may be subject to varying temperatures, fog and precipitation, and wind-induced vibration. Cameras must be built to withstand these conditions over years of exposure, or housed in a protective enclosure.

Another environmental consideration that can affect camera choice is the image area's illumination. Installations that depend solely on natural daylight and conventional night-time highway lighting will need a wide dynamic range along with features such as automatic gain control to provide reliable image capture. The use of supplemental or infrared illumination is an option but may require cameras with special sensors.

A third consideration is the camera's connectivity to both power and communications. Most transportation applications require external power because battery-powered installations can be costly to maintain. Wired or wireless network connectivity to image-processing and data-storage elements is also required in many applications. Even cameras with built-in processing and storage usually need a connection for external control and data transfer.

Performance and connectivity

Once environmental concerns are addressed, camera selection depends on the application's specific need for resolution, performance and functionality.

In traffic monitoring, a vision system observes the traffic moving within its camera's field

Need to know

Different transportation applications have differing needs in terms of camera performance

- The wide range of technical and user requirements for transportation vision systems means that developers need a broad selection of imaging technology to choose from
- Transportation authorities should look for solution providers with a wide range of camera and image sensor technology, including area and line scan camera technology with all the key features needed in transportation applications, as well as system design expertise to address the diverse needs of transportation vision systems

(Opposite) **Teledyne DALSA's Genie cameras are based on high quality, highly sensitive CCD and CMOS sensors with global shutters**
(Left) **Modern traffic applications require advanced imaging solutions**

of view and uses simple object detection software to count the number of vehicles passing through per unit of time to provide a real-time, wide-area description of traffic conditions. The camera can be relatively simple for this application, requiring only enough resolution and speed for the computing element to perform simple shape recognition and counting as cars pass by. The cameras can typically work in monochrome with available lighting because they need only to distinguish between a vehicle and an empty road. A USB-type connection is often sufficient for power and communications connectivity.

Tolling enforcement is a little more demanding. The vision system captures the image of a vehicle passing through a checkpoint and identifies the vehicle using automatic license plate recognition (ALPR) software. An intelligent transportation system can then use that identification to send the vehicle's registered owner a bill for the toll charge. Toll gates are typically well illuminated at night, so the camera does not need an extended dynamic range; thanks to toll-gate speed restrictions, the camera does not need to be ultra-fast.

Image processing and communications needs are likewise minimal as the camera only has to capture and store an image of the vehicle as it passes through the toll gate. Image-processing functions can be handled offline. To successfully prosecute toll evaders, however, law enforcement requires proof of a vehicle and driver match to the license number and full-vehicle color capture. This means that toll-enforcement cameras need high enough resolution to ensure reliable automatic license plate recognition, and color operation and a wide enough field of view to capture an entire image of the vehicle.

Red light enforcement has similar requirements, but is even more challenging. In this case, the camera must offer a wide dynamic range and automatic gain control to capture usable images in lighting conditions that range from day to night.

In speed enforcement, the way the vision system determines a vehicle's speed is the major factor in camera choice. If a radar system triggers image capture, the camera may only need enough resolution and speed to capture and store an image suitable for post processing. Communications requirements are minimal as the vision system does not need real-time connectivity to a network.

If the vision system itself makes the speeding determination, camera speed requirements change substantially. The camera must be able to capture multiple images of the vehicle as it passes through the field of view (or two or more fields of view in the case of multipoint systems) to measure vehicle movement between images and calculate speed. A speed-enforcement vision system may also need enough computational power to perform ALPR in real time to ensure the same vehicle is captured in successive images, and network communications to a central database in the case of multipoint speed enforcement systems.

Security and access control

Two different types of cameras are needed in access control and security inspection applications. The capture of images for driver face and license plate recognition requires an area scan camera similar to that used in red light and tolling applications. For under-vehicle inspection, however, a line scan camera may be the best choice.

Line scan cameras capture a thin, one-dimensional slice of an image, and as an object moves across the camera's field of view, a properly timed series of such slices can be combined to create a traditional two-dimensional image of the object. Line scan cameras provide some of the fastest image capture rates at the highest resolutions available, and can obtain fine details in difficult conditions.

A line scan camera is ideal in security inspections because it can build an image as a vehicle moves past a checkpoint and can capture an entire vehicle in a single image, regardless of vehicle size. The cameras in these access control and security inspection systems must offer high-speed connections to an external computer to perform face and threat recognition in real time.

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The requirement for imaging standards in ETC applications

For those in the electronic toll collection (ETC) industry, there has, for a long time, been an ongoing effort to establish standards and best practices in the RFID (radio frequency identification) technology sector. North America's ETC industry is under a mandate to migrate toward a US interoperability schema, as articulated by the nation's highest lawmakers. MAP-21, the Moving Ahead for Progress in the 21st Century Act (PL 112-141), enacted in July 2012, established new Federal legislative language regarding ETC interoperability as follows: 'Section 1512 Tolling (b). Not later than four years after the date of enactment of this Act, all toll facilities on the Federal-aid highways shall implement technologies or business practices that provide for the interoperability of electronic toll collection programs.'

MAP-21 has yielded great results with national interoperability, possible today with existing multiprotocol tags and readers. However, there remains little discussion surrounding how to deal with motorists who choose not to display a valid RFID tag in their vehicles. A solution that consistently works in parallel with almost every high-speed toll collection lane around the globe is the high-performance imaging system. To date, very little industry attention has been given to developing operating standards, performance guidelines, or even establishing common definitions of the language used for such imaging systems.

Imaging standards

The imaging systems of today are simply not the systems of the past. Today's vehicle data is collected through highly engineered, purpose-built components that match optics with illumination including complex character recognition algorithms. This tight coupling of design elements produces the highest-performing imaging systems ever used in the transportation sector. In fact, imaging systems might just be the fastest and most affordable option for true national interoperability. Utopia, one might think, but unfortunately confusion still exists. Through ambiguous and undefined industry terms such as 'attach rates', 'accuracy rates' and 'error rates', some suppliers are able to create the illusion of procurement specification conformance.

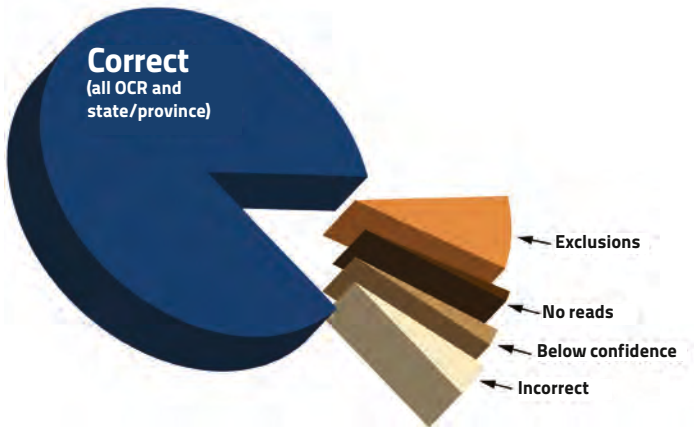
License plate recognition (LPR) systems have been around for more than 30 years. One misconception is the ability of LPR systems to read 100% of all vehicle plates 100% of the time. Although ideal, this is simply not possible. End users and manufacturers often have different ways of stating their LPR system claims, which ultimately leads to customer dissatisfaction or mistrust with what is being stated.

It is time for the ETC industry to demand the same level of scrutiny toward the performance characteristics of imaging systems that has been applied for decades to the RFID industry. Accuracy and attach rates are typically two of the top requirements. Unfortunately, not every LPR manufacturer measures them in the same way, so having clear definitions is a good way to hold your LPR provider accountable. Below are simple equations to help the definition discussion:

ETC attach rate = (correct + incorrect)/(correct + incorrect + no reads + below confidence)

ETC read accuracy = correct/(correct + incorrect)

The facts support the perpetuation of multiple technologies in the high-speed electronic toll collection industry. Currently, after nearly 25 years of transponder-based toll collection, less than 30% of the vehicles in North America are RFID enabled. Yet nearly 100% of all vehicles on the roads have an issued license plate. For this reason alone, imaging systems are here to stay.



(Above) **LPR accuracy breakdown**
(Left) **Perceptics' 7th generation image processing platform (G7)**

Need to know

Standards would help to regulate LPR operations and overcome confusion in the industry

> MAP-21, the Moving Ahead for Progress in the 21st Century Act (PL 112-141), enacted in July 2012, established new Federal legislative language regarding interoperability of ETC as follows... 'Section 1512 Tolling (b): Not later than four years after the date of enactment of this Act, all toll facilities on the Federal-aid highways shall implement technologies or business practices that provide for the interoperability of electronic toll collection

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Advanced imaging solutions for modern traffic applications

Point Grey's latest Grasshopper3 USB3 Vision models feature advanced CMOS sensors

Over the past five years we've seen an increase in global shutter CMOS (complementary metal–oxide–semiconductor) sensors on the market and they are gaining popularity in the traffic sector. There are several reasons for this. CMOS technology has a lower power consumption than alternative solutions and the sensors are less expensive than CCD (charge-coupled device) sensors because they're cheaper to manufacture. Furthermore, smear and bloom aren't an issue with CMOS devices.

Global shutter CMOS technology enables images of fast-moving vehicles to be captured without motion distortion, a critical requirement for applications such as open road tolling or automatic license plate recognition (ALPR).

The CMOS advantage

To meet the needs of the industry, Point Grey's latest Grasshopper3 USB3 Vision models feature Sony's second-generation Pregius global shutter CMOS sensors. The IMX250 and IMX252 sensors set new benchmarks for global shutter CMOS imaging performance by dramatically reducing pixel size and substantially lowering temporal dark noise. The smaller 3.45μm pixel size enables more pixels to be packed into a smaller optical format, allowing for a wider variety of more compact and lower-cost lenses to be used. These new high-resolution Grasshopper3 cameras are ideal for multilane monitoring. They offer excellent low light sensitivity and a high dynamic range for increased ALPR recognition rates in diverse lighting conditions. The IMX250 and IMX252 sensors support many features such as high-speed triggering and region of interest (ROI) functionality, which enables users to select smaller HD 1080p or 720p image sizes that run at faster frame rates.

The 3.2MP Grasshopper3 GS3-U3-32S4M-C model is based on the color and monochrome versions of the 1/1.8in model. The Sony IMX252 global shutter CMOS sensor features a 2048x1536 pixel image resolution and runs at 121fps (frames per second).

The 5MP Grasshopper3 GS3-U3-51S5M-C model is based on the color and monochrome versions of the 2/3in model. The Sony IMX250 global shutter CMOS sensor has a 2448x2048 pixel image resolution. The Grasshopper3 with the IMX250 sensor is the fastest 5MP USB3 Vision camera in its class, running at 75fps.

Need to know

Next-generation CMOS technology allows for optimized imaging performance

- Temporal dark noise is noise generated by the sensor and camera circuitry, and is influenced by the electrical design
- Temporal dark noise can be amplified when the camera gain is increased, degrading image quality
- A low temporal dark noise allows for more signal gain without sacrificing image quality
- Historically, CCD sensors have much lower temporal dark noise when compared with CMOS sensors. However, Sony's sensor design features more accurate signal measurement technology, enabling the sensor to achieve a low temporal dark noise

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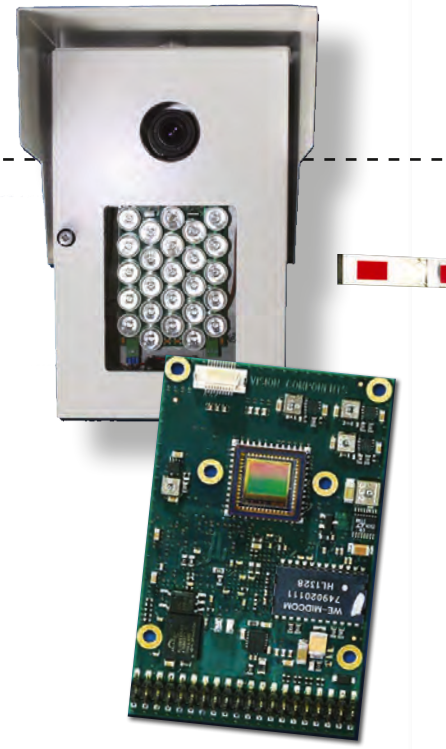
Cost-effective and efficient license plate recognition

Fast, reliable and economic intelligent traffic monitoring systems that enable precise vehicle identification are in demand all over the world. In Bulgaria, atto-Systems, a provider of industrial image-processing systems, has developed a very cost-effective, comprehensive automatic license plate recognition (ALPR) solution for the domestic market, based on a clever combination of OEM components and tailored software.

In October 2015, 400 of these systems were delivered to 200 locations across Bulgaria's road network. They perform a continuous traffic count, vehicle classification (10 categories), speed detection and license plate recognition, for vehicles traveling at speeds of up to 200km/h (125mph) in up to two lanes. Featuring a recognition accuracy of more than 95% for Bulgarian license plates, the systems are installed on purpose-built gantries and are triggered by sensors in the road. At the heart of this system is Carrida, a very fast and precise ALPR software solution from Germany-based embedded imaging expert Vision Components, a long-term partner of atto-Systems.



(Left) **More than 200 locations in Bulgaria have been equipped with an ALPR solution from atto-Systems**
(Above and right) **The Carrida software engine from Vision Components is at the heart of the ALPR solution atto-Systems developed for the Bulgarian market**

Need to know

A fast and capable software engine powers a Bulgarian ALPR solution

- Vision Components' smart cameras feature an extremely compact design, complete encapsulation and no moving parts, making them ideally suited to industrial OEM solutions
- For standalone ALPR applications, Vision Components offers Carrida Cam, a camera system running the Carrida SW engine. The tiny embedded solution is available with or without IP67 protection class and consumes less than 3W, making it ideally suited to self-sufficient outdoor applications.

Optimized solution

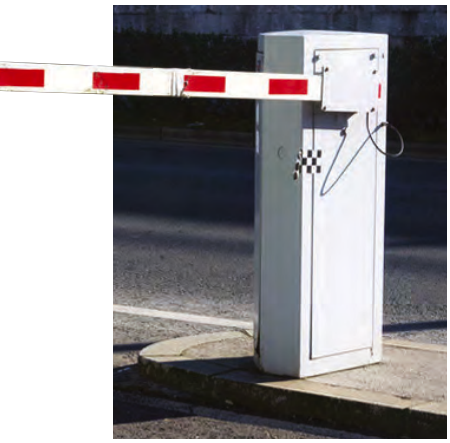
The high-performance, hardware-independent OEM software runs on the Linux-based VCSBCnano Z board camera and features a typical recognition accuracy of more than 96%. Carrida has been widely deployed in ALPR applications and has consistently proven to achieve high levels of recognition accuracy.

It reliably identifies dirty, damaged or skewed license plates, even in poor or changing lighting conditions. Carrida automatically recognizes all plates displayed in one image and vehicle plates in several lanes simultaneously. Suitable for use with Windows- or Linux-based mobile or embedded systems, Carrida reads all common still image and video formats and is easy to integrate into existing security and surveillance applications.

The OEM software achieves high recognition rates for license plates all over the world, despite considerable plate variations from country to country that often prove too challenging for conventional ALPR solutions.

"Using Carrida on the Z-board embedded camera enabled us to implement a compact solution very quickly in a cost-efficient way," says Jörg Beutel, managing director of atto-Systems. "Due to our long-standing partnership with Vision Components, we know we can rely on the high quality and long-term availability of the hardware and software. And in using a more powerful hardware platform we are able to offer new functions, for example a non-trigger free-flow version, in the near future."

atto-Systems has given Carrida a number of additional features to create a tailor-made, all-in-one solution, including a preselection of image areas that likely contain a license plate. Only these cropped image areas are sent to Carrida, thus allowing for faster evaluation.



The system also features a processing routine to handle peaks in demand, a blacklist/whitelist option and a streamlined user interface for easier setup of lines and parameterization. To ensure maximum functionality in all light and weather conditions, atto-Systems has also developed a special lighting solution and has integrated a heater and ventilation, as well as temperature and moisture sensors, into the weather-proof outdoor housing.

Application success

Based on Vision Components' Carrida ALPR software and Z series board level camera, as well as other OEM components, atto-Systems has created a very economic complete ITS solution for installation on highways and road bridges in Bulgaria that achieves highly precise high-speed recognition.

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by **Larry Yermack**

We should use the ITS World Congress events as an opportunity to work together

In early October, I attended the ITS World Congress in Bordeaux and had the opportunity to speak at an Executive Session. I even got to spend a few days of rest and relaxation in Paris before the conference and was reminded of how well the French treat food.

I've participated in most of the World Congresses so I had a pretty good idea how it would run. With that as prologue let me take advantage of this forum to muse on the idea and the reality of a World Congress and offer some of my usual candid thoughts.

The first World Congress was in Paris in the mid-1990s and I had just left government for the world of consulting engineering. I had just developed E-ZPass, the toll scheme in Northeastern USA, and was eager to see what was happening beyond the US shores. I was surprised at how organized the European countries were, as well as how impressive the unified plan for deployment from Japan was. At first glance I saw seamless development and deployment elsewhere, while I had struggled with independent agencies in seven states to agree on a joint technology.

Over time, I came to realize that the internecine struggles between governments and operating entities was a global phenomenon and not just limited to the USA. Based on that reality, I guess I'm not surprised that there is too little international cooperation among the ITS community. Some years back, when I was ITS America board chair, I initiated a dialog with ERTICO-ITS Europe to develop an international position on how ITS was an essential element of sustainability. The idea was to work together on a position that we could then individually use with our governments to generate support for ITS. That effort faded away after several meetings and a draft white paper that neither of us was able to use effectively.

Perhaps the time is once again ripe for real international cooperation. The Congresses are a forum for what I call 'show and tell'. All of the major panels have an equal representation from the USA, Europe and Asia, selected by their associations. We do hear a lot of great presentations, but do not have cooperation on the agenda.

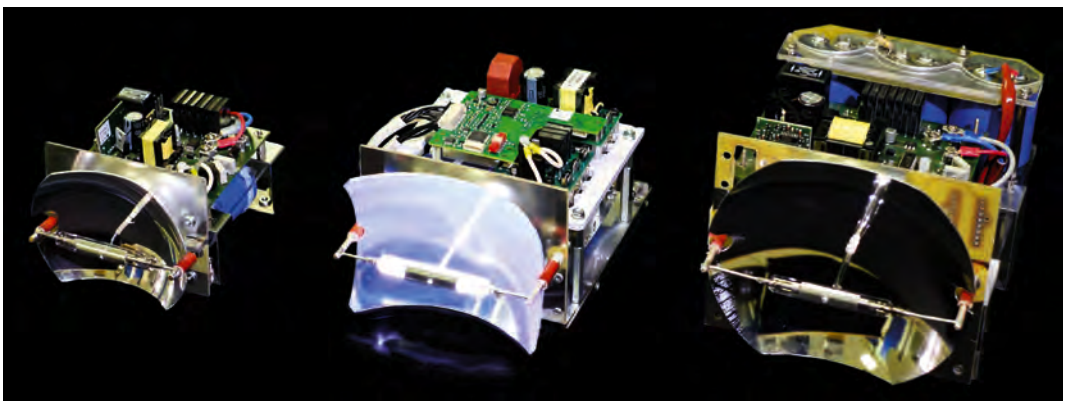
Perhaps the time is once again ripe for real international cooperation

In a struggle for public resources, infrastructure is not faring very well in the USA, so it's no surprise that the technology to make it more efficient fares even less well. I have to believe that our friends in Europe and Asia face the same challenges with government funding. Privately funded and commercially available ITS will fill in part of the need, but dedicated public funding for ITS infrastructure will still be needed at a higher level than today.

Maybe we can use the World Congress as a forum to polish our arguments, develop joint position papers, and help each other to achieve the level of deployment that we know is required. Let's be a World Congress and not just a World Conference.

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

How to leverage system performance in photo enforcement



(Left) **Phoxene high-end flash devices**

Automatic enforcement systems operate in various lighting conditions. However, picture analysis can be made impossible, even with ambient light, as a result of insufficient daylight, backlighting, windshield reflection or atmospheric backscattering. The ratio of exploitable images is a key differentiator when competing for public tenders.

With a high-performance flash, images can be captured with reproducible high quality, 24 hours a day, 365 days a year. This is because the light emitted by the flash is directional, focused on the shot scene, and its power surpasses the ambient light. This is also achieved at a reduced cost, because with a powerful flash, a medium-price, average-sensitivity camera is sufficient, and consequently the cost of the imaging subassembly is reduced.

A cost-effective solution

The flash is a key enabler of enforcement systems in the sense that it enables them to meet the requirements of various enforcement situations (as shown in Table 1).

For photo enforcement systems that are installed both in urban areas or isolated in the countryside, the characteristics of the flash can impact total system cost in different ways. For instance, a flash device with a 12V power supply and low power consumption makes integration into the system easy, reduces the cabin cooling constraints and eases the overall power management. Ownership costs can also be limited when the flash device is equipped with high-quality capacitors, smart discharge management and long-life lamps.

Smart and flexible flash

The industry trend toward smart communication systems involves embedded intelligence, remote control and management of devices integrated within a system. A smart flash device can, for instance, enable proper tracking of actual emitted shots or emitted light intensity as well as dynamic control of the light to be emitted, according to the road lane to be illuminated or to ambient light conditions.

In order to respond to the increased demand for connectivity, in 2016 Phoxene will introduce a new generation of flash devices enabling real-time and remote control of the flash unit through a standard RS485 interface.

Table 1: Photo enforcement solutions

Enforcement scenario	Solution given by high-end flash
Long reach	A powerful flash equivalent to bright sunshine
Large crossing	Light is focused with beam angles adapted to the scene
Traffic light enforcement	Two successive shots at two different light intensity levels
Multilane highway	Light intensity adapted to each lane
Fast, close together, following cars	Fast flash sequences at constant illumination level
Vision-friendly image capture	Flash equipped with red or infrared qualified filters
Mobile battery-operated unit	12V low-consumption flash device

Need to know

A quick comparison between Xenon flash and LED technologies

- At equal light power, a Xenon flash is half the size and five times cheaper than an LED
- An LED will have a longer lifespan than a Xenon flash, but a Xenon flash with a lifespan of more than 100,000 shots is largely sufficient for photo enforcement applications

With an optimized optical design and innovative control electronic circuits, the 12V Phoxene flash has a very low standby consumption of 2.5W and a working power limited to 45W. Taking into consideration enforcement conditions and system specifications, Phoxene flash devices are available with a wide variety of options, among them light power, beam angles, repetition rate and casings.

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Dynamic signs provide reliable, real-time information

The M6 toll road (M6toll) is a 27-mile stretch of six-lane highway bypassing the most congested section of the M6 motorway around Birmingham, UK. When it opened in 2003, toll pricing was based on five vehicle categories, with initially two and now three tariff periods. The original fixed tariff signs offered little flexibility; the three tariff periods crowded the sign and overloaded drivers with information.

The Department for Transport recently granted permission to the M6toll operator, Midland Expressway Limited (MEL), to replace the fixed signage with real-time signage using LED technology. However, communicating dynamic tariff information to motorists in a reliable and timely manner is not easy.

MEL engaged Variable Message Signs (VMS) to design a system that would deliver the necessary levels of reliability and flexibility, with built-in resilience to withstand a major component, power or communication failure.

(Above left) **The new M6toll signs show the current prices, and the next time period and prices** (Above) **The signs mount directly onto existing posts**

Need to know

LED-based real-time signage is optimizing operations on the UK's M6 toll road

- The signs draw power from a 12VDC battery bank, which is constantly charging during normal operation
- The battery bank will provide enough power to run the signs for a minimum of 12 hours after a power outage
- The battery cabinets are also fitted with an external power connector, so that a temporary power supply or generator can be quickly connected if required
- Each site is powered independently from its own battery cabinet

Flexibility and reliability

Each new sign is a standalone VMS comprising two independent columns of LED display modules. Under normal conditions, the left-hand column displays the current tariff time period and, for each vehicle category, the current tariff. The right-hand column displays the timing of the next tariff period and the corresponding charges.

Each column has its own power supply and control box, so in the event of one module, or even a whole column failing, the remaining healthy sign will automatically switch to displaying the current prices so that the road user will always know what the current tariff is.

In the unlikely event of an LED module failure, they are easily swapped, to ensure that downtime is minimized.

The signs are controlled from MEL's control center using VMS TRAMS system integration software via GPRS networks. Two independent multinetwork GPRS communication units are built into each sign. If one network has an outage, or data communications are turned off, the sign switches automatically to the alternative network.

The signs are programmed for a period of up to one year in advance, so in the event of a communications outage with both communication networks out of action, the signs will run autonomously using the programmed timetable and a GPS signal to ensure the accuracy of the tariff information to drivers.

To minimize disruption, the new signs were required to fit onto the same mounting posts as the existing fixed signs. VMS produced a 60mm low profile design to match any post configuration, with separate control boxes for flexible mounting.

Character module heights from 100-320mm are employed to accommodate the variation in the speed of approaching traffic, which can be 30mph on local connections, and up to 70mph on the M6 links.

The new signs offer MEL tremendous flexibility to provide drivers with real-time information and to optimize use of the toll road, with the aim of increasing overall traffic and easing congestion on the overburdened M6 motorway and adjacent roads.

"The replacement of our fixed tariff signs with dynamic signs represents an important investment for the M6toll," says James Hodson, director of motorway operations at MEL. "The level of information that can be displayed on the new signs will be a big improvement and will help us to deliver better customer service."

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Multiphase blank-out signs: do more with less

The debate about the future of roadside dynamic messaging in the connected world has been ongoing for about five years. Duplicating messages within vehicles or eliminating dynamic roadside messaging altogether are topics of mild speculation at every intelligent transportation strategic session around the world. However, every conversation seems to conclude with a 'do more with less' summation with regard to dynamic messaging.

Roadside messaging is here to stay, so how can communication along the roadside be more efficient and have greater impact while staying compatible with the connected future? One approach uses new multiphase LED design techniques and technologies as a solution in site-specific applications.

SES America (SESA) has overhauled the concept of extinguishable messaging or blank-out signs (BOS) to provide a cost-effective, multiple-message solution, for the short and long term. The solution is ideal for state and municipal agencies whose mantra is 'do more with less', not only with regard to messaging, but also in terms of budgets and maintenance. Versatile multiphase blank-out signs are ideal when displaying three to four messages or symbols as an alternative to more complex descriptions with multiple lines of text.

SESA's thoughtful engineering with LED technology allows engineers to create a wide variety of symbols and text combinations, accommodating either standard size or custom-built housings, a key element in messaging transformation. SESA's multiphase BOS are engineered without a polycarbonate window panel, eliminating the 'phantom effect', which typically causes confusion for motorists. This windowless design maintains a higher contrast ratio for a cleaner, more durable appearance.

A single sign can be used for multiple messages, such as a 'no right turn' sign (left) **or a pedestrian crossing signal** (below) **– achieving the functionality of traditional dynamic message signs at a much more affordable cost**

Need to know

Multiphase blank-out signs add to the changing landscape of dynamic messaging

- Multiple blank-out signs enable the display of several symbols or text
- They have a flexible and customizable design: any size, any dimension, any color and any symbol
- Features include vehicle detection, automatic brightness control and low maintenance technology
- Recent high-profile applications for BOS include tunnel lane management, bridge traffic control, weigh stations, toll roads and over-height detection warning systems

Fit for purpose

Meeting all MUTCD (manual on uniform traffic control devices) requirements, SESA's multiphase technology can display multiple symbols or text on the same blank-out sign. This could include lane assignment or mandatory lane control arrows, where all arrow options can be displayed on one compact sign at a sizeable inventory and maintenance cost advantage.

Another example is a current weigh in motion (WIM) project in Georgia. Here BOS has saved the agency over 55% on the cost of an alternative DMS (dynamic message sign) solution.

In a smaller, directional mobility format, using multiple symbol messages, the SESA engineering team has saved another client 65% of the cost of one alternative design. Using symbols rather than words, this mobility project was engineered with string technology, eliminating expensive printed circuit boards while allowing for an affordable freedom of design. String technology also has a much lower maintenance cost in terms of parts and labor. These mobility blank-out signs were further enhanced with size-appropriate visors for greater visibility and weather protection.

Multiphase BOS applications, such as these directional signs, fit well into the connected world, allowing for easy translation within the vehicle.

Rural or urban, connected or unconnected, the emerging use of LED technologies and designs for multiphase BOS is the epitome of the 'do more with less' mantra and the connected world.

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Thinking outside the road weather box

Traditional road weather information systems (RWIS) employ myriad atmospheric and road sensors to provide critical weather data so that efficient road weather management decisions can be made. These decisions increase public safety on our roadways, protecting lives and property. Although RWIS are necessary tools for any road weather management program, they can be cost prohibitive to put in every weather hazard location.

Strategically placed road weather alert systems that address a specific weather hazard can provide critical alerts to the traveling public. These alert systems are inherently less expensive because they address the specific hazard in a location and can work autonomously for even lower costs. The weather alert system works by activating fixed or dynamic warning signs or flashing beacon signs directly from the weather sensor. This information, when placed in the correct location, can give the motorist the information needed to make an informed decision about how to safely navigate the weather hazard.

(Above) **The fog warning system in Illinois responds to emissions from the power plant**
(Right) **Dynamic 'Icy bridge' warning sign**

Need to know

Dedicated RWIS that address specific hazards can cut costs and increase effectiveness

- In addition to localized fog and dynamic icy road warnings, other examples include warning signs on elevated roadways that trigger when high winds are present, as well as signals that trigger pre-emptively when winter driving conditions exist
- Warnings can also be designed for pedestrians in the event that a parking lot is wet or icy

Dynamic alerts

A good example of a road weather alert system is a fog warning system in southwest Illinois. Here, a power plant creates localized dense fog along the adjacent roadway. This happens because the power plant creates its own micro climate by adding water vapor from its steam vents. When the atmospheric conditions are just right, fog forms, causing a major hazard for the traveling public.

A fog warning detection system was installed along the roadway to increase public safety during the fog events. The system comprises five visibility sensors along the roadway of the affected area. When any of the sensors detect fog, a signal is sent over a radio system to activate a message sign that reads 'Reduce speed' and flashing beacons with a sign that reads 'Fog/ice ahead'. There are signs installed at both ends of the roadway running past the power plant. This dynamic warning to motorists provides the information needed to make the decision to slow down and use caution.

The road weather alert system concept can be applied in many other weather hazard situations. For example, say an agency has existing 'Bridge may be icy' signs that are static and present throughout the year. If motorists pass this sign daily they may not consider the warning when the actual conditions exist. Weather sensors can be added to retrofit the sign to trigger flashing beacons and add dynamic functionality when icy conditions are actually present, to give vehicle operators the information needed to slow down and take caution when crossing the bridge.

These outside-the-box ideas reduce the costs of the systems and increase the return on investment by strategically placing instrumentation where it is most effective. The ultimate goal of road weather systems is to protect lives and property; we can do this directly by providing reliable and accurate messages to the public.

Free reader inquiry service

High Sierra Electronics
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Location-specific road weather warnings

Without too much thought, readers can probably name at least one location in their area that has a higher than normal crash rate when the weather turns bad. Maybe it's when it snows, or when it's frosty, or when the area is affected by fog and low visibility, or even flooding. The key is that it happens here more quickly than the rest of the local network, or maybe even when the rest of the network is fine. Crashes occur more frequently here because drivers do not anticipate the sudden change in weather conditions.

The obvious solution is that we need to warn motorists locally before they enter the location. Possible warning criteria include ice, snow, low visibility, flooding and high winds.

Limited effectiveness

This concept may not be new to some readers. In some regions of the world, using a road weather information system (RWIS) to activate flashing beacons, turn on a sign, or display a message, has been tried before. For low visibility and wet road notification, the systems have worked quite well. That is partly because the sensors that detect those conditions are fairly straightforward. Detection of ice and snow has been more challenging because, up until recently, systems had to use embedded roadway sensors to do the monitoring.

Embedded roadway sensors are a great tool for decision makers, because they work well when a human is viewing the data and making a decision. They do not work as well when the process is automated using a decision algorithm. This is partly because roadway sensors must infer the road condition from only what they can measure.

(Above) **System in Aspen, Colorado, USA warns motorists of refreezing snow**
(Opposite) **RWS200 algorithms allow for complex local decision making**

Need to know

Advanced road weather monitoring enables better management of trouble spots

- Together, Vaisala Road Surface Condition Sensors and the Vaisala Road Weather Station RWS200 are a complete solution
- The RWS200's data management unit relay interface enables complex algorithms to be set
- The RWS200 monitors conditions and activates the relay when custom conditions are met
- A solution that uses the most advanced RWIS and the most advanced sensors, along with a thorough review of the site, will ensure that a trouble spot sees a reduction of crashes and delays caused by inclement weather

Keys to success

To successfully develop an intelligent transportation system (ITS) solution that can lower crash rates and improve highway maintenance of a trouble spot, some critical steps need to be followed. First, it is important to identify which weather conditions are causing the localized change. Is it caused by an increase in localized atmospheric moisture? Does it appear the road surface temperature is colder than surrounding areas? Or is there a body of water nearby?

Performing a full meteorological assessment of the site, including a thermal map of the region to determine the temperature profile of the road, will help to pinpoint exactly what is causing the problem. Next, the correct RWIS sensors must be selected in order to measure the conditions most effectively. The Vaisala Road Weather Station RWS200 is a flexible RWIS platform that enables users to choose industry leading sensors that are ideal for whatever the application requires. Users should make sure that they have the correct atmospheric or surface sensors required at the location to ensure the correct conditions are measured. Finally, users should consider placement carefully, as locating them based on the proximity of utilities or for convenience is not an option – location is extremely important.

The right solution

One of the biggest differences in RWIS today is the advent of the grip/friction sensors, such as the Vaisala Road Surface Condition Sensor. This non-intrusive sensor uses laser technology to detect water, ice and snow on the surface, so it can actually measure true road conditions. With this information, the

surface condition sensor is then able to calculate the coefficient of friction of the road surface with the water, ice or snow on it.

This single value of grip, or slipperiness, provides a single decision point on road condition, which has many applications. The coefficient of friction is a value that ranges from 0 to 1.0. A typical dry road surface reported by the Condition Sensor reports the friction as 0.82. A wet road would be around 0.7, and a snowy or icy road could range from a 0.6 to a 0.4. The value is reported in real time and changes frequently, depending on what the sensor detects on the surface of the road. This value can greatly improve the algorithms needed to make decisions, and can provide an easier decision process.

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by **Don Hunt**

How will automated vehicle development affect DOTs and highway management?

Automation and robotic technologies have been relatively slow to move into personal vehicles. Certainly there have been notable auto safety improvements that are automation-enabled, such as air bags, electronic stability control and anti-lock braking, and electronic systems have resulted in much improved vehicle efficiency. Still, the basic dimensions of driving have remained unchanged for decades.

This is changing, however. Auto manufacturers are rapidly advancing the ability of vehicles to drive themselves under certain conditions, such as stop-and-go congestion and on freeways. An era of new automation is sweeping the industry and the incremental march is moving toward a fully self-driving car. While the near-term impact on DOTs is not large, within two to three decades the influences of self-driving vehicles on highway capacity, auto ownership, travel mode, parking and land use are open to broad speculation.

One immediate effect, however, is for DOTs that also control their state's Department of Motor Vehicles (DMV). DMVs have a large role as vehicles become more automated, because they license vehicles and vehicle operators. If a vehicle has no operator (Google is designing its vehicles with no steering wheel, accelerator or brake pedal), it's easy to see that there will be a government regulatory challenge. As recently noted by the California DMV, vehicles are currently safety tested by manufacturers under federal oversight. No similar system exists today for driverless vehicles.

Meanwhile, manufacturers will continue to push levels of vehicle automation. Most auto makers have made announcements, or at least predictions, about automated vehicle market introduction. Fully automated freeway driving has been demonstrated in prototypes from Honda, PSA Peugeot Citroën, Mercedes, Volvo and Audi, among others, with predictions that such technology will be available by the end of the decade.

Manufacturers, if they were waiting for 'smart highways' of the future to introduce automation, would have a long wait. Instead, auto makers will take what we have given them, an aging but fairly consistent highway system (thanks to the *Manual on Uniform Traffic Control Devices*), and forge ahead with or without transportation agencies.

> DOTs should refrain from adopting state-specific driverless vehicle regulations

Despite this rapidly changing technology, it is my belief that DOTs should refrain from adopting state-specific driverless vehicle regulations. The temptation is to adopt new regulations to respond to the perceived benefits of being progressive and stimulating economic development, but it might be best to let a few large states set the direction. If many states develop driverless car regulations, it will mean that they will all have to rewrite driverless car regulations when the real facts are known. Moreover, it's possible that existing vehicle regulations can do the job all the way to Level 2 or 3 automation as long as the driver remains in the equation. Level 3, according to NHTSA, is limited self-driving automation, where the driver is not expected to constantly monitor the roadway, but must be in a position to take vehicle control with some notice. Level 3 will be the highest level of production vehicle automation for at least the next decade. The driverless vehicle, Level 4, is a more distant goal.

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

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A flexible approach to highway safety

Freeways and multilane divided highways typically have strong barriers to protect motorists from severe head-on crashes caused by involuntary carriageway crossovers. These concrete or metal road-restraint systems offer the capacity to stop light and heavy vehicles, while providing protection for those inside the carriageway as required by national and European standards, generally within performance classes H2 to H4.

These barriers are often broken at set intervals by gaps: paved areas of different lengths that enable vehicles to change carriageways when necessary. Gaps provide the required space for roadworks and accident clean ups, as well as a means for service vehicles, such as snowplows, to make U-turns under special conditions.

However, these discontinuities can be very dangerous. Vehicles passing through the gaps or those making U-turns can cause accidents, with disastrous effects. Indeed, an out-of-control vehicle crossing the gap often hits one or more oncoming vehicles. The sum of the kinetic energy of the vehicles involved in the crash makes this almost certainly fatal for vehicle occupants.

Modular gap solution

Initial solutions to close the gaps with permanent guardrails have not been effective, because they cannot be easily removed when necessary. Lindsay Transportation Solutions Snoline, however, has designed a modular system that can quickly and easily close gaps of any length. The S-A-B (Save A Bus) system can be opened in a few minutes in different ways, according to the requirement. It also gradually absorbs impact with a reduced dynamic deflection and can redirect vehicles at a small angle.

The special barrier comprises 14.2ft-long modules joined by double steel hinges. Each is formed with a triple wave steel beam strip. The end supports are anchored to the ground and have lateral coupling connections to the barrier. The sides of the module are joined by strong steel supports, which include mounting supports for the hinges and the removable frame posts. Wheel units are located between the side panels and are lowered to the ground when the barrier is opened.

Each end ground anchor can absorb the longitudinal forces of an impact vehicle, which means that each section is independent of the existing barrier to which it is connected. As a result, the system doesn't transmit any notable force to the existing barrier.

S-A-B is designed so that the modules can be opened singularly or in parts to create a quick emergency route. Alternatively it can be opened completely to quickly provide a two-lane traffic diversion counter-flow route for traffic. The system can be opened in a few minutes without the need for any special equipment.

For all of these reasons, S-A-B was installed on new Italian highways around Milan, where road safety and emergency management were prioritized during design and construction.

S-A-B is a very smart system with a high containment level that can be easily connected to most barriers and guardrails with standard or customized transitions. The system requires little maintenance and is very easy to repair in case of impact. Because it is pre-assembled when delivered, it also is quickly and easily installed, which is why countries around Europe have chosen to use it on their roads.

(Left) **S-A-B system installed on the A54 in Italy**

(Left) **Installation of a S-A-B system in Slovakia**

Need to know

An innovative solution to barrier gaps provides impact resistance without restricting access

- The S-A-B system Opresents a cost-effective solution to the problem of providing openings in a median barrier
- The system can be opened and closed, partially or totally, without expensive electrical power supplies or sophisticated controls, and secure lock systems can be provided to ensure authorized usage only

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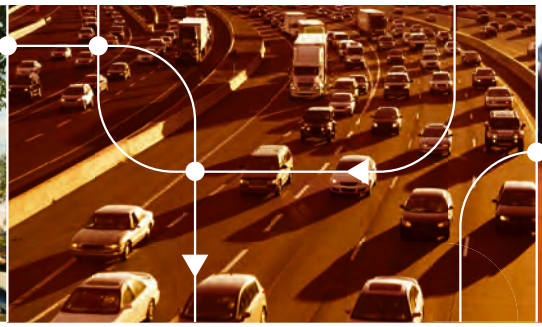


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The ITS manager at Auckland Transport, New Zealand

A traffic systems engineer at the Illinois Department of Transportation, USA

The principal technologist at the Department of Transport and Main Roads, Australia

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- Intelligent road studs, pavement markings and lighting
- Advanced parking management solutions
- Workzone safety developments
- Advances in traffic simulation and modeling
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Godfrey Hooper, publication manager: godfrey.hooper@ukipme.com
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"The technology for V2V and V2I is not really marketable right now because if you buy it, there's nobody for it to talk to. And there's no infrastructure to talk to because we haven't deployed that equipment"

Malcolm Dougherty, director of Caltrans

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"Not only do we have all the market leaders present, we also connect traditional industries with future technology"

Carola Jansen-Young, senior marketing communications manager, RAI Amsterdam

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"Do not underestimate the incredible speed with which the mobility revolution is taking place"

Lukas Neckermann, managing director, Neckermann Strategic Advisors

Hear from key industry players speaking at the 30th Automotive Industry Meeting in Barcelona here traffictechnologytoday.com/barcelona

"The Compass 4D services give bus drivers an early warning about dangerous situations"

Steffen Rasmussen, manager of Copenhagen's traffic and urban life department

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"We are pleased to welcome Ford as the first auto maker to use Mcity to test autonomous vehicles"

Peter Sweatman, director, MTC

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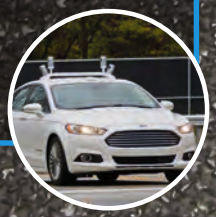

"The first problem with eliminating, or strictly limiting, regulation of these new and exciting services is consumer protection"

Samuel I Schwartz, transportation engineer

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LOW LIGHT SENSITIVITY AND HIGH DYNAMIC RANGE

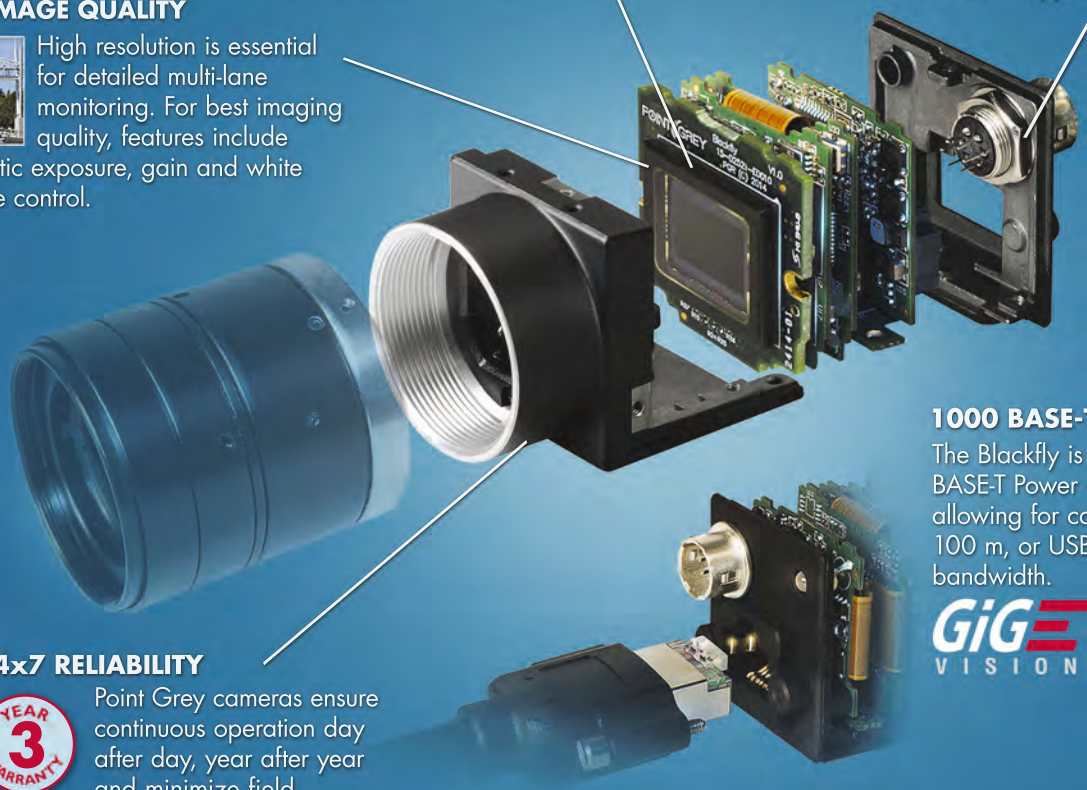
The latest global shutter CMOS sensors such as Sony's IMX249 offer excellent low light sensitivity and high dynamic range for increased ALPR recognition rates in diverse lighting conditions.

PRECISE TRIGGERING AND FAST SHUTTER SPEEDS

The GPIO connector allows for precise triggering and the Blackfly's fast shutter speeds enable accurate image capture for red light and speed enforcement applications.

HIGH RESOLUTION AND IMAGE QUALITY

High resolution is essential for detailed multi-lane monitoring. For best imaging quality, features include automatic exposure, gain and white balance control.



1000 BASE-T POE or USB 3.0

The Blackfly is available in 1000 BASE-T Power Over Ethernet (PoE), allowing for cable lengths up to 100 m, or USB 3.0 with 5 Gbit/s bandwidth.

GiGE VISION USB3 VISION

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Point Grey cameras ensure continuous operation day after day, year after year and minimize field maintenance time and cost. Supported by a 3-year warranty.

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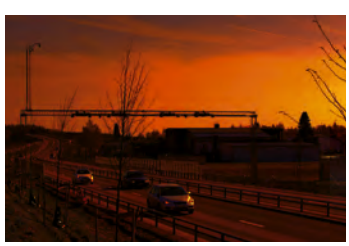

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