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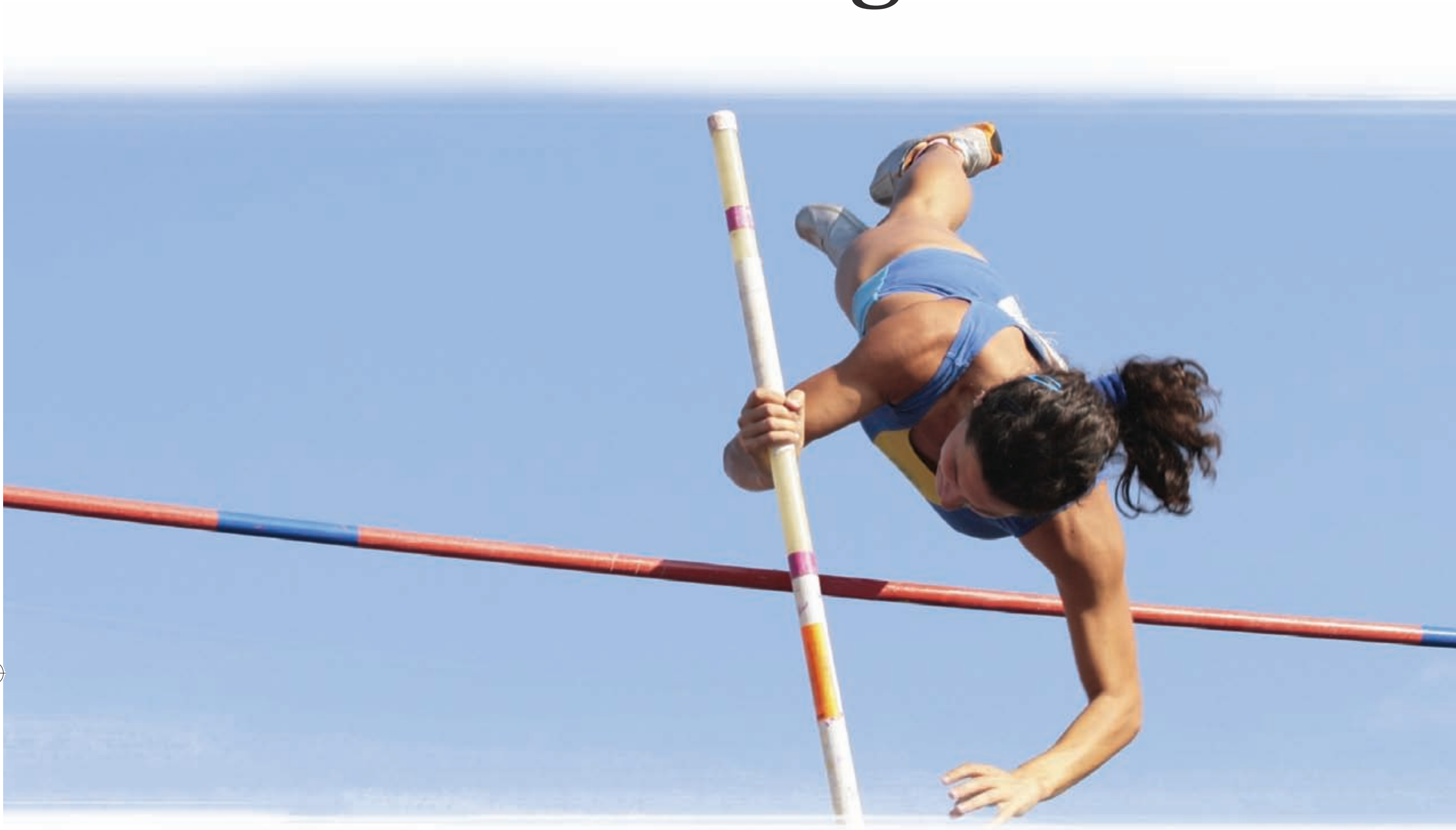

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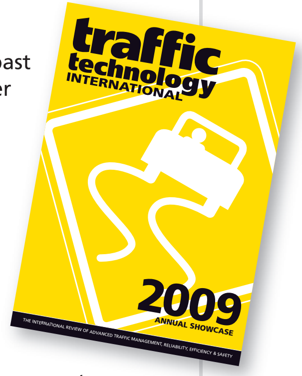
FOREWORD

Congestion in many regions of the world was down substantially in 2008, as volatile gas prices and economic constraints – I don't use the 'R' word – forced people to consider mobility a little more carefully. In the UK, for instance, road traffic fell to its lowest levels for more than 30 years, as British drivers opted to leave their cars at home. According to the Department for Transport, Brits drove 3.1 billion fewer miles in 2008 – the biggest decrease on record, costing the Chancellor of the Exchequer an estimated £165 million (US$241 million) in reduced fuel duty income. The scenario is similar in many other countries, including Canada, Germany, Singapore, and Australia, and it is particularly noticeable in the USA, where, in January 2009, the USDOT reported a decline of 12.9 billion vehicle-miles traveled (VMT) in November 2008. This 5.3% drop is the largest since monthly data estimates began back in 1971. The cumulative November 2007-November 2008 total decline of 112 billion VMT dwarfs the 49.9 billion VMT decline of the 1970s – an era of high gas prices, fuel shortages and, for those who can recall it, a pretty nasty rece… financial period.

Despite the reductions of last year, the figures are no doubt just a 'blip'. Indeed, most analysts agree that the longer-term outlook is for congestion to get much worse, so although managing jams may be a fraction less stressful over the next 12-36 months, ultimately normal service will resume. The UK's Automobile Association recently predicted that by 2041 there will be 44% more cars on the UK's roads, and that car trips will increase by around 24%. This is something the UK's road network will find hard to handle. In fact, motorization is set to increase markedly in many – if not all – countries around the world. This will have a subsequent effect on emissions and fuel resources. A leading authority in the traffic sector recently told me that there is perhaps only enough crude oil in the world for just over 40 years of supply. The depletion of traditional resources won't equate to reduced congestion, however. Electric and hybrid vehicles will almost certainly be commonplace by 2041, and will simply clamor for the same limited roadspace that exists today. The job of the traffic engineer – you, the reader – is not anticipated to get easier any time soon. And the issue of funding will definitely continue to be a recurring theme.



I've lost count of the number of times I've been told over the past three years that chronic congestion is a 'disease'. But as one reader recently felt obliged to point out in an email, the sooner we acknowledge the true nature of the problem that we're facing, the sooner we can stop chucking dollars at it. "The truth is," the correspondent from NJ Transit wrote, "chronic congestion is not a 'problem' to be solved – it's just one of the many environmental factors that affect people's choice of where to live and work." The more capacity we add, the easier the decision will be to live further and further away from our place of work. And the only way to stop continually having to add new capacity is to stop continually adding new capacity. "For temporary relief," he suggests, "corridor managers should work with major peak traffic generators to stagger peak demand, using monetary incentives if necessary to spread the peak demand." And for permanent relief? "They [corridor managers] should work to implement policies that restrict capacity growth on the local and regional roads that feed the corridor." Chronic localized congestion resulting from this policy will help maintain the natural equilibrium between roadway capacity and land development at current levels, in doing so focusing new development toward localities with existing spare capacity, and reducing growth in unplanned travel demand. "We'll still need to grow," he insists, "but we'll be able to do it in a managed way."

The job of the traffic engineer, this particular traffic engineer concludes, is not to focus on chronic congestion but to minimize incident-related congestion. I believe the following 135 pages – with articles ranging from workzones and ramp metering to integrated corridor and active traffic management schemes – reflect that. If you would like to share any of your success stories in next year's edition, please do get in touch.

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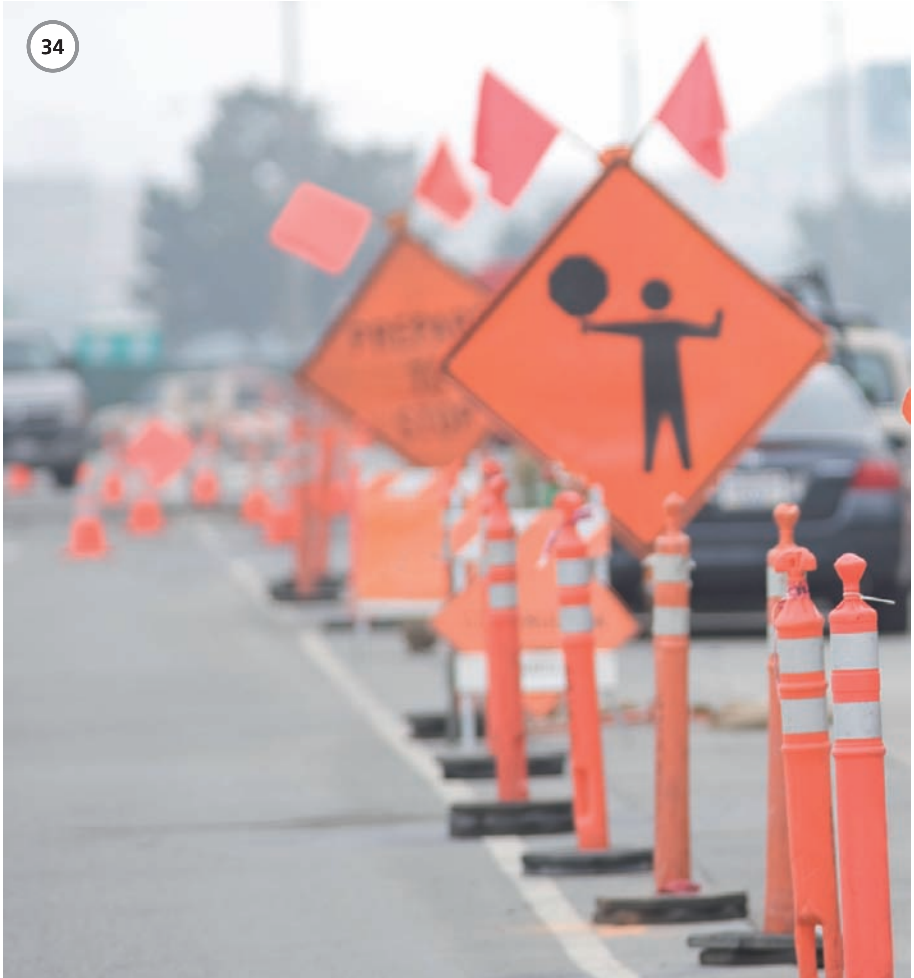

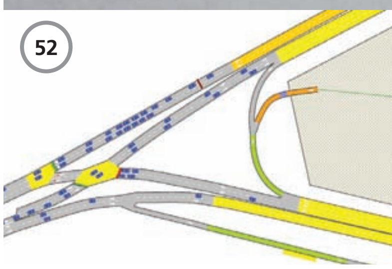

SECTION 3
DEMAND MANAGEMENT

SECTION 4
DETECTION/MEASUREMENT

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Accident Research Centre

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traffic technology INTERNATIONAL

SECTION 1:
TRAFFIC SAFETY

by Richard F. Beaubien

STRATEGIC IMPORTANCE

MANAGING TRAFFIC INCIDENTS FOR SAFER FREEWAYS IN METROPOLITAN DETROIT

An array of ITS technologies is being put to good use in the Detroit area. But it is the behind-the-scenes efforts of several organizations working together for the same aim that is the most impressive aspect

The Michigan Department of Transportation (MDOT) has deployed an extensive system of ITS technologies on the freeway system in metropolitan Detroit. Increasingly, these technologies are being used to manage traffic incidents. The traffic incident management program provides an organizational structure that makes the freeway system operate more safely and efficiently. Tools used by MDOT for traffic incident management include CCTV cameras, dynamic message signs, a freeway courtesy patrol, and partnerships with public safety agencies.

The Metropolitan Detroit Incident Management Committee started as an ad hoc group in 1992, when organizations interested in improving response to traffic incidents joined forces to develop a program for metropolitan Detroit. In the early 1990s, the agreement for cooperation was formalized with letters of commitment from the director of MDOT, the director of the Michigan State Police, and the executive director of the Southeast Michigan Council of Governments (SEMCOG). SEMCOG acted as a surrogate for local governments in metropolitan Detroit, whose public safety officers are an important element in developing a successful incident management program. As the responders to incidents in metropolitan Detroit are taking advantage of ITS technologies, the Metropolitan Detroit Incident Management Coordinating Committee has been adopted as a committee of the Intelligent Transportation Society of Michigan. This adoption recognizes that responders are, in fact, users of ITS technology. In general terms, incident responders involved in the committee include police, fire, hazardous materials responders, emergency medical, tow vehicles, road agencies, and the broadcast media. Subcommittees on freeway operations, courtesy patrol, arterial operations, and planning for operations have been added to the regular meeting schedule.

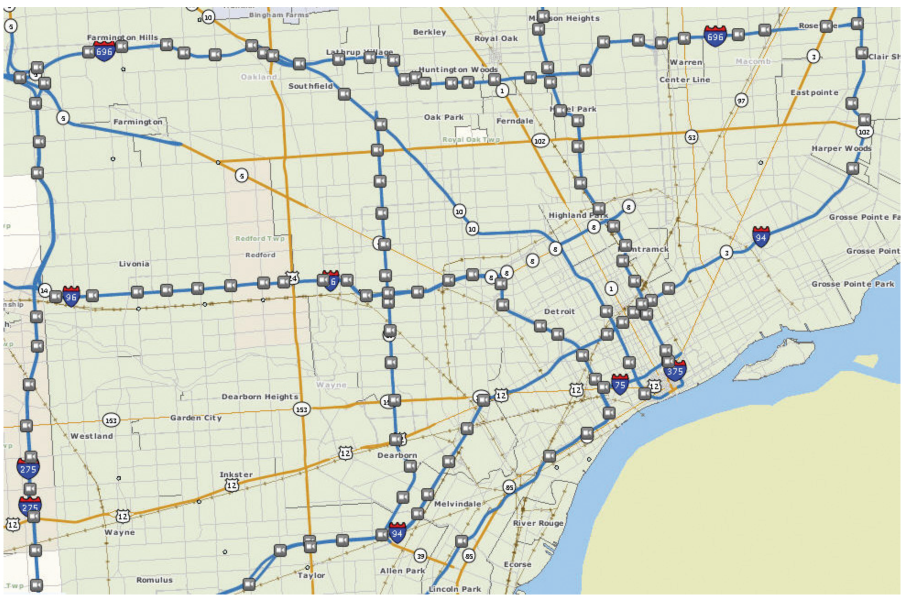

Figure 1: Locations of the video cameras that are situated on metropolitan Detroit's main freeways

BLUEPRINT FOR ACTION

During the mid-1990s, the Incident Management Coordinating Committee developed a program for improving incident response in metropolitan Detroit entitled the 'Blueprint for Action'. The Blueprint for Action developed a list of 12 recommendations and attached a timeframe, lead agency, and estimated the cost for each of these recommendations. As a result of the Blueprint for Action planning, four major improvements have been made to the incident management response effort in metropolitan Detroit.

The first is the combining of the Michigan State Police dispatch operations with the MDOT ITS Center in Detroit. Michigan State Police dispatchers for metropolitan Detroit are physically located in the TMC with access to all the CCTV cameras available on the metropolitan Detroit freeway system. This allows the Michigan State Police dispatchers to view approximately 160 CCTV cameras covering about 200 miles of metropolitan Detroit freeways. This access helps dispatchers send fire and ambulance responders, when

The workshop was intended to educate first responders on how to keep not just responders safe but how to keep the public safe when responding to freeway incidents

appropriate, to the scene of an incident even before the state police arrive at the location.

The second improvement is expansion of the CCTV camera and DMS coverage on metropolitan Detroit freeways. At the time of the development of the Blueprint for Action, the freeway surveillance system covered approximately 32 miles in downtown Detroit. The system has since been expanded to cover an additional 170 miles of metropolitan Detroit freeways, including cameras and signs adjacent to the freeways serving Detroit's metropolitan airport.

Third was the establishment of the Freeway Courtesy Patrol. This started with one van privately supported to assist motorists traveling on I-75 in downtown Detroit. Freeway Courtesy Patrol coverage has now expanded to include more than 24 vehicles operating on nearly all the metropolitan Detroit freeways. The Freeway Courtesy Patrol is now aiding stranded motorists at the rate of approximately 35,000 motorist assists a year.

The fourth improvement was to encourage the state legislature to change the law regarding abandoned vehicles. The abandoned vehicle time limit has been reduced from 48 hours to 18 hours, in stages with two separate legislative actions. Removing abandoned vehicles more quickly from the roadside has made metropolitan Detroit freeways safer.

ENGAGING PUBLIC SAFETY

When there is a crash, the police must be there, and they are typically the first on the scene. Fire and ambulance services may also be needed, but the police are nearly always on the scene when transportation operations are affected by crashes. As crashes are a subset of traffic incidents, it has been widely recognized that the police have an important role to play in traffic incident management. The Michigan State Police have been a partner with MDOT in operating the freeway system in metropolitan Detroit. The regional dispatch center is co-located with the Michigan ITS Center, so the dispatchers have access to the approximately 160 CCTV cameras showing about 200 miles of the freeway system. Knowing the conditions on the road before dispatching officers is a major plus for the Michigan State Police dispatchers.

However, the Michigan State Police do not have the manpower to cover the complete freeway system in metropolitan Detroit in a way that allows the most rapid response at all times. As a result, local police departments have taken the responsibility to respond to freeway traffic incidents when the State Police cannot arrive as quickly.

SHARING VIDEO IMAGES

As local police departments need to be involved to make the freeway system operate as safely and efficiently as possible, MDOT is making the video images of the freeway system available to local police and fire dispatchers through secure internet access. City police departments with access to these video images include Detroit, St Clair Shores, Southfield, and Auburn Hills. Currently there are nearly 90 organizations with access to the video images, including 35 public safety, 20 transportation agencies, and four emergency management centers. These real-time views of the freeway help the local police be more effective in clearing incidents quickly, resulting in less exposure to hazards and reduced delay to motorists.

> **"Sharing the video images promotes discussions about regional traffic responses, including priority control of cameras"**

In metropolitan Detroit, freeway cameras are controlled by MDOT and are located along I-75, I-275, I-96, I-696, I-94, M-10, M-39 and M-59. MDOT established a Traffic Incident Management (TIM) internet-based utility to permit public safety, transportation, and other government agency representatives to access a subset of the 164 CCTV cameras owned by MDOT for real-time freeway traffic surveillance across the Detroit metropolitan area. Authorized users have the ability to log on to the TIM utility from any location using a standard internet connection and web browser, yet without the need for additional plug-ins. Figure 1 shows the location of the cameras and Figure 2 shows a sample video image.

Sharing the video images promotes discussions about regional traffic responses,

"If fire service, ambulance service, or tow trucks are needed, it is better to get those services rolling before the police officer gets on the scene"

including priority control of cameras. The vast majority of the roadway cameras currently in the region are under the control of MDOT, and the other agencies with access to the video images use the MDOT images provided. Occasionally, the agencies will ask MDOT operators to pan or zoom a camera to help with their response efforts, but the control of the camera remains with MDOT. As more camera images from other agencies become available, protocols for the sharing of these images will be developed. The Road Commission for Oakland County and MDOT have developed an understanding that will allow MDOT operators to have access to new cameras along Opdyke Road, which parallels I-75 in the City of Auburn Hills. There is a further agreement that MDOT operators can have some limited control of the traffic signals on Opdyke Road if traffic needs to be diverted from the northbound I-75 during a traffic incident. More agreements are anticipated as more cameras come on line, but the principle of sharing video images among transportation operating agencies in metropolitan Detroit has been established.

RESPONDER SAFETY WORKSHOPS

Recognizing the need for coordinated operations with public safety agencies,

Figure 2: Video image of traffic on the I-75

MDOT has begun a process of educating first responders on how to keep responders safe and how to keep the public safe when responding to freeway incidents. The workshops are oriented to responder safety and give some practical tips on how to control traffic in the event of lane closures.

First responders are encouraged to wear high-visibility clothing when they leave their vehicle so that they can be seen by motorists. At night, an officer in a blue uniform is almost invisible. First responders are shown how to set up the traffic cones that might be needed in the event of a lane closure, and they practice setting up lane tapers. The workshop provides a summary of upcoming construction activities on metropolitan Detroit freeways and introduces the access to live freeway video images available to public safety officials from CCTV cameras operated from the Michigan ITS Center. Responder safety workshops have been held for the City of Auburn Hills, City of Canton, City of Novi, Brownstown Township, Oakland County Sheriff, and Macomb County.

Public safety answering points – the dispatchers for police and fire emergency services – are not always anxious to have access to the freeway video images. It seems like another responsibility, something else to watch. However, once they realize that this is a tool, available when they need it, they find it useful in deciding what to send in response to a traffic incident. If fire service, ambulance service, or tow trucks are needed, it is better to get those services rolling before the police officer gets on the scene. This reduces response time, and faster responses can save lives and time for travelers.

CONCLUSION

Metropolitan Detroit has managed traffic incidents for safer freeway operations by sharing video images with responders, holding regular Incident Management Coordinating Committee meetings, and conducting responder safety workshops. The sharing of video images is a relatively inexpensive means of promoting regional cooperation for transportation system operations. It does not require the establishment of a new regional traffic authority with powers of taxation and traffic enforcement. It merely allows traffic information to be shared in a timely manner, allowing appropriate responses to traffic incidents to be implemented or deployed. Sharing video images is a cost-effective way to share resources among agencies responsible for transportation operations. Responder safety workshops bring first responders into the traffic operations process in a tangible way that emphasizes both their personal safety and the safety of travelers. Responders are trained to wear reflective clothing for their own personal safety and how to position themselves safely with respect to traffic flow. They are also trained to use traffic signs and delineation to make traffic flow more smoothly and safely around a traffic incident scene. ■

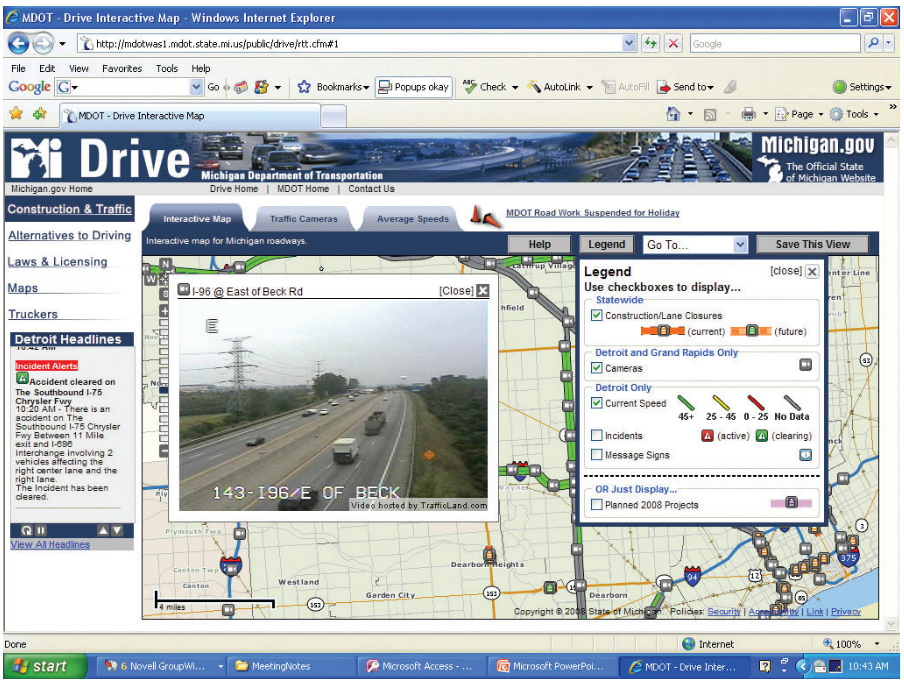

Figure 3: Michigan Department of Transportation website access to video images of the network

Richard F. Beaubien is an associate with Hubbell, Roth & Clark Inc, and is based at the company's offices in Michigan, USA

by Jaap Vreeswijk, Tobias Schendzielorz, Paul Mathias, Philippus Feenstra & Jasper Pauwelussen

VIRTUAL AID

DRIVING SIMULATOR STUDY FOR INTELLIGENT INTERSECTION SAFETY

A European project using volunteer drivers and placing them in different driving scenarios in a simulated environment is making pioneering efforts to improve safety for all road users at intersections

Where traffic movements cross – especially when different modes of transport are involved – dangerous situations occur frequently. For example, Dutch statistics indicate that in the period from 2004 to 2006, 42% of all registered road accidents occurred at intersections. About two-thirds (69%) of these accidents were registered in urban areas, 30% on roads with maximum speeds ranging from 60 to 90km/h and 1% on motorways.[1] The main causes of accidents at intersections included misjudgement and rule violation.[2] Therefore, the European research project SAFESPOT[3] (which is co-funded by the European Commission) is developing a roadside application to decrease the number of accidents at controlled intersections. By means of vehicle-to-infrastructure communication, advanced sensing and data fusion techniques, and a dynamic digital map, SAFESPOT aims to increase the safety margin of road users in time and space. Great care, timing and effectiveness are crucial aspects when developing a safety system. Therefore, a driving simulation experiment was performed in an early stage of system development.

The application, named 'Intelligent Cooperative Intersection Safety' system (IRIS), is a roadside application that identifies safety-critical situations at intersections and generates appropriate measures to support road users and warn them of potential dangers. IRIS tracks, analyzes and predicts the movements of all individual road users (e.g. vehicles, pedestrians and bicycles) and warns when a dangerous situation has been identified. An in-vehicle human-machine interface displays the warning messages.

Based on the accident statistics, IRIS addresses three scenarios that have a significant share in the number of accidents at intersections: red light-violating vehicles (including emergency vehicles), left-turning vehicles (conflict with oncoming traffic), and right-turning vehicles (conflict with parallel vulnerable road users).[4]

"IRIS addresses three scenarios that have a significant share in the number of accidents at intersections"

FOLLOWING PROCEDURE

The IRIS procedure consists of five subsequent activities (see Figure 2). First is data collection from a local dynamic map (LDM)[5] – static data to build an intersection representation and dynamic data (e.g. detector values, floating car data) with a frequency up to 2Hz. Second is prediction of trajectories – most probable path along a 'reference track' that represents a typical driving line of a vehicle passing an intersection. Third is situation analysis and assessment – identification of conflicts and violations. Fourth is measure generation – threat assessment based on probability, time-to-collision and SAFESPOT's Safety Margin Concept (e.g. critical, safety and comfort). Fifth is alert system activation – send warning message using the Vehicle Ad-hoc Network (VANET).[6]

The purpose of this simulator experiment was to support the implementation activities and validate the application concept. In an

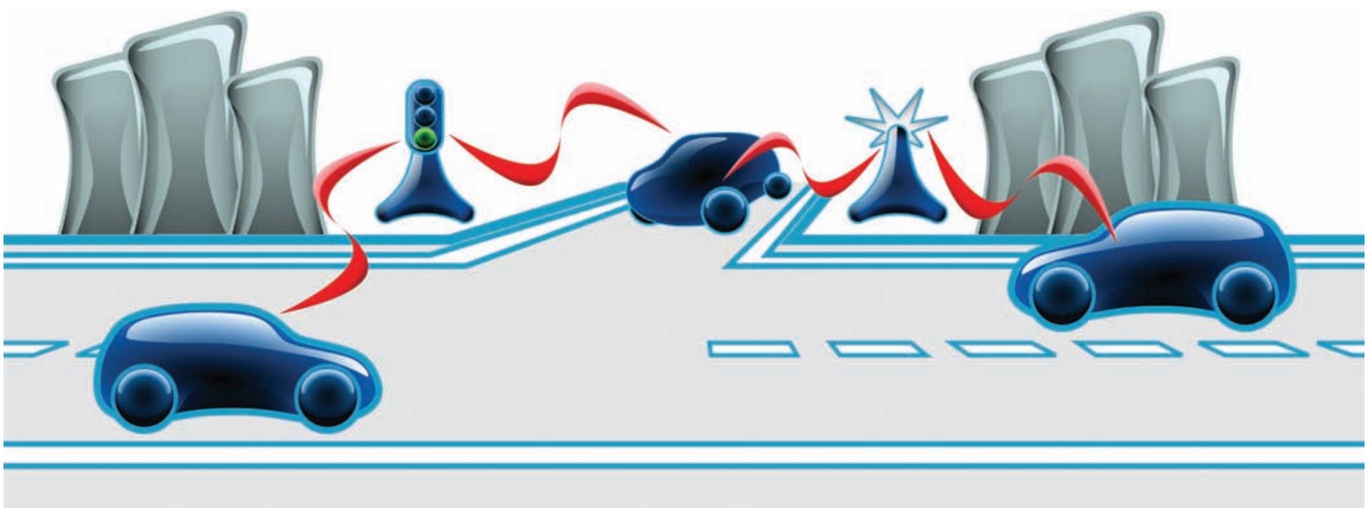

Figure 1: Impression of the IRIS system, which identifies safety-critical situations at intersections and warns road users of potentially dangerous scenarios

early stage of specification and development, simulation is useful to explore and estimate the timing of applications, derive optimal parameter settings and to estimate the potential impact. Also, simulations create clear and comprehensive demonstrations of an application and its use. The objective of the experiment was to assess the IRIS concept in various conditions and learn about user acceptance, system helpfulness and system usability.

METHOD

The driving simulator experiment consisted of three scenarios. A warning for a passenger car violating the red light was given in the first scenario. The second had a warning for a conflict with a scooter when turning right, and the last scenario had a warning for a police car ignoring the red light. The three scenarios are shown in Figure 3. The simulation network consisted of six successive urban intersections with a legal speed limit of 50km/h. Scenarios one and three used the first four intersections, whereas scenario two used intersections five and six. By means of traffic signs, the participants knew that they had to take a right turn at these two intersections.

Scenarios one and three were driven with different settings for the time of warning and the velocity of the red light-violating car. The time of warning was a function of the participant's velocity *v* (dynamic) and the deceleration *a* required to have a stop at the intersection stop-line. A warning was given when the distance-to-stop-line (DTS) was smaller than the distance required to halt at the stop-line with a given deceleration, i.e. when DTS < $v^2/2a$. Based on literature[7] and *a priori* testing, required deceleration values of 2.5 and 5m/sec^2 were used. The velocity of the red light-violating vehicle was tested for 30km/h and 60km/h, i.e. below and above the legal speed limit. Scenario two had two settings for the position of the warning; a warning at 20m and 40m before the intersection. For all scenarios it was assumed that the IRIS system was able to identify the conflict and determine the threat early enough to generate a message.

The fixed-base driving simulator used in this experiment was a fourth-generation Volkswagen Golf mock-up, located at TNO Soesterberg in the Netherlands. The mock-up had normal controls (including manual transmission). The road and traffic environment were projected on three rectangular screens, and the mirrors were projected as insets on these screens.[8]

The icons (Figure 5) appeared on a display at the right side adjacent to the steering wheel, and were based on the work of the INTERSAFE project.[9] A single short beep accompanied the icons.

Each participant drove six runs. The first run was a practice run to get used to the driving simulator environment. In the remaining runs, scenarios one and three were driven twice and scenario two once. Within each run, two conditions were simulated. The velocity of the approaching car was kept constant within each run. The conditions were counterbalanced among the participants. Subjective measures were gathered by a questionnaire that was completed after each run. Eight multiple-choice questions were answered for the two conditions per run. The questions were related to the criticality, driving comfort, traffic safety, timing, braking, looking at the display, understanding the icon, and which of two warnings they preferred.

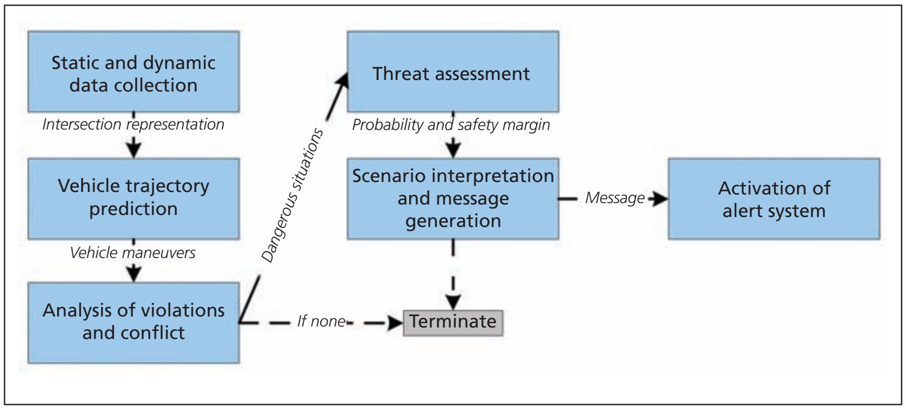

Figure 2: Activity flow diagram of the Intelligent Cooperative Intersection Safety (IRIS) system

Figure 4: The fourth-generation VW Golf fixed-base driving simulator at TNO Soesterberg

RESULTS

The data was analyzed by means of analysis of variance (ANOVA) and Tukey's LSD post-hoc tests.

Some differences were found between a police car and a normal car both approaching from the right at an intersection and ignoring the red light. A significant effect was found for the criticality between car types (police or normal car) and their velocity [$F(1,11)= 6.03$, $p<0.05$]. A Tukey test showed that a normal car was experienced as more critical than a police car when both drove 60km/h. Regarding the timing, there was a marginal significant effect on the two-way interaction between car type and velocity [$F(1,11)= 3.71$, $p<0.1$]. A post-hoc Tukey test showed a significant effect between the warning-time ratings for the normal car driving 30km/h and the police car driving 30km/h [$p<0.01$]. The experienced warning time for the police car came later than for the normal car when they both drove at 30km/h (Figure 6). This implies that in the final application the warning for a police car might be given earlier than for a normal car when they approach with a velocity of about 30km/h. Finally, there was a two-way brake-force interaction effect between car type and their velocity [$F(1,11)= 14.63$, $p<0.01$]. A Tukey test showed that the participants experienced a need to brake harder for a normal car compared to the police car, when the cars were both approaching with 60km/h [$p<0.05$] (Figure 6). Hence, although there were no differences in timing and criticality, subjective differences with respect to the car types were indicated.

Some differences were found for the approach velocity as well. An ANOVA showed a significant effect on the rated own traffic safety for the interaction between

Scenario one: car from right

Scenario two: conflict with scooter

Scenario three: police car from right

Figure 5: Examples of icons shown in the Intelligent Cooperative Intersection Safety (IRIS) system

velocity and acceleration [$F(1,11)= 11.44$, $p<0.01$]. A post-hoc Tukey test showed a significant effect between cars approaching at 30km/h and 60km/h [$p<0.05$] both for a required deceleration of 2.5m/sec^2. The approaching car with a velocity of 30km/h was given a higher traffic safety effect than with 60km/h. The approaching cars were programmed in such a way that they would hit the driver at the same time instant, i.e. independent of the velocities. The results might be explained by the fact that a car driving at 30km/h and initially hidden by a building appears earlier compared with a car driving at a velocity of 60km/h. Hence, in further development of the IRIS application,

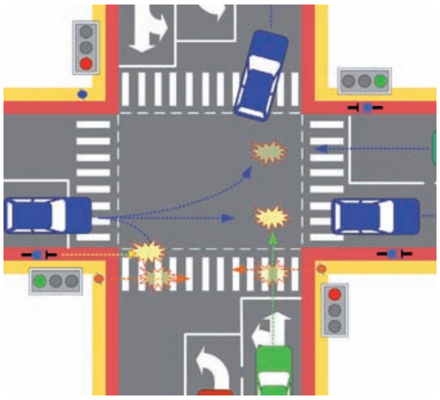

Figure 3: Intersection scenarios – scenarios one/three and two are highlighted

"The objective was to assess the IRIS concept in various conditions and learn about user acceptance, system helpfulness and system usability"

the approaching velocity has to be taken into account.

Differences were also found with respect to required deceleration by the participants – i.e. the required deceleration to have zero velocity at the stop-line. But these results are trivial since the warning was provided later when the required acceleration was set higher. Consequently, a higher brake force is required and the situation becomes more critical. Regarding driving comfort, no significant effects were found. This implies that for this experiment, the comfort was neither increased nor decreased.

For the scooter, only a marginal effect was found [$F(1,11)= 3.31$, $p<0.1$] for the timing. The drivers noticed that a warning at 20m before the right turn came later than a warning at 40m for the right turn. The mean scores for both situations were between on time and a little too late. So the warning could be given earlier if practically possible.

CONCLUSIONS

The driving simulator study has shown that IRIS has the potential to enhance the traffic safety and identified configuration recommendations. In addition, the driving simulator experiment has been proved to be useful in an early stage of specification and development of an application, to assess timing, potential impact and parameter settings in various conditions, while also learning about user acceptance, system helpfulness and usability. Setting up the experiment produced new and valuable knowledge relating to the design of the system. Demonstrations in real-life traffic, meanwhile, are planned in Helmond, the Netherlands, and Dortmund, Germany in the first half of 2009. ■

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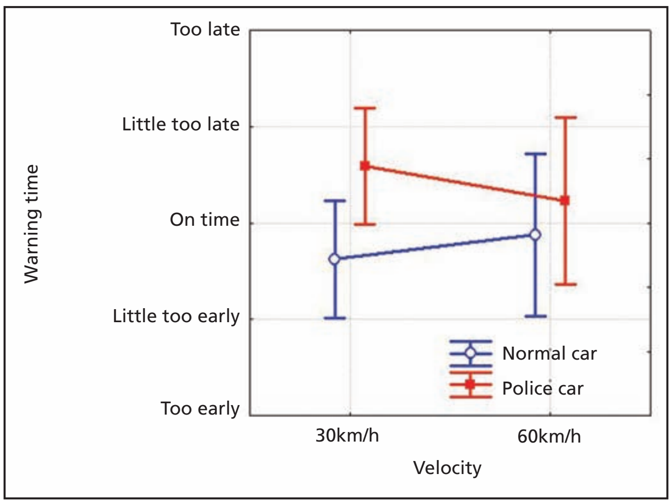


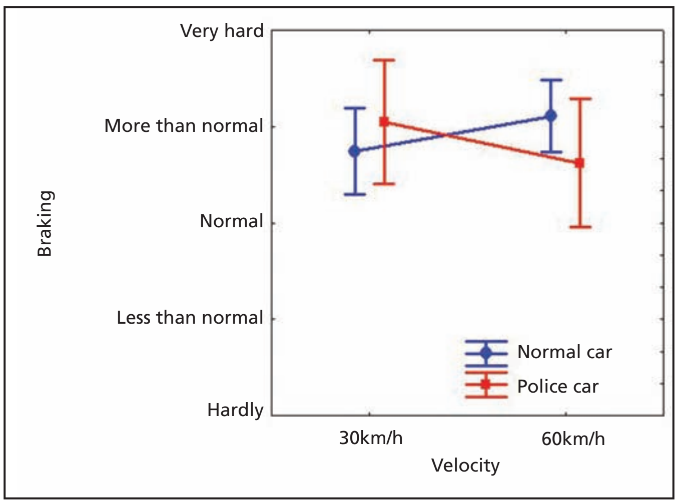


Figure 6: ANOVA (analysis of variance) and Tukey's LSD post-hoc tests were used to enable comparitive analysis between a police car and normal car

by Ian Moore

SMOKE SCENE

TUNNEL EARLY WARNING SOLUTION WITH VIDEO SMOKE DETECTION

The rapid response to potential incidents in tunnels is critical and highlighted by some recent high-profile tragedies. The use of CCTV technology – and also smoke-detection systems – is therefore essential in maintaining safety

There is little doubt that the confined nature of a tunnel – by virtue of its small cross-sectional area – presents a uniquely challenging environment in relation to fire safety. Factors such as the length of tunnels (with some now stretching more than 50km), the difficulty of access, and the higher heat release rate from fire, make any delay even more critical when it comes to the potential for a blaze to be tackled and, crucially, those people inside to be evacuated.

Against the backdrop of a number of major fire-related incidents over the past decade – including the Mont Blanc Tunnel in 1999, which claimed the lives of 39 people, and in March 2007 a fatal fire in the Melbourne City Link Tunnel – there has been increasing interest in the application of CCTV cameras in conjunction with video analytics technology, specifically video smoke detection (VSD), to provide vital early warning of incidents.

The Palm Jumeirah tunnel in Dubai is a major engineering feat that required the installation of highly sophisticated video smoke-detection systems

As time is always critical with all fire detection systems, it is clear that smoke detection is needed and not heat detection to attain this advanced notice of impending danger. Sadly, the reality is that in the past many people have perished due to smoke inhalation and – in road tunnels – the accidents resulting from the reduced vision of drivers by the time that a heat-detection system has initiated.

Road tunnels are high-risk areas that demand attention to safety, particularly fire detection

Smoke detection in road tunnels was a previously unsolvable scenario, due to the dirty environment, which not only would have created many false alarms due to vehicle exhaust fumes but also the near-impossible task of maintaining any devices so they remained operational within their limits. Due to its design and complex algorithms, VSD has the potential to overcome these problems.

TUNNEL VISION WITH VSD

Initially developed for the nuclear industry, VSD works in real-time with standard CCTV images that are then analyzed by specialized image-processing software. This seeks out the particular pattern that smoke produces by applying extensive detection and known false-alarm algorithms.

By programming the software to look for anticipated motion patterns of smoke over a specified area within a camera image, and analyzing pixel changes, VSD has the potential to deliver an exceptionally fast response – typically in seconds. Crucially, once smoke has been detected the system can alert the operator, as well as delivering a visual representation of the smoke on the system's monitor.

Unlike more traditional methods, this ability to effectively detect smoke at source means that VSD does not have to rely on the proximity of smoke to a detector and is therefore unaffected by distance. Whether the camera is situated 10m or 100m from a risk area, VSD has the capacity to detect smoke in the same amount of time, providing an early warning that would be impossible with conventional detection. In addition, as the location of smoke can be readily identified by using cameras at multiple points, the VSD system can supply valuable management information, allowing users to be directed away from any incident while avoiding the most dangerous areas. This situational awareness is particularly beneficial in tunnels with a gradient, where smoke will tend to gather more on a particular side of a fire when it rises.

"Sophisticated algorithms allow it to readily distinguish between smoke and steam, which might prove problematic for other detection solutions"

VSD is based on the computer analysis of video images provided by standard CCTV cameras and uses advanced image-processing technology and extensive detection and known false-alarm algorithms

It is important to stress that VSD is distinct from other camera-based detection systems that are, in all reality, motion detectors or obscuration change detectors. These are unable to differentiate between smoke and other sources of movement, so are liable to generate a high level of false alarms. This is not, however, the case with VSD, in which sophisticated algorithms allow it to readily distinguish between smoke and steam – scenarios that might prove problematic to other solutions.

RAPID RESPONSE FOR SYDNEY

For the practical application of CCTV camera-based VSD, the Sydney Harbour Road Tunnel – the largest privately funded public works project in Australia – offers an impressive reference point in terms of the capability of this technology to provide a rapid response to potential fires.

Sydney Harbour Tunnel was constructed back in 1992 and was fitted with the best fire protection systems available at that time. These measures consisted of thermal point detectors spaced every 15m over each lane, and more than 40 CCTV cameras. In 2000, an additional 48 cameras were installed facing oncoming traffic throughout both bores, complemented by a manual deluge system operated from a dedicated 24-hour manned control room in North Sydney.

The catalyst for the move to implement a new VSD solution came from an ongoing program of intensive training and monthly maintenance by the Sydney Harbour Tunnel Company (SHTC). With advances in technology, the tunnel's management was keen to look for more effective systems of fire detection.

In conjunction with the Sydney Fire Brigade, a series of controlled vehicle fires were created to test the tunnel exhaust system's ability to remove smoke, the activation of the point detectors, and the capability of the deluge system to suppress a fire. At this stage, the Sydney Harbour Tunnel management decided to include VSD in the trial.

During the live burning of the vehicles, temperatures at the fire site reached in excess of 500°C. The operation of the deluge system was delayed to allow the fire to develop and for a large volume of smoke to spread along the tunnel. Activation of any of the tunnel's alarms was monitored. After approximately five minutes – and a full-blown fire with extreme temperatures – the deluge was operated and the fire contained.

The live images of the fire were screened through the VSD system and the first alarm was generated within 14 seconds of visible smoke and prior to any visible flames. A further 30 alarms were generated throughout the remainder of the test burn. At no point during the tests did any of the older automated systems within the tunnel generate an alarm.

As a result of the successful tests, VSD was then procured by the Sydney Harbour Tunnel Company to cover 80 of the tunnel's existing CCTV cameras.

A NETWORKED FUTURE

Looking ahead for future tunnel projects, there could be a trend in VSD moving toward systems that come with a networked capability, so any solution is not limited to being monitored locally on site.

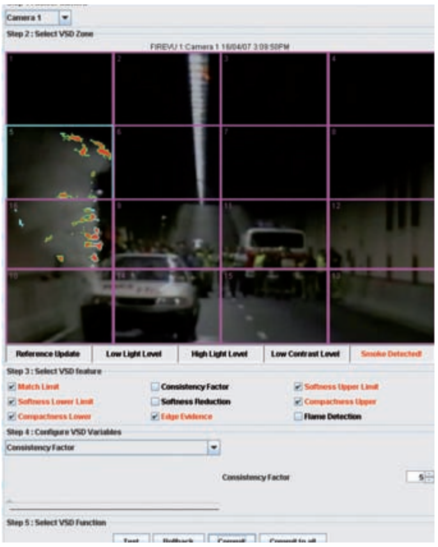
Now with the latest IP-enabled systems, such as FireVu, there is the potential to offer 24-hour remote monitoring and fast response to incidents, with alarm and associated video images distributed to an unlimited number of locations for review through using a network's TCP/IP as the communications backbone.

From a tunnel operator's perspective, a key advantage is that one control center can potentially be used to monitor a number of FireVu VSD tunnel installations. Crucially, there is virtually no limitation on the distribution of alarm information as the system can be monitored on any PC. System faults are also reported via IP, and alarm information can be sent by SMS and MMS to mobile telephones, handheld units, and via email.

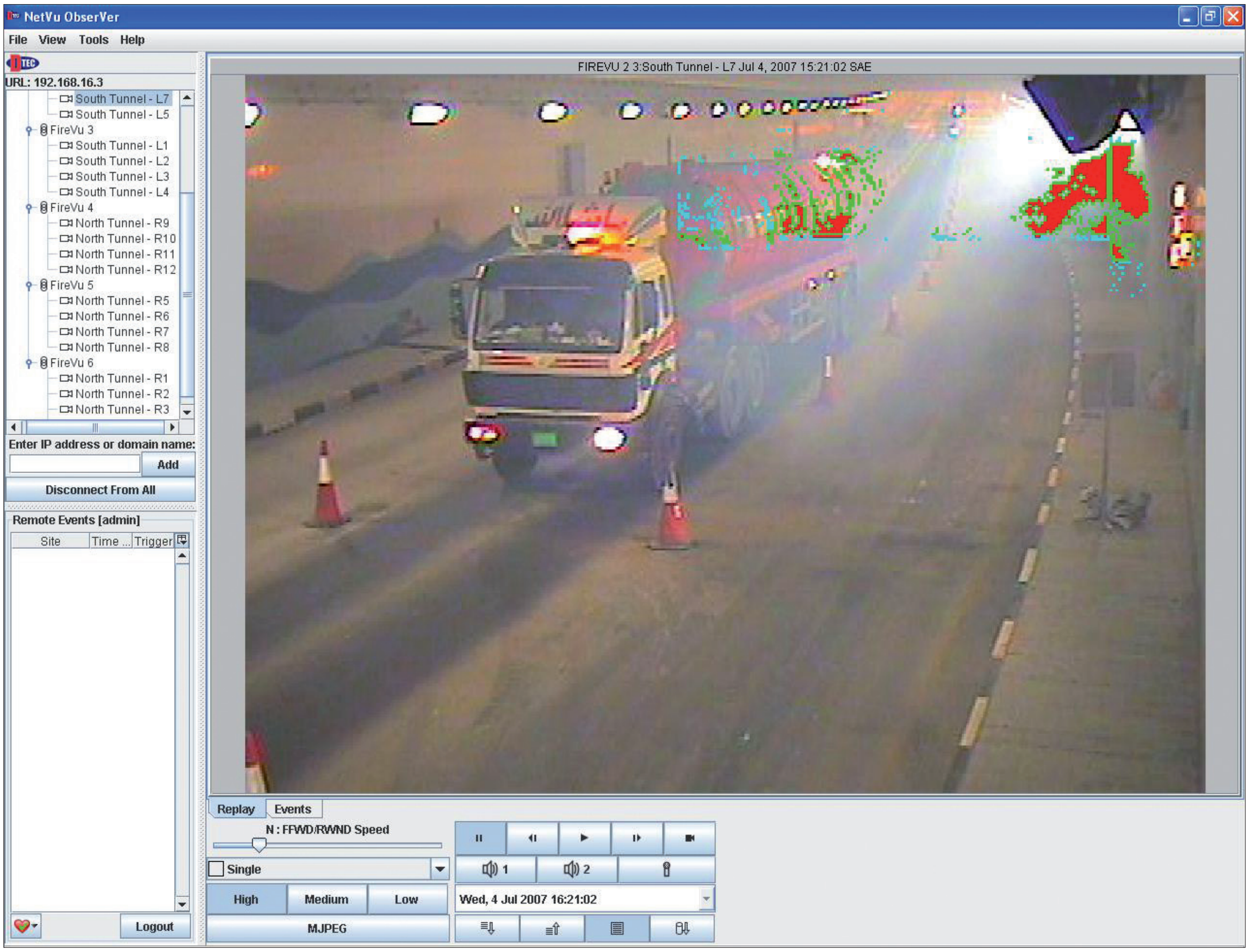
As this approach uses TCP/IP as the communications backbone it also allows easier and faster monitoring and diagnosis of installations and hence the quicker resolution of any maintenance issues.

In addition, as all alarm events are recorded on the system's Digital Video Recorder (DVR), these can be readily accessed for pre- and post-event analysis, allowing the operator to view what or who caused the incident. This capability can help to identify any changes that need to be made to a tunnel's fire safety plan.

D-Tec's advanced VSD system is being used to provide a rapid response to potential fires in the AU$554 million Sydney Harbour Tunnel



Whether the camera is situated 10m or 100m from a risk area, VSD will detect smoke in the same amount of time



VSD technology enables a fast response to a potential fire, saving valuable time even in voluminous areas or where a high airflow may be present

Reconfiguring the system – when alterations have been made to the facility being protected – can also be carried out remotely, thereby removing the cost and delay associated with traveling to a site.

Significantly, FireVu – which shares a common NetVu-connected technology base with other AD Group systems and its NetVu ObserVer GUI (Graphic User Interface) – can be integrated with a range of facilities management measures and security systems. This means the same interface can be used to call up images associated with a fire incident or a criminal attack.

PALM JUMEIRAH TUNNEL

A positive example of the application of the latest IP-based VSD in road tunnels is the main link at the famous Palm Jumeirah man-made island in Dubai. In this case, seven FireVu units have been supplied, tested and commissioned by fire specialist BSS-ME.

The box-like Palm Jumeirah tunnel is undoubtedly a major engineering feat – having required 185,000m^3 of concrete and 30,000 tons of reinforcing steel – and has been designed and constructed to hold three individual bores with the outer two bores carrying three lanes of traffic and

pedestrian walkways in each direction. The inner tube is used as a service tunnel and also in the event of an incident for emergency evacuation.

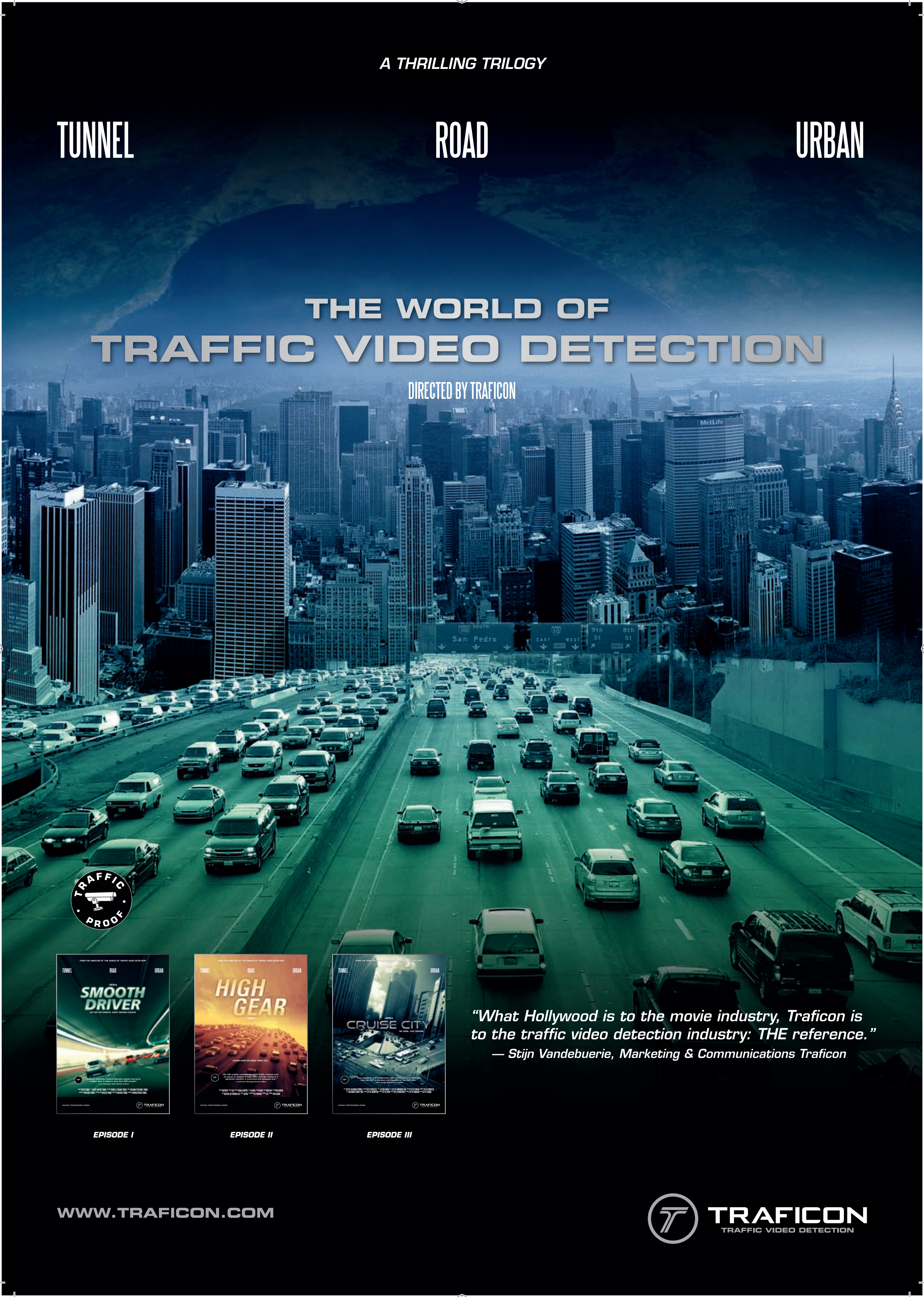
For the Dubai tunnel solution, the networked FireVu units installed by BSS-ME are connected to 28 fixed CCTV cameras positioned strategically throughout the tunnel's two outer bores – 14 in each. Crucially, the cameras used for VSD are the same as those for security and other surveillance tasks in the tunnel, such as traffic management, which helps to maximize return on investment.

As a result of the successful tests, the VSD was procured by the Sydney Harbour Tunnel to cover 80 of the tunnel's CCTV cameras

Now monitored around the clock by the VSD solution, the operators of the 1.4km-long, 40m wide, underwater link can be assured of the fire safety of this vital connection between Palm Jumeirah's spine and the main crescent part of the island.

Ultimately, the future will see many more examples of CCTV being applied intelligently to deliver fire safety benefits in areas such as tunnel safety, where there are critical gaps in the capability of existing, conventional alternatives. This is underlined by the fact that, when time is of the essence, it is smoke and not heat detection that has the real potential to save lives. ■

Ian Moore has over 28 years' knowledge of electronic systems, and over the past 19 years has specialized in fire detection and security systems. Studying electronics as a Royal Navy engineer, he subsequently gained experience at Chubb Alarms, Siemens Cerberus, and Zellweger Analytics. Now, as managing director of Detector Technologies Limited (D-Tec) – part of CCTV specialist AD Group – his expertise in video smoke detection is much in demand and he is often asked to speak at seminars on the subject of fire detection, For further information, please email info@dtec-fire.com


A THRILLING TRILOGY
TUNNEL
ROAD
URBAN
THE WORLD OF
TRAFFIC VIDEO DETECTION
DIRECTED BY TRAFICON
TRAFFIC PROOF
SMOOTH DRIVER
HIGH GEAR
CRUISE CITY
EPISODE I
EPISODE II
EPISODE III
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TRAFICON
TRAFFIC VIDEO DETECTION

by Greg Szrejber, Alireza Hadayeghi & Brian Malone

SAFETY DRIVE

TOOLS FOR IMPROVING ROAD SAFETY IN A FAR-REACHING AND EFFECTIVE WAY

A case study from Canada shows how taking a far-sighted approach, combined with the use of sophisticated engineering technology, can achieve long-term improvements to a whole region's road safety record

Identifying sites with potential for safety improvements is the initial step that is usually taken by transportation agencies in their safety management programs. However, identifying and conducting detailed engineering studies of candidate improvement sites is very expensive and time-consuming. As funds for safety improvements are limited, it is important to spend the resources as effectively as possible. A new initiative has been undertaken by the region of Halton in Canada that involved all municipalities within the region, as well as Halton itself. The project entailed the development of safety performance functions (SPFs) and network-screening tools. This allowed for the automation of ranking processes involved in determining locations with the best potential for safety improvements, within each municipality involved.

This article will expand on the processes used for data capture, storage and safety analysis, utilizing GIS technology, SPFs and collision over-representation through the use of the Traffic Engineering Software (TES).

Figure 1: The municipality of Halton is in the heart of Ontario's economic heartland in Canada

REGIONAL DATA

The Halton region is one of Canada's most dynamic areas. It is strategically located in Ontario's economic heartland, within the Greater Toronto Area, as shown in Figure 1. Halton covers more than 232,000 acres of land (939km^2), including a 25km frontage onto Lake Ontario, and comprises the local communities of Burlington, Halton Hills, Milton and Oakville.

A total of 20,894 collisions occurred on the arterial and collector intersections and road segments between 2000 and 2004. From the total number of collisions, the distribution between collisions that occurred at intersections and those occurring at road segments was about 65% and 35% respectively. The percentages of severe (fatal and injury) collisions were about 21% and 20% for intersections and road segments respectively. From the intersections, four-legged signalized intersections had the highest number of fatal collisions, with 12 occurrences. On the other hand, for the road segments, two-lane rural roads had the highest number of fatal collisions, which for these roads was found to be 18.

Each municipality and the region of Halton uses TES, which accurately integrates collision data, traffic count data, and road characteristics data into one corporate database. This integration and ease of access saves time and provides accurate and complete data for analysis, developing safety tools, and for establishing safety programs. The region of Halton took advantage of having one integrated system and developed with the help of Synectics Transportation Consultants a network-screening process using the TES. The result was that the region and municipalities were able to identify and prioritize problem intersections and road

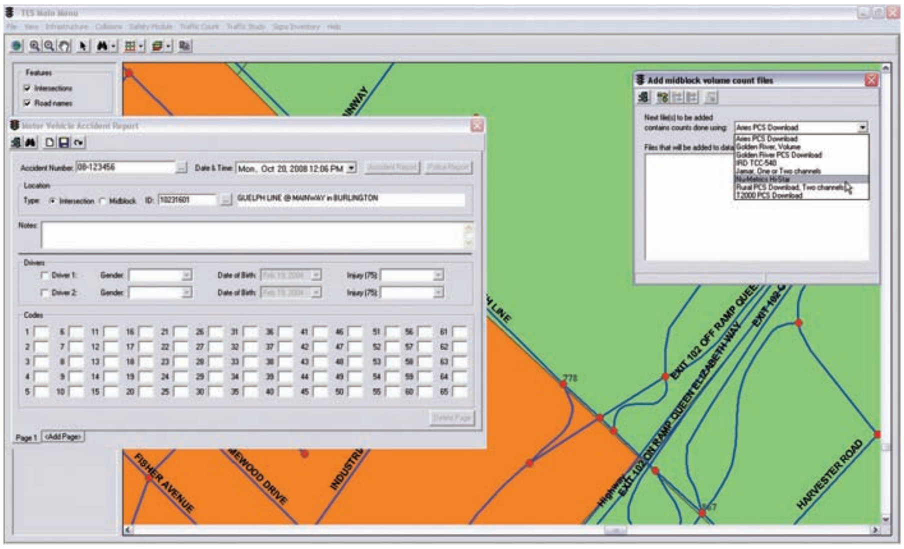

Figure 2: The above shows the collision input form and traffic count data import interface

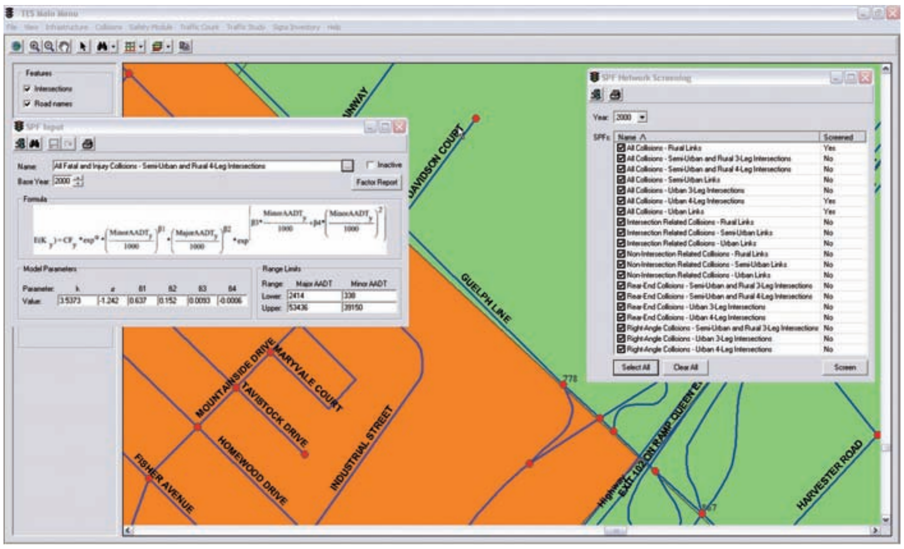

Figure 3: An SPF form, using intersection and road configurations, collision and traffic volume data

"The region and municipalities were able to identify and prioritize problem intersections and road segments"

segments, allowing for the strategic spending of funds toward the most problematic locations where improvements would yield the largest increase in road safety. Also, the municipalities were able to effectively compare their road network analysis results among themselves, allowing relative comparison that further promotes efficient spending of funds within the region.

METHODOLOGY

The methodology used in this study was to incorporate the infrastructure, collision and traffic volume data maintained by the region municipalities with the TES and the 'safety performance' quantitative traffic safety analysis. Specifically, the approach used SPFs and a network-screening process built into TES to identify 'sites with promise' based on their potential for safety improvements.

The data required for the development of SPFs was efficiently input by each municipality into a corporate database. For example, traffic count data was imported from recorders. The collision data was input and validated through a data-entry user interface. Figure 2 shows the collision input form and the traffic count data import interface.

Users were also able to add any other data into the database, such as infrastructure data, images of the collision reports, speed studies, AutoCAD drawings, photos, and any other documentation associated with a location. Essentially, all information about anything related to the specific location was accessible to the user.

The intersection and road segment configurations, collision and traffic volume data were used for the development of SPFs.

Once these functions were built into the TES Safety Module, the process of identifying sites with promise and over-representation analysis was conducted automatically, as shown in Figure 3.

The Safety Module is capable of selecting the location group, choosing the appropriate model form, applying the EB framework, calculating and ranking the potential for safety improvement (PSI) for all the intersections and road segments in the network, as well as conducting an over-representation analysis for each section.

The reports area of the Safety Module was used to perform analysis on the network-screening data. Specifically, it was used to generate reports to compare PSI values of various locations and to review any over-representation information for locations, as shown in Figure 4.

An over-representation analysis was conducted for each location to identify what the collision causal factors may be relating to geometric, operational, environmental, temporal and also collision-related characteristics. This was accomplished by determining what categories (if any) of a given characteristic were over-represented in collisions for each location with high PSI index rankings. These tests are based on the statistical procedure known as the 'Chi-square Test of Significance' and the results provide information linking collision occurrence to potential causal factors.

The over-representation analyses serve two main purposes. They help to refine the list of locations that should be considered for safety improvement. Secondly, the results of these analyses aid in the task of identifying specific safety problems and issues during field investigations, thereby providing guidance on countermeasures and treatments to consider for making effective safety improvements. That is, the over-representation analyses provide

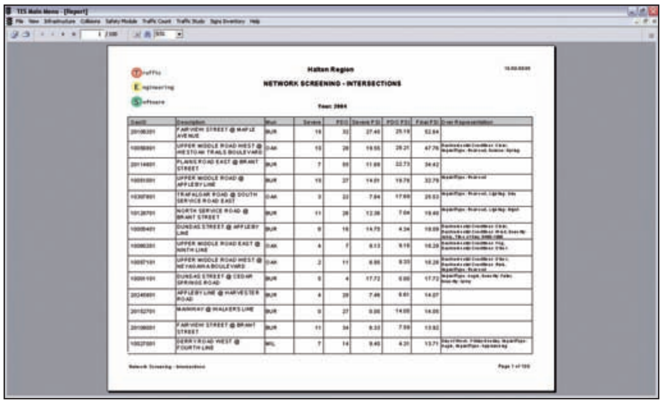

Figure 4: Comparing PSI and over-representation at various locations

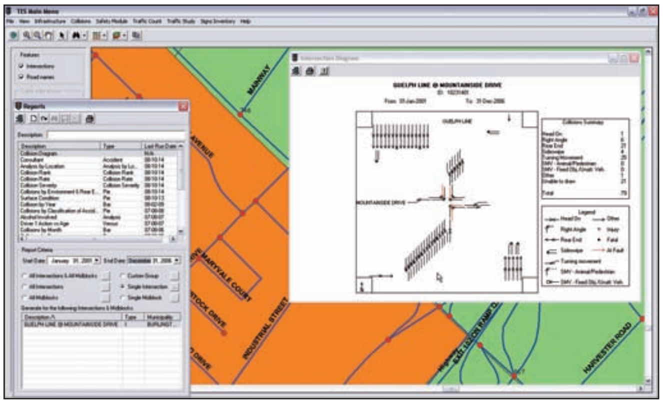

Figure 5: Query builder and collision diagram to enable detailed analysis

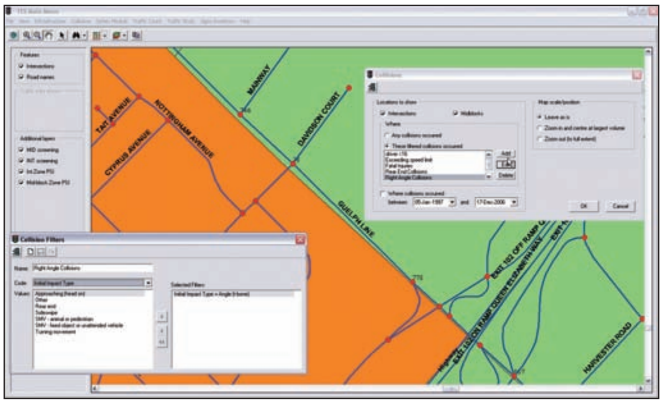

Figure 6: GIS filters helped locate the most dangerous locations instantly

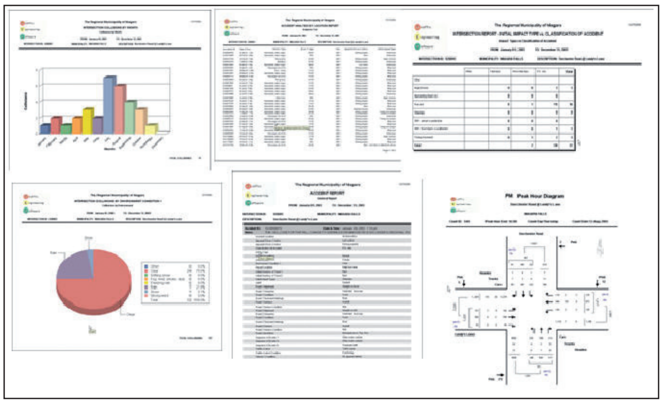

Figure 7: Reports compare past and present data, allowing evaluation

"Without such a system in place, time would be wasted looking for data instead of defining the problem and finding a solution"

additional information to help focus on specific collision characteristics during the subsequent field investigations. For example, knowing that collisions are over-represented at night, during inclement weather, only for angle collisions, and on Saturday night only provides valuable information for identifying the collision types to look for. This, in turn, helps to focus on the locations and traffic movements that are associated with these collisions during the field investigation, thereby providing guidance on remedial measures that would be effective if implemented for making safety improvements.

The over-representation analysis was supported by the collision diagrams and query builder for detailed analysis of the location, in order to find the different contributing causes, and is illustrated in Figure 5. Pre-made templates were used, and users were creating their own to find the source of the problem and the solution to the problem.

A screening process at the neighborhood level was also developed and incorporated into the TES GIS module. This allowed the region and area municipalities to evaluate how the road network within different neighborhoods was performing. The corridors that required attention from the safety perspective were clearly indicated. Without any third-party GIS applications, the municipalities were able to utilize GIS technology to easily filter their most dangerous locations almost instantly, as well as the locations with the biggest potential for improvements, as shown in Figure 6.

Reports were created (as shown in Figure 7) to compare past and present data, allowing for the evaluation of the effectiveness of different initiatives, and to forecast future preventable problems.

CONCLUSIONS

The quantitative safety analysis approach and methods developed and implemented allowed the establishment of a proactive road safety improvement program that is capable of identifying, planning, designing, prioritizing and implementing safety-related projects. The municipalities were able to effectively conduct analyses on a micro and macro level, as well as compare their road network analysis results among themselves, allowing relative comparison that further promotes efficient spending of funds within the region.

All municipalities within the region of Halton were using the same integrated TES system. This helped them obtain, store and analyze everything occurring on their road network, leading to more integration, accuracy and efficiency within road safety programs. Without such a system in place, time would be wasted looking for data instead of defining the problem and finding a solution. As is already known, not only is crash data required, but road characteristics and count data are also crucial to effectively determine the key problems and craft the appropriate solutions. Therefore, a system that integrates all this data is a necessity. Ultimately, the ability to further improve road networks is within reach, by combining expertise with tools such as TES. ■

Greg Szrejber is founder and president of TES Information Technology Ltd. Brian Malone is president of Synectics Transportation Consultants. Alireza Hadayeghi is a PhD candidate with more than eight years' experience in transportation planning, traffic engineering, statistical modeling and road safety

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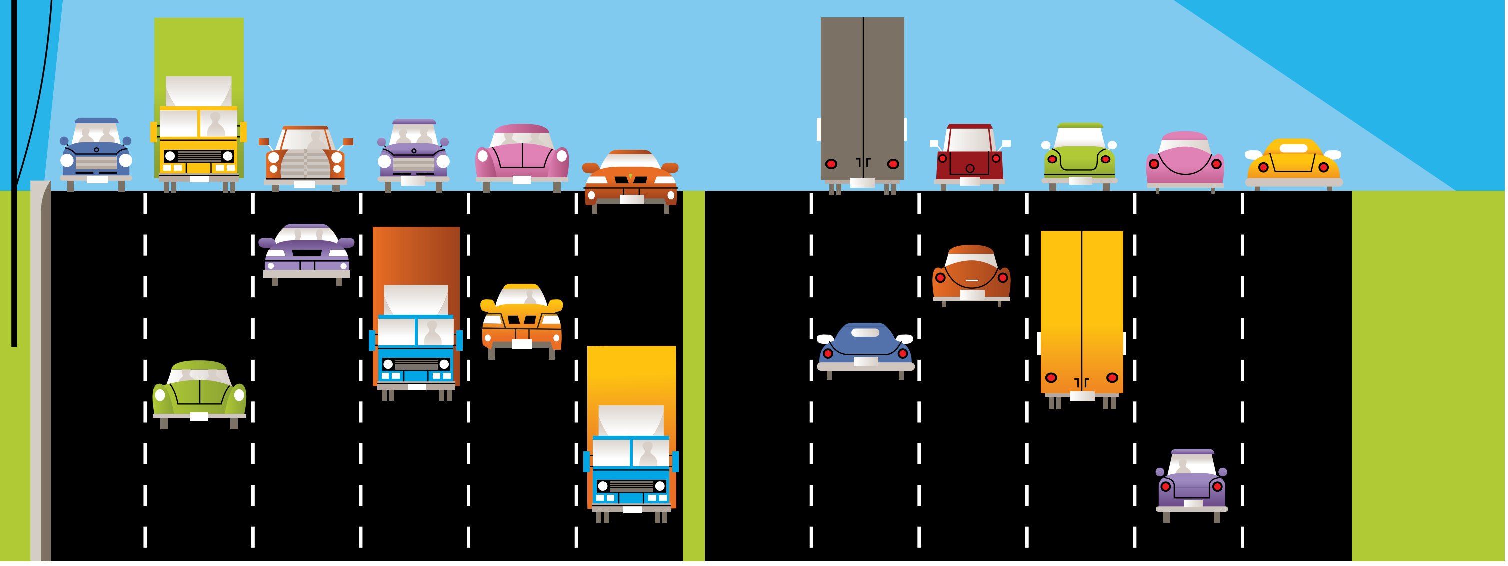

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ASSISTANCE NEEDED

CHALLENGES AND REQUIREMENTS FOR THE NEXT GENERATION OF ADAS

Advances in electronics and software allowed the introduction of the first generation of ADAS. These systems have great potential to improve safety, but their penetration is still low – an issue that needs to be overcome

Between the 1950s and the 1990s, a great deal of work focused on the passive safety arena. New restraint systems or improved passive safety structures helped auto-makers to build safer cars. From the late-1970s and early 1980s, a second step was taken in terms of electronic-based active safety systems – such as anti-lock braking (ABS), traction control (TCS) and, since 1995, electronic stability control (ESC). The introduction of electronics and its evolution then played a major role. At the turn of the century – and with the continuous improvement of the above-mentioned systems – the development of in-vehicle ADAS (Advanced Driver Assistance Systems) has quickly gathered pace.

Despite the fact that the penetration of ADAS is increasing every day, it is still not representative within the market volume, and there are several factors behind this. The high price of such systems has been prohibitive and has meant that they have been launched primarily in high-end vehicles. There is also a lack of awareness among the driving public about the benefits that ADAS can offer. Another drawback has been the fact that they are standalone and mono-technology systems.

Together, these reasons represent a limit on the enormous safety improvement possibilities such systems can bring to society. Now, though, it is time for a further evolution of ADAS: new, more mature and better-performing systems, capable of being introduced in a cost-effective way in several market segments and affordable to most of the population. This will be one of the biggest challenges in the coming years, hence the European Commission pushing through initiatives, such as eSafety (with the goal of halving the number of deaths in 2010 compared with 2001's figures), and 'i2010: Intelligent Car'.

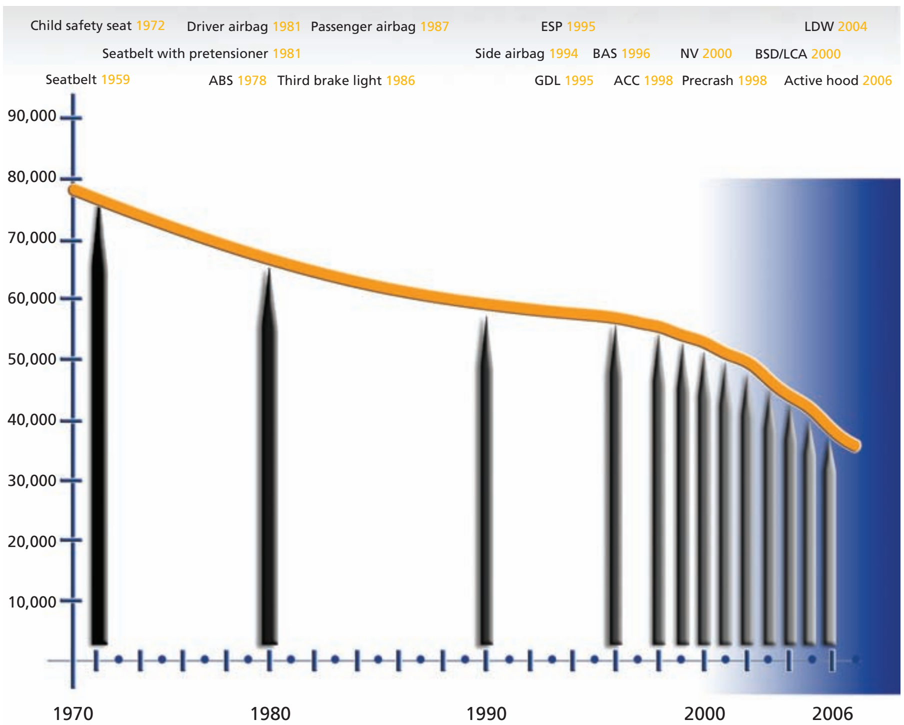

Figure 1: Showing the introduction of safety systems and evolution of road fatalities in Europe

ACCIDENT CAUSATION ANALYSIS

What are the most common causes of accidents? If we examine the Spanish road traffic administration figures,[1] more than 4,100 people were killed over the course of 2006 in road accidents, bringing painful and important economic consequences. This equates to more than 94 deaths per million inhabitants, slightly over Europe's average figure of 87. When referencing the Spanish figures, some important clues can be extracted from the main causes of accidents.

In more than 20% of accidents, the drivers fail to apply priority regulations. Additionally, the drivers show signs of distraction in around 20% of the total number of accidents, while almost half of the victims are produced in poor light conditions (43.5%) – even though it represents only one-tenth of the total driven distance. More than 600 pedestrians were killed in traffic accidents, and more than half of these were as a result of poor light conditions. One out of every three accidents takes place at intersections. In Europe, this figure is about 25%,[2] while 56% of the total accidents involve two or more vehicles, and head-on collisions achieve a rate of more than 30%. Illegal speed only represents around 2.5% of the total accidents, but inappropriate speed represents 15% of the total figures.

Moreover, drivers' understanding of some driver assistance systems is not particularly advanced. More than half of the total drivers cannot take advantage of the full braking capabilities of today's vehicles, while only one-third of the total population knows the benefits of systems such as ESP.[3]

It can be concluded that three main elements play a major role in an accident: the driver, vehicle, and infrastructure. The first is involved in almost 90% of accidents, so the newer driver assistance systems can provide a valuable aid for the driver and will bring about reductions in accidents.

CHALLENGES AND REQUIREMENTS

As soon as several ADAS functions are introduced in a car, there is an opportunity to combine synergies to improve overall performance, to reduce cost, to look for new functions, and to better manage human-machine interface (HMI) aspects.

In that sense, 'data fusion' will increasingly become a buzz phrase. Combining data gathered from different sensors, such as radar or imagers, is the best way to minimize disadvantages and reinforce individual performance. This gathered data will be common to different applications with the same constellation of sensors. But data fusion will not only be carried through conventional sensors. Digital maps with improved capabilities will also play an increasingly important part, providing additional information that may help to boost performance. Also, car-to-x (C2X) technologies will appear to merge with existing variants.

Incoming systems will be considered as a global development, taking advantage of the information available through the complete network of sensors and able to monitor 360º around the vehicle. Along with this focus, new systems will be introduced to the market. As well as second and third generations of existing adaptive cruise control (ACC), lane departure warning (LDW)/lane-keeping assist (LKAS), night vision or blind-spot detection (BSD) systems, other possibilities such as full automatic emergency braking, traffic sign recognition, pedestrian detection, curve speed warning, intersection assistant, 360º pre-crash systems, or, at the end of the road, collision avoidance will be offered.

These new systems will bring about some amazing benefits, such as better management at intersections due to cooperative driving or intersection assistant systems. There could also be a reduction of head-on collisions through the use of frontal collision warning (FCW) or collision mitigation by braking (CMbB) prior to AEB systems. Also, better driving performance might be experienced in poor light conditions when using night vision.

Also worth mentioning is that many pedestrian lives can be saved through the use of intelligent pedestrian detection systems. And the inattention or distraction that causes so many accidents can be reduced by utilizing systems such as LDW or LKAS.

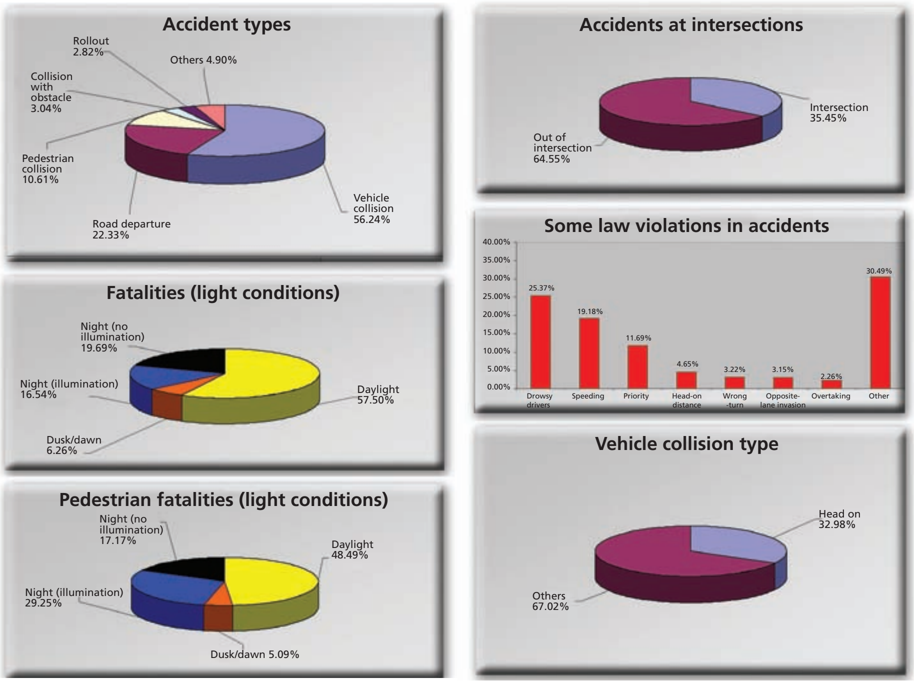

Figure 2: The above graphs and charts show examples of accident causation analysis statistics in Spain

Safety improvements are not the only benefits that can be achieved through the use of ADAS, as environmental issues can also be tackled. New assistance and/or cooperative systems may improve figures in this field. For instance, notable fuel reduction could be achieved by using ACC systems on a large number of vehicles. And it is well known that 'every avoided accident is an avoided traffic jam'. Some statistics show that something equating to 1% of total GDP is lost in traffic jams in countries such as France. The prediction is that developments in ADAS will face challenges in the near future, emanating from the different requirements of each individual system, but also considering all safety systems on a vehicle as a whole.

SENSORS AND PERFORMANCE

New ADAS sensors must offer appropriate range and reliability, combined with precision. Their consumption should remain low and their size should be as small as possible. Special effort should be devoted to designing cost-effective sensors to be introduced in all vehicle segments, and they should also meet electromagnetic emissions directives. Commonly used sensors can be classified as:

Radar: 77GHz frequency is used for long-range applications (LRR) and 24GHz for short and medium range (SRR, MRR). Radar's main characteristics are an almost weather-independent performance and very good reliability when determining distance and relative speed of the objects detected. In the future, 79GHz-based radars are proposed as the new standard for SRR and MRR applications.

Lidar: Multi-beam or scanning lasers achieve a good performance determining distance, and also offer a very good lateral resolution. In addition, they are cheaper than LRR-based sensors.

Vision: Image processing can offer some capabilities not provided by radar or lidar, of which object classification or lane assignment are among the possibilities.

Other promising sensing technologies such as photonic mixer devices (PMD) or equal polarized light techniques are even spreading the potential to better understand the environment of the vehicle. Non-physical sensors should also be considered, as they can provide useful information that cannot otherwise be found. Data from ADAS-upgraded digital maps is being integrated in some next-generation systems to boost their capabilities. Also, C2X communications can mean adding more information about surrounding traffic or the status of the infrastructure.

With this many sensors, data fusion takes on a major role, but this requires great processing power, something that comes through the evolution of electronics, as it should merge and process the data coming from several physical and non-physical sensors. The goal is to combine every tool installed to boost individual performance and minimize possible inconveniences.

Figure 3: The Advanced Dynamic Driving Simulator at CTAG's Spanish facility

However, it must also be taken into consideration that some requirements might be too strong for some safety applications. For instance, when talking about a Blind-Spot Detection (BSD) system, it might not be necessary to have an accuracy down to the centimeter in relation to the distance to the detected object. Here, a good compromise between real requirements and sensor (price, size, etc) must be taken into account.

HUMAN-MACHINE INTERFACE

Another substantial challenge is related to the HMI development, as it can determine the success of a complete system. Easy-to-use and easy-to-understand procedures should be considered in the very early stages of the design of the final systems. It is also important to consider the HMI solution globally, taking into account all ADAS functionalities, avoiding standalone HMI concepts for every function.

Several disciplines are included in this development, including physical and cognitive ergonomics, design, specific HMI technologies (displays, text-to-speech, haptic solutions, etc), rapid prototyping tools, testing with driving simulators, etc. The development should be considered via a multidisciplinary approach, but always keeping the final user at the center of the whole process. Research and acceptance clinics can effectively gather expectations of target customers, and can also be used to validate the proposed solutions.

Also considering HMI as an important topic, the growth of the over-65 population in Europe is another relevant issue. A new adaptive approach that is simple and easy to understand should be fulfilled, as this important age group must not be forgotten in the development phase.

Figure 4: CTAG's advanced prototypes with ADAS and IVIS (In-Vehicle Information Systems)

ELECTRONIC DEVELOPMENT

Another challenge when developing next-generation ADAS is related to the high complexity of the required electronic development. Reliability is a key issue, and special tools and procedures should be considered to guarantee the right performance of the developed systems in both hardware and software. In this sense, several concepts become very relevant, such as FlexRay as a deterministic high-speed data network,[4] CMMI or SPICE as software development methodology,[5] or AUTOSAR as standardized software architecture.[6] In addition to these are virtual and real extensive testing using hardware and software in-the-loop techniques, network analysis tools, driving simulators, special tracks and state-of-the-art data-loggers to reduce time and development cost.

"Promising sensing technologies include photonic mixer devices (PMD) or equal polarized light techniques"

There are some key aspects regarding development and integration of future ADAS systems, including short time-to-market, making solutions cost effective enough to reach a high penetration rate, making them affordable to the major portion of the population, as well as legal aspects and regulations. Some legal aspects should also be taken into consideration such as limitations in the future for ultra-wide-band 24GHz emissions – indeed, a 79GHz frequency is proposed. Also, some regulations regarding ADAS might be required, such as compulsory deployment or tax reduction to boost its penetration and reduce prices by high-scale production. To look for solutions and try to understand in a deeper way the requirements and challenges for next-generation ADAS, several activities are being carried out at Spain's CTAG.

Different ADAS have been implemented in three experimental prototypes equipping several state-of-the-art sensors and technologies. These include 77GHz LRR, 24GHz MRR (covering up to 40m with 80º beamwidth), and scanning laser sensors (200m maximum range with a beamwidth between 100° and 150º). They also include CMOS image sensors (also effective in the NIR range), FIR cameras, digital maps with extended functionalities for ADAS applications, and C2X communication modules. With this array of sensors, it is possible to monitor all 360º surrounding the vehicle, implementing different ADAS, some of which are summarized below:

Longitudinal control (ACC, FCW, CMbB). Using the data coming from radar and lidar sensors, together with the information provided by the image sensor, it is possible to develop some longitudinal control systems, such as ACC Stop & Go, FCW or even CMbB.

Lateral control (LDW/LKAS and BSD/LCA): Tracing and tracking a vehicle's path is possible with a CMOS sensor placed behind the windshield, and the LDW system is implemented over this information. An LKAS system is also being explored. Also, with the information coming from radar

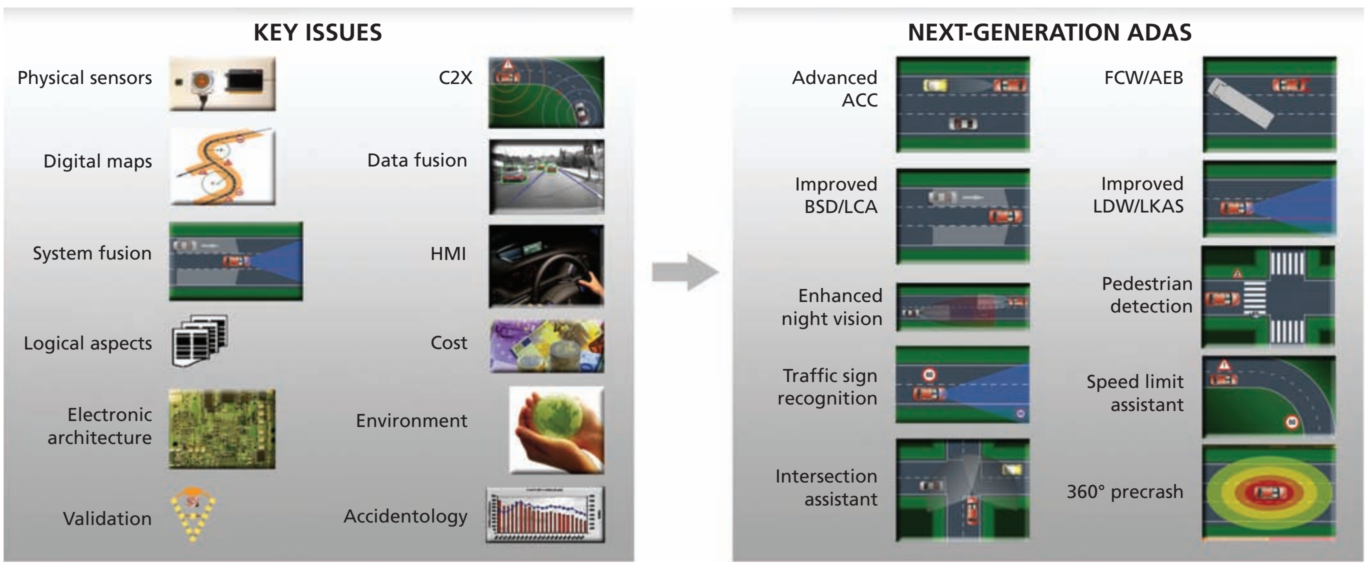

Figure 5: Key issues associated with in-vehicle safety systems and (right) the incoming next-generation ADAS systems expected to make a big difference

and lidar sensors, the adjacent lanes are also controlled (BSD and LCA systems).
Night vision: CTAG is exploring the possibilities of both FIR and NIR technologies to compare their performance. Information is shown on a special display placed over the instrument cluster.
Other warning/assistance systems: Pedestrian detection, traffic sign recognition (TSR), Curve Speed Warning (CSW), and Intersection Assistant are also implemented into the vehicles as part of a wide range of possibilities offered by the redundant constellation of sensors.

Nowadays, every ADAS integrated in the vehicles is being tested and improved, both from an engineering and user perspective, providing specific and very useful information to engineers about sensors, algorithms and final performance.

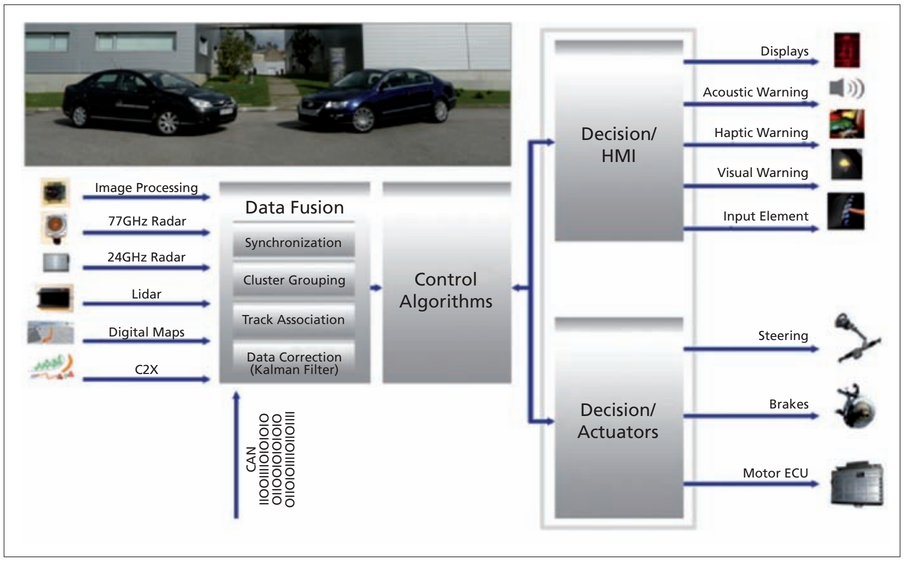

Figure 6: CTAG's data fusion architecture, which makes use of a variety of differing sensor technologies

DATA FUSION

Data fusion is a key point in the further development of ADAS, and as a result CTAG is devoting a special effort to this field.
In general, the organization's data fusion strategy makes use of all the different sensors available (radar, lidar, image sensors, digital maps and C2X technologies). It consists first of a synchronization phase between all sensors. Later on, cluster grouping is conducted before tracking association. Then, a Kalman Filter is applied to correct data if necessary. Individual requests from every scenario are taken into account to provide the best possible information. But data fusion is not solely for physical sensors; C2X and maps are also used. The following lists data fusion studies currently being explored.
ACC: A combination of radar and image processing is a natural step to increase the efficiency of systems such as ACC. Radar can provide accurate information regarding relative speed and distance to vehicles, while image processing provides data related to object classification and lane assignment. Information gleaned from digital maps is also taken into account, to better understand and manage the desired path of the vehicle.
Traffic sign recognition: Image processing-based TSR systems can be improved with map information and C2X technologies.
BSD/LCA: For other applications, such as BSD/LCA, pure physical sensor fusion is combined (radar/lidar), boosting advantages of each detection technology and limiting its possible disadvantages.

As previously stated, HMI is one of the key elements for the successful development of ADAS functions. CTAG is exploring this field with a multidisciplinary approach, making use of its Advanced Driving Simulator to conduct experiments to better understand the user ability to manage the different ADAS warnings. In fact, special emphasis has been placed on the analysis of a driver's reaction when a combination of warnings are delivered simultaneously.[7]

Several solutions for the different problems have been analyzed and an overall HMI concept for the different ADAS implemented has been developed and integrated within the prototype vehicles.[8] Several usability studies are being carried out both on the Advanced Dynamic Driving Simulator and on real roads.

Figure 7: Examples of new sensors (car-to-X, for instance) with 360° monitoring

ELECTRONIC ARCHITECTURE

Electronic architecture – combining in-house-created tailored electronics and software with flexible industrial PCs – was also a big issue in the development. A common electronic hardware/software architecture was created to provide support to all ADAS, and special consideration was given to vision-related systems, with a common FPGA-based hardware platform specially developed to provide support to all frontal-looking applications. Additionally, bus requirements (requested speed) were also considered.

Finally, when it comes to the time to validate and to improve the behavior of the different systems, the aid of a data-logger is very important, as it can provide useful information regarding performance of the vehicle in different real scenarios, and can greatly speed up the development.

The development of ADAS is a quite young discipline in the automotive industry. Nevertheless, it represents a great improvement on in-vehicle safety. With the help of the evolution of electronics since the start of the 'noughties', important steps have been made in its development.

However, greater achievements are to come with new and more mature systems, which will take advantage of the combination of new sensors and will be considered as a common development. This also brings some challenges and requirements, such as reliability, appropriate HMI, reduced power consumption, package, and – above all else – an affordable price to make systems available to the mass market.

In this regard, CTAG is working on the development of ADAS functions on several research projects, combining different fields of competence and disciplines, such as sensors knowledge, algorithm development, software and hardware engineering, HMI, and electronic design. Ultimately, every research project is reflected by several prototypes implemented by CTAG – a tool that is also used to test and validate the designs and developments that CTAG carries out – helping to prepare for the highly challenging requirements the automotive industry will face in the future. ■

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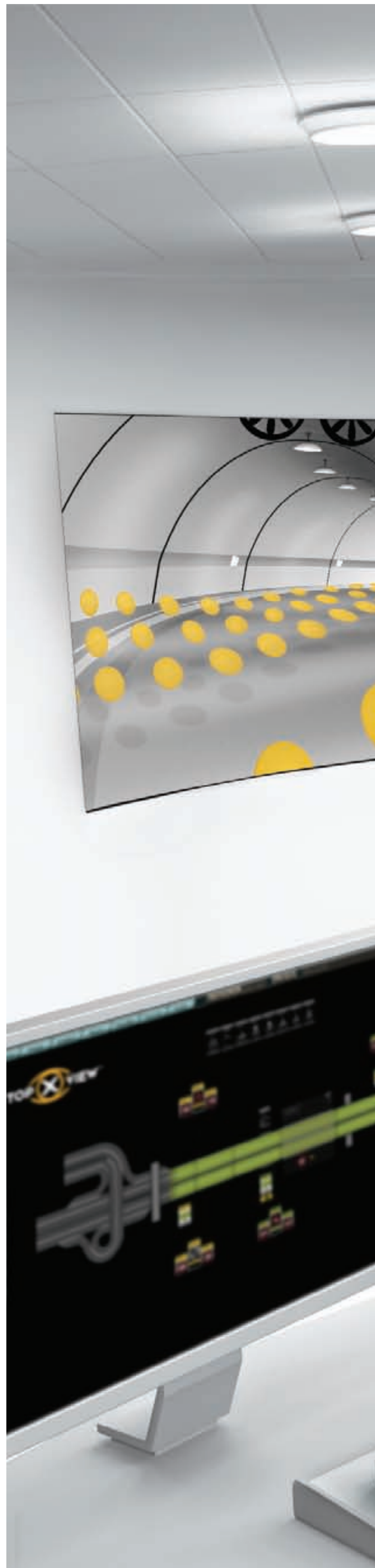

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SMART TRAFFIC MANAGEMENT

by Jani Andersson

EDUCATIONAL PROGRAM

ENFORCE OR EDUCATE? WHATEVER THE STRATEGY, RADAR IS A VALUABLE SOLUTION

There are a number of methods to quash speeding. This range of radar products aim to educate rather than persecute, while also ensuring that any violations that are created are as fair and accurate as possible

The subject of radar-based traffic technologies – particularly those used for enforcement – is one that doesn't generate the same level of interest awarded to other, more high-profile technologies. Although police departments and highway authorities are continually bombarded with pitches for the latest (and most expensive) video- or ALPR-based technologies, it is no wonder that the merits of radar are frequently underestimated. Radar may not be an 'all singing, all dancing' option, but it is proven, accurate and a cost-effective solution – a crucial distinction in these difficult economic times.

Many companies working with radar are observing a steady growth in sales and a great deal of repeat business that echoes what they already know: once you try it, you don't want to be without it. One such company is Decatur Electronics Europe (the sales arm of Decatur Electronics USA), based in Finland. The company offers a wide range of radar-based products, both for speed enforcement and for the less heavy-handed approach of trying to alter driver behavior – i.e. getting drivers to slow down without needing to 'punish' them financially.

The speed advisory kits are easy to install, and are now offered with a solar-powered option

The OnSite 50 pole-mounted speed display

YOUR SPEED IS...

One of Decatur Europe's best-selling lines is its OnSite speed display products. These are purely advisory (although they can be used for enforcement if desired). The aim with these signs is to encourage drivers to pay attention to their speed in locations where exceeding the limit is more dangerous than usual. Typical applications would be school zones or rural locations where the speed limit drops substantially when entering more built-up areas.

The range of mobile OnSite speed display signs is popular for use in construction zones, to promote safety for construction workers and road users alike.

At first glance, these products appear to be fairly simplistic: they flash on and off and display a vehicle's speed when the posted limit is exceeded. There are no variable messages or 'smiley face' icons, which ensures that driver distraction is kept to an absolute minimum. The signs have been specifically tailored to be read quickly and not avert attention away from pedestrians or other hazards on the road. However, what goes on behind the scenes is a lot smarter than this basic outline would indicate.

In an interesting indictment of some small sections of the driving population, the signs come equipped with two counters. One sets the threshold speed which, if exceeded, causes the reading to flash up a few times. The other is to set a cut-off speed – if this is exceeded, no speed reading is displayed. The point of this? To discourage irresponsible drivers from using these signs to 'test' how fast their car can go.

Decatur has been in the radar industry for more than 50 years, so its technology is well honed and among the most advanced available. Although a sophisticated technology, how it actually works can be explained fairly basically (a useful point, when considering that these products are being sold to regular people – not necessarily engineers or technology experts).

The company's SI-3 radar antenna tracks vehicles moving toward the OnSite signs using preset thresholds of time and sensitivity. In such a scenario, there must be ample time for a vehicle to be measured in order to display its speed before it has passed the speed display sign. A vehicle's speed is displayed on a non-glare, two-digit display that is visible from up to 1,000ft. The 18in-high, full-matrix LED characters automatically adjust their brightness depending on ambient light. As the signs use digital radar, cosine error (the error that occurs if a radar box cannot be placed in line with the road) is automatically corrected using technology built into the box. Consequently, these signs offer an impressive level of accuracy – ±1km/h on both the stationary range and the trolley range.

The Latvian police is impressed with the accuracy and user-friendliness of Decatur's units

"As accident figures suggest, some drivers ignore all attempts to educate them into traveling at safer speeds"

Such a high accuracy brings with it an additional benefit: it is more precise than many drivers' speedometers. In Finland, drivers are actively encouraged to use these signs to check the accuracy of their 'speedos' and confirm that they are not unknowingly driving over the posted limit.

The signs are also extremely rugged and durable, and Decatur prides itself on the straightforward plug-and-play nature of these low-maintenance products. But there is another less visible selling point: their ability to be used for data collection. Available in every model is the EZ Stat traffic statistics software package, which includes a plug-in data-collection module and software for the user's PC. This allows the collection and forwarding of data for statistical analysis, which is a valuable way for authorities to monitor figures such as average speed on a stretch of road, traffic density, and top speeds, as well as monitoring the effect that the sign itself has on influencing speed in a particular area.

The latest news in this regard is the launch of solar-powered display signs, brought to market in Q4 of 2008, which are an advance in terms of flexibility. One problem that occurs quite frequently when mounting stationary signs is that power may not readily be available at the ideal mounting location, so using solar-powered signs removes the hurdle. Decatur has recently shipped the first of these new units to customers in the UK and the United Arab Emirates. The company is also observing much interest from existing customers looking to upgrade signs to the new variants.

Decatur's LCD rearview mirror has a space-saving, user-friendly video display incorporated

WHEN A WARNING IS NOT ENOUGH

In an ideal word, drivers would simply respond to advisory messages and adjust their behavior accordingly, but as the accident figures suggest, some simply ignore all attempts to educate them into traveling at safer speeds. So as long as there remains a need for speed enforcement technology, Decatur will continue to develop products to combat those who disregard the rules.

The company's most popular line of speed enforcement products is the Genesis II Select range – a rugged, user-friendly in-vehicle series utilized by police officers worldwide. Similar to the technology used on the display signs, the Doppler effect is put to good use. Radar antennae send out microwave signals that bounce off vehicles and back, thereby allowing the vehicles to be tracked over a set distance. The systems are able to measure targets that are moving in four different directions. In 'opposite-direction mode' (i.e. both vehicles traveling in different directions), a target coming toward the police vehicle can be measured with the front antenna and a target coming from behind can be measured with the rear antenna after it has passed the vehicle. In 'same-direction mode', a target approaching from behind can be measured with the rear antenna, while a target traveling in the same direction (after overtaking an unmarked police vehicle) can be measured with the front antenna.

All digital signal processing is conducted in the radar head and the Genesis II Select range offers some of the fastest and most reliable processing power on the market. The units work by tracking the strongest – the closest – target and automatically switching to track the next target. They are continuously switching targets (and displaying targets' speed) as traffic travels past the police car.

The primary application is to enable enforcement officers to verify vehicle speed so they can pull over speeding drivers and issue them with a citation. But the data can also be used to complement video-based enforcement, and can be linked to video systems, with the radar data overlaid on the image for additional evidence of violation.

Independent testing has established that these products offer approximately 98% accuracy, and Decatur states that accuracy is ±1kmh while the enforcement vehicle is stationary and ±2kmh while moving.

One customer that has achieved great results with the Genesis II Select radars is the state police in the Republic of Latvia, which purchased and installed more

The Genesis II Select in-vehicle speed enforcement range is used by authorities across the world

than 120 of Decatur's in-vehicle units. So impressed are they with the products' performance that there are plans are under way to invest in even more units.

Much of the positive feedback the company receives relates to innovations that save valuable space inside police vehicles. This is achieved by incorporating the radar or camera display into the rear-view mirror. One of the features that users find particularly valuable is the ability of the radars to track and display the speed of two vehicles at the same time. This is handy in a number of situations, particularly where some vehicles may be masking other potential violators. Imagine, for instance, a large truck is approaching the enforcement vehicle, which the radar will naturally pick up as the strongest (closest) target. But what if a passenger car behind is accelerating hard to overtake the truck? When officers see the overtaking vehicle, they can simply press a 'faster-function' button and the radar will simultaneously measure the speed of both truck and the offending car. This means the radar is able to show the speed of the 'second-strongest' target well before it becomes the strongest target.

As well as being a useful display tool for enforcement officers, this ability to monitor and record more than one vehicle at a time enhances their ability to provide fair and accurate citations. Radar's ability to distinguish the 'next-strongest' target (which may be traveling faster than the strongest target) means there are no cases of 'mistaken identity' – where one vehicle receives a citation that was actually meant for the car in front – as can sometimes occur with other methods of speed enforcement.

STILL TO COME

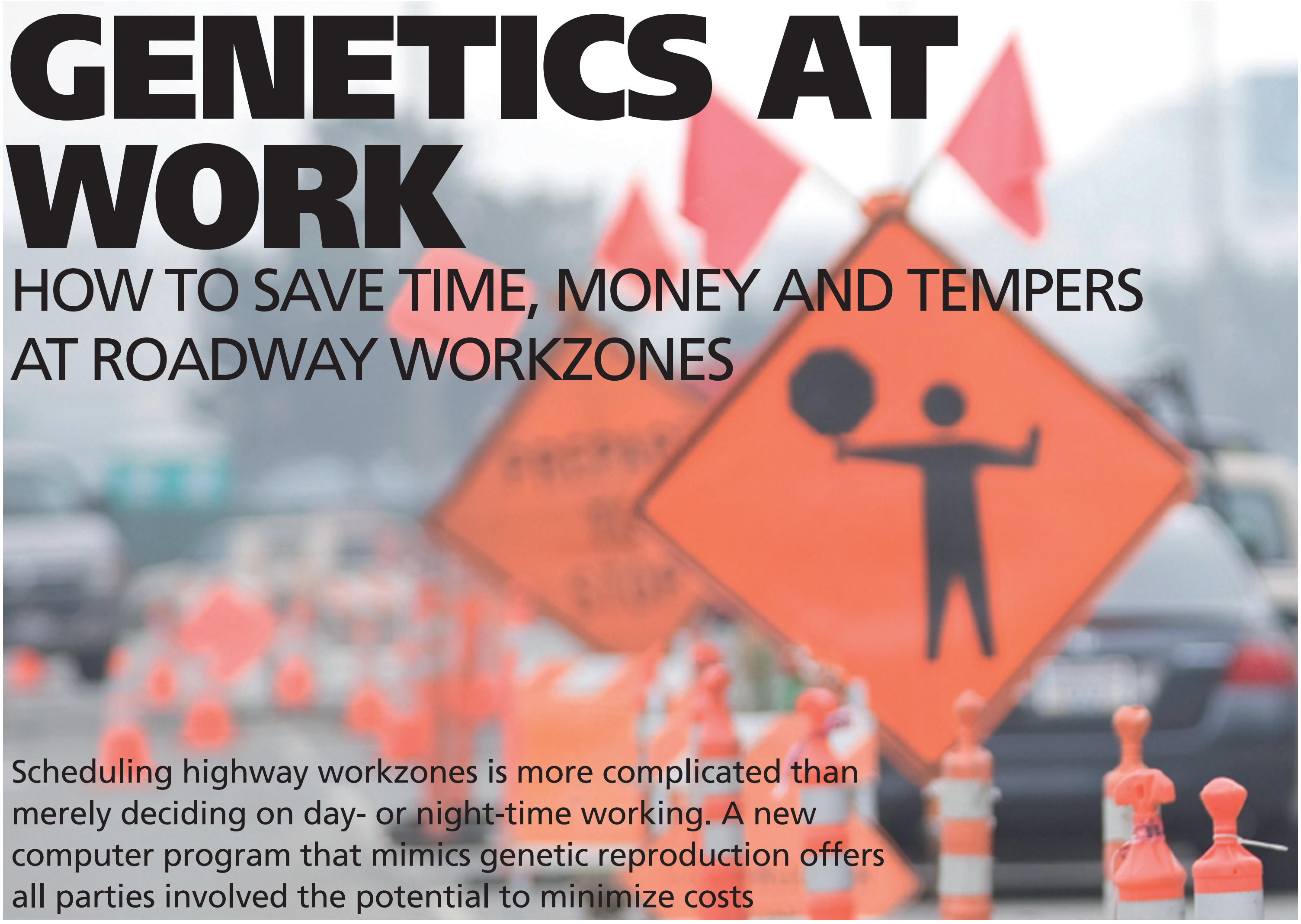
The ongoing success of Decatur's radar products allows the company to invest in research and to be quick off the mark to develop new applications. The big news in 2009 will be the announcement of a joint venture between Decatur and a European ALPR expert. The first results of this cooperation will be the announcement of a photoradar-based automatic system that uses the company's directional technology. This new system is currently in its final testing stage, so further details are anticipated to be revealed soon. ■

Jani Andersson is the CEO of Decatur Electronics Europe and is based at the company's HQ in Finland

traffic technology INTERNATIONAL

SECTION 2:
TRAFFIC MANAGEMENT

by Yimin Tang, PhD & Steven I-Jy Chien, PhD



GENETICS AT WORK

HOW TO SAVE TIME, MONEY AND TEMPERS AT ROADWAY WORKZONES

Scheduling highway workzones is more complicated than merely deciding on day- or night-time working. A new computer program that mimics genetic reproduction offers all parties involved the potential to minimize costs

Scheduling maintenance activity in highway workzones might seem simple, but planning it in a way that will minimize total costs for road users and the transportation agency is remarkably complex. That's where a computerized genetic simulation can help.

According to a 2000 survey sponsored by the US Federal Highway Administration, one in three drivers (33%) is dissatisfied with workzones on the roads they travel; only traffic congestion causes a higher level of dissatisfaction (43% of drivers), with pavement conditions, safety, and bridge conditions considered less troublesome. In view of the generally rising cost of fuel, driver dissatisfaction with workzone travel delays (and the associated fuel costs) is bound to grow.

Turning part of a roadway into a workzone affects not only drivers but also nearby businesses, the agency responsible for the road, and the contractors performing the roadwork. All of those parties would like to schedule the workzone activity so as to minimize their own costs and inconvenience. Drivers and business owners might want to limit the work to night-time hours to keep it from affecting daytime traffic. The agency might prefer working around the clock to get the project finished as quickly as possible. Contractors might consider night work an inconvenience to their crews and an unnecessary additional expense, preferring to confine the work to daytime shifts to reduce costs.

In fact, scheduling roadwork is considerably more complicated than just choosing daytime versus night-time hours. Repeatedly setting up and removing workzones is much less productive than continuing the activity without interruption. Night-time work requires additional lighting and attention to safety, and productivity is generally lower than when working in daylight. Using additional workers and equipment to accelerate the construction pace may shorten project duration, but it adds to the expense. Lengthening the project's duration can avoid premium pay rates and level out the intensive demands on labor/equipment, but the cost savings might not be sufficient to justify shifting the burden to motorists and businesses, which will have to suffer congestion and delays for a longer period.

As it is so complex, researchers have conducted several studies to find ways of optimizing the scheduling process. Indeed, a recently developed mathematical model offers the potential to generate a schedule that minimizes the total cost to all parties. Workzones typically shift, expand, and contract – almost like a living organism – so it is perhaps not surprising that this promising new model is an algorithm that mimics genetic reproduction and evolution. The model generates a succession of potential solutions to an overall cost function, allowing mutations to occur and promoting the evolution of increasingly satisfactory solutions.

COST FUNCTION COMPONENTS

The model minimizes a mathematical function that represents the project's total cost, which is the sum of three components. One consists of the values of material, equipment, and labor required for each combination of crew size and work time for a given type of maintenance activity.

The second cost component reflects the fact that work in a given segment may be suspended as a result of equipment breakdowns, delays while awaiting delivery of materials, or to reduce the workzone impact on traffic during high-volume

Workzone delay is very costly to the movement of goods and people, so scheduling is all-important

periods. The cost of having workers and equipment idle during those periods must be included in the project's total cost (unless those assets can be kept productive by reassigning them to other work segments).

The overall cost function also includes road-user costs. These consist of the value of the extra time each motorist spends in the workzone due to reduced speed, the cost of operating the vehicles during that additional time spent in the workzone, and the cost of any damage resulting from the accidents that will inevitably occur in the workzone.

The total cost function is the sum of these three components, each of which depends upon the start and ending times for the workzones, as well as the crew option selected. As a result, the cost function includes many parameters, such as roadway capacity (with and without the workzone in place); the expected traffic demand, and an assumed value of time for road users. It also includes set up and removal costs for each activity area, expected accident costs, and labor costs (which vary if a combination of day and night work is contemplated).

The cost function is difficult to optimize as the overall project may be divided into a variable number of workzones where different activities may be occurring (at times, some work elements may even be idle). Computing the project's total cost would entail calculating the costs of each workzone, and then summing up the costs of all planned workzones. This would be a tedious task, and trying numerous combinations of workzone schedule and crew options to find an optimal solution would be particularly daunting. Computer modeling using a genetic algorithm offers a quick and effective alternative.

"Effective scheduling of workzone activity is complex, but thousands of dollars can be saved by making small schedule adjustments"

OPERATING THE ALGORITHM

The process begins by having the computer make what amounts to a wild guess. The computer generates a large number of potential schedules in a population pool. The potential schedules must all satisfy the constraints of the project (such as total workzone length and maximum project duration). Then the computer ranks each potential schedule according to the resulting total cost. A lower-cost schedule is ranked higher than the more expensive alternatives. Meanwhile, the highly ranked schedules may gain more opportunities to propagate even better new solutions. That reproduction takes two forms. First, the computer generates a new offspring solution from two desirable parent solutions by interchanging some of their elements, a so-called 'crossover.' Just as in the reproduction of living organisms, the offspring now contains some elements (biologically known as 'genes') from each parent. As a second manipulation, the offspring is 'mutated' by randomly modifying an element.

In each iteration of the algorithm, the higher-cost schedule is discarded and the

Minimizing the impact of workzone delays positively impacts safety, mobility, access, and productivity

lower-cost one is retained in the population pool. The process is stopped after a predetermined number of iterations, and the schedule that produced the least total cost is identified as the optimal solution.

The process may be further refined by repeating the entire model run, beginning with multiple, randomly generated population pools. Ultimately, the optimal solution is found by selecting the best of the lowest-cost schedules produced by numerous runs. It almost takes longer to describe this process than it does to perform it. In one case involving repaving a three-mile section of a four-lane street, a desktop computer accomplished 30 runs of the genetic algorithm, with 200 generations each, in less than four minutes.

EXAMPLE SOLUTION

In the above repaving example, the optimal solution was to have the workzone set up and operational from 18.45hrs on day one until 07.15hrs on day two. Removing the workzone for the next 2.5 hours accommodates morning peak-period traffic. The workzone is then re-established and repaving occurs from 09.45hrs until 13.15hrs on day two, when activity ceases, in order to accommodate heavy afternoon traffic. Work resumes at 18.30hrs on day two, and the project is completed the next morning at 06.30hrs on day three. The project duration is 35.25 hours, but the actual work time is 27.5 hours. Under the parameter values assumed in the example, the total cost for this schedule is US$143,699 per lane.

"Ultimately, the optimal solution is found by selecting the best of the lowest-cost schedules produced by numerous model runs"

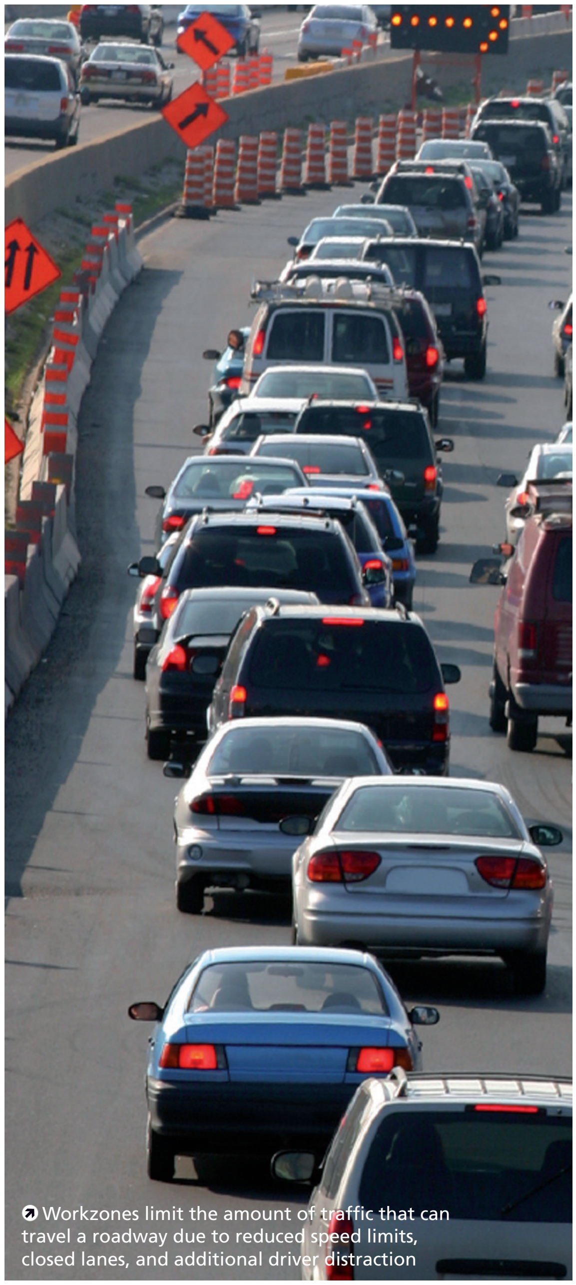
EXTENDING THE ANALYSIS

Even when the algorithm produces an optimal solution, it still might not be the best one possible. Neverthless, changing the value of one input parameter and re-running the computer program may make a substantial difference. For instance, vigorously promoting route diversion before and during a workzone project could significantly reduce the traffic volume passing through the workzone.

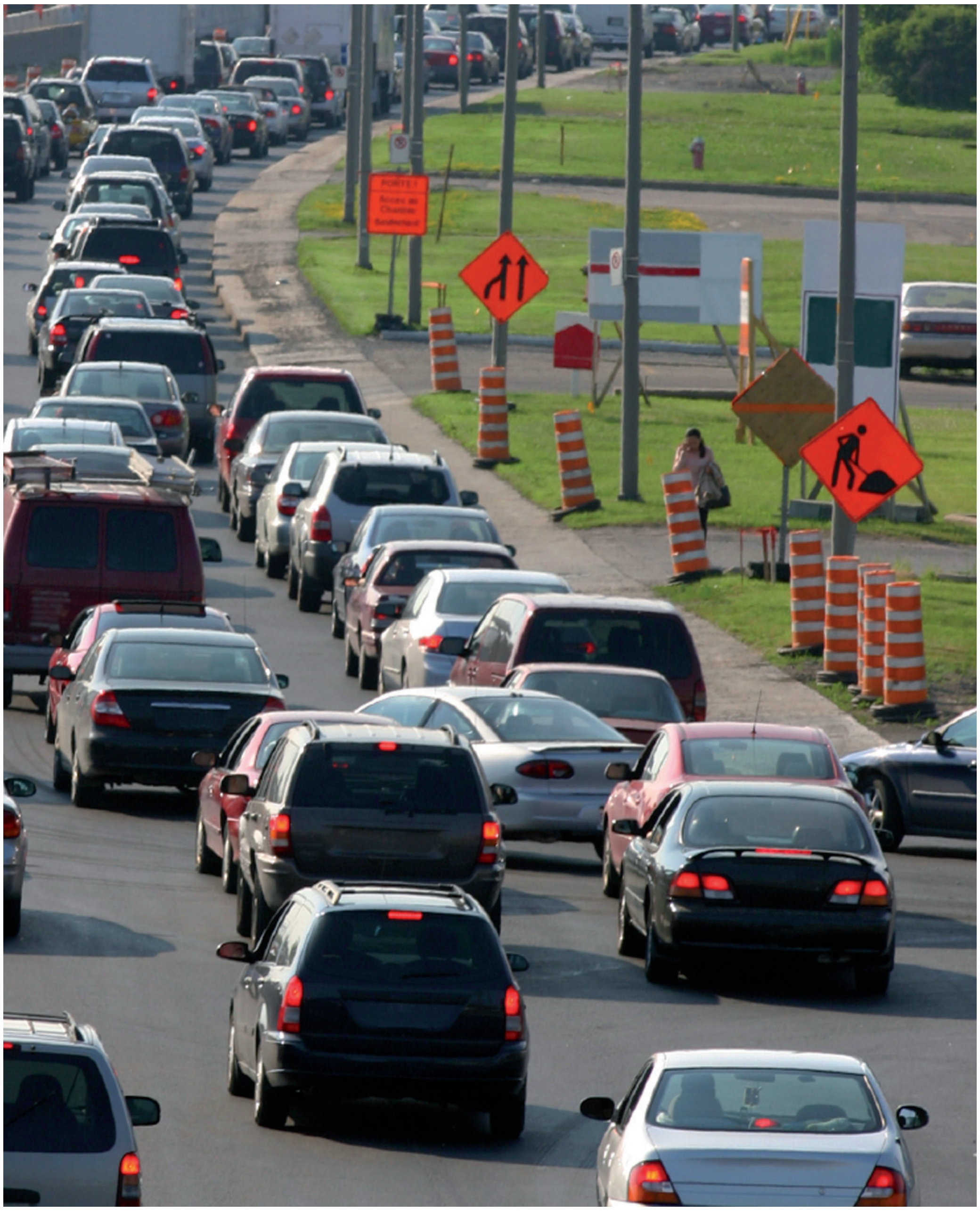
In the example described, reducing the daily traffic through the workzone from 45,000 to 40,000 vehicles reduces the project cost to US$137,233 per lane. The schedule changes slightly (with work activity running from 18.00hrs on day one until 07.15hrs on day two, from 09.30hrs until 15.15hrs on day two, and from 18.00hrs until 06.45hrs on day three). The project duration increases by 90 minutes, and the actual work time increases by 4.25 hours, but the total cost decreases by US$6,466 per lane. Such counterintuitive results illustrate the importance of computer modeling.

When rerunning the algorithm with different input values, it is important to change only one variable at a time (a process known as sensitivity analysis). If more than one variable were to be altered at a time, the individual effect that a given variable has on the outcome would be unclear. However, it may be useful to modify several input variables sequentially.

The following examples illustrate how sensitivity analysis can help project planners assess the value of traffic reduction through diversion, and can even help them plan work activity levels. Four different crew options were examined for the example project. Each option used different numbers of workers and pieces of equipment to generate different levels of productivity. Crew option one represents the lowest feasible productive option, and crew option four is the highest. For each option, the algorithm was run repeatedly to generate optimal schedules for average annual daily traffic (AADT) volumes, ranging from 20,000 to 60,000 vehicles in 5,000-vehicle increments. As expected, increasing the traffic volume increased the total project cost for each crew option, but the amounts of increase were very different. Increasing the AADT from 20,000 to 60,000 increased the total project cost 176%, 51%, 20%, and 12% respectively for crew options one through four, which suggests a highly



Workzones limit the amount of traffic that can travel a roadway due to reduced speed limits, closed lanes, and additional driver distraction



productive crew option is more suitable for projects on heavily traveled roadways.

Further analysis showed that the second crew option was the most cost effective for AADT less than 37,000, but the third option was best for AADTs between 37,000 and 46,000. The fourth option – which had the highest production cost but the shortest project duration – was the most cost-effective of the four options when AADT exceeded 46,000 vehicles. The first option was not favorably regarded in this example because it had the lowest production output. The finding of this example demonstrates how project planners can plan cost-effective work schedules according to various traffic conditions.

Sensitivity analysis can also be applied to other parameters in the total cost function. For example, changing the assumed value of a road user's time – increasing it to US$20/hour from the US$15/hour originally used – shifts the economical ranges of AADT downward. The thresholds for choosing each of the three crew options become AADT less than 35,000, AADT between 35,000 and 45,000, and AADT greater than 45,000 respectively. This suggests that a higher-cost, accelerated project schedule may be justifiable in a region where road users are more sensitive to workzone travel delays and the resulting lost-time value.

IMPORTANCE OF SCHEDULING

Approximately 80% of capital expenditures for highways go to projects that impose workzones on existing roads – many of which are already congested. Drivers are frustrated with spending extra time traveling through workzones, and they are increasingly sensitive to the associated reduction in the gas mileage they achieve. At the same time, the contracting agencies and the contractors are being squeezed between escalating costs and reduced funding.

Highway construction and maintenance costs rose three times faster between 2003 and 2006 than in any three-year period since 1990. The Highway Trust Fund faced imminent depletion before a last-minute infusion of US$8 billion from the federal general fund in September 2008. All parties have compelling reasons to make workzones as cost effective as possible.

Effective scheduling of workzone activity is complex, but thousands of dollars can be saved by making small schedule adjustments. Evaluating alternatives and constructing an optimal schedule would be an overwhelming task for human beings, but it is ideally suited for computer modeling. In particular, a genetic algorithm can quickly generate valuable information that can help make effective scheduling possible. ■

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↑ In times of limited funding, preservation and maintenance are key to conserving deteriorating roads

by Robert Bertini, Oren Eshel, Hau Hagedorn & Chris Monsere

RATING RAMPS

EVALUATING PORTLAND, OREGON'S ADAPTIVE RAMP METERING SYSTEM

Although ramp metering is becoming an accepted and popular strategy for reducing congestion, a long-term deployment is needed before the results and benefits of this form of traffic management can be accurately assessed

Ramp metering is a common traffic management strategy used to control the flow of vehicles joining a freeway. The theory behind the technique is to balance increased ramp delay and mainline performance. As one of the few freeway corridor management tools available, ramp meters are usually implemented to achieve two main goals: to limit the amount of traffic joining a freeway to prevent flows from reaching capacity, and to break up the platoons of vehicles discharged from an upstream arterial traffic signal. Effective ramp metering has the potential to improve traffic flow, traffic safety and air quality. It can reduce congestion and fuel consumption, and manage demand by discouraging short trips.[1]

In the state of Oregon, USA, ramp meters have been in use since the early 1980s, originally deployed along a six-mile stretch of I-5. The implementation combined inductive loop detectors and CCTV cameras with a pretimed metering plan. This strategy was based on limited analysis of historical patterns. Since that time – and with the advances in more robust freeway surveillance, communications and improvements to traffic-responsive metering algorithms – Oregon has transitioned to using the system-wide area ramp metering (SWARM) system as a replacement for the pretimed strategy.

In May 2005, the SWARM system was implemented in stages and is currently operational on all freeway corridors, apart from a small section connecting two main corridors near downtown Portland. SWARM was developed by the National Engineering Technology (NET) Corporation, now known as Delcan, under a contract with the California Department of Transportation (Caltrans). The algorithm was first implemented in Orange County (District 12) and later in Los Angeles and Ventura Counties (District 7) in the late-1990s.

THE STUDY

Optimal ramp metering strategies are often debated, but all involve trade-offs between imposing delay on those vehicles already on the freeway and those attempting to join. The amount of delay that can be imposed on vehicles at on-ramps is often constrained by physical limitations for queue storage.

Early ramp metering systems were designed to cope with 'typical' traffic conditions and unable to incorporate real-time variations in freeway conditions. Consequently, the effectiveness of the fixed-time system deteriorated substantially with large variations in freeway conditions, or when non-recurrent conditions (such as incidents) occurred on freeways.

In conjunction with a team of researchers from the Portland State University ITS Lab, the Oregon Department of Transportation (ODOT) recently conducted an in-depth analysis relating to the impacts of the SWARM implementation in the Portland, Oregon region.

The objective of the research was to compare selected freeway and ramp performance metrics under SWARM versus pretimed operations. To facilitate this comparison, the ramp meters were operated for two consecutive weeks under each configuration. The corridors studied are shown over the page in Figure 1.

A system-wide area ramp metering (SWARM) system is being implemented in the Portland, Oregon metropolitan area, replacing the previous pretimed ramp metering strategy

"Optimal ramp metering strategies are often debated, but all involve trade-offs between imposing delay on those vehicles already on the freeway and those attempting to enter"

Archived traffic sensor data from the Portland Oregon Regional Transportation Archive Listing (PORTAL) was essential in evaluating the ramp meter performance. PORTAL was designed as the official ITS data archive for the Portland metropolitan region, and has been archiving 20-second speed, count and occupancy data from dual-loop detectors positioned in each mainline lane just upstream of on-ramp locations since July 2004.[2] The archive also stores hourly weather (from the National Oceanic and Atmospheric Administration), incidents, and messages posted on the region's dynamic message signs.

To better understand the impact and benefits of implementing a traffic-adaptive metering approach, an empirical analysis of the pretimed versus SWARM operations was selected as the appropriate methodology. The comparison period spanned two weeks of pretimed operation and two weeks of SWARM operation (although only weekdays were evaluated). At the completion of the study period, the archived data was filtered for significant weather, incidents, or data quality issues, and these days were subsequently excluded from the study. Weather information, incident logs, and communication error reports were taken from the PORTAL archive.

PERFORMANCE METRICS

Vehicle miles traveled (VMT), vehicle hours traveled (VHT), and delay were selected as the three primary measures of mainline freeway performance. The metrics were then calculated for each 20-second observation with the assumption that each detector station was representative of traffic conditions until the next downstream detector station.

The change in ramp delay is a key performance metric that requires data on both ramp demand (vehicles entering the ramp) and outflow to be computed. Although nearly all of the ramps in the study corridors had detectors placed at the ramp entrance used to capture entering volumes, counts at these detectors were not set up by ODOT to be archived (the detector only serves to inform the local controller of potential queues). Using a programmable logic controller (PLC), input signals from the entering and departing vehicles were collected and aggregated over the peak analysis period. Ramp outflow was contained in the archived data. A combination of the known outflow

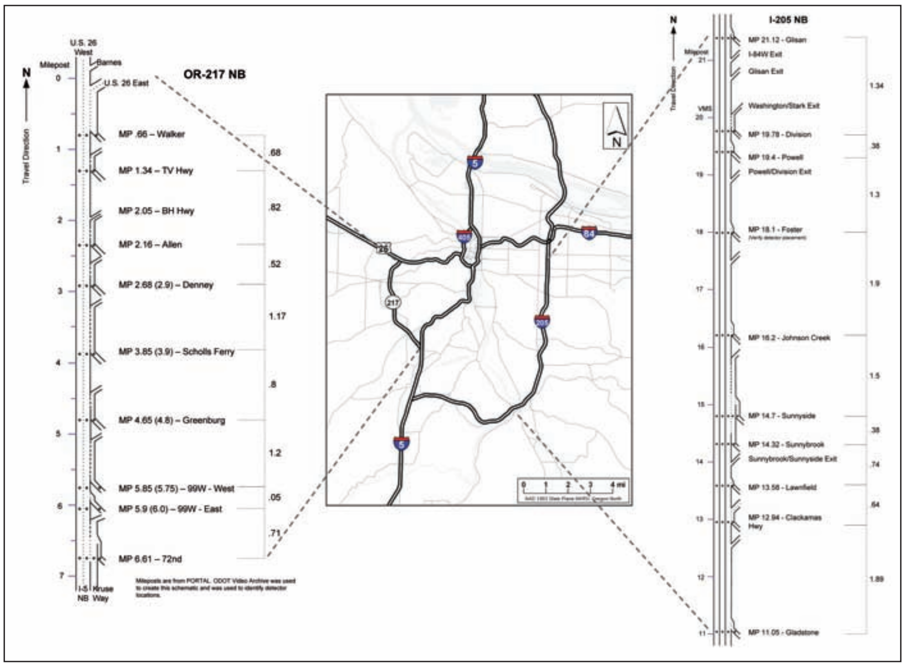


Figure 1: Freeway network in the Portland, Oregon metropolitan area

combined with the application of simple queuing theory for demand estimates was used to calculate ramp delay.

The final performance metric captured by the study was the ability of the existing communication infrastructure to handle the data-intensive nature of the adaptive metering system. The SWARM algorithm requires consistent and accurate data from the advanced traffic management system (ATMS), as well as the ability to send new commands (metering rates) to the controllers on a frequent basis. In pretimed operation, the ATMS system polled each ramp controller to obtain each 20-second data packet. In normal operations, some of these communication polls 'failed' and were flagged in the archived data. To estimate the overall impact of SWARM on corridor communications, the percentage of 20-second readings missing or corresponding to communication failures for each station was calculated.

Visualization through the use of contour plots was an invaluable tool in the detailed analysis of the study. By constructing plots of the fundamental traffic flow relationships of flow, occupancy and speed for each station and day, each analysis day could be categorized as either least, moderately, highly, or very highly congested. Grouping of analysis days by similar traffic conditions allowed the researchers to study the ramp metering under various traffic conditions.

CHARACTERIZATION

By analyzing the plots of each detector station for a number of five-minute observations in the congested regime – coupled with time-space speed contour plots to determine the spatial extent of congestion – each day could be characterized. Much of the performance information was visually summarized by constructing speed contour plots from the 20-second archived data. Additional information was presented by overlaying the activation and deactivation times of metering. A sample of this plot type is shown in Figure 2.

The plots clearly showed corridor congestion and communication failures – represented as 'zero' speed readings where congestion was not likely (in the lower left of the plot region near the Clackamas station from 06.00-10.00hrs). As an example, the scale of communication failures can be seen rather dramatically in Figure 3, which showed the failures for each station and day in the corridor. It was clear that SWARM operation impacted data quality.

Additional contour plots were constructed to further analyze changes in vehicle hours of delay. Figure 4 was constructed to show the changes in moderately congested average delay under SWARM in the time-space plane. Green colors indicated that SWARM operation resulted in less delay, while red colors revealed the opposite. The figures communicated the spatial and temporal variability in the comparisons; further plots were used to delve into the trends.

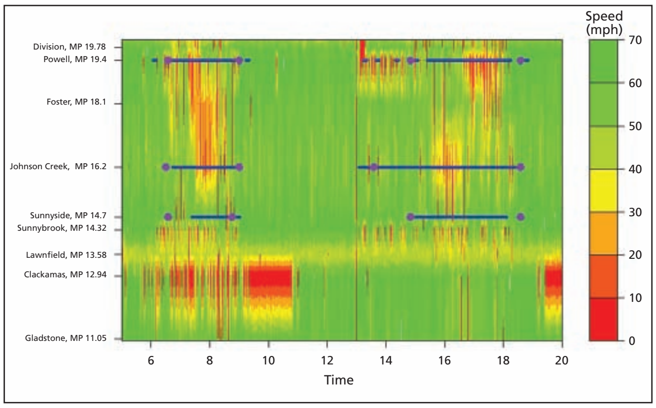
"An important finding was that implementation of the SWARM algorithm resulted in significantly more data communication failures"

CONCLUSIONS

The SWARM system in the Portland, Oregon metropolitan region produced mixed results. For one of the corridors (I-205), the results were generally positive. In the morning peak period, SWARM operation resulted in decreased mainline delay and decreased variability in the delay. For the afternoon peak period, improvements were also found with the exception of moderately congested days, which resulted in an increase in mainline delay. On OR-217, however, significant increases were found in overall average delay. Reliability also decreased under SWARM for this corridor.

The contrasting results for SWARM performance between the two freeway corridors can partially be explained by the general differences between the two facilities. OR-217 is a relatively short freeway (seven miles) bounded on both ends by freeway-to-freeway interchanges. The ramp spacing is generally short (0.75 mile average) and the freeway contains numerous auxiliary lane drops and adds. In the afternoon, the unmetered merge with a busy arterial and northbound freeway (I-5) traffic resulted in recurrent congestion. The I-205 freeway corridor is unbounded, has greater ramp spacing (one mile average), and maintains three through lanes. Only one auxiliary lane add/drop is present. Peak per mainline lane flows are generally higher on OR-217 than on I-205.

It was confirmed from the empirical evidence that in all cases evaluated, the SWARM algorithm as configured by ODOT allowed more vehicles to enter the freeway mainline. The higher per lane flows combined with less desirable geometry on OR-217 may explain why higher metering rates produced a significant increase in mainline delay.



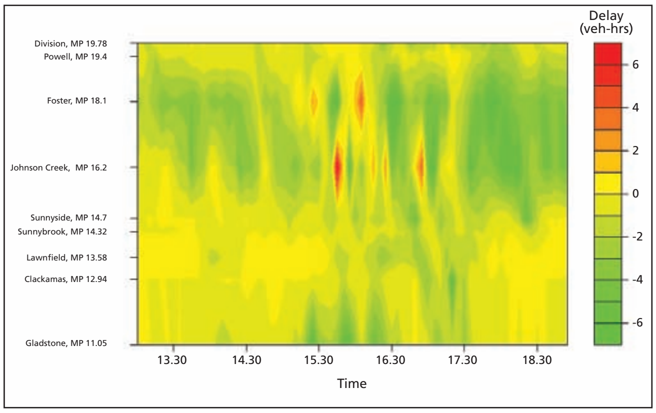
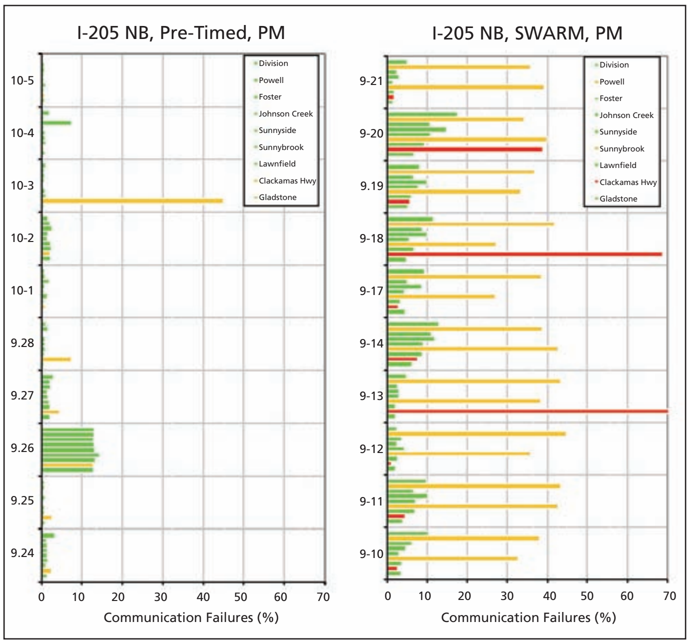


Figure 2: Speed contour with meter activation times
Figure 3: Average percent communication failures by day and station
Figure 4: Changes in moderately congested average delay under SWARM in time-space plane



IMPROVING RAMP METERING

To improve system operations, tunable SWARM parameters that distribute the volume reduction (or excess if local density is smaller than the required density) to upstream on-ramps based on demand and queue storage of each on-ramp should be evaluated. The conclusions from the study must be tempered due to lack of ramp demand data. If an assumption is made that ramp demand changes correspond with the measured freeway VMT changes, it is likely that ramp delay decreased under SWARM operation (that is, more vehicles were allowed on the freeway, which would equate to lower delay for vehicles on the ramps).

Another important finding was that implementation of the SWARM algorithm resulted in significantly more data communication failures. Although this outcome is specific to the ODOT communication infrastructure and hardware, it was not anticipated. These failures have the potential to impact other traveler information programs that depend on the freeway surveillance data as well as the SWARM algorithm. Following the study, ODOT investigated and implemented measures to improve communications.

Finally, the results of the project have encouraged ongoing evaluation and continuous improvement of the ramp metering system, and in general the overall freeway management system. It is clear from the analysis that meter activation times and rates are necessary to evaluate system performance. Incorporating additional logging capabilities into the SWARM system would make it easier to automatically evaluate the system operations on an ongoing basis. In addition, the freeway surveillance system should be modified to incorporate vehicle counts from the ramp queue loop detectors. If data is appropriately collected, applying simple queuing theory should allow ramp delay to be calculated. ■

"The results of the project have encouraged ongoing evaluation and continuous improvement of the ramp metering system"

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[2] *Bertini, R. L., Hansen, S., Byrd, A. and Yin, T., PORTAL: Experience Implementing the ITS Archived Data User Service in Portland, Oregon. In Transportation Research Record: Journal of the Transportation Research Board, No. 1917, Transportation Research Board of the National Academies, Washington, DC, 2005, pp90-99*

by Glenn Havinoviski

ADVANCED TO GO

ACTIVE TRAFFIC MANAGEMENT: WHERE IT IS – AND THE WAY FORWARD

One of the ways to meet the challenges of increased travel demand, diminishing funding and degradation of traffic flow is to deploy ATM – an approach to enhance capacity and safety without expanding infrastructure

The onslaught of traffic congestion globally means that transport agencies and authorities are facing a wall of challenges in managing freeway and tollway mobility. These include maintaining a satisfactory level of service, reducing traffic incidents and addressing operational issues that are becoming more dynamic and less predictable based on time of day or day of week. For example, during traditional off-peak periods, such as Saturdays, some roads may often have the same or greater congestion than during normal rush hours. Such conditions may even occur in both directions simultaneously.

In an attempt to solve these problems, freeway and tollway operators have applied a number of strategies to manage both travel demand and real-time operations. Congestion management techniques using real-time control systems such as ramp metering that regulate the flow of traffic entering the system are popular. While dynamic pricing of certain facilities (e.g. HOT lanes), which regulate demand to provide an uncongested facility under all corridor travel conditions (typically higher tolls during periods of high demand), are also becoming more widespread.

Active traffic management (ATM) schemes are also being looked at. As defined by the US FHWA in *Active Traffic Management: The Next Step in Congestion Management*, ATM represents "the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing traffic conditions". Such strategies can work in a complementary fashion with the other strategies described above, further improving the efficiency of operations.

ATM involves deployment of various ITS tools, such as lane control signals, variable speed signs, dynamic message signs, CCTV cameras, and traffic flow/incident detection systems. ATM techniques – deployed either individually or ideally together in an integrated fashion – may include dynamic lane control (reversible operations, closures of lanes due to downstream incidents, roadworks or other blockages), or variable speed limits (adjusted based on traffic flow, weather conditions and safety considerations). They can also include road queue warning systems (advising of traffic queuing due to an incident or blockage downstream), and the use of hard shoulders as traffic lanes to improve traffic flow during peak traffic, incidents or evacuations.

ATM applications are known to produce substantial benefits, including reductions in travel time and accidents, in addition to improved traffic throughput.

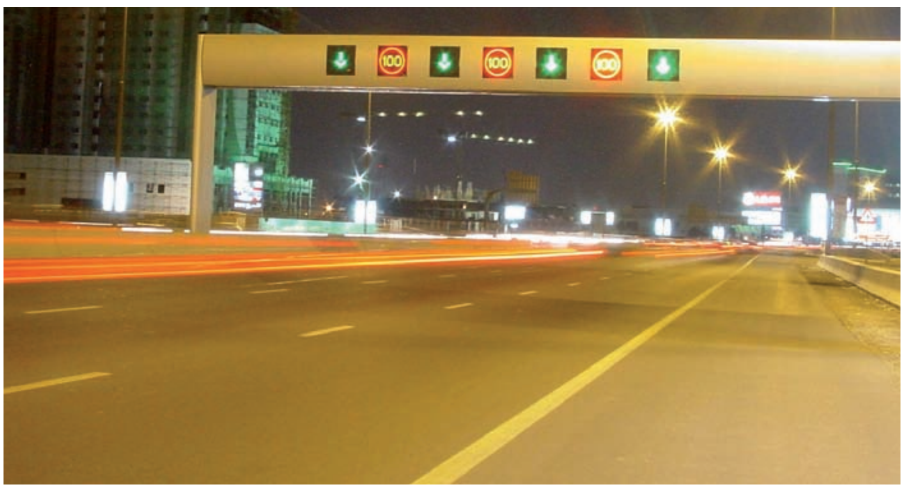


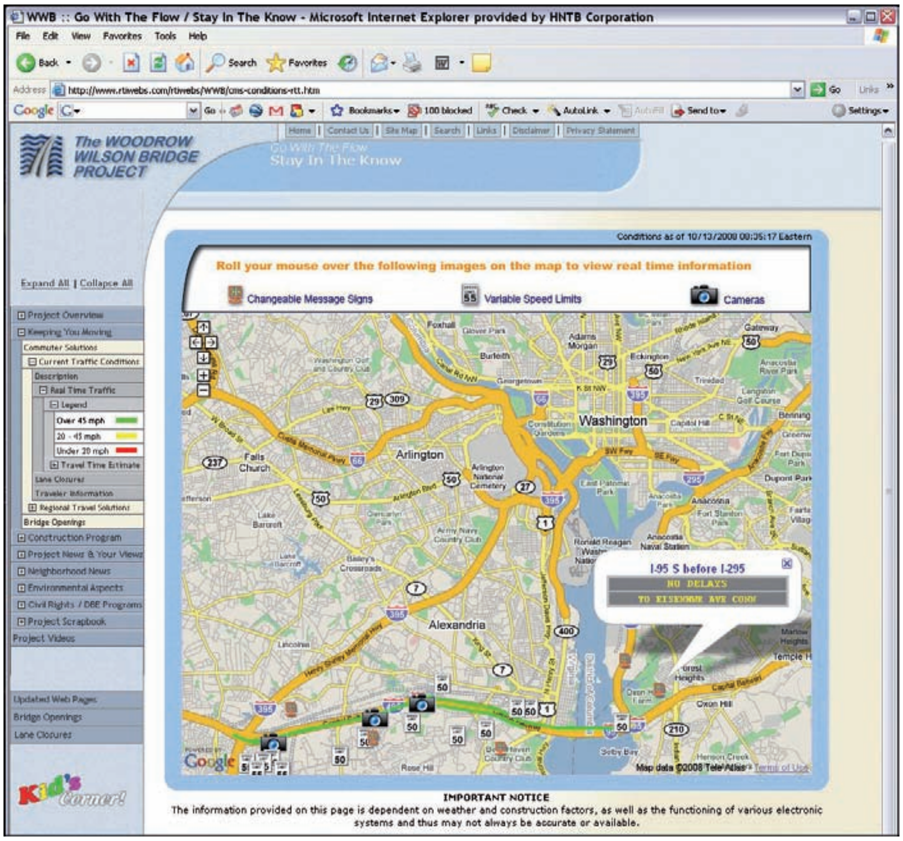
Photo courtesy of Ortana

Dubai's Intelligent Traffic System includes lane and speed control signals which – in combination with other ITS displays – provide dynamic lane control, variable speed limits and congestion warning capabilities

LANE CONTROL SIGNALS

None of these techniques by themselves are new. Lane control signals typically provide an indication of whether a lane is open (green downward arrow or signal), closed (red 'X' or signal), and occasionally a transitional display (yellow 'X' or a yellow diagonal arrow identifying the adjoining lane to which the driver should merge).

Lane control signals have been commonplace for bridges and tunnels for many years, particularly as a tool to



↑ To better manage traffic flow through the workzone along the Capital Beltway, Virginia DOT implemented a portable workzone ATM strategy. The system also includes the ability (illustrated above) for drivers to access such information over the internet before traveling

"ATM has been known to produce substantial benefits, including reductions in travel time and accidents"

Photo courtesy of Texas Transportation Institute

↑ Illinois Tollway's I-94 queue warning system combines microwave detection at the start of the exit ramp with advance warning beacons

enable reversible or two-way operations in tunnel bores or bridge spans put in place due to closures on the other directional roadway. One of the safety challenges in this application is managing opposing traffic flows within the same roadway. Tools may include the use of cones, movable center barrier systems, and auxiliary warning devices (e.g. flashing strobe lights), which augment a red 'X' display above the lane that contains opposing traffic and is not physically separated from the other lanes.

On arterial routes in numerous US cities, overhead lane signals are used to enable reversible lane operations on key routes with highly directional peak traffic flows and limited capacity.

By the 1990s, motorway control applications in Europe used overhead lane signals as a means to warn of a downstream lane closure and divert traffic to available open lanes. Dynamic operation of such systems depends on detection of incidents in travel lanes and either response by operators or use of automated incident response strategies. The systems are most appropriate along roads where there is limited or no hard shoulder space, as well as for frequent road maintenance work. Spacing of lane control devices on overhead structures or gantries is typically configured so that the next structure is visible once the first one is passed (a range of between 0.25 and 0.5 miles, depending on geometrics and terrain).

By providing such spacing, a 'virtual taper' is set up over two or three gantries, such that a lane closure is displayed on the first gantry as a yellow display, followed by a red display on the second gantry and – for closer-spaced displays – perhaps a third gantry prior to the actual lane blockage.

VARIABLE SPEED LIMITS

Variable speed limit (VSL) systems have frequently been used on freeway facilities in conjunction with lane control signals to reduce allowable speeds in conjunction with measured downstream traffic flows as well as lane reductions. In the USA, the New Jersey Turnpike provided an early VSL system as part of an early real-time traffic management system, which included neon blank-out text message boards. Most of the signs remain today, augmented by standalone VSL signs, but are in the process of being upgraded to standard dynamic message signs.

Other agencies such as Virginia DOT have implemented VSL displays ahead of bridge-tunnel facilities in the Hampton Roads region, which vary according to weather or prevailing traffic conditions.

Washington State DOT has recently designed and deployed a VSL system for a 7.5-mile corridor along the I-90, including the Mount Baker Ridge Tunnel and Mercer Island Lid. The design replaces existing neon blank-out signs with full-color LED signs that will typically display VSLs, but can be overridden with tunnel warnings (e.g. road or lane closure).

VSLs may be set up according to several types of conditions. Most commonly, the speed reduction is enacted to reduce the differential between upstream and downstream travel speeds, thereby reducing sudden braking and the potential for rear-end collisions when a slowdown occurs. Often this is achieved in conjunction with queue-warning activities. Speed limit reductions may occur as a result of weather or ambient light conditions as well. On some facilities, notably the M25 motorway around London, UK, VSL is integrated with video enforcement, with violator license plates

ITS ELEMENTS	DYNAMIC LANE CONTROL	VARIABLE SPEED LIMITS	ROAD QUEUE WARNING SYSTEMS	USE OF SHOULDER AS TRAVEL LANE
CENTRAL ELEMENTS				
Central traffic monitoring and management enhancements	Primary	Primary	Primary	Primary
Response plan development and real-time selection	Primary	Primary	Primary	Primary
Law enforcement coordination		Primary		Primary
ROADSIDE COMPONENTS				
Lane control signals	Primary			Primary
Variable speed limit signs		Primary		
Dynamic message signs			Primary	Primary
Closed-circuit television (CCTV) cameras	Primary		Primary	Supporting
Real-time traffic flow data (detection, VII, etc)	Supporting	Supporting	Primary	Supporting
Video-based incident detection	Supporting	Supporting	Supporting	Supporting

being photographed where the vehicle's speed exceeds that displayed on the sign.

In the USA, VSLs are still in limited use on freeways and toll roads, but are increasingly being implemented for workzones. One key limitation is that many states' vehicle codes mandate that speed limits be fixed using static signage (school zone speed reductions are an exception, but generally do not pertain to freeways and tollways.) So, VSL implementation may depend on the revision of enforcement laws on the use of static speed signage.

"In the USA, VSLs are still in limited use on the freeways and toll roads, but are increasingly being implemented for workzones"

ROAD QUEUE WARNING

Road queue warning systems have taken on a variety of different forms depending on the need, such as mainline traffic queuing, queues on exit ramps backing into a mainline freeway or tollway, and queuing as a result of workzones.

Queue warning systems for mainline blockages are commonly deployed in Europe in combination with lane control and VSL applications – effectively creating an integrated operations solution. In Germany, overhead signs above each lane display the downstream traffic condition (e.g. congestion and delays, icing), along with accompanying VSL displays, which either indicate no speed limit (normal condition on many sections of the autobahn), or advisory speed limit in the vicinity of the downstream blockage.

Although these have been most common in Europe, queue warning systems are becoming more common elsewhere, including in the USA. In 2000, for example, the Illinois State Toll Highway Authority (ISTHA) was particularly concerned about warning drivers about congestion on a major exit ramp backing into the Tri-State Tollway – a concern that had been highlighted by a major rear-end collision. The ramp serves substantial summer traffic bound for a large theme park north of Chicago. The resulting solution used a combination of traffic flow detectors located along the exit ramp near the gore area, along with advance mainline warning flasher and signs triggered by congestion on the exit ramp.


Photo courtesy of FHWA

↑ ATM in Hessen has resulted in travel-time reductions of up to 20% and accident reductions of up to 30%, while increasing capacity by 25%

Photo courtesy of FHWA

↑ One of the first hard shoulder running applications in the UK was part of an integrated ATM application on the M42 motorway

ISTHA has been expanding the number of queue warning systems as a result of the first location's success. Two additional locations were added at other exit ramps on the tollway system and future work on ramp junctions throughout the 300-mile network will require these systems. Recognizing the impact of arterial signal operations on the exit ramps, John Benda, ISTHA's general manager, maintenance of traffic, explains: "The systems are also prepared for future interconnect with crossroad signal systems, so we can relieve exit ramp traffic before back-ups reach critical lengths."

ISTHA has also purchased five portable queue detection/camera trailers for workzone and special event management.

HARD SHOULDER RUNNING

To provide improved travel capacity during peak travel periods without expensive roadway and corridor expansion, some transport authorities and agencies have instituted periods where hard shoulder running is permitted – in other words, the use of a traffic shoulder as a travel lane. Although some applications in past years (notably the southbound I-5 south-east of Los Angeles) involved simple static signage permitting shoulder use during fixed periods, more recent systems include the use of lane control signals above the shoulder, along with accompanying regulatory signage. Shoulder running has been implemented in several places, such as on I-66 in Fairfax County and I-264 in Virginia Beach, Virginia, I-190 east of O'Hare Airport in Chicago, and in Birmingham, England (M42 motorway).

The highly visible system along the I-66 in western Fairfax, near Washington DC serves a highly congested corridor. To improve corridor capacity in the peak travel directions, Virginia DOT implemented a combination of HOV operations in the left-most travel lane and the use of the right shoulder as a travel lane on a five-mile segment of the I-66 in both directions. The operation is regulated by the use of lane control signals over the shoulder lane, in combination with static regulatory signs that describe the hours of shoulder traffic operation. As peak travel periods have expanded in recent years, so have the hours of operation.

Recent systems planning work along this corridor has considered the ability to implement shoulder running on a real-time basis during heavily traveled but 'non-traditional' peak periods (e.g. Sunday afternoons), but such activities would require further investigation and approvals, particularly if occurring without providing an operational schedule to the driver.

Hard shoulder running requires extensive operational preparation – this includes physical 'sweeps' of the shoulder corridor before permitting shoulder access, whether through operator monitoring of video cameras along the corridor, or through the use of service or maintenance patrol vehicles driving along the corridor to confirm the route is clear. Keeping the shoulder clear during the period is a major challenge as well, given that the shoulder may normally be used for police pull-offs (e.g. for speeding) as well as incident pull-offs. Frequent emergency and enforcement pull-off areas should be provided along corridors with hard shoulder running.

Photo courtesy of Virginia DOT

Since the early 1980s, I-66 in Fairfax County has included hard shoulder running during rush hours

INTEGRATED ATM STRATEGIES

Most of the largest and newest ATM applications are integrated and include more than one of the above techniques and use a toolbox of numerous ITS technologies, as shown in the table on *p*44. Examples of some newer integrated systems include:

M42 motorway (Birmingham, England): This system combines VSL, queue warning, and shoulder running. Although there were initial objections and concerns relative to implementing hard shoulder running, it has resulted in significant benefits, such as travel-time reductions of 30% (due specifically to the hard shoulder running) and accident reductions of more than 10%.

Dubai, UAE: Dubai's Intelligent Traffic System is one of the newest ATM deployments in the world. Congestion and safety issues have multiplied with the doubling of the Emirate's population in the past decade. It was determined that ITS deployment would have the potential to reduce congestion and accidents. The resultant project (recently completed and operational) utilizes a combination of CCTV, dynamic message signs, point-based and wide-area detection with ATM tools including lane control signals and variable speed limit indicators. ATM is used to better control the variability of speeds between vehicles, as well as to warn of lane blockages ahead, owing to limited shoulder space.

ATM DEPLOYMENT CHALLENGES

Although there are clear benefits to ATM based on deployments in Europe, there are still a number of challenges – including legal, operational, and implementation – that must be considered and addressed for ATM techniques to be successfully deployed and operated.

For instance, in legal terms, the limitations in some states relative to enforcing non-permanent speed limit displays should be addressed. In addition, enforcement and incident pull-offs into shoulder lanes when hard shoulder running is implemented should be addressed, along with enforcing illegal shoulder running when the system is not in operation.

Operationally, the level of automation needed to operate the system daily must be identified, while the level of staffing needed to monitor and operate it should be identified, particularly with shoulder running and lane control operations.

In terms of implementation, cost-effectiveness of deployment versus expected benefits should be determined – the level and density of ATM control devices and detection/monitoring equipment is higher than for more passive traffic and incident management systems. In addition, it must be assured that ATM control devices are installed in a manner that complements and does not conflict with static guide signage displays. Finally, it would be wise to consider the potential for various ATM-related information (speed limit, queue warnings in particular) to be made available utilizing vehicle-infrastructure integration technologies in the future.

Amy Tang McElwain, who manages planning activities for VDOT's Nothern Region Operations, sees substantive benefits in ATM in general, beyond the investments VDOT has already made in shoulder lane control and workzone speed management. Although expansion of such initiatives has been affected by the current economic conditions and resulting funding limitations, McElwain admits: "We will look into ATM strategies to improve safety and mobility."

THE WAY FORWARD

ATM, as with other ITS applications, is best implemented following a systems engineering process that is integrated with an overall national, regional or corridor ITS program development process. One of the initial elements within this process is development of a clear Concept of Operations (ConOps).

The ConOps document should lay out the overall approach to implementing, operating and maintaining the ATM, taking into consideration current operational, enforcement and maintenance responsibilities. Specific goals and objectives for a particular ATM application should address the local priorities – notably the relative importance of safety, incident management and capacity improvements. Once these goals and objectives have been defined, the ConOps must target specific policies and procedures that may need to be modified, replaced or instituted. Additionally, the level of automation for system operations must be defined in light of the system complexity, as well as available operations staffing and resources.

A key advantage of integrating several ATM strategies as well as integrating other more traditional traffic and incident management activities (including traffic flow monitoring, ramp metering, quick incident response using service patrols) is the ability to leverage the costs of equipment and system functionality.

Such integration includes coordination of ATM with existing detection and CCTV systems to establish incident presence, coordination with DMS to provide consistent messaging relative to shoulder or other lane blockages, and integration with the new centralized traffic management systems to execute such coordinated strategies.

Glenn N. Havinoviski is an associate vice-president and ITS group director for HNTB Corporation, based in Arlington, Virginia, USA by Vassili Alexiadis, Brian Cronin, Steven Mortensen & Dale Thompson

INTEGRATED APPROACH

ANALYSIS, MODELING, AND SIMULATION RESULTS FOR THE ICM TEST CORRIDOR

The USA's most important corridors have traditionally been managed individually. By looking at corridor assets as a system, however, the Integrated Corridor Management initiative helps transportation corridor managers and operators to better manage congestion while empowering travelers

Congestion impacts many people's daily lives, wasting fuel, lengthening trips, and threatening business. To address these challenges, though, the USDOT kickstarted the Integrated Corridor Management (ICM) initiative in 2005 by demonstrating how ITS technologies can be used to efficiently and proactively manage the movement of people and goods in major transportation corridors. The initiative aims to pioneer innovative multimodal and multijurisdictional strategies that optimize existing infrastructure to help manage congestion in the USA's corridors.

The USDOT is working with the industry to establish a continuous improvement cycle to apply to the integrated management and operations of transportation assets in the nation's multimodal corridors. Figure 1 depicts a process in which, by defining clear corridor-level performance objectives, archiving operations data, and analyzing the performance of mitigation strategies, agencies can improve the performance of existing systems through the use of ITS.

In 2006, USDOT selected eight 'Pioneer Sites' to partner with and define their Concepts of Operations and requirements for the ICM Initiative. They include Oakland and San Diego in California, Dallas, Houston and San Antonio in the state of Texas, Montgomery County in Maryland, Seattle in Washington, and Minneapolis, Minnesota. In parallel, USDOT used a test corridor to develop and test an Analysis Modeling and Simulation (AMS) approach to understand the potential benefits and impacts of implementing ICM strategies. The USDOT has already started working with three of the eight Pioneer Sites – Dallas, Minneapolis, and San Diego – to use the analysis approach for their integrated corridor management systems.

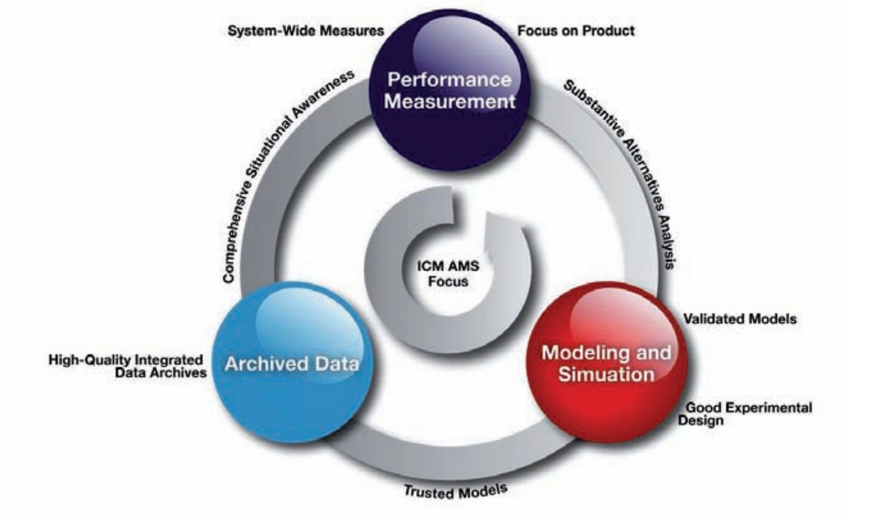


Image courtesy of Nobilis/USDOT

Figure 1: This graphic depicts a process in which, by defining clear corridor-level performance objectives, archiving operations data, and analyzing the performance of mitigation strategies, transportation agencies can improve the performance of existing systems through the use of ITS

PRINCIPLES OF METHODOLOGIES

In developing and applying AMS methodologies, there are a number of principles, listed below, that apply.

Focus on integration of existing tools: The ICM AMS effort does not focus on developing new analytical tools – instead it focuses on a relevant, meaningful application of existing modeling and simulation tools.

Recognize current limitations in available tools and data: There are known gaps in existing analysis tools that the AMS methodology must bridge, and bridging these gaps requires the interface of existing analysis tools with different capabilities.

Be vendor-neutral: Developed AMS methodologies and interfaces must be vendor-neutral and not favor one specific tool over others.

Consistency of analytical approaches and performance measures: The application of the AMS methodology to the various Pioneer Sites must be consistent in terms of analysis approach and performance measures. Consistency is important when trying to synthesize lessons learned from each site into national-level guidance.

Image courtesy of Cambridge Systematics/USDOT

Figure 2: The map shows the ICM Test Corridor

Image courtesy of Cambridge Systematics/USDOT

Figure 3: The test model networks for the macro-, meso-, and microscopic traffic analysis tools

Benefit-cost analysis: Expected benefits resulting from the implementation of ICM strategies will be compared to expected costs to produce estimates of benefit-cost ratios and net benefits associated with the deployment of ICM strategies.

MODELING APPROACH

The Test Corridor AMS approach was designed to capture the strengths of various analysis tools with the breadth of using travel demand models, mesoscopic simulation models, and microscopic models. It was designed to address key gaps in current modeling approaches, including the analysis of traveler responses to traveler information, the analysis of strategies related to tolling/HOT lanes/congestion pricing, and also the analysis of mode shift and transit.

The Test Corridor AMS approach encompasses tools with different traffic analysis resolutions. All three classes of simulation modeling approaches – macroscopic, mesoscopic, and microscopic – may be applied for evaluating ICM strategies. Such a modeling approach provides the greatest degree of flexibility and robustness in supporting subsequent tasks for AMS support of Pioneer Sites.

The AMS methodology applies macroscopic trip table manipulation for the determination of overall trip patterns, mesoscopic analysis of the impact of driver behavior in reaction to ICM strategies, and microscopic analysis of the impact of traffic control strategies at roadway junctions. Absolute convergence may not be achieved as a result of inherent differences at the various modeling levels. The methodology will seek a natural state for practical convergence between different models, and the iterative process will be terminated or truncated at a point where reasonable convergence is achieved. The methodology also includes a simple pivot-point mode shift model and a transit travel-time estimation module, the development of

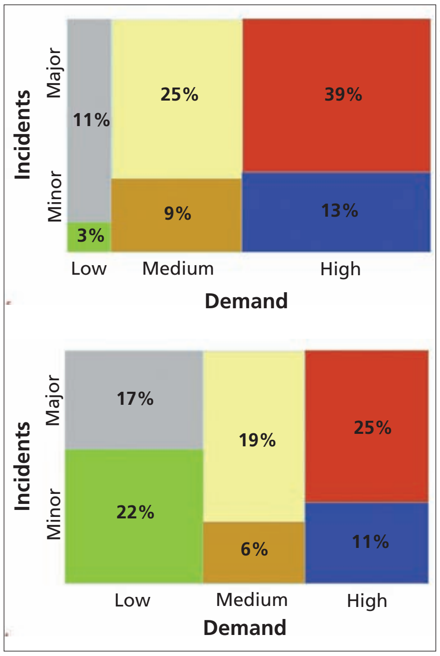


Image courtesy of Cambridge Systematics/USDOT

Figure 4: Test corridor operation conditions frequency and intensity percentage of workdays (top); Percentage of total annual delay (above)

interfaces between different tools, and the development of a performance measurement and benefit/cost module. Figure 3 shows Test Corridor model networks for the macroscopic, mesoscopic, and microscopic traffic analysis tools.

OPERATIONAL CONDITIONS

The ICM AMS framework provides tools and procedures capable of supporting the analysis of both recurrent and nonrecurrent corridor operational conditions. In the Test Corridor AMS, non-recurrent congestion conditions entail combinations of increases of demand and decreases of capacity. Key ICM impacts may be lost if only 'normal' travel conditions are considered. As shown in Figure 4 (left), the different operational conditions take into account medium and high travel demand, with major and minor incidents.

The relative frequency of nonrecurrent conditions – based on archived data – is important to estimate in this process. Figure 4 shows the overall frequency in operational conditions for the Test Corridor, including percentage of days in the year categorized by different incident and demand levels. Major

PARAMETER	VALUE	COMMENT
Analysis year	2005	The analysis year is based on the available model year in the regional travel demand model
Time period of analysis	AM peak – two hours (07.00-09.00hrs)	The analysis period is determined by the peak-hour trip table available in the regional travel demand model. The actual analysis period in the mesoscopic and microscopic simulation models will include an initialization period of 15 minutes and a demand dissipation period of 30 minutes
Incident location	Postmile 23	Over 55 incidents have occurred around this postmile point between May 2006 and May 2007
Incident duration	Two lanes closed for 45 minutes starting at 07.15hrs	Obtained from incident duration from the PeMS database and Caltrans 'TMS Master Plan' study

Table 1: The above presents a summary of the settings for the Test Corridor analysis

"To be able to compare different investments within a corridor, a consistent set of performance measures was applied"

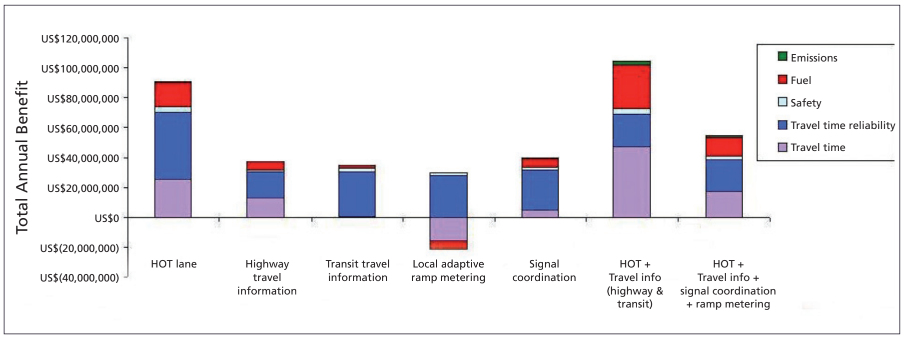


Image courtesy of Cambridge Systematics/USDOT

Figure 5: Summarizes monetized benefits for each ICM strategy for the major incident operational conditions with medium travel demand

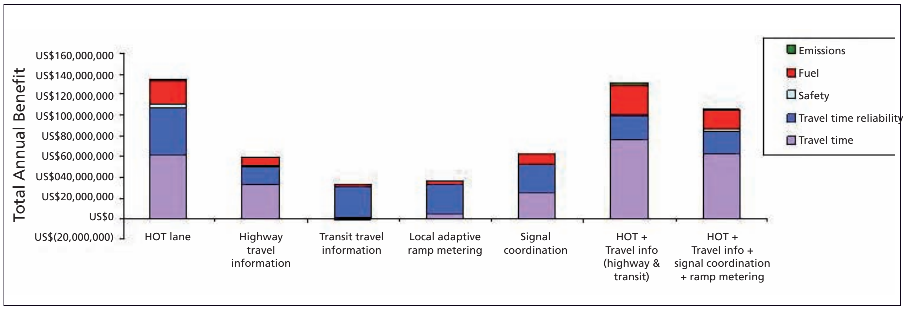


Image courtesy of Cambridge Systematics/USDOT

Figure 6: This figure summarizes monetized benefits for each ICM strategy for the major incident operational conditions with high travel demand

incidents are defined as having duration over 20 minutes, and minor incidents as having duration under 20 minutes. In the Test Corridor, major incidents together with high demand characterize 25% of all workdays (red or upper-right cluster in the left part of Figure 4), while 22% of all workdays (green or lower-left cluster) feature both low demand and minor incident conditions. The right part of Figure 4 shows that 39% of total annual delay (red or upper-right cluster) occurs on the worst 25% of days, while 64% of annual delay (red plus yellow) occurs on the worst 44% of days. Conversely, only 14% of annual delay (grey plus green) occurs on the remaining 39% of days.

The most likely incident location for the Test Corridor was determined by analyzing incident frequency. The Test Corridor at the incident location provides alternative arterial routes and alternative transportation modes, including bus and rail Bay Area Rapid Transit (BART) lines.

ICM STRATEGIES

A variety of ICM strategies were selected for testing, including zero ITS baselines, highway traveler information, transit traveler information, ramp metering, HOT lanes, and arterial traffic signal coordination.
Zero ITS baselines: Four combinations of medium-/high-travel demand and major/minor incidents with conventional transportation infrastructure, but no ITS.
Highway traveler information: Combinations of medium-/high-travel demand and presence of a major incident with a) pre-trip and enroute traveler information with 20% market penetration, b) VMS, and c) combination of pre-trip and enroute traveler information and VMS.
Transit traveler information: Traveler information on incident location and severity provided drivers with the opportunity to drive to a transit station where parking was available and use transit to get to their destinations.
Ramp metering: Freeway traffic management can be obtained by controlling the vehicles entering the freeway through local-adaptive ramp metering.

TEST CASE SCENARIOS

The Test Corridor comprises the I-880 corridor between the cities of Oakland and Fremont, California, for a distance of about 34 miles, or more than 250 lane-miles. As one of the main arteries of the freeway system in the San Francisco Bay Area, I-880 includes 34 miles of freeway connecting Silicon Valley with the East Bay. I-880 serves the Port of Oakland, Oakland International Airport, and the Oakland Coliseum, as well as a major concentration of residential, office, industrial, and warehouse land uses. I-880 serves both as an access route for major inter-regional and international shippers and a primary intraregional goods-movement corridor. Facilities in the Test Corridor include the I-880 freeway, arterial highways, the Alameda-Contra Costa Transit (AC Transit) bus routes, the Bay Area Rapid Transit (BART) rail, and intercity passenger and freight rail lines.

HOT lane: HOT lanes provide the potential to optimally use the high occupancy vehicle (HOV) lanes while generating revenue.
Arterial traffic signal coordination: Evaluation of coordination strategies.

In addition, combinations of traveler information, transit, ramp metering, and HOT lane strategies were evaluated.

PERFORMANCE MEASURES

To be able to compare different investments within a corridor, a consistent set of performance measures was applied. These provide an understanding of travel conditions in the study area and demonstrate the ability of ICM strategies to improve corridor mobility, throughput, reliability, and safety based on current and future conditions. They also help prioritize individual investments or investment packages within the Test Corridor for short- and long-term implementation.

Where possible, the measures were reported by 'mode' (single occupancy vehicle or SOV, HOV, transit, freight, etc), 'facility type' (freeway, expressway, arterial, local streets, etc) and 'jurisdiction' (region, county, city, neighborhood, and corridor-wide).

The performance measures focus on four key areas, including mobility, reliability, safety, emissions and fuel consumption. Mobility describes how well the corridor moves people and freight, while reliability captures the relative predictability of the public's travel time. Safety captures the safety characteristics in the corridor, including crashes (fatality, injury, and property damage), and finally emissions and fuel consumption captures the impact on emissions and fuel consumption.

MODE SHIFT

A known gap in the analysis of ICM relates to the performance and impacts of transit services. Mode shift in the Test Corridor can be influenced by adverse traffic conditions and by ICM strategies (such as traveler information systems, etc). Modeling of mode shift requires input of transit travel times, which are calculated by network segment and at key decision points in the corridor.

The pivot-point mode shift model developed for Test Corridor AMS works with trip tables from the travel demand model, and with more accurate travel times estimated by simulation models. This approach provides: a) calculation of transit travel times for each requested level of analysis given the corridor conditions or operations input; b) incorporation of inputs from each level of analysis to adjust transit travel times per segment and decision point; and c) generation of outputs that can be incorporated into the other modeling tools as analysis adjustment factors. This approach supports the corridor analysis of transit in an ICM environment, and provides the information necessary to account for the interrelation of impacts with the traffic operations in the corridor.

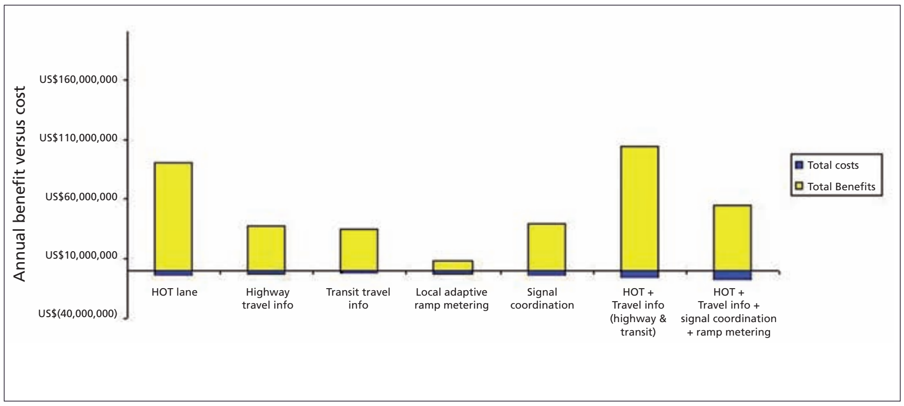


Image courtesy of Cambridge Systematics/USDOT

Figure 7: This figure presents benefits and costs, benefit-cost ratios, and net annual benefits for different ICM strategies under major incident operations conditions with medium travel demand

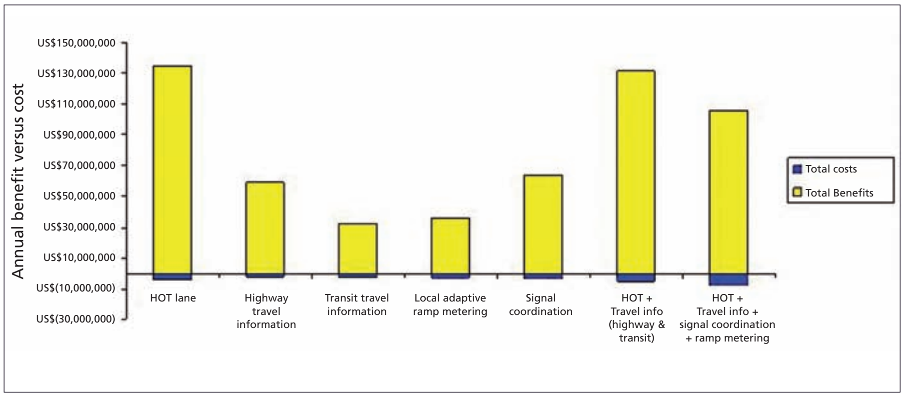


Image courtesy of Cambridge Systematics/USDOT

Figure 8: This presents benefits and costs, benefit-cost ratios, and net annual benefits for different ICM strategies under major incident operational conditions with high travel demand

For the identified mitigation strategies, the analysis team prepared planning-level cost estimates, including life-cycle costs (capital, operating, and maintenance costs). Costs were expressed in terms of the net present value of various components.

Figures 5 and 6 present summaries of monetized annual benefits for each ICM strategy for the major incident operational conditions. Figures 7 and 8 present benefits and costs, benefit-cost ratios, and net annual benefits for different ICM strategies under major incident operational conditions. Monetized benefits are combinations of five performance measures, including travel time, reliability of travel time, safety, emissions, and fuel consumption.

Overall, deployment of ICM on the Test Corridor produces a 10-year benefit of approximately US$570 million. Around one-half of ICM benefit is on high demand/major incident days (representing 25% of commute days). A comparison of benefits across operational conditions reveals that the effectiveness of ICM strategies varies under different prevailing conditions. For example, an ICM strategy such as freeway ramp metering is shown to produce positive overall benefits under high travel demand, but may produce system negative benefits under medium travel demand.

AMS results show that in the presence of a major incident (two freeway lanes blocked for 45 minutes), 1-4% of travelers affected by the incident shifted to transit. For the Test Corridor, the HOT lane and highway traveler information are consistently the most effective ICM investments in terms of both benefit-cost and net annual benefit.

There were a variety of Test Corridor AMS results specific to benefits resulting from different ICM strategies.

> **"Highway traveler information produces a large benefit, especially in the case of unexpected events such as a major incident"**

Alternative transportation methods are offered along the Test Corridor route

For instance, the conversion of the existing HOV lane to a HOT lane produces significant benefits, with the Benefit-Cost (B-C) ratio ranging from 14 to 39, and with net annual benefit of US$50 million to US$135 million.

Highway traveler information produces a large benefit, especially in the case of unexpected events such as a major incident. In this case, the B-C ranges from 16 to 25, with net annual benefit of US$37 million to US$59 million.

Transit traveler information produces less benefit than highway traveler information, but it's still positive. The B-C is 16, with net annual benefit of US$33 million to US$35 million. Up to 4% of travelers will mode shift to transit in response to a major incident.

In the Test Corridor AMS, drivers were provided with real-time information both pre-trip and en route about incident conditions, expected delays, availability of transit and highway options, travel times for

The Integrated Corridor Management initiative: efforts to date to reduce surface transportation congestion have focused on optimization of individual networks

these options, and availability of parking. Travelers shifted to transit if the combined (transit access/egress plus transit trip) travel times provided travel time savings greater than one minute.

Local adaptive ramp metering was tested in the Test Corridor AMS. In high-demand days (36% of all workdays), the B-C ranges from six to 12, with net annual benefit of US$16 million to US$36 million.

In the high-demand scenarios, arterial signal coordination produces good B-C ratios, ranging between 12 and 20. As expected, in the medium-demand scenarios, the B-C is less (ranging between four and 13), because there is less congestion and thus less incentive for drivers to divert to arterials. Net annual benefit of arterial signal coordination is US$11 million to US$63 million depending on demand and incident conditions.

The combination of ICM strategies also produces significant benefit. The B-C ranges from seven to 25, with net annual benefits of US$36 million to US$132 million. The AMS framework applied to the Test Corridor has the capability to dynamically adjust the price of the HOT lane in response to changing traffic conditions, provide information to direct travelers to transit and other routes, update the ramp meters, and change arterial signal timings. The 'Combination' results take these dynamic relationships into account. Lastly, a key finding in the Test Corridor AMS is that the combination of some ICM strategies may result in benefits that are less than the benefits produced by some individual strategies. In some circumstances, some ICM strategies may work across purposes.

CONCLUSIONS AND NEXT STEPS

The ICM AMS methodology offers several benefits to corridor managers. Firstly, it offers a predictive forecasting capability that corridor managers lack today to help determine which combinations of ICM strategies are likely to be most effective under different conditions. AMS also allows corridor managers to 'see around the corner' and discover optimum combinations of strategies, as well as conflicts or unintended consequences inherent in certain combinations of strategies that would otherwise be unknowable before implementation. Additionally, with AMS, corridor managers can understand in advance what questions to ask about their system and potential combinations of strategies to make any implementation more successful. Finally, AMS provides a long-term capability to corridor managers to continually improve implementation of ICM strategies based on experience.

The Test Corridor modeling validates the ICM concept. Dynamically applying ICM strategies in combination across a corridor is shown to reduce congestion and improve the overall productivity of the transportation system. In addition, the AMS methodology is able to analyze the individual and combination effects of ICM strategies under different operational conditions. New analysis capabilities were successfully tested and produced intuitive results. These new capabilities include the analysis of mode shift to transit, impacts of congestion pricing, and impacts of traveler information. The ICM performance measures were readily reported for all affected modes, facility types and jurisdictions, and across all types of performance measures.

Starting in mid-2008, the USDOT worked with three of the eight ICM Pioneer Sites (Dallas, Minneapolis, and San Diego) to model and analyze strategies to be implemented as part of its planned integrated corridor management initiative. The analysis will follow the approach defined in this article and will be tailored to the models, data, and strategies available and to be implemented in each corridor. The analysis should be completed by the middle of 2009. ■

"AMS allows corridor managers to 'see around the corner' and discover optimum combinations of strategies"

Dynamically applying ICM strategies in combination across a corridor reduces congestion and improves the overall productivity

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by Alexandre Torday & Alex Gerodimos

FUSION POWER

COMBINING THE BEST OF ALL WORLDS FOR BETTER TRANSPORT SIMULATION

Instead of viewing today's various modeling tools as separate and incompatible entities, a more effective method is to integrate them and start to regard each individual component as part of an overall toolbox

For decades now, transport engineers have been increasingly relying on the use of mathematical models and specialist software for analyzing the performance of current and future transportation networks. Macroscopic software packages (generally based on static paradigms) pioneered the field, and were followed later by more disaggregated and dynamic models. Benefiting from the steadily increasing availability of affordable computing power, these more detailed models have become the tool of choice for operational studies, commonly in the form of microscopic simulators. Among other dynamic models, mesoscopic ones have more recently started to receive attention as a viable and interesting compromise between the macro and micro levels. With the introduction of new technologies, data of unprecedented quantity, detail and ultimately quality is set to become available – making nanoscopic models a viable future prospect and an interesting direction for various forms of research.

THE QUEST FOR VICTORY

The proliferation of levels, approaches and software packages inevitably creates a temptation to compare. Comparisons quickly mutate into contests that focus on limitations – after all, those can easily be identified by taking a critical look at a model's underlying assumptions. For example, a static model is by definition not appropriate for studying the impact of different adaptive control regimes. A dynamic equilibrium assignment approach is probably not the most realistic way of predicting driver response to a non-recurrent incident. Using a microsimulator for a 35-year strategic plan without information on the location and capacity of roads – let alone traffic control plans, types of vehicles and driver behavior – is likely to be a waste of resource. Mesoscopic models, whether working with platoons or individual vehicles, are not the most precise when dealing with merging, oversaturated flows, actuated detection and interactions with pedestrians at crossings. And the list continues. Today's fastest microsimulator may be good enough to run a simulation of the entirety of Singapore faster than real time, but it is still far too slow for carrying out real-time traffic analysis in the entire Los Angeles metropolitan area. With its detailed modeling of a driver's decision-making process every fraction of a second, a nanoscopic model seems a promising and appropriate way of analyzing aspects such as emission patterns or ADAS. But what about its (currently) disproportional calibration and computing time requirements?

"The obvious conclusion is that there is no overall 'contest winner' and that each model has its limitations and strengths"

The obvious conclusion is that there is no overall 'contest winner' and that each model has its limitations and strengths and those depend on the intended application, data availability, time horizon and evolution of computing and ITS technology. In that sense, promoting a model, principle or approach (no matter how well conceived and developed) as a one-size-fits-all solution seems doomed to fail.

However, this is only the theory. In practice, model developers and practitioners need to do the best job with what they have available so they often have to deal with the temptation to cross a model's 'natural' boundaries. Working with a particular model over several years allows one to develop intelligent 'workarounds', which extend the model's applicability by masking its limitations. The use of devices that vary by model and include penalties, dynamic approximations, fictitious entities and so on is sometimes deployed in real-life projects to include, in proxy form, aspects that were not originally included within a particular framework. Still, no amount of creativity and enthusiasm will make microsimulation the best approach for a 50-year strategic plan, or a static traffic assignment approach the best platform for real-time traffic forecasting. Some boundaries are hard.

↑ Assessing the full impact of new tramlines on traffic conditions in major cities requires the combined use of pedestrian and vehicle simulation models

PERFECT MATCH

Specialist consultants typically adopt an impartial approach, opting to acquire and learn a variety of tools and to use 'the right model for the right job'. Practically, it is both attractive and appropriate to devise informed rules of thumb for choosing a particular approach. Although this is clearly less error-prone than a dogmatic approach, one might question whether it is actually possible to compartmentalize transport engineering projects in such a neat way. Is it really possible to speak of a 'static assignment project' and a 'microsimulation project'? What if one needs both models within the project? And what about mesoscopic approaches? Should we look for 'mesoscopic project' opportunities? What's more, what if one needs to use two types of models iteratively – or even concurrently?

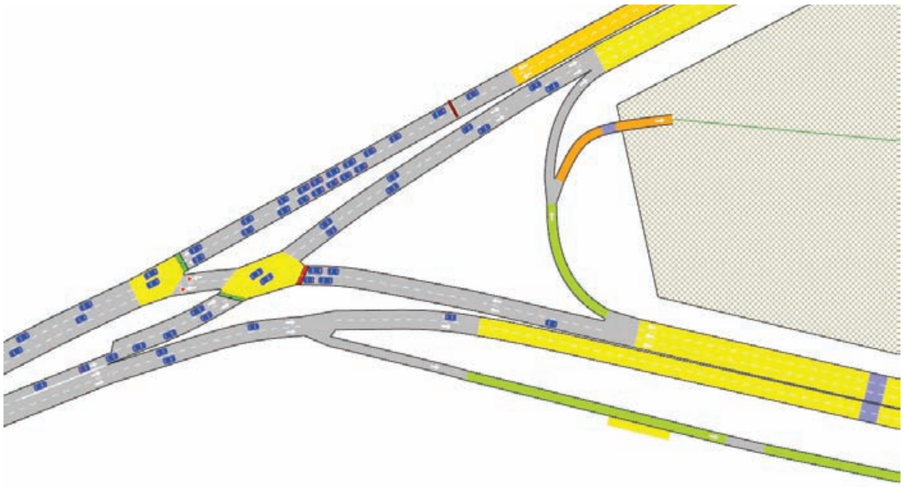
In TSS's experience, real-life traffic engineering and traffic management projects have such varied requirements that drawing lines based on narrow modeling paradigms becomes an artificial exercise.

The company has recently completed a number of projects assessing the impact of new tramlines on the traffic conditions of major European cities. At the detailed level, this is an exercise of optimizing adaptive control (tram preemption) so as to keep the tram moving while minimizing the impact on cross traffic. It is also subject to various other criteria that vary by city.

There is plenty of detailed input and output information available and required, making this type of study a strong candidate for microsimulation. But where should the data come from for such a detailed study? The origin-destination matrix for the base case can be obtained from surveys, but what about the predicted impact of the tramway on modal split? And what about the impact that actual (as opposed to hoped-for) tramway performance will have on modal split? It soon becomes clear that this is not a 'microsimulation project', but rather a complex impact assessment study necessitating the use of (at least) a modal split model, a public transport assignment model, an equilibrium model that may be static or dynamic depending on the available data, and a microsimulation model. In this context, individual models are best tailored to dealing with tasks, not projects.

PREDICTION SYSTEM

The statement that dynamic and disaggregate models are generally much more appropriate for real-time traffic forecasting than static and aggregate ones is hardly controversial. However, once again, the final answer is not that simple. First of all, the identification of the area that needs to be included in an online model is typically the result of extensive what-if analysis in the preparatory phase. The aim of this offline analysis is to quantify the network-wide effect of local disruptions. The task lends itself to a static assignment model as it involves vast areas, comprises hundreds of scenarios, and only seeks to establish an approximate understanding of the impact. Finally, it needs to be performed rapidly.



Snapshot from a hybrid simulation. Traffic around the signalized intersection is simulated microscopically (sections with vehicles) with the mesoscopic model simultaneously applied to the surrounding area (sections in colors)

The Aimsun Online project in Madrid made use of both static assignment models (offline phase) and microsimulation (online phase)

"Real-life traffic engineering and management projects have such varied requirements that drawing lines based on narrow modeling paradigms becomes an artificial exercise"

For the online part, when dealing with a metropolis of several million inhabitants and a corresponding number of trips, mesoscopic models provide an excellent balance of performance-versus-calibration requirements, but only for some parts of the network. Other parts may include complex roundabouts, be subject to actuated control, or contain busy pedestrian crossings and other 'problem' areas for which microscopic simulation is more suited. This is a case where not only are the two models (micro and meso) complementary, but they need to be used together at the same time, giving rise to a hybrid simulation that fuses the best elements of both. In this context, individual models are best tailored to dealing with parts of tasks within an overall project.

The model integration that TSS advocates is possible to implement either within a single multi-level framework, or by integrating modeling approaches originally developed independently. The second method relies on the exchange of information via files and lacks some of the convenience, possibilities and economy of the first method. Multiple tools imply duplication of cost, effort and data, and propensity for error. That said, the multi-tool approach is feasible and can be considered in projects where different models are used in sequence. Where TSS believes that a single model and software architecture has a distinct advantage is when models must be used concurrently or iteratively. Working inside the same software is not just a case of convenience for the user (or the developer). For one, the coherence of the two models forming a hybrid is a necessary condition for its robustness and fidelity and the ultimate reason why fusion is the way forward. ■

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by Rod Klashinsky

THE WEIGH FORWARD

METHODS FOR DEALING WITH HEAVY TRUCKS ON TOLL ROADS

In various applications – particularly within the tolling area – WIM has long proved itself to be a valuable option for roads managers. Today, sophisticated systems are on offer that will evolve to form the WIM technology of the future

The wear and tear on pavements, bridge structures, and other components of the transportation infrastructure caused by an individual vehicle is directly proportional to the weight of that vehicle or axle. In fact, as gross vehicle and axle weights increase, the damage to highway and bridge infrastructure increases exponentially, as was concluded by the American Association of State Highway Officials (AASHTO) Highway Study. Where WIM is applied, both axle and gross vehicle weights (GVW) are monitored. A truck may be GVW-compliant and still have individual overweight axles causing costly damage to infrastructure.

Traditional methods of recouping the costs in the form of either fuel taxes or tolls based on vehicle type can only factor in weight on a cost-averaged basis, spreading the charge across all vehicles in a class. This process therefore overcharges underloaded vehicles and undercharges overloaded vehicles, relative to the actual cost of their consumption of the transportation infrastructure. This, in turn, promotes overloading, as the cost per mile decreases with each extra pound carried. There is also an additional cost of biasing the system to encourage overloading from the increased accident rate – overloaded vehicles have a greater stopping distance, reduced maneuverability, increased risk of rollover, and an increased rate of mechanical failure.

APPLYING WEIGH-IN-MOTION

WIM has a long history of application in data collection for use in planning transportation infrastructure. This has expanded to use in enforcement in sorting compliant from violating vehicles to increase throughput and ease congestion

Clockwise from top: WIM@Toll plaza; weighing scales; truck driving through a WIM station at inspection stations. The incorporation of RFID for AVI and various video imaging technologies has increased the scope of WIM into one of the main elements of what is now known as ITS. Most recently, in the ongoing search for ever-more efficient methods of funding the building and maintenance of roadways and bridge structures, both public and private sector leaders are turning to the concept of tolls based on vehicle weight.

WEIGHING STRATEGIES

In order to change to a toll strategy that charges by weight and penalizes overloading, it is necessary to weigh and classify vehicles. There are three main options for doing this. The first is to have static weighstations on the tollway. Although the most accurate, this method has a number of drawbacks. For instance, vehicle throughput is very slow compared to other options, resulting in delays and congestion. It also requires an additional large infrastructure investment and staff to build and man the weighstation, while the departure from the weighstation and merging of heavy vehicles with the main traffic stream also poses a safety hazard.

A second option is to have high-speed WIM lanes on the tollway. This method is the least intrusive as it involves no impediment to traffic flow. The challenge is that it requires a way of identifying all heavy vehicles at highway speeds. There are currently three methods in common use for automatically identifying vehicles in the traffic stream, including LPR systems, optical OCR systems, and RFID tag systems. Although many vehicles can be identified by using one or all of these methods, there are still a number of vehicles that require identification by alternate means or further verification. By utilizing low-speed WIM, operators can verify the identification of heavy vehicles which are missed or unidentified by these other methods.

The third option is to have low-speed WIM lanes at toll plazas. This method integrates the weighing operation into the normal toll collection process at the plaza. The WIM operation requires little additional delay. When combined with ETC, this system can process the majority of vehicles without stopping, while still allowing manual collection from vehicles that have not subscribed to the ETC program (the efficiency is significantly increased by having some WIM toll lanes reserved for ETC vehicles only).

TODAY'S BEST METHOD

For these reasons, it appears that at the present time WIM at the toll plaza is the most easily implemented and efficient method of collecting tolls based on weight. International Road Dynamics (IRD) has installed a number of WIM@Toll plaza systems in India, China and Korea, and has systems at the planning stage in Africa, the Middle East and North America. The company has always had an international focus, with products and services aimed at the global market. This has meant developing systems that meet needs specific to the regulations, procedures and traffic patterns of the locale, as well as meeting local compliance requirements and working with local contractors and an administrator.

↑ The costly and inconvenient pavement damage that is caused by illegally overloaded trucks

↑ WIM@Toll entry lanes, Hunan Province, China

IRD has been instrumental in all stages of development of modern computer-based WIM systems. Some of the pioneering theoretical concepts for WIM systems were proposed by the founders of IRD in the mid-1970s. Research projects in the late-1970s were used to develop the hardware and software components required to bring WIM systems from theory into practical application. In the 1980s, the systems went into commercial production and IRD became a corporate entity to produce and deliver WIM systems to customers worldwide. As it has developed, the company has expanded the technologies that it can integrate into an ITS system. IRD now installs and maintains all major types of WIM technology such as single loadcell, bending-plate, Lineas Quartz and piezoelectric in its systems. It uses a range of video imaging technologies, including color, low light and infrared imaging, LPR, OCR, and RFID to assist in vehicle identification. Almost every system it produces will include various vehicle dimensioning sensors, such as height sensors, light curtains, tire width sensors and axle sensors. Toll and commercial vehicle operations or truck weighstation systems now frequently employ some form of DSRC for AVI/ETC.

Large-scale systems require computer networking for communications between system components, data collection, database operations, user access, and web-based operations. IRD has implemented and operates large-scale systems that incorporate both private network and internet-based networking solutions.

Traditionally, data collection, weight and dimension enforcement, truck weighstations and toll collection have been separate operations in the management of the transportation infrastructure. Integration of these fields into one system equates to efficiency. IRD's successful implementation of WIM@Toll systems is based on its years of expertise in WIM, AVI, ETC, video imaging, database management, and application service provision.

The concept of tolling based on weight as a fair and equitable way to recoup the cost of consumption of transportation infrastructure by a commercial carrier is an idea whose time has come. Today, the most expeditious way to implement toll by weight is through WIM at a toll plaza, and the structures, equipment and expertise are already being put to use in IRD's WIM@Toll systems.

Future trends toward universal RFID of commercial vehicles indicate further integration of transportation management functions, and this will, in all probability, include toll using high-speed WIM. ■

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by Richard Jelbert

BEHAVIORAL ANALYSIS

PREDICTING THE FUTURE BY UNDERSTANDING TRAFFIC BEHAVIOR

Next-generation traffic forecasting systems are set to transform the accuracy of journey planning, which will in turn markedly reduce congestion and allow operators to make more efficient use of the road networks

Despite huge advances in traffic management systems over recent years, the current generation of journey planning websites and sat-nav devices simply cannot deliver journey routes or journey times with any reliability or certainty. In reality, the navigation device route option typically bears no relation to the route presented by the website and the estimated journey time will also be different – often significantly so.

The reasons for these inaccuracies are easily understood. Critically, none of these services are able to amend the route or expected time of arrival (ETA) based on time of day and day of the week of travel – or take into account the effect of incidents and accidents. Secondly, the knowledge within the current devices, websites and applications about how fast vehicles can travel on any part of the road network is extremely inaccurate. And finally there is no variation that reflects the vehicle being used or the driver's individual driving style. Without these, the consumer is left to choose between adding considerable contingency time – or run the risk of being late!

It is clear that there is a pressing need for fixing these deficiencies and developing a new generation of journey planning and navigation services and devices.

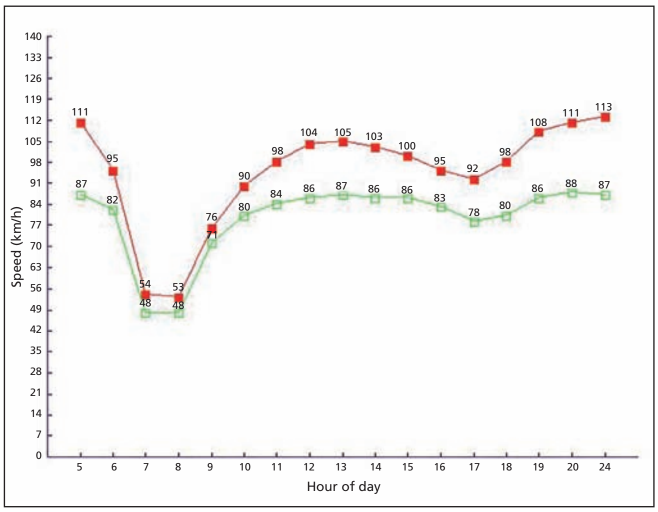
TRAFFIC FORECASTING

Many users of sat-nav devices have been introduced to the Traffic Message Channel (TMC), or traffic services that report live events (with varying delays ranging from several minutes to several hours), which are very useful during a journey, thereby helping the driver to avoid road closures, heavy congestion or accidents.

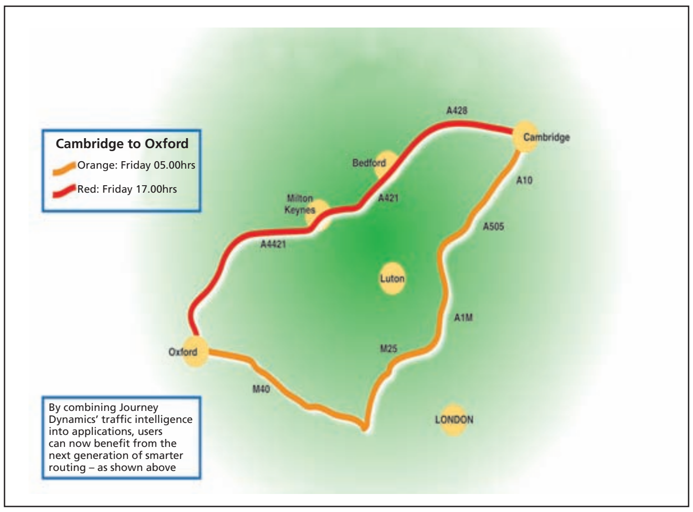
Some of these services are more accurate than others. Some rely on fixed traffic sensor masts by the side of the road, or sensor loops embedded in the road. Others use radio phone-in services and GPS-based live data from thousands of cars on the road, sensing when roads become congested wherever they are. Important though this is, just knowing the road speed is not nearly as comforting to a driver as knowing why the road is slow. From experience, it is clear that GPS-based traffic feeds – with the additional explanations from drivers calling a phone-in line – gives excellent coverage and detail.

However, current live traffic services cannot help with the planning and time estimation of a journey. Instead, traffic forecasting (also known as predictive traffic) has emerged to help in the all-important planning phase. It can even help during the trip where live data coverage is not available.

Successful traffic forecasting technology understands the normal daily cycle of traffic loading on the roads and junctions and uses this information to forecast accurate journey times and congestion. This, in turn, helps devices and websites to select the most appropriate route for the journey at that time of day. This is a major step forward from current systems that make very basic



Speed forecast (car and truck), Wednesday, taken from an M25 sample



Two different routes based on traffic intelligence at different times of day

Although satellite navigation devices have become highly popular among users, the certainty and reliability of the information offered is under scrutiny

assumptions concerning possible speeds, attributing a single fixed speed value to each road type for all times of the day and in all circumstances. Typically, five or seven speeds are selected and fixed in this way. The result of this basic approach is an average estimated time of arrival (ETA), which cannot be right and typically results in an error of around 30% in the journey time estimation (representing over 30 minutes on a two-hour journey). This compares to around 8% when using the next generation of traffic forecasting technology – nearly a fourfold improvement in accuracy.

These results are impressive and achievable as the new technology takes into account the many factors that can determine journey length, such as congestion and the many other driver experiences, including road type, weather, and if it is day or night. Most importantly, every driver has his or her own preferences for speed and driving style – a factor known as 'driver personalization'.

Research has shown that around 26% of journeys are impacted by a traffic event, over 50% are impacted to some level by congestion, and 15% are impacted by weather – but 100% of journeys are influenced by driver personalization. The next generation of traffic forecasting technology has been designed to factor in all of these complex influences on forecasts, adding greater accuracy and flexibility to the route-planning process.

Taking such factors into account enables journey times to be estimated to within a few minutes, as opposed to the tens of minutes for current systems. By using this new way of traffic forecasting in the planning phase of a journey, better route options can be achieved for that particular time and day of the week, with a more reliable ETA and estimated time of departure (ETD). And combining this with the live traffic feeds during the journey delivers a powerful level of intelligence to transform the accuracy and confidence of routing decisions, when to leave, and where to go in the event of an incident.

THREE FORECASTING APPROACHES

However, vendors have several different approaches to delivering traffic forecasting – all resulting in different levels of accuracy. The 'historic' products use road loop data or GPS track logs to extract speeds and build up a picture of road conditions over the time of day and day of the week. Although this approach uses real speed information from the past to predict the future, it demands huge amounts of data to cover an entire country's network in sufficient detail and confidence. For example, the UK road network is made up of 3.9 million individual road links (a road 'link' is the smallest unit of road measurement in use today).

To work around these limitations, historic products typically support only higher class roads, such as motorways and trunk roads, and avoid minor roads altogether, so they do not have the information required to understand a real journey covering the multitude of road types used. In summary, historic data products require large volumes of high-quality probe or GPS track data covering entire networks, which is not always readily available.

> **"Current live traffic services cannot help with the planning and time estimation of a journey"**

An alternative strategy is to use a pure model-based approach. Government-based and other statistics relating to population density, driver population sizes, average journey length, industrial areas, residential areas, and many more factors are built into a simulation, and the load on the underlying road network is calculated based on volume capacity of the roads and the likely demands from the driving population.

This method is very useful for 'what if' scenario calculations, such as population growth, but the model needs very careful setup and calibration and it takes a long period of time to gather the correct source data and perform the testing and analysis required to make sure the results are believable. This is a difficult process, demanding specialist skills and tools.

The output is also typically concentrated on the higher order roads such as motorways and trunk roads, as a result of the size of the simulated grids (boxes) in the model. It is also difficult for this type of model to pick up specific localized behavior, as it uses a set of general assumptions to derive the speed forecasts.

The third way is a hybrid approach – pioneered by Journey Dynamics – which combines the best from the historic data (based on reality) and model approaches (based on general behaviors). Rather than basing the model on general statistics from government sources, this solution analyzes the source historic data for patterns of related behavior and applies them in the model intelligently across the entire road network to generate a traffic speed forecast for every road link by hour of the day and day of the week. This approach results in a product that supports all road types, by hour of the day, day of the week, and all roads down to road link level, providing both a forecast speed and a speed range.

TESTING, TESTING

Given the importance of accuracy in this market, it is extraordinary that many of the products currently on the market are unable to substantiate their performance claims with published testing methodologies. For customers, this makes product comparison hard to achieve – a key fact given that forecast error typically ranges from 8% in the most accurate products to 26% in others. Yet it is a simple process to undertake a side-by-side test to compare and validate forecast traffic products based on a proven methodology.

The test uses a database of several thousand real driven test journeys for different vehicle types traveling at different times of day, in different areas, and on different days of the week.

"Simply saying the randomness of traffic makes forecasting a nonsense is like saying forecasting the weather is too difficult so we should give up"

Journey Dynamics' research suggests over 50% of journeys are impacted to some level by congestion

Travel times can vary by 32% between cars and trucks, as cars allow for greater driver personality

Each real test journey has a start time and end time and the list of road links traversed between the start and end points, and is then passed through a traffic forecast application to calculate forecast journey time and compare it with the actual journey time. The results are then expressed as a percentage difference of the actual time and analyzed to calculate the average values and the spread of the results. In terms of journey time accuracy, this method gives a close emulation of the potential user experience.

However, the complexity of this market and the number of factors that contribute to forecast accuracy are in danger of creating consumer confusion. There is a very real need for an independent testing house to step forward and operate an independent test process for predictive traffic products to deliver much needed clarity and confidence.

FORECAST INFLUENCES

In addition to understanding the underlying traffic forecast approaches – historic, model, or hybrid – users need to recognize the various dimensions to a traffic forecast product, each of which has an impact on its overall performance. It is also important to consider for what purpose the forecast speeds are going to be used and how any reduction in resolution can affect the user experience. For instance, if the forecast information is degraded too far, it might still be able to provide a better ETA estimation, but will not have the resolution or detail to help with routing-related questions.

Time is obviously a key dimension for forecasting, but the market has providers delivering speed forecasts that range from using a five-minute time segment through to others that only use two daily segments (off peak and on peak). With limited space on PNDs and 'smartphones', the five-minute approach adds significant data volume for little or no apparent additional accuracy, while off-peak and on-peak only products degrade the speed profiles to a level where ETA and routing services become far less reliable. Studies have shown that the ideal time segmentation is one hour, providing the required accuracy without data overload.

It is also important to recognize that the physical road length associated with each speed forecast will influence forecast accuracy. Analysis undertaken at Journey Dynamics reveals that road link level forecasting is the best way to allow for the expression of intersection and junction behavior. Combining long chains of links together to form longer segments – often using the same segments as the TMC reports – 'over-averages' the achievable speeds and, again, can cause false forecasting, particularly around busy junctions or other bottlenecks. Frequently these areas become congested more quickly than the road link attached to them, but this fact is diluted as a result of the loss of spatial resolution.

However, many products only support motorway and trunk routes (and only at TMC segment level) and miss out most of the important local roads that we all use at the beginning and end of trips. To achieve the greatest accuracy, forecast products will need to use road link level forecasting across all roads and road types.

VEHICLE TYPE

Travel times can vary by as much as 32% between cars and trucks with the largest differences seen in lighter, less congested traffic. This is because cars allow for greater driver personality than larger vehicles, as trucks are subject to many more controls, including legal restrictions on speeds and physical limitations based on weight.

Tests show a dramatic reduction in accuracy if the speeds of the two vehicle types are processed together – as is the case with products based on road loop data, which does not typically differentiate vehicle type. GPS probe data, on the other hand, is often marked by vehicle type, which makes it possible to separate the data and obtain the highest accuracy.

↑ The next-generation traffic forecasting will add greater accuracy and flexibility into route planning

This is a fast-developing marketplace that has the potential to dramatically transform the user experience. Indeed it is clear that congestion will not reduce any time soon and therefore there is a vital need to enable travelers to understand how (and when) to use the entire road infrastructure to the benefit of us all. By delivering effective, accurate journey planning across the entire road network, there is a very real opportunity to reduce congestion markedly, making more efficient use of the roads as well as demonstrating the beneficial impact of driving at a different time of day.

However, developing highly accurate traffic forecast products requires more than just averaging speeds. It requires a passion for detail and accuracy, and the willingness to try new techniques to gain a deeper understanding of all of the influences that take place on every journey we drive each day, and then the determination to challenge and test every assumption. Simply saying that the randomness of traffic makes forecasting a nonsense is like saying forecasting the weather is too difficult so we should give up! Similar to weather, accurate traffic forecasting allows informed decisions about the journey ahead, providing unprecedented confidence about journey time and the best route, as well as reducing congestion at the same time. ■

Richard Jelbert is the chief technology officer of Journey Dynamics, provider of the next generation of advanced traffic intelligence. For further information, please log on to www.journeydynamics.com by Björn Sabel

EXCHANGE AND SMART

MAKING LIFE EASIER FOR THOSE NEEDING TO BUY, SELL OR SHARE TRAFFIC DATA

The increasing demand for traffic information going to and from an array of different sources in a variety of formats raises several challenges regarding how it is actually exchanged

The demand for traffic information from all users of road systems is getting greater by the day. As congestion increases, demand from road administrators for traffic data also increases. With pressure for more cost-efficient systems and improved safety on networks, administrators need to find new ways of obtaining data.

It seems that everyone is aware of this situation but they all have difficulties in solving the problem. One solution could be to intensify and simply apply more technical systems to measure traffic, but this would not necessarily mean that everyone would automatically benefit from this information, as there are many challenges in terms of the distribution of information to and from road users.

There are also challenges when it comes to the exchange of information between different technical systems. There is a lot of information that road administrators get from roadside systems that could be very useful for motorists (if it could be fed to in-vehicle navigation equipment, for instance).

The cost of applying more roadside traffic measurement techniques to satisfy the need is also high, as it involves a range of expenses, such as costs for the equipment itself, installation costs, costs to find electricity in the field, and the ever-present concern relating to communication costs.

ISSUES WITH EXISTING METHODS

The problem with most existing traffic information solutions is that they are built to serve a single use or function within the traffic system itself, and not meant for distribution to external systems in standardized formats, such as web applications or navigation equipment. Most road administrators today also own and operate their systems for the specific use of upholding the traffic system and not to communicate to external parties. If they are to communicate traffic information from their systems externally to the public, it will be conducted through their own information channels and in a way that they feel is appropriate based on experience. They seldom take the opportunity to use the force and potential that the free market could contribute in the effort to spread information to everyone who uses the road, in different traffic applications. They are simply not used to distributing traffic information and data to other parties. For example, take an important system such as VMS, where the traffic controller can relay vital messages to signs on the road. This information is very much appreciated by the motorists on the road who happen to see the sign. But what about the people who need the information but do not see the sign? This information could also be very important to motorists who have yet to enter that road, or who simply did not see the sign. Few (if any) road administrators offer the ability to export that data to external systems, such as in-vehicle navigation devices, that can make use of such information. This

For road networks to perform efficiently, improved methods of exchanging information are needed, but a number of challenges must first be overcome is understandable as the diverse market has many different products with different interfaces and ways to communicate.

The solution is to make traffic information and data more accessible for the market, so that it can be used by more systems and achieve greater value and use of the information. Also, the exchange of information between motorists that use the roads is important. Drivers on the road are often the first to detect incidents, so information such as floating car data is becoming more interesting, as data sent from the GPS units in vehicles with position and speed parameters can be used to determine traffic flow on the roads.

Open source is the solution for many developers to boost the development of new applications. The same thing applies to information: we need tools to open up different sources of information in order for developers to be successful in the development and use of new applications. Navigation devices such as those sold by Tom Tom, Garmin, Navigon and others rely on obtaining information from different sources in order for customers to have any practical use of their devices.

CHALLENGES TO OVERCOME

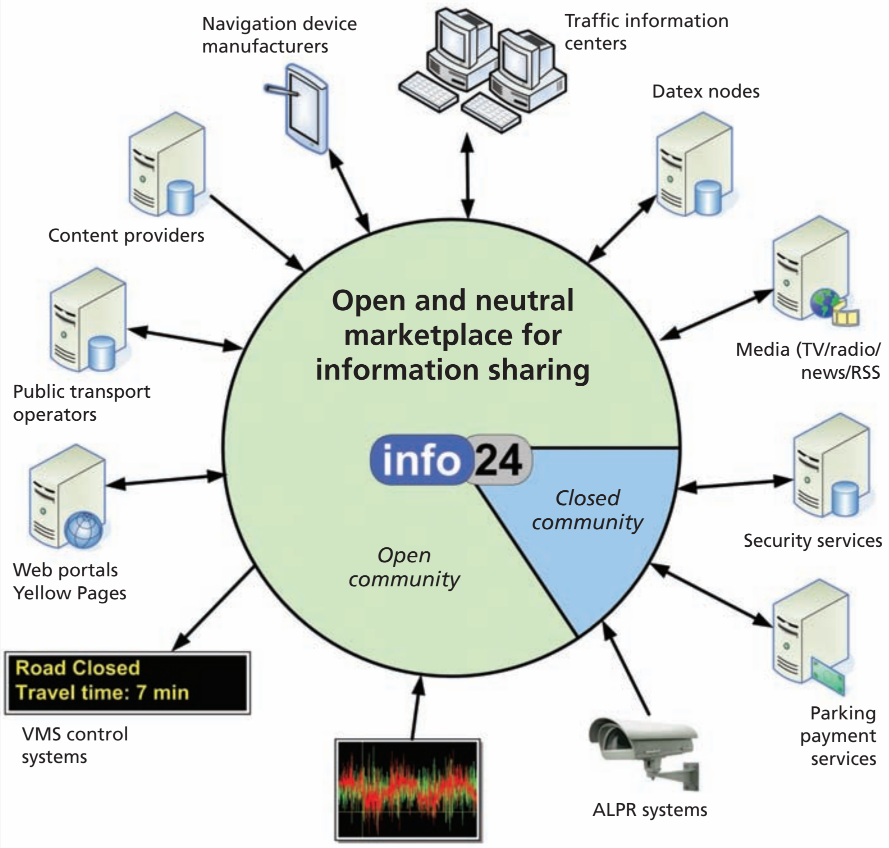
Traffic information, traffic data and web-cams all come in very different formats, from many different systems, sources and owners of information. This presents an array of problems, such as technical, legal, and financial challenges. Here, there is a clear need for tools to help with the problems of the exchange of information. On top of this, if you add the complexity of handling real-time information, you need new types of tools to exchange a continuous flow of information.

One solution to the increasing demand for accurate traffic information is to improve the exchange of existing information that both the motorists and the road administrators possess.

A neutral marketplace that makes it possible to exchange information from different sources and different formats could be the answer and result in a major improvement in the development of new solutions. If the result also made it possible to deliver the technical information in a unified format from different sources, then success could almost be guaranteed.

This way of thinking also moves the focus from technically driven environments to more modern information-driven environments. This is what the market needs today to speed up the time to market for many upcoming applications.

Info24 is a Swedish company that has seen this problematic scenario of information chaos and is adopting the role of a neutral information exchange. The company's focus is on the exchange of real-time information from different sources and formats to one or multiple users in a business-to-business environment.



How Info24 can aid the exchange of information

The company decided to be neutral, meaning it limits its activities to the exchange of information; it does not have any interest in the devices on the road or on the technical management side. This makes it possible to work with different competing systems and players in the market. Info24 guarantees absolute information integrity between players in similar positions in the same way that a bank guarantees integrity between different customers.

credit card transactions and employs the same secure system for the exchange of traffic information.

The potential offered by the exchange services from Info24 also improves the time to market for many companies. Traditionally, a solution of exchange between different formats takes months of programming and testing, not to mention the time and effort spent searching for different traffic information or data to exchange.

"One solution to the increasing demand for traffic information is to improve the exchange of existing information"

The information exchange offered by Info24 is built on a Software as a Service (SaaS) perspective on a modern Service-Oriented Architecture (SOA) platform. This ensures a cost-effective solution as it delivers the exchange of information as a service, so you don't have to buy any hardware or software systems.

The platform is further built on a scalable solution for real-time data exchange and is capable of handling hundreds of millions of transactions. In addition, the platform is used for exchanging financial

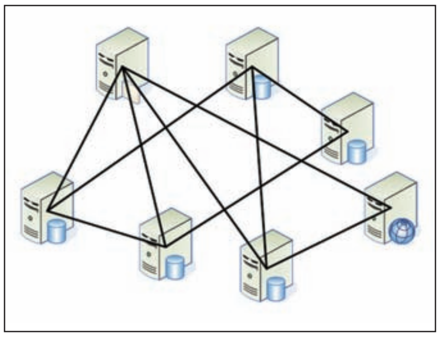
Combining different information from different sources and different owners also poses legal challenges as the information tends to vary in both cost and terms of use from the sources. Info24 has solved this by first of all creating a legal framework for handling the legal processes between parties. There are standardized agreements that regulate buying, selling and sharing information: everyone knows what to expect and there are rules regarding the use of information, which makes things very clear and minimizes questions and problems.

Secondly, Info24 takes on the role of an information broker, with the legal right and the financial incentive to handle and uphold the exchange of information on specified service levels (SLA). This also tends to make the process faster and shortens the time to market to perform the exchange, with legal agreements signed both by the source for the resale of the information and with the different prospective buyers of the information.

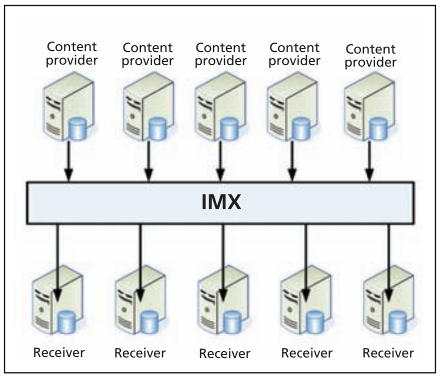
EXCHANGING INFORMATION

The ultimate aim is to achieve plug-and-play data integration, where you can easily add or exchange different data from different sources whenever they are available. With this possibility of exchange in mind, there are different ways for information to be exchanged, depending on whether you want to buy or sell information, or even simply share information with another company or organization.

This opens up new possibilities for the business-to-business environment, using methods that are taken from the consumer world, with social networking sites such Facebook, where people openly share information with each other. What Info24 is doing is to take this into the business-to-business domain.



Traditional multiple point-to-point connections result in high installation and maintenance costs



Cost-effective collection and distribution through a distributed information exchange

"Improving information flow will, in turn, have the desired effect of an increased quality of service"

Bear in mind that the business world often, if not always, creates rules for the exchange of information to build trust and predictability in the flow of information. This is a crucial part in all information sharing. Nothing is shared, bought or sold without rules. However, what Info24 has done is to simplify this important part and offer the information exchange with an agreement that outlines the rules for use of the information, as well as the SLA (Service Level Agreement).

There are several different types of information for sale, such as traffic information, information on parking facilities, weather, information from public transport, and different types of traffic data. Everything is on offer and ready to use.

If a client decides to buy information, they can choose to bundle it with several different types and then choose a format that suits their needs for a unified technical delivery to their own systems. It also means that prior to the purchase, a legal agreement concerning how the information can be used will be needed, which is comparable to an agreement in small print when buying software. Once a client has purchased the information, the information flow is ready to use in real-time.

The company also offers the potential for customers to sell their information through it. To do this, the customer gives Info24 the right to resell its information on its own terms. Info24 subsequently takes on the responsibility and the work involved in reselling the information within a business-to-business environment, which minimizes the work of an individual when selling information. The customers use Info24 as a sales channel and an operator for the information exchange.

Information can also be shared with other trusted organizations, rather than be sold commercially. Info24 offers to make the exchange between parties and thereby offers its integration facilities in both open and closed environments. This service is popular among organizations that need to exchange information, but do not have the resources or time to enable this themselves. The role of Info24 here is more of an enabler.

GET CONNECTED

There is also help for companies that would like to collect or distribute traffic information or data from – or to – their own system. This is a way for companies to outsource the collection or transformation of their own data with the use of the exchange services from Info24. This is typically used by road administrators or authorities to collect data from different sensors and then distribute it directly to their own systems.

REAL-WORLD CASE STUDIES

There are a number of organizations already using Info24's range of services in various environments. One example is work being conducted by the multinational company Eniro. The company has a high demand for traffic- and traffic camera-related information for use on its Yellow Pages websites in Sweden, Denmark and Finland. Info24 collects and processes traffic information from many different sources in the respective countries and then distributes it to the Eniro systems for presentation on the maps on the different public web portals.

Another key client of these services is Parkeon – one of the world's largest manufacturers of pay and display machines for parking. Info24 is contracted by Parkeon to collect and distribute financial credit card transactions from on-street parking in several countries in northern Europe. Info24's role is to collect and process the information from the machines to banks and customers. This involves the exchange of business-critical and confidential data in various formats, through multiple communication channels to different recipients in various formats.

The Swedish Road Administration also uses Info24's exchange services to integrate to – and collect data from – on-road traffic sensors and systems from multiple suppliers and manufacturers, so that the data can be sent to its distributed traffic databases. In the first quarter of 2009, Info24 is launching an online marketplace for the exchange of information (www.its-exchange.com) designed for buying, selling, sharing and exchanging real-time information.

Using the right tools to improve the exchange of information between everyone that uses the road system – or is in charge of managing it – will result in huge improvements in the flow of information. This is why Info24 offers multimodal information sharing, and the company works with all different types of traffic, including trains, aircraft, and even boats.

Improving information flow will, in turn, have the desired effect of an increased quality of service provided by or for the road administrators, and also increase the quality of experience for the motorists. It is also a very cost-effective way to improve quality. As the information already exists, there is no need to employ expensive new systems for measuring the traffic flow. ■

Björn Sabel is the CEO and co-founder of Info24. The company began operations in 2005 and Sabel is responsible for overseeing its strategic goals as well as maintaining an entrepreneurial momentum for implementation and practical work. He was previously co-founder of Mowic AB – a Swedish mobile data operator within the third generation Mobitex 420MHz technology from Ericsson. He can be contacted by emailing bjorn.sabel@info24.se

by Bob Edelstein

TOP-FLIGHT MANAGEMENT

WHY TRANSPORTATION MANAGEMENT CENTERS SHOULD GET OFF THE GROUND

Some TMCs already operate on a multi-agency and multimodal basis. If, in certain cases, an airport was factored in, it could improve operations, increase system efficiency and economy, and give travelers a better service

Today, it is not unusual to see several different agencies integrated into transportation management centers (TMCs), either through communication links or actual co-location in a single facility. Along with roadway traffic operations, these multipurpose centers can include emergency operations centers, police, 911 dispatch, traveler information, and Homeland Security functions. Some TMCs have even become multimodal by incorporating bus and train transit systems. The next potential extension of this trend is to begin integrating airport operations into TMCs.

CUSTOMER BENEFITS

Improving the airport user's experience will be a primary benefit of this integration. Engineers and architects design control centers in ways that make sense to them, but it is vital to also consider the ultimate customer's perspective. The key question is how the person going to the airport to catch a flight or meet a passenger can have an efficient, positive experience. This means avoiding things such as frustrating and stressful jams on the way to the airport, wasting precious time while searching for a parking space, or unusually long delays in the security line. With airport participation, a TMC could provide information that the traveler needs to make decisions about when to leave for the airport, what roads to take, and whether transit alternatives might be preferable for a particular trip.

Another important benefit of integrating airport information into a regional transportation management system is improved response times for life-saving emergency operations. When a serious traffic incident occurs, getting injured people to a hospital can quickly make a life-or-death difference. That pertains not only to a car crash (whether on or off airport property), but to an aircraft crash as well. An extensive, integrated system would allow smooth routing of rescue vehicles along both the highway system and the airport roads, as well as providing direct information about the status of a damaged aircraft and its occupants.

In addition to the direct benefits to the traveling public, an airport-inclusive regional TMC would enhance the center's internal functioning. For example, having staff from all of the agencies work side by side on a daily basis would increase

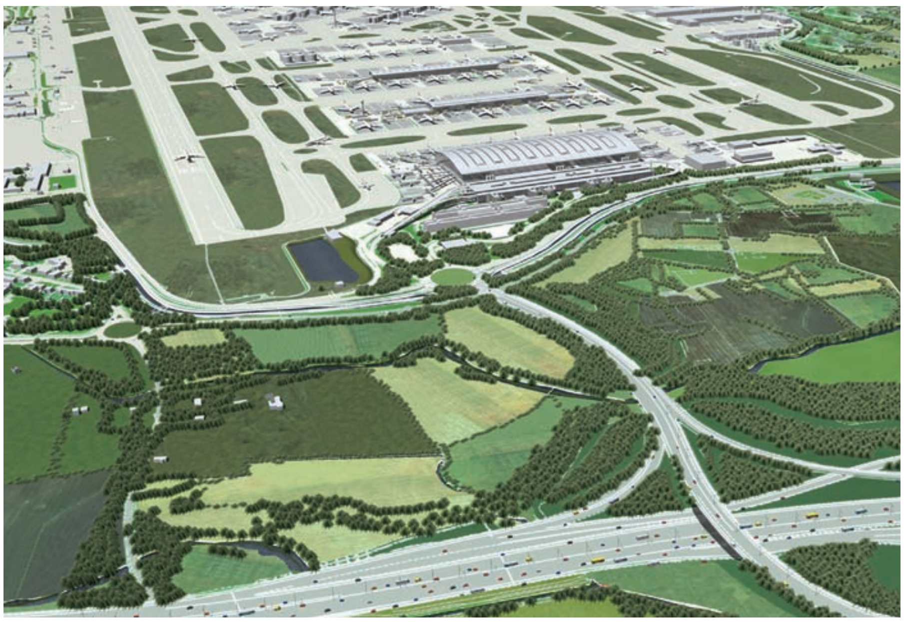


Image courtesy of YRM Architects

Heathrow's Terminal 5 sits next to the M25 motorway, one of the busiest stretches of road in the UK

Image courtesy of Vanderlande Industries

Integrated operations centers could enhance efficiencies for all concerned

Image courtesy of UFIS Airport Solutions

The ground operations center at Bangkok's Suvarnabhumi Airport

operational efficiency, as knowing each other personally and being co-located would facilitate staff decision-making during an incident. Representatives of all the appropriate agencies could discuss the situation face to face and reach a decision without taking the time to make phonecalls to remote locations.

CONSOLIDATED PROCESS

Each agency operating in a consolidated TMC brings in its own systems. For instance, the police, fire, and rescue departments rely on computer-assisted dispatching and their own radio communication systems. Traffic operations use computer systems for signal control and dynamic message signs. Naturally, housing all of these systems in one location results in some overlap and commonality among the support systems, the communications systems, the servers, and all the technical equipment required in the computer room. When properly implemented, this integration results in enhanced operating systems. Airport operations staff could benefit from this efficiency, as well as from the opportunity to share common support functions. Rather than each agency needing its own IT and administrative support staff, these resources can be shared among all the participants in a multimodal TMC.

Similarly, consolidating the various agencies' operations in one location produces economies of scale by allowing participants to share the initial costs of construction, as well as the ongoing costs for operations and maintenance. In the past, separate buildings would be constructed and operate from a 911 center, an airport operations center, a regional TMC, and an emergency operations center. A more cost-effective approach is to have all of those share space and facilities in a single structure. The economies add up, both for technical and costly equipment such as the videowall, consoles and computer rooms, and for less specialized spaces such as training areas, restrooms, and breakrooms.

Consolidating a wide range of operations into one TMC also enhances the opportunities for obtaining grants and funding. For example, in the USA, a combination of funds might be available from programs within the Federal Highway Administration, Federal Aviation Administration, Federal Transit Administration, and Department of Homeland Security. The availability of multiple funding sources, coupled with the

"An airport traffic control system could also facilitate congestion pricing, and convey that information to drivers"

The Sea-Tac International Airport in the city of Seattle, with 14-mile light rail line

Image courtesy of Sea-Tac International Airport

Image courtesy of Florida DOT

Integrating TMC partners should be consistent with a shared vision and concept of operations

construction and operational efficiencies, makes consolidation and co-location doubly attractive.

OPERATIONAL CHALLENGES

Integrating the systems used by various agencies is a relatively manageable technical process. Integrating the people from those agencies into a cohesive, efficient operation inside the control center is more challenging. Accomplishing it will first require assessing the needs and operating procedures of each agency, and identifying any potential conflicts among the agencies. If, for example, an aircraft is damaged on a runway or taxiway, several agencies might want to control surveillance cameras in conflicting ways. Although emergency responders might want to focus on the aircraft itself to assess the need for fire or rescue vehicles, the airport controllers might want to look at the nearby ramps to identify ground vehicles and other aircraft in the area. And security personnel might want to scan the adjacent fields to detect any unauthorized people fleeing or approaching the disabled plane.

For that reason, it is essential to establish a set of standard operating procedures before the TMC even becomes operational. After each agency's needs and typical operating procedures are identified, all parties should meet to establish joint procedures that prioritize and coordinate appropriate actions for each agency. Following management adoption of the standard operating procedures, all TMC operations staff must be trained to know and follow them.

Developing a co-location agreement is also essential. It identifies the operational responsibilities of each partner, and specifies the financial commitment of each agency for both the construction costs and for ongoing operations and maintenance costs.

"As London prepares for the 2012 Olympic Games… organizers plan to integrate many different operating departments into one control center"

FUTURE ENHANCEMENTS

Integrating an airport into a regional TMC extends the center's typical benefits to a broader set of applications. For example, the parking facilities at Baltimore-Washington International Airport are equipped with a management system that advises drivers where to find available parking spaces. On entering the garage, drivers see a message indicating how many spaces are available on each level. Then, when entering a particular level, they see a message showing how many spaces are available in each direction they might turn. Finally, a red or green 'X' above each space lets the driver identify open spaces. If such a system were integrated with the regional TMC, drivers nearing the airport would have the information they need when deciding which parking facility to use.

An airport traffic control system could also facilitate congestion pricing, and convey that information to drivers. Such a system would impose higher fees on the more convenient parking spaces located near the terminal. Knowing where spaces are available, how traffic is flowing on airport roads, and how long it is taking to clear security inside the airport, drivers would be able to decide whether to opt for the premium lots or to leave enough time for their journeys and select the less expensive, more remote parking.

Integrating airports into transportation management centers is an extension of the trend toward multimodal applications

Image courtesy of Vab

Congestion pricing could also be used to reduce jams and multiple-lane 'double parking' in curbside pickup and drop-off areas. During periods of heavy use, assessing tolls through license plate recognition programs could encourage drivers to divert to parking facilities to discharge or pick up passengers, as well as regulate the number of taxis and shuttle vans using this valuable curbside space. Again, providing this information to drivers is an essential component of the program. Typical TMC methods of conveying information can be used, such as websites, traveler advisory radio stations, DMS, and 511 interactive voice-recognition telephone systems.

The use of performance measures is a developing trend in the TMC industry that can certainly be applied to multimodal sectors as well. Establishing goals and setting specific targets for functions such as incident clearance times or passenger arrival-to-departure times are laudable objectives, but they are meaningless unless the processes are monitored and assessed. To achieve the desired results, it is essential to track actual performance and identify bottlenecks. Co-locating many different partners into a control center does make the process more complex. The individual expectations of each of the agencies must be identified and coordinated to ensure that the goals for the entire integrated control center are being reached.

Predictive algorithms could also be extended to the entire process of not only reaching the airport, but reaching the departure gate in time to catch a flight. This is not merely a matter of identifying patterns over time and conveying expected trip durations to passengers (although that in itself would be useful). It also offers the potential to improve operations within the TMC. Using historic data compiled by the center's detection devices, times and locations of typical congestion periods could be identified – not only on roadways, but also in parking facilities and within airport terminals. Drawing on that information, the predictive algorithms could automatically point surveillance cameras toward those locations at those times. This would relieve the center operators from the burden of trying to anticipate where accidents or congestion are likely to occur. Over time, these predictive algorithms would collect enough information to produce better estimates of travel time and better anticipation of problem locations along the roadway and airport terminal networks.

EFFICIENT IMPLEMENTATION

Integrating airports into regional TMCs is an extension of the trend toward multimodal applications. It has not yet been fully implemented, however, despite some movement in that direction. For several years, Los Angeles World Airports has operated a TMC at Los Angeles International Airport. It uses CCTV cameras and traffic signal software to monitor and manage traffic movements on roadways around the central terminal. Traffic information is broadcast over the airport's advisory radio system. Although the system shares information with the regional TMC, they do not share the same space and, therefore, do not benefit from the various efficiencies described above.

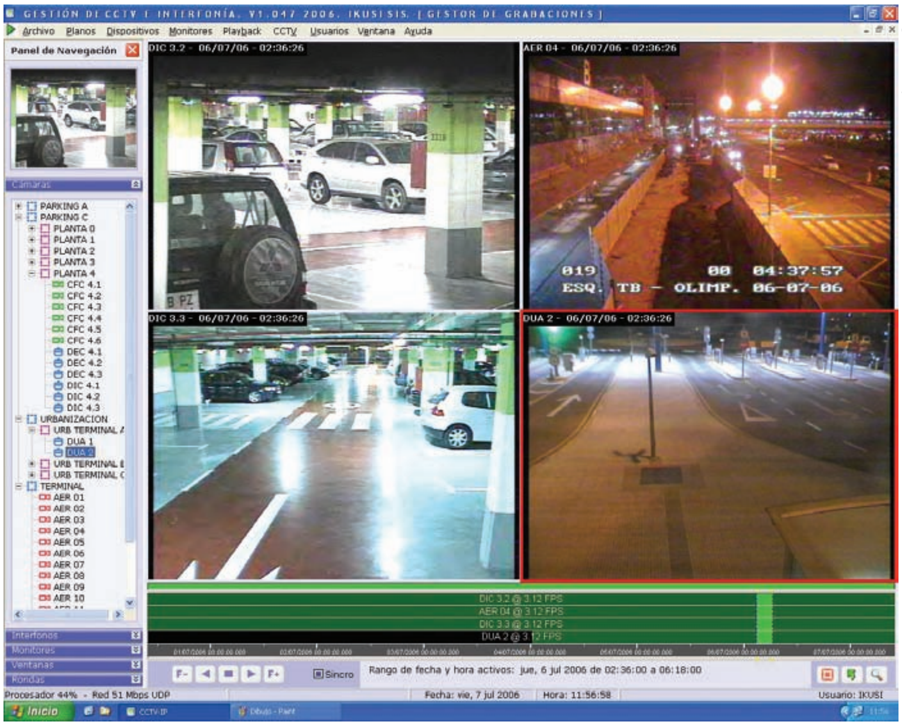


Image courtesy of Ikusi

A digital CCTV system monitors parking areas, airport concourse, and surrounding infrastructure

Although it is not expected to include airport operations, an instructive example of an interagency, intermodal TMC is currently taking shape as London prepares for the 2012 Summer Olympics. Organizers plan to physically integrate many different operating departments into one control center, which will include the people overseeing operations of the freeways, as well as transit bus and train systems. The planners realize the importance of not just getting everyone together in the same facility, but ensuring that the people work together as a unified team. They meet with each partner and with the group as a whole to develop joint standard operating procedures and arrive at a comprehensive agreement, then provide training to operations staff.

FIRST OFF THE BLOCKS?

The first true integration of an airport into a regional TMC may occur in New Jersey. The South Jersey Transportation Authority sponsored a project definition study to consider building a TMC next to the Atlantic City International Airport terminal. As set forth in the study, the center would control not only airport operations, but 911 emergency dispatch operations, the traffic signal system for Atlantic City, and traffic management on the Atlantic City Expressway. It would also include an emergency operations center to deal with disasters of any kind. Currently, funding is being sought to proceed with development of the integrated traffic operations and public safety command center.

It would be useful to identify three airports – one small, one medium, and one large – and develop a concept describing how each selected airport could be physically and functionally integrated into an appropriate regional TMC. The concept should then be vetted, not only among the study participants, but by operators from other similar-sized airports. Out of this process, a demonstration program could be formulated and funding sought to establish prototype projects. Evaluating these projects for a year or two should be sufficient to decide whether to recommend extending the concept to a national program. Such a proposal would be timely in the USA, as the federal transportation program reauthorization bill will be developed and approved in the near future.

Extending TMC operations to airports and integrating them with regional transportation management systems will not be appropriate for every airport in the USA. But for carefully selected candidate locations, it could mean improved operations, more economical and efficient management systems, and better service for the traveling public. ■

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DATA REPORT

IMPROVED MOTORWAY TRAFFIC FLOW SUPERVISION SYSTEM

New work being conducted in Croatia is spurring interest among traffic managers worldwide. Could better methods of data acquisition – and better use of the data that is collected – save roads from gridlock?

Exciting and ambitious developments are occurring on Croatia's roads, with the development of an advanced nationwide traffic data acquisition, organization and reporting system. The system is dedicated to collecting in-field raw traffic data and transforming it into a variety of complex traffic reports that will satisfy a whole spectrum of different demands from road operators. There is an existing traffic management system in Croatia that was primarily developed, manufactured and implemented by Telegra, but the company is now working on the implementation of a new system and service that goes beyond existing system functionality.

The basic objectives of establishing such a system can be divided into two groups: narrow and broad. Narrow or internal goals include acquisition, processing and dissemination of raw traffic data, while broad or external goals expand on the application value of collected traffic data. Accomplishment of narrow goals is a prerequisite for achieving the broad ones.

Narrow goals cover five areas, including motorway traffic data acquisition, traffic data acquisition – the latter allows calculation of AADT (average annual daily traffic), ASDT (average summertime daily traffic), and other traffic flow characteristics calculated for different time intervals (hour, day, week, month) – and development and exploitation of reliable AADT and ASDT prognostic models. Other narrow goals include data processing for articulate and perceivable traffic data representation, and motorway user privacy protection.

The broad or external goals of establishing such a system in a way that is meaningful to motorway management and that underlines the necessity of traffic boom management are many and varied. They include smart motorway infrastructure management, acquiring a quantitative basis for traffic research and prognoses, more efficient planning, designing, building, reconstruction and maintenance of motorway infrastructure, and also building a more efficient junction network.

Other broad goals include focusing on determining a particular section's stratum and developing more efficient traffic control in exceptional as well as in normal traffic conditions. Longer-term broad goals include the capability to monitor the effects of tolls, as well as determining the effects of traffic density on pavement deterioration, and conducting cost-effectiveness evaluations.

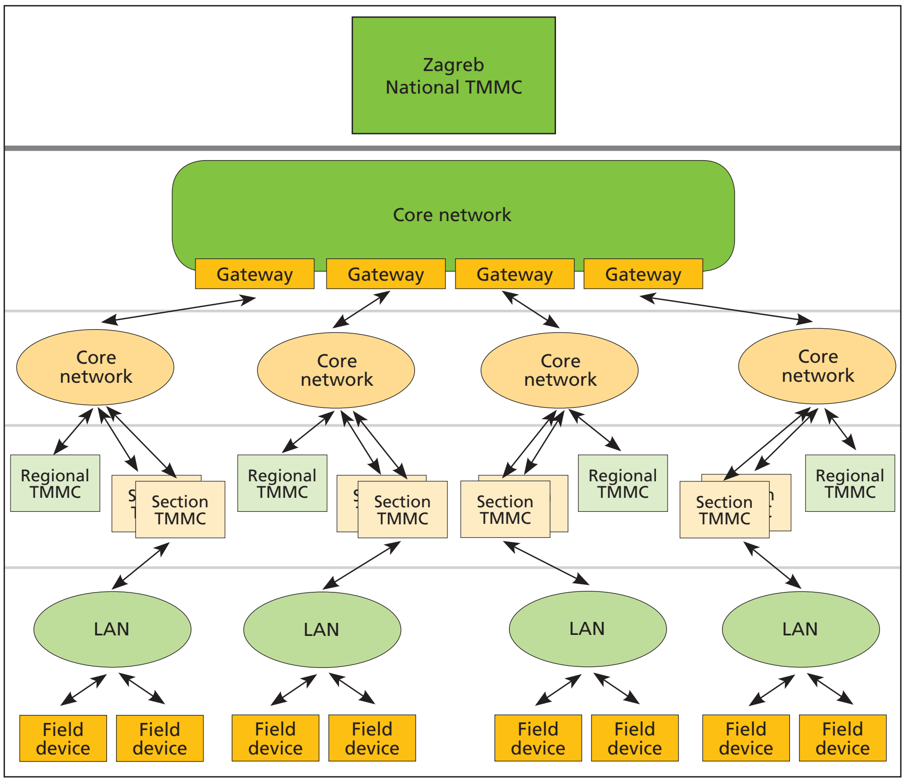


Figure 1: How existing traffic management and maintenance centers fit in with the whole network

EXISTING SYSTEM

The existing traffic supervision, control and management system has the ability to oversee the level of traffic, environmental and infrastructure conditions. Automatic traffic counters within the system classify counted vehicles into (8+1) categories. The existing traffic maintenance and managing centers (TMMCs) were intended for motorway maintenance and traffic management and were built at locations suitable for weather, traffic, video, and other relevant data acquisition (Figure 1).

A central unit within the TMMC polls slave devices in the field, and among other data it retrieves short- and long-term traffic data. The acquired traffic data is relative to an assigned but changeable time interval (in Croatia, one minute for short-term and one hour for long-term) and is stored locally on a TMMC server, from where it can be exported to a limited number of traffic reports. Its main task is not traffic counting and the described system uses none of the data stored in this database.

TMMCs are designed as standalone systems, and have their own independent LAN, yet allow for the possibility of broadscale integration through WAN. With the dramatic increase of traffic flow nowadays, this issue is becoming more

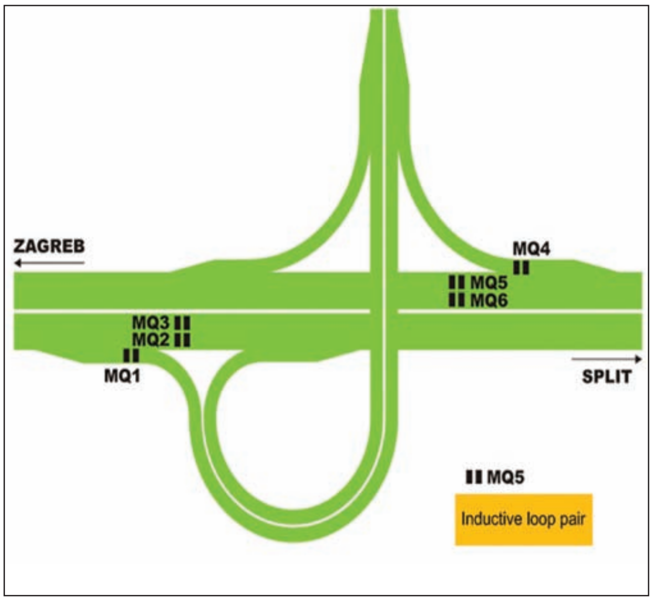


Figure 2: Typical implementation of traffic counting under a TMMC

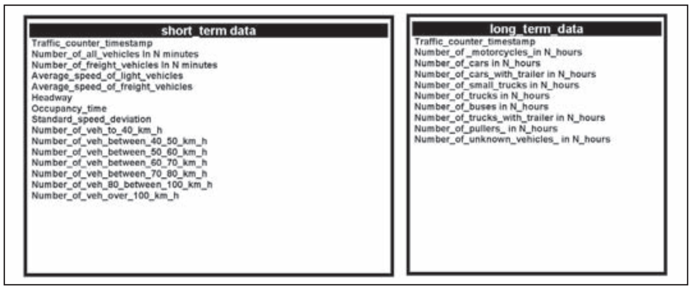


Figure 3: Long-term data can be used to generate traffic reports

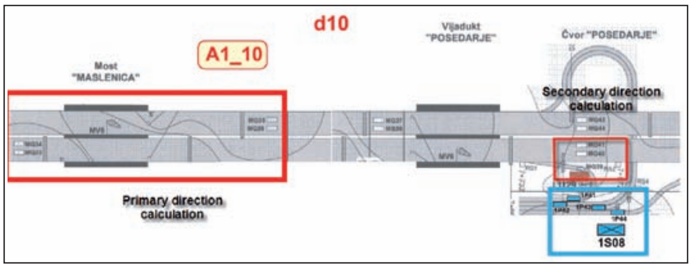


Figure 4: The data from Figure 3 is used to create so-called counting stations

actual and efforts were taken toward achieving this specific goal.

The existing system is based on the German standard known as TLS (Technische Lieferbedingungen für Streckenstationen), which – through its modular implementation – unambiguously determines a traffic system's functionalities and interfaces, independent of the equipment manufacturer. TLS ensures efficient and rational motorway exploitation through its key element, the Roadside Outstation (RO), which among various devices (such as VMS, programmable LED displays, ramps, etc) also manages the automatic traffic counters that were a main focus of this project.

Furthermore, all traffic-related data throughput between these ROs and the rest of the system is channeled through a Central Traffic Computer (CTC), which is the information source for the suggested system and provides avoidance of the rest of the non-traffic counting oriented system.

PROPOSED NEW SYSTEM

The proposed system consists of several key elements, including automatic traffic counters (one per traffic lane), CTCs and their data retrieval programs, a database, and finally a web server and user application. In the configuration of the existing system (geographical distribution as in Figure 1), there is a CTC data-retrieval program assigned to the CTC in each TMMC. The data retrieval program is connected to the same LAN (switch device) to which the CTC is assigned, which avoids or reduces communication breakdowns. All incoming data is processed by the retrieval program and filtered into several types of incoming traffic data per traffic lane, forming a remote database entry. The system is distinctively data loss-proof as it uses a local buffering module contained in the data-retrieval program. This module is activated each time that a remote database connection loss is detected. After the connection is restored, database entries are formed from the saved CTC telegrams and registered in the database. At this point, both short-term and long-term traffic data is available to the user via a web application and can be converted into a list of complex traffic reports.

> **"Both short-term and long-term traffic data is available to the user and can be converted into a list of complex traffic reports"**

SYSTEM ORGANIZATION

System organization can be overviewed by looking at its database entities: counting station (a formula assembly logically comprising several traffic counters); junction (traffic object dividing two motorway sections); section; and current traffic.

As already mentioned, current traffic data can be short-term or long-term, with assigned but changeable intervals. Short-term data is an indicator of the current traffic flow and is used only for GIS representation of the current motorway traffic density status, while long-term data is used in all subsequently generated traffic reports (Figure 3).

This data is then used in the creation of counting stations (junction or section counting stations), which are best illustrated above in Figure 4.

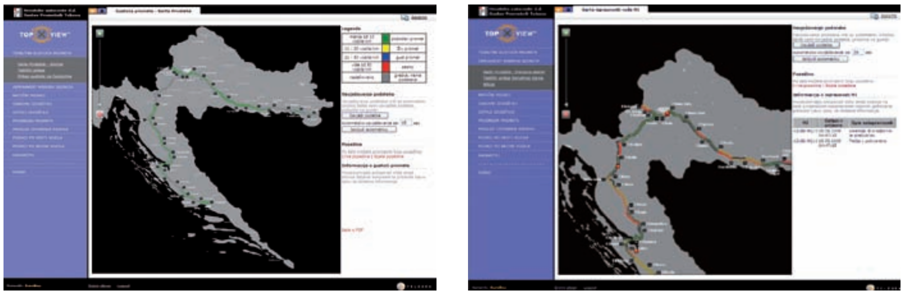
This has created a section counting station A1_10 using the following formulae:

Primary direction 1 calculation:
MQ33+MQ34
Secondary direction 2 calculation:
MQ39+MQ40+MQ41

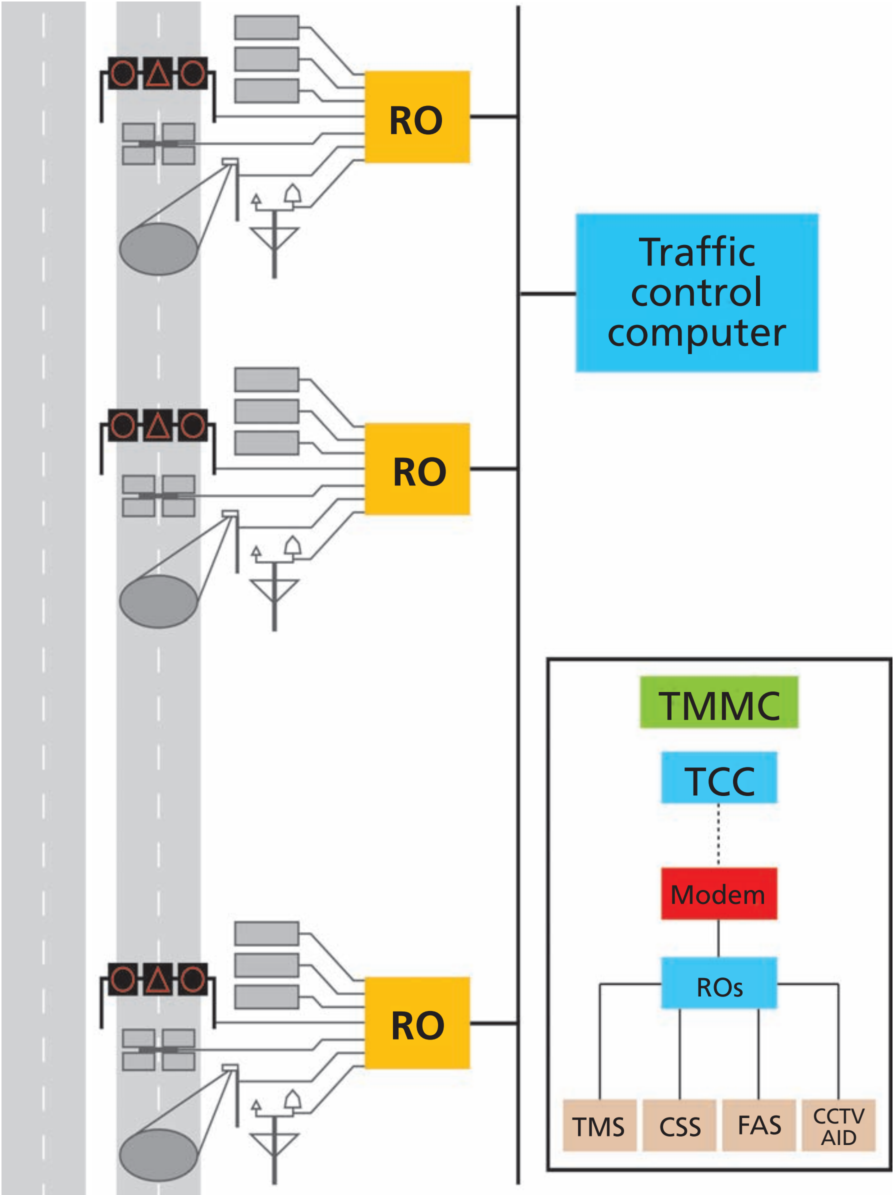
The secondary direction formula is used if for any reason the primary direction data is unavailable. Furthermore, every database entry, if missing, can be calculated from existing data using configurable parameters and interpolation algorithms based on time and/or space.

USER APPLICATION

The web-based user application is simple to operate and allows the possibility of



Traffic density and traffic counter status monitoring generated using the web application



The proposed new system for Croatia, as integrated by Telegra Europe, comprises several elements

AADT and ASDT with numerical and graphical traffic data values	
Average daily traffic	• Average daily traffic within a specified period • Average daily traffic for weekends or working days within a specified period • Average daily traffic for summer, the rest of the year or the whole year • Average daily traffic weekly within a specified period
Hourly traffic	• Hourly distribution of traffic flow as a percentage of AADT • Average horary traffic in daily hours for a period • Average horary traffic in daily hours within a year • Average horary traffic distribution within days of the week
200 ceiling hours	• 200 highest traffic density hours distribution by an AADT percentage • 200 highest traffic density hours distribution by all day hours • 200 highest traffic density hours distribution by week days • 200 highest traffic density hours distribution by month days

Table 1: Reports that can be generated by the system

Croatia aims to have a unified national system

exporting traffic reports to the majority of the standard formats. Its purpose is to enable insight into two types of data: traffic infrastructure data and traffic data itself. Obtainable traffic data can be divided into several types, such as number of vehicles (counting data), traffic flow structure (that is, vehicle classification data), as well as raw data from each counting station.

Traffic infrastructure data includes automatic traffic counter data (type, location) and counting station data (location, section or junction), primary and secondary connected counting station (for configurable parameter interpolation methods). Traffic infrastructure data also consists of section data (length, motorway), junction data (location, motorway), and motorway data.

After successful data processing (including plausibility checks on several levels and sophisticated data interpolation) and the user's confirmation of the data validity, any of the reports shown in the table can be generated for any section, junction or motorway and any time in graphical (SVG) or tabular form. Using short-term and status data, the web application is also capable of GIS real-time traffic density and traffic counter status monitoring.

FURTHER IMPROVEMENTS

This system is an assembly of different subsystems that enable motorway traffic flow data acquisition and processing, and is for motorway management and exploitation. The continuous increase in traffic density is creating situations where having a car is becoming a disadvantage as it is often impossible to travel rapidly and safely.

Telegra's provision of this system to highway operators in Croatia will provide invaluable data for the future planning of traffic infrastructure development. The full value of the implemented system is yet to be shown, as Telegra has successfully implemented traffic prognostic models based on past data series that will show their full value after a reasonably long period of system implementation. ■

Robert Ryslavy is a sales engineer and analyst for Telegra, and is based at the company's European headquarters in Croatia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traffic technology INTERNATIONAL

SECTION 3:
DEMAND MANAGEMENT

by Dan Reagan

CULTURE SHOCK

HOW CULTURE DICTATES POLICY IN THE WORLD OF PUBLIC-PRIVATE PARTNERSHIPS

Public-Private Partnerships have existed in one form or another for hundreds of years. Could they be the ultimate solution to drag the USA out of its current transportation funding and congestion crisis?

After a long-running battle that captured national attention, at the end of September 2008 one of the most closely watched Public-Private Partnership (PPP) proposals in the USA met its end. State legislators in Pennsylvania failed to act on the proposal – championed by Governor Edward Rendell to solve the state's transportation funding issues – to lease its turnpike. Pennsylvania Transportation Partners – led by New York City-based Citigroup and Spanish firm Abertis Infraestructuras – allowed the US$12.8 billion deal to expire on September 30. Proponents had hoped the 75-year lease offer would serve as a model for large-scale PPPs across the country, addressing the state's immediate needs for infrastructure investment and offering best-practices ideas for the turnpike's management.

Just two weeks earlier, Missouri DOT discontinued talks with Missouri Bridge Partners to fast-track a major rebuilding program as a result of tighter credit and added cost. The US$700 million funding for the bridge project will come, instead, from state bonds. Meanwhile, on the other side of the Atlantic, the UK had logged more than 700 signed PPP deals by the end of 2007, for a cumulative value of US$56.19 billion since the beginning of the decade. Although this makes Britain the market leader in Europe, others have followed its lead. Italy, Spain and Portugal are active, and France is showing increasing interest. Ireland and Greece have an impressive volume of projects on record, while Germany is removing the legal barriers that could make it a significant player in this market. The concept has traveled to India as well, with US$47.3 billion scheduled for highway investment alone over the next five years, 75% of it coming from PPPs. Japan also has 20 new PPP projects in the pipeline.

Australia's transport sector was one of the first to use PPPs to deliver infrastructure, with the states of Victoria and New South Wales pioneering public-private road partnerships – Sydney now has the world's largest network of urban toll roads. As of October 2005, approximately 25% of all contracted PPP projects within Australia were related to the transport sector.

Even the USA's close neighbors have embraced these new partnerships. Mexico, for instance, ranks third among all of the developing nations for PPP investment, with more than US$55 billion invested in 130 projects over the past decade, and President Calderon recently announced an investment of US$2.96 billion in new work to help Mexican economic development in these financially troubled times. Around 20% of all new infrastructure in Canada's British Columbia is now designed, built, and operated by the private sector.

Many US drivers still view roads as 'free', so acceptance of privatizing roadways has been slow

REFLECTION OF NATIONAL CHARACTER

Every nation in the world is looking for ways to finance repair to crumbling infrastructure or expand facilities to meet population growth. With many economies currently in – or on the verge of – recession, PPPs offer one part of the solution for budget-strapped national governments to deal with their substantial deficits. The time, it seems, is especially right for this delivery mechanism. Why, then, is the USA so out of step with the trend?

PPPs can take many forms. In essence, the National Council for Public-Private Partnerships defines a PPP as a contractual

"Every nation in the world is looking for ways to finance repair to crumbling infrastructure or expand facilities to meet growth"

A conceptual drawing of the TransTexas Corridor – a 4,000 mile system of integrated corridors and transportation modes

agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. In addition to the sharing of resources, each party shares in the risks and rewards potential in the delivery of the service and/or facility.

What's not said in the definition – and what we've come to understand from observing the development of PPPs – is that the ultimate form of the partnership depends very much upon the culture of the country (which also determines the form of its government) entering into the agreement. That's why PPPs cannot be applied, even to Europe, on a uniform basis.

In centralized countries such as the UK and France, it is easier to coordinate PPP policy – and perhaps attract market interest – than in countries where more decisions are made at state, regional and municipal levels. Some countries may have a central PPP unit.

For example, only the Flemish region in Belgium has its own PPP unit, while in Germany there are various PPP units at the Lander level that are complemented by a PPP Steering Committee. In the more centralized countries, the Ministry of Finance usually has responsibility for the central PPP unit, which is supported by smaller PPP units within other ministries. Generally, these units manage policy development and implementation, dissemination of best practice, standardization of processes and documentation, reviewing of project proposals and the facilitation of specific projects. Sometimes these responsibilities are divided between more than one body. The National Development Finance Agency in Ireland, for instance, is the centralized procurement body, but PPP policy development falls to the Ministry of Finance. Moreover, PPP models vary greatly from region to region, with Latin America, Europe and Central Asia focused on divestitures and manage-and-operation contracts with concessions. East and South Asia emphasize greenfield projects with new construction.

GAS TAX: THE FACTS

In the USA, the federal tax is US$0.184 per US gallon. In addition, each state has its own tax, ranging from US$0.08 in Alaska to US$0.565 in California. The average is US$0.31 per US gallon.

A typical driver in the USA operates a vehicle that gets 22 miles (35km) per gallon and drives about 15,000 miles (24,000km) per year. Therefore, the typical driver pays the following in gasoline taxes annually:

- US$0.184 (Federal) + US$0.31 (state average) = US$0.494 per gallon;
- US$0.484 divided by 22 miles per gallon = US$0.0223 per mile;
- US$0.022 per mile times 15,000 miles per year = US$334.50 per year in gasoline taxes.

Unfortunately, not all of that goes to administer, maintain, and rehabilitate existing highways, or to construct new highways, as many states use much of the state tax (federal tax is statutorily dedicated to transportation) to support education, healthcare, and many other programs important to the general public.

PPPS IN ALL SECTORS

The PPP landscape outside of the USA is pushing rapidly into the education, health, water and waste water sectors, as well as government buildings, rail and prisons. Leisure, social housing, office accommodation, and solid waste treatment are also growing in importance.

But roads remain the dominant sector, especially in Europe, where the concession model has a long history. The first recorded crossing over the River Thames, known as Old London Bridge, opened in 1209 and was built under a toll concession granted by King Henry II to Peter of Colechurch, officer of the Church of St Mary Colechurch. What would today be called a PPP existed between the King and the church to finance and build the bridge in return for the right to collect tolls on it. And throughout recent history, user fees have been commonly accepted on Europe's roadways. Southern European nations especially, such as France, Italy, Portugal and Spain, have traditionally favored the use of tolls to finance their infrastructure needs.

European governments have long understood the need for investment in roads, and Europeans expect to pay for good transportation – and expect to pay for the use of specific roadways. Furthermore, the gas tax in Europe pays for an array of social programs, while in the USA that tax is dedicated to road construction.

The USA first stepped into the PPP spotlight with two landmark transactions. In October 2004, the eight-mile Chicago Skyway, a toll road, was privatized. A consortium between Spain's Cintra and Australia's Macquarie was awarded the contract to operate the Skyway under a 99-year US$1.83 billion lease. In January 2006, Governor Mitch Daniels of Indiana awarded a 75-year lease of the Indiana Toll Road to the same consortium for a fee of US$3.8 billion and a commitment to undertake US$400 million in road improvements.

Even before these events, however, there was interest in a major PPP program. In 2000, Texas had proposed the Trans-Texas corridor, a multimodal 4,000-mile system. A swath of land up to 1,200ft wide would accommodate highways, railroads, utility transmission lines and possibly truck-only or freight lanes. The only funding mechanism, officials said, that could pay for such an endeavor within a reasonable period of time was a PPP, and Governor Perry backed the idea. The state solicited bids for a new multi-modal facility that would run from Dallas to the Rio Grande River near Laredo – a distance of almost 500 miles. Despite strong negative public reaction to the concepts of wide corridors and tolling, ultimately Cintra was awarded the contract. Americans, particularly Texans, don't like to pay tolls. Since that time, two additional contracts have been awarded to private entities for metropolitan improvements, and Texas DOT has awarded two contracts as a PPP to a local public tolling agency, again in a metropolitan area.

Today, over 21 states have adopted legislation authorizing the use of PPPs for the design, construction, financing and operation of transportation facilities and the issue is on the legislative agenda for several more this calendar year, but opposition has slowed implementation.

GOOD ROADS FROM BICYCLES

The Good Roads Movement took place in the USA between 1880 and 1916. Advocates for improved roads led by bicyclists turned local agitation into a national political movement. Early organizers cited Europe, where road construction and maintenance was supported by national and local governments.

In its early years, the main goal of the movement was education for road-building in rural areas between cities, and to help rural populations gain the social and economic benefits enjoyed by cities where citizens benefited from railroads, trolleys and paved streets. And they wanted to ride their bicycles on good country roads. Good road advocates involved themselves in local politics. Support for candidates often became crucial factors in elections.

However, at the turn of the 20th century, interest in the bicycle began to wane in the face of increasing interest in automobiles. Organizations then developed to accomplish such cross-county projects as the coast-to-coast east-west Lincoln Highway (1913), headed by automobile parts and automobile racing magnate Carl G. Fisher, and later his north-south Dixie Highway 1915, which extended from Canada to Miami, Florida.

'FREE ROADS' REVERSES HISTORY

Opposition to tolling in America – especially when administered by a profit-making enterprise – remains strong. US drivers view the roads as free, as they believe their federal and state gas taxes underwrite construction and maintenance.

"US drivers view the roads as free, as they believe their federal and state gas taxes underwrite construction and maintenance"

'Free roads' – a concept foreign to European drivers – is embedded in US history. As early as 1916, the federal aid highway program prohibited the use of tolls on federally funded roadways. After the Second World War, President Eisenhower's Federal Highway Act of 1956 appropriated US$25 billion to construct over 68,000km of interstate highways. Although collecting user-fees on existing toll roads was grandfathered, by law tolls were not allowed on the new Interstate Highways System. Ironically, this lack of enthusiasm for tolling is a reversal of US history.

With its relatively heavy concentration of population and wealth at the end of the 18th century, New England led the nation in road-building. Between 1790 and 1840 – commonly referred to as the 'turnpike era' – some 240 corporations built more than 3,700 miles of toll roads. Every part of New England except Maine acquired an extensive turnpike network, with Connecticut leading with approximately 1,600 miles.

The Lancaster Turnpike, chartered by Pennsylvania in 1792, was the first toll-road corporation in the USA, although previously there had been a few experiments with toll roads based on the English model of a turnpike trust with a bonded debt to pay in Virginia, Maryland and Connecticut. Rhode Island established the second such corporation in 1794 and within two years, each of the New England states had chartered at least one turnpike. In 1800, two-thirds of the 72 toll roads in the USA were in New England, with 23 in Connecticut. Throughout the country, by 1828 there were over 7,000 miles of private toll roads – including toll canals – used largely to move freight by horse, wagon and barge. Notable among this road-building, in 1806 the government authorized the first federal road – the Cumberland Road to the Ohio River – which was non-toll and therefore set a precedent for 152 years.

The great expansion westward in the late-19th century was driven by a major PPP between the federal government and the private railroads. The government provided the right-of-way and related development property, while the railroads used private capital to build rail facilities

PPPs are seen as the most effective resource in funding the USA's crumbling roads infrastructure and rolling stock. Toll funding developed important mining roads and intercity roads in California, Colorado, and Nevada. Over time, private involvement declined as states and the federal government increased the pace of road construction. The concession model was revived when the first automobiles arrived on the scene: the Long Island Motor Parkway (1908), the Ambassador Bridge in Detroit (1929), and the Detroit-Windsor Tunnel (1930) are just a few early examples.

SHIFTING US POLICY

A major shift in US policy occurred during the Great Depression of the 1930s when private providers went bankrupt and were taken over by governments that needed to maintain vital services. Similarly, most of the toll bridges on the upper Hudson and Delaware Rivers, on the Mississippi River, and in the San Francisco Bay area developed as concessions, were bought up by state and bi-state agencies with the expectation that they would become toll-free.

Throughout the 1930s, the federal government adopted an activist role in spurring the economy through public works and public payrolls. Then, the mentality of control formulated during the Second World War and beyond set the government's role as provider of services for the public sector, and governments at all levels expanded their size, scope and level of control.

Other events as well changed the course of history for toll roads in America. According to researchers at the Reason Foundation, several factors prevented the fully fledged development of a private toll road industry in the automobile era. The highly publicized scandals surrounding the New York Bridge Company and the frauds committed during construction of the Brooklyn Bridge in the 1870s gave toll bridge charters a bad reputation. Second was the invention of highway trust funds supported by dedicated motor fuel taxes. This form of highway funding proved highly effective and inexpensive to collect. The fuel tax was quickly adopted by every state, as a result of the 'Good Roads Movement' in the late-1800s. Also, the invention of the state toll road agency provided a way to fund large-scale projects with toll revenue bonds, with the cost advantage of being able to issue the bonds at tax-exempt rates. The Pennsylvania Turnpike became the model for a host of other states and later urban and regional toll authorities that built and maintained some of America's most important highways.

The American Society of Civil Engineers estimates that US$1.6 trillion is needed over a five-year period to bring US bridge and highway infrastructure to a good condition

> **"A shift in culture can only take place over time, but there are stirrings of a new acceptance for PPPs"**

The modern era of PPPs began in the late-20th century when President Reagan – following the lead of Britain's Prime Minister Margaret Thatcher – made privatization a legitimate part of public policy discussion. Major toll bridges in San Francisco and Detroit, using a concession model as it existed in Europe, were the first signs of a renewed private sector involvement.

It took generations to develop the mindset of a 'free' road. Today the cultural pendulum appears to be swinging back. People don't want higher taxes, and there's the growing realization that taxes alone can't fund the trillion dollar investment required to support the country's infrastructure needs. Officials are looking for other ways to fund the work. California and Texas, for example, are considering the possibility of investing public employee pension funds in projects, as they can be structured to return about 10-12% over a long period. Pension fund managers want solid, long-term investments, and the premise is that people will always be using the roadways.

Furthermore, people are becoming more comfortable with the idea of a private entity making money on a highway, especially if their toll pays for better service and less congestion. In regions of the country where commuter and light rail and bus rapid transit are being considered, PPPs are receiving less opposition simply because this kind of transit has always been funded by taxes and individual user fees – and a PPP would be just another option.

A shift in culture can only take place over time, but there are stirrings of a new acceptance for PPPs. This age-old solution to infrastructure funding is a viable way for the USA, along with the other countries of the world, to meet today's unprecedented budget needs. ■

Dan Reagan is PBS&J senior program manager for Alternative Contracting for the USA

In 1958, the Chicago Skyway cost US$101 million to construct and took around 34 months to build

by Reggie Gardner

COMPLEX, BUT SIMPLE

IMPLEMENTING AN AUTOMATED VARIABLE TOLL PRICING SYSTEM

Automated toll and travel-time information systems can have a marked positive effect on traffic flow, but require a dedicated balance between simplicity and functionality that doesn't compromise cost efficiency

Albert Einstein is often quoted as having said, "Everything should be made as simple as possible, but not simpler." The point, of course, is that in attempting to manage complexity, it is possible to simplify something so much that it no longer works. Nowhere is this truth more evident than in the world of ITS. Complex applications such as automated toll and travel-time information systems can be difficult to design, implement and use. Many DOTs are hesitant to employ such systems for fear that they will be too complicated, or – in order to minimize costs – agencies opt for over-simplified technologies and then discover they don't work as intended.

With automated toll and travel-time information systems, the goal should not be to find the least expensive system, nor the most complex, but rather the system that provides the best performance for the monies invested. To that end, there are several factors that agencies should seriously consider when designing or evaluating these systems. The collection of accurate traffic data is an important consideration, while ease of roadway configuration, intelligence of data-processing algorithms, and flexibility in data distribution are also key. Attention to these important basic factors will help simplify these complex applications without compromising their cost effectiveness.

Of course, one of the first questions an agency will ask is why a system is needed for automated tolling or travel times. The goal of both systems is to improve traffic flow by increasing road-usage efficiency. Both systems benefit the public by giving drivers the chance to choose their commute based on current traffic conditions. Toll pricing that can be adjusted automatically and dynamically based on conditions offers great value to motorists and effectively manages congestion in the toll lane, while simultaneously it generates much needed revenue for the agency. Accurate travel times – which are often displayed on overhead or roadside VMS – can be quite useful to motorists on the roadway, especially when alternate routes are available.

DATA COLLECTION

To be effective, both systems require accurate, real-time traffic data to perform the necessary analyses and calculations. In addition, such systems may need to have lane-by-lane data (especially when toll lanes run adjacent to normal lanes), historical data to model what is expected to happen based on current conditions, as well as knowledge of extreme conditions, such as road closures or weather that might impact traffic flow.

Today, traffic flow data is generally collected by one of three technologies: point detectors; vehicle probes; and delay points. Point detectors count cars and measure speeds on a lane-by-lane basis and include video cameras, radar sensors and inductive loops. Vehicle probe data provides information about general traffic flow but cannot provide data per lane. Examples include GPS trackers, license plate readers, and toll ticket or tag readers. Delay points monitor the amount of time that it takes a vehicle to travel through a specific area and can be provided by barrier toll plazas equipped with queue detectors.

Ideally, systems will properly handle data from multiple sources. In best-case scenarios, agencies would combine these three technologies to obtain a complete picture of what is occurring on the roadway. So agencies not only need to consider how they collect data, but they also need a system that can integrate with each type of data source. Finally, extreme conditions that occur infrequently are best handled manually. Agencies should seek out systems that can be manually overridden when massive closures or weather-related problems occur.

ROADWAY CONFIGURATION

To make best use of the traffic data collected, automated tolling and travel-time information systems need to be configured

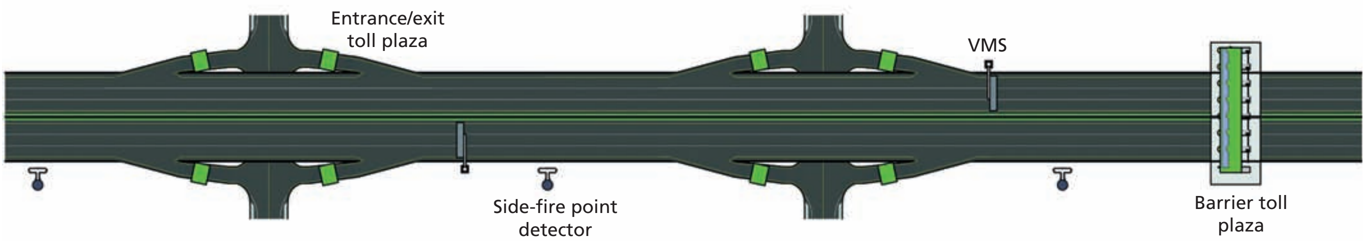


Figure 1: The above shows initial roadway configuration and asset definition. A visual tool should be provided to define the road's physical elements

"Agencies not only need to consider how they collect data, but they also need a system that can integrate with each type of data source"

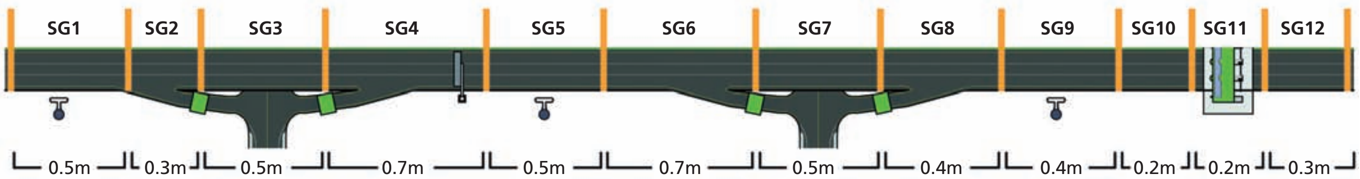


Figure 2: Route broken into segments for a single direction. The segments provide a way to assign one or more data sources to individual road segments

to the roadway and its specific assets, including the location of on- and off-ramps, the installation sites of VMS and detection devices, and the distance required to traverse the route. To simplify operation, the system should provide a visual tool that defines the road's physical elements. Figure 1 illustrates how such a tool might display a road that has been configured with assets such as side-mounted point detectors, entrance/exit toll booths, VMS, and a barrier toll plaza.

Once the road is configured and its assets defined, users can select one direction of travel at a time and define logical segments that comprise that route. These segments provide a way to assign one or more traffic data sources to individual segments of road. For example, by using the visual tool illustrated in Figure 2, an agency can see that point detectors will provide excellent lane-by-lane coverage in the road segments in which they are located, but probe data will be needed to provide a general view of overall traffic flow in the areas between point detectors. They can also identify areas, such as barrier toll plazas with queue detection that can provide delay data. In the event of specific incidents that affect traffic flow, operators can manually override the system by setting delay factors, such as time or speed reduction on one or more segments.

In this way, the system is configured to handle multiple data sources for each segment; probe data will overlap with point detector data, and delay data will be available at certain spots to provide the agency with override capabilities. Finally, the system should be configured to weigh each data source and prioritize the collected information so that the system can calculate and determine the most accurate output of that data.

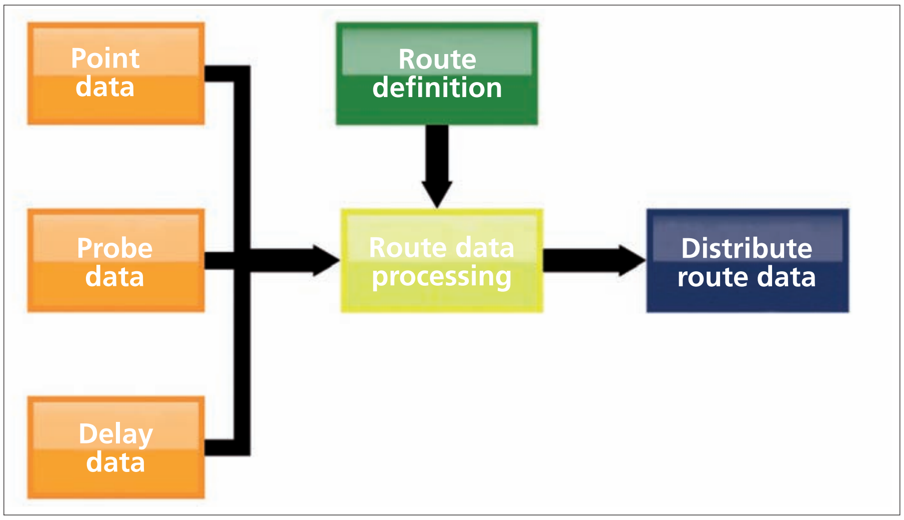


Figure 3: The above diagram shows a high-level view of the data flowing through a system

GENERATING ROUTE PRICING AND TRAVEL-TIME INFORMATION

Configuring a route will be an infrequent operation. Performing the calculations needed for automated toll pricing and travel-time information will be conducted repeatedly and frequently. The process can be complex, but it must be executed quickly and reliably. Figure 3 offers a high-level view of the data flowing throughout a system. The route data-processing module shown is only concerned that the necessary data is available in the correct format at execution time. The process of retrieving these data points can therefore be handled by one or more external systems that are capable of reliably delivering the data on time and in the proper format.

This still leaves the route-processing module with plenty of work. For the system to be effective, the route-processing module needs to be configurable to produce travel times or variable toll prices, while allowing users to set a minimum data threshold required for functionality. It also needs to offer error notification when data threshold requirements are not met or other errors occur. In addition, it should be capable of distributing final results in various formats, including XML, HTML, email, ftp, and relational database tables, while working with manual overrides for individual route segments for the entire route.

The key to making accurate calculations is having data from all sources present and current when the route processor executes. Figure 4 illustrates that once the configuration step is completed, all other steps must occur every time we wish to update the information. This process can be repeated as often as every few seconds, which is important as the older the data is, the less valuable the resulting toll and travel-time information becomes.

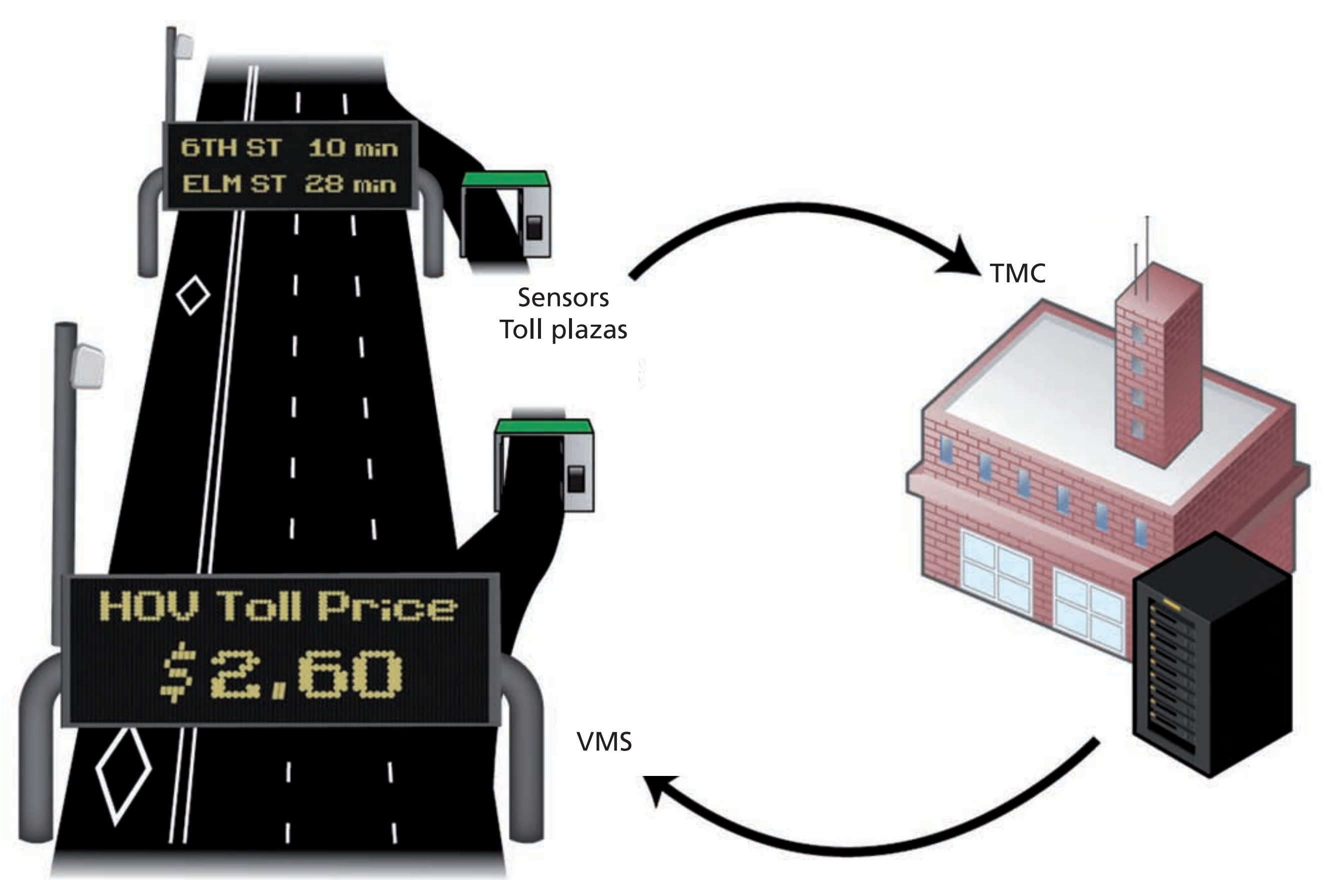
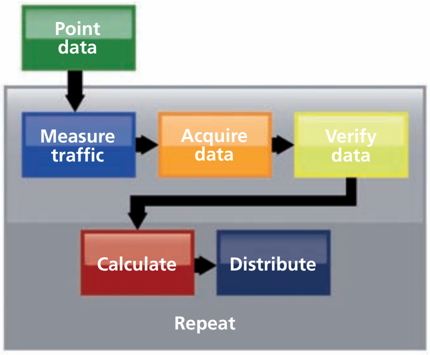


Figure 4: The distribution of data

There are various ways to calculate travel times or to measure the congestion that affects toll lane processing. Some methods rely solely on current data points, such as speed and volume, while others make use of historical data to model what will happen based on current conditions. In either case, the system needs to use the appropriate algorithms to calculate the desired information, based on available data and user preferences.

In review, to simplify an automated toll or travel-time information system, configure the travel corridor with every type of detection device available, then configure the route-processing module to produce the type of output desired and to distribute that data as needed. Finally, let the system run automatically until it becomes necessary to manually input data to improve the accuracy of the output.



Logical steps in a route processing system

"From field detection devices and communication networks to back-end software applications, maintaining the complexities of these systems at a manageable level is imperative"

DATA DISTRIBUTION

Travel times are commonly displayed on VMS but they can also be distributed to public websites, 511, and other public information systems. Toll lane prices, on the other hand, require a much more targeted distribution. Motorists need to know at specific decision points on the road whether to use the toll lane or not, and they need to know immediately if there is any change in price.

Our roads are becoming increasingly congested. Agencies universally agree that they need to make the best possible use of every traffic measurement – and every means of informing motorists of existing conditions – to effectively manage traffic flow. Automated toll and travel-time information systems are just two of the tools that can have a significant impact on congestion, and the complexity of these systems can be staggering. From field detection devices and communication networks to back-end software applications, maintaining the complexities of these systems at a manageable level is imperative.

The system outlined here is neither over-simplified nor overly complex: it allows for simple operation while retaining the flexibility necessary to grow with changing traffic conditions and advancing technologies. In practice, it requires an initial configuration, but subsequent processes can run without human supervision, except under specific circumstances. The end result is an automated system that can have a significant positive effect on traffic, simple and cost-effective, without limiting performance. ■

Reggie Gardner is a software developer at Wavetronix. He currently serves as a product manager for the Command line of data appliances and joined the company in 2004. He has over eight years' experience in his field

by Yaron Hollander

DOWN TO THE PLANNING

FORECASTING DEMAND AND REVENUE FOR MANAGED LANES

There are a variety of challenges in forecasting demand and revenue for managed lane projects, but the following principles have recently been implemented successfully in the development of several forecasting tools

Managed lanes have recently gained much attention as a way of balancing the need to improve the level of highway service and the desire to restrain traffic growth. Such lanes are introduced as additional tolled lanes, parallel to existing general-purpose lanes, to encourage car sharing and public transport ridership. High-occupancy and public transport vehicles are often exempt from paying the toll. The key feature that distinguishes these facilities from other tolled routes is the use of variable pricing to control the level of service: toll levels are continuously adjusted to keep the number of users low enough so that speed does not fall below a preset limit.

Most managed lanes projects are built as public-private partnerships. The process that precedes their construction includes various stages, such as feasibility testing, planning, preparing tenders and bids, detailed design, and securing financing. During this process, both the public and private bodies involved require estimates of the expected number of users, forecasts of traffic, and calculation of the associated revenue.

Over the years, the transport industry has developed powerful approaches to estimating future travel demand and predicting how this demand splits between travel modes and available routes. However, these classical approaches struggle to incorporate the special features inherent to managed lanes schemes.

DYNAMIC MECHANISM

To estimate demand for using the managed lanes we primarily need a model that replicates the way drivers choose a specific route from the origin of their journey to their destination. The selected routes can either use or not use the managed lanes. It is assumed that at one or more locations in the highway network, there are decision points where electronic signs (or conventional signs with partial electronic display, such as the one illustrated in Figure 1) provide drivers with information about travel time on the alternative routes and about the toll that would apply if they join the managed lanes at that point. We generally expect drivers to choose the route that minimizes their generalized cost of travel – i.e. the sum of the actual toll and a monetary equivalent of the travel time.

Forecasting route choice is standard practice among travel demand analysts and is commonly conducted using 'static assignment' models, which load the demand onto different elements of the road network so that the resulting travel times meet some preset equilibrium conditions. Static assignment models are often sufficient to generate reasonably accurate estimates of route choice, despite the fact that they assume that traffic conditions and the associated route choices are uniform along a relatively long period (conventionally an hour or longer). But such an assumption is inappropriate when the network includes managed lanes, because the toll is likely to be adjusted several times during the modeled period and, as a result, there will be changes in the choice of a driving route within the hour modeled.

Advanced models of route choice are sometimes based on 'dynamic assignment'. In these models, the period of analysis is divided into short time steps. When users during a certain time step choose a driving

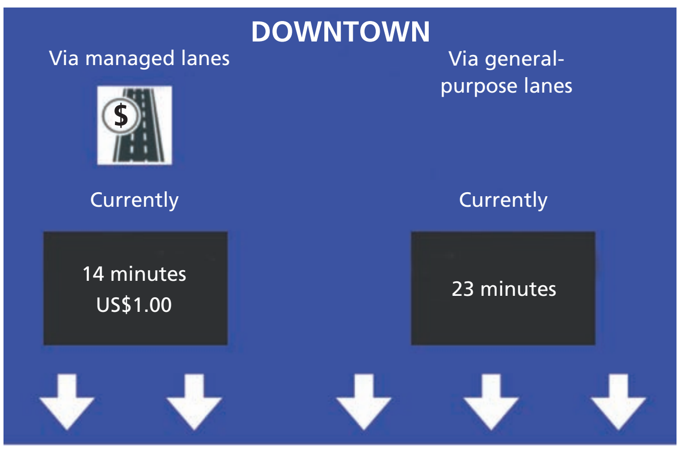


Figure 1: Located in the network are decision points where electronic signs provide drivers with alternative route travel times and toll lane information

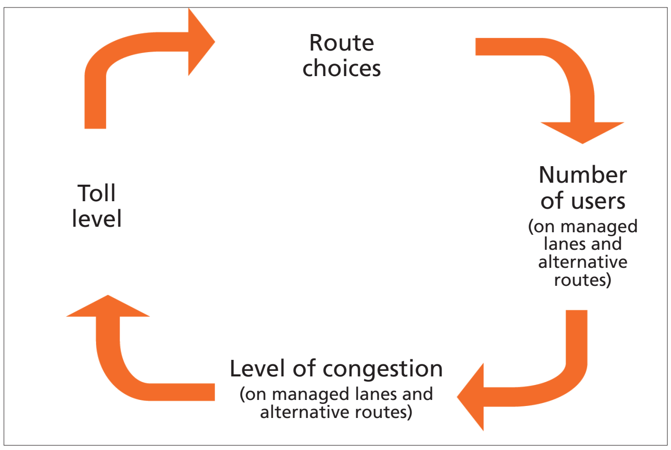


Figure 2: A model with full demand-supply dynamics, in which a change in the number of users affects the level of the toll charged

The innovative I-15 Managed Lanes Project will be the first of its kind in the state of California and will maximize capacity and relieve traffic congestion

route, they take into account the level of congestion caused by decisions made by other users in previous time steps. Although this is a more realistic representation of the dynamic nature of the demand, dynamic assignment remains equally static in the representation of the supply, as it does not allow continuous adjustment of the level of toll to the number of users. A realistic representation of a network that contains managed lanes therefore requires building a bespoke tool that allows for the dynamic nature of both supply and demand.

Some analysts avoid the need to build a complex custom-built model by solving a series of simplified versions of the original problem. The managed lanes are coded as a road with a fixed toll: each element in the series is a standard route choice model in which a different level of toll is assumed. Based on the demand and revenue estimates calculated in the different cases, the analyst can infer a likely range and can use logical judgement to choose specific values out of this range to produce the final demand and revenue forecasts. This approach is generally acceptable and undoubtedly it saves considerable effort during the stage of model development. But it is also clear that it does not exhaust our ability to replicate within the model the response to the continuous toll adjustments, despite the fact that the toll adjustment mechanism is known to us and does not need to be forecast.

An alternative is a model with full demand-supply dynamics, as described in Figure 2. As each change in the number of users of the managed lanes affects the level of toll charged, the network loading procedure has to be of an incremental nature. That is, only a small number of users choose a route through the network at each iteration of the model. After their choice is made, the level of congestion is recalculated and the toll is adjusted accordingly before the next group of users is taken through a similar process. It is convenient to formulate the incremental procedure such that each demand increment corresponds to the demand entering the modeled area during a single time step (typically a few minutes), so that the continuous adjustment of the toll represents its actual fluctuation over time.

When a demand forecasting procedure is conducted incrementally – and only a small number of users are loaded onto the network simultaneously – it is important to ensure that the calculation of the congestion level takes into account all traffic. During the stage when part of the modeled traffic has still not selected a driving route, the congestion level needs to be repeatedly calculated as long as the loading process is ongoing. It is also vital to ensure that queues that remain following each stage of loading are passed onto the next stage, and that the model allows queues to build up.

"When estimating the demand for using a tollway, the assumption that all travelers have the same value of time is not sufficiently realistic"

NETWORK REPRESENTATION

To estimate future demand for a managed lanes scheme, we are primarily investigating the choice between the managed lanes and the general-purpose lanes within a single corridor. A certain complexity lies in the fact that the number of users attracted to this corridor may be affected by the introduction of the managed lanes, or by the level of service they offer. Also, if the managed lanes have multiple points of entrance and exit, travelers may opt to use them only along specific sections. The route choice problem is therefore not a trivial one, but it should still be stressed that it will normally be more effective to narrow the problem and focus on a limited number of key routes.

This is demonstrated in Figure 3, which shows an illustrative road network (in green) in which managed lanes (in red) are introduced along a certain corridor. As already explained, it is possible to solve a full route choice problem for the entire area shown if a fixed level of toll is assumed on the managed lanes – but developing a full network model that features dynamic toll adjustment is an ambitious task. In our experience, a more efficient approach would include the following four stages.

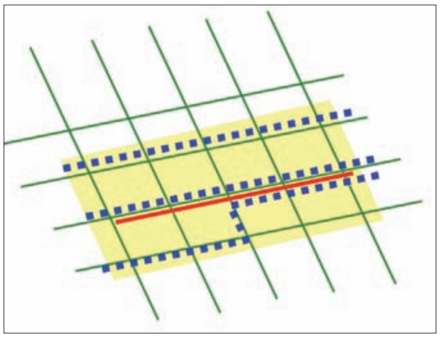


Figure 3: Focusing a simplified network may be sufficient if the area of influence of the managed lanes is identified correctly

First, a full network model is run several times with different levels of 'fixed' toll on the managed lanes, to identify the part of the network that contains the main alternatives to the managed lanes corridor. A corridor (or a driving path) can be considered an alternative if the generalized cost of using this corridor is lower or not significantly higher than the respective cost of using the managed lanes when the toll is at any realistic level. The shaded area in Figure 3 illustrates an area that may be identified at this stage.

Second, information is extracted from the full network model on the generalized cost of all feasible driving routes (between different origins and destinations) passing through the core area identified earlier. Several such routes (but not all of them) are illustrated by the blue dotted lines.

Third, a separate model is developed for the choice between the alternative driving routes in this set. This can take the form of a logit model, as is common for modeling traveler choices. In terms of its geographical detail this is a simplified model, but this allows the use of any programming language or spreadsheet macro, rather than the more restrictive network analysis packages, to fully incorporate the dynamic demand-supply mechanism discussed earlier. Clearly, among the routes included in this model are some routes that use the managed lanes and some that do not.

Finally, the corridor choice model is calibrated and validated so that it can properly replicate observed choices in the base year (typically, without the managed lanes) before it is employed to produce forecasts of future scenarios. Note that as this model no longer has explicit representation of individual road links in the network, its calibration may involve specifying relatively simple speed-flow functions for each corridor or route, to facilitate estimating how travel times along a corridor vary when the traffic through the corridor changes.

The conversion of the full network model into a spatially simplified problem, focusing on the choice of a corridor, is an opportunity to include in the model additional features not permissible in conventional highway assignment models. For example, some concessions to build and operate managed lanes include a requirement to operate public transport services along the same corridor, and thus users also have the alternative of using these services instead of driving. The availability of a public transport alternative along a similar route can be accounted for in the same choice model (although additional data sources may be required to calibrate a model that also covers a choice between car and public transport).

"Solving a series of simplified versions of the original problem is acceptable, but it does not exhaust our abillity to replicate the response to the continuous toll adjustment"

In addition, only when a choice model is tailored for the specific managed lanes scheme in discussion is it possible to include in this model the full list of rules used to continuously adjust the toll, as these rules vary from one case to another.

In most managed lanes, the general rule is that the toll is raised when the number of users increases. But this is interpreted in a variety of ways in terms of the amount of money by which the toll is increased or reduced each time (either a fixed step size or a variable one); the frequency of toll changes; minimum or maximum tolls; and minimum or maximum levels of traffic the tolling mechanism is required to attract to the managed lanes. It is important that the forecasting tool replicates the mechanism that continuously modifies the toll as realistically as possible. Failure to do so in the model might result either in forecasts that are unlikely to materialize or in forecasts that are realistic but not compliant with the legal requirements of the concession.

A RANGE OF VALUES OF TIME

In models for forecasting travel behavior the value of time is often defined as the amount of money travelers are willing to pay for a reduction of one minute in their travel time. The value of time is used to convert the travel time into a monetary equivalent when calculating the generalized cost of each alternative driving route. Classical demand models often assume a uniform monetary value of time, which is ascribed to all travelers and represents their average behavior. In many contexts this approach is satisfactory despite its simplicity. But when estimating the demand for using a tollway, the assumption that all travelers have the same value of time is not sufficiently realistic. At any given time, some drivers will choose the managed lanes because they are willing to pay the toll in return for the time saving offered, while others will not be willing to do so. We therefore consider a range of values of time when predicting whether different drivers will use the managed lanes or alternative routes.

This raises two challenges, the first of which is related to the estimation of this range. Identifying the different values of time in a population typically requires finding a statistical distribution curve that matches survey-based evidence on travelers' willingness to pay for travel time savings. Such a curve is illustrated in Figure 4.

Techniques to derive the distribution of the value of time are in common use, but there is not sufficient awareness of their

Image courtesy of Maryland Department of Transportation

Maryland's Statewide Express Toll Lanes (ETLs) Managed Lanes Scenario Network Initiative

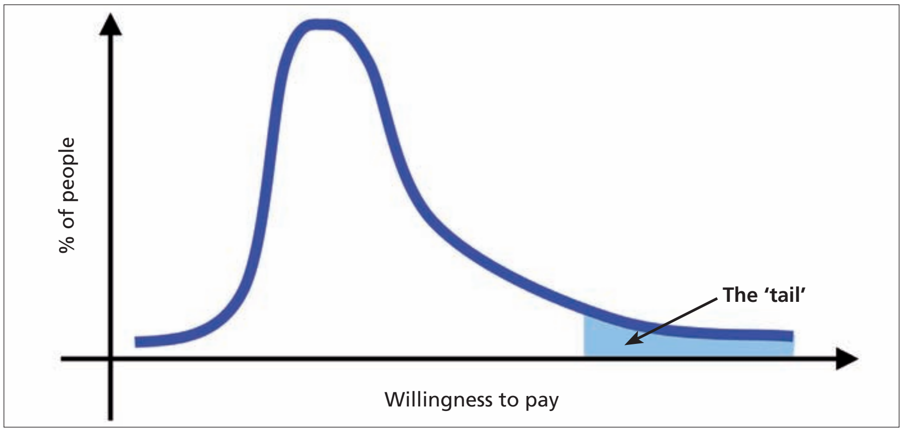


Figure 4: The above illustrates a distribution curve that matches survey-based evidence on travelers' willingness to pay for travel time savings

"Different assumptions can lead to very different estimates of the proportion of travelers willing to pay the toll"

drawbacks. Most techniques are parametric – i.e. the analyst is required to guess which family of distribution curves (e.g. the family of normal curves, lognormal curves, or other families) describes the spread of values in a database from a survey. Parametric techniques will identify the member of the family – namely a curve with specific mean and variance – which fits the data but will not correct the analyst if the original assumption of a family of curves is wrong. Very often, the amount of available data does not allow unequivocal identification of the right curve. It is also insufficient for using nonparametric techniques, which do not require any assumptions to be made but are very data-hungry. The 'tail' of the distribution of the value of time – i.e. the estimated proportion of travelers with very high or very low values of time – is particularly sensitive to the preliminary assumption of a family of curves. Different assumptions can lead to very different estimates of the proportion of travelers willing to pay considerable prices to save time, and so they might result in different forecasts of demand and revenue, with no confidence as to which is more correct.

The sensitivity of the outputs to these outliers stresses the importance of rigorous estimation of the range of values of time. Namely, the sample that this analysis is based on should be larger than commonly gathered for other purposes. A very wide distribution of the value of time should not be accepted unless this is supported by multiple tests of goodness-of-fit. Explicit attempts should meanwhile be made during data collection to reveal the maximum value of time (or, say, the 90th percentile), to ensure it is not exceeded.

The other challenge is in the application of a value-of-time distribution, once identified. The value of time affects the choice between driving routes, as the managed lanes are likely to be preferred if the toll is lower than the monetary equivalent of the time saving they offer – which varies between travelers according to their individual value of time. The approach taken to deal with this variation can be

Courtesy of SANDAG

Example of managed lanes on a US freeway

combined with the incremental loading approach described earlier, so that each group of travelers the model loads onto the network has a different value of time (taken from the distribution previously estimated). Note that there has to be an element in the model that re-estimates the choices of travelers with any particular value of time once travelers with other values of time have made their choices, as the flows and speeds throughout the network may change after each step. This can be achieved by running the incremental loading process iteratively, returning to the first increment once the loading of the last one has been completed. Advanced system dynamics can also be used, starting with an initial pattern of route choices and then triggering a process that repeatedly shifts travelers between routes if they can benefit from such a shift.

THE OBJECTIVE FUNCTION

A model for a system that includes managed lanes can be used not only to estimate demand and revenue with given toll rates, but can also assist in establishing the optimized toll level.

The final range of tolls to be charged and their associated traffic levels are critical for the detailed design of the managed lanes scheme, but this adds an additional source of complexity. If we set up a model not only to estimate how the managed lanes perform but also to improve this performance, we must specify an objective function. The objective may be a maximum revenue, or minimum total travel time, or maximum level of traffic. Considerations that are not selected as the objective are likely to be added as constraints (for instance, maximum revenue with a maximum constraint for the toll and minimum constraint for the level of traffic). The choice of an objective function and constraints depends on the agreement between the operator and the relevant authorities, but it should be observed that different objective functions will lead to substantially different results.

A comprehensive forecasting tool that incorporates the above features will continuously adjust the level of toll as a response to the varying level of demand. Although this would point to an efficient tolling regime, it may create 'loops' in which the toll repeatedly goes up and down or changes very frequently. This may not appear acceptable to the public, despite their theoretical efficiency. If the freedom of the toll adjustment procedure in the real managed lanes is likely to be restricted in any way to add stability, then similar constraints have to be added to the model

In summary, conventional models for estimating the demand for transport facilities and the associated revenue lack some features that are critical when forecasting traffic and revenue for managed lanes schemes. Bespoke forecasting tools can be developed, incorporating explicit representation of the requirements from the toll adjustment procedure; a dynamic supply-demand feedback mechanism; and a range of valuations of travel time savings across the population. Such models are capable of forecasting the impact of dynamic tolling on highly congested and complex road networks, yet a high level of geographical detail in this analysis is not always required. Although the development of managed lanes schemes across the world poses some real challenges to the traffic forecaster, these innovative methods are being developed to improve the representation of drivers' route choices in urbanized areas. ■

A transport analyst for 10 years, Yaron Hollander has worked for Steer Davies Gleave in London since 2006, most recently on the development of advanced forecasting tools suitable for managed lanes. He can be contacted at yaron.hollander@sdgworld.net by Alfred Lurigados & Stephan Andriuk

CHANGE? NOT ANYMORE...

THE OPERATIONAL CHALLENGES OF CONVERTING TO ALL-ELECTRONIC

Andy Warhol once said, "They always say that time changes things, but you actually have to change them yourself." This attitude will help take the Miami-Dade Expressway into a new era of efficiency and improved customer service

The Miami-Dade Expressway Authority (MDX) operates and maintains five of the most critical east-west expressways in Miami-Dade County, totaling 67.8 miles. Of those five, only four are tolled with a total of just six tolling points. Each expressway is tolled using an 'open-barrier system', with distinct tolling points that allow for numerous free movements on the system. Although most tolling points are bidirectional, there are two that are only tolled in one direction. As in many heavily urbanized areas, expressway entrances are spaced at roughly one-mile intervals. Drivers can make over 80 possible trip movements, none of which are tolled. To put the problem into perspective, 45% of users traveling the MDX system pay a toll, while all others use the system for free – as recently as June 2007, only 28% of the system users actually paid! Systematically, MDX will leverage electronic tolling to close the system; from the master plan, to the recent unveiling of the first All Electronic Toll (AET) section in 2007, to the complete transformation in the next few years. In the end, there will be no more 'change'. 'Pay only for what you use' is the axiom used when talking about closing the system. The questions are, how and by how much?

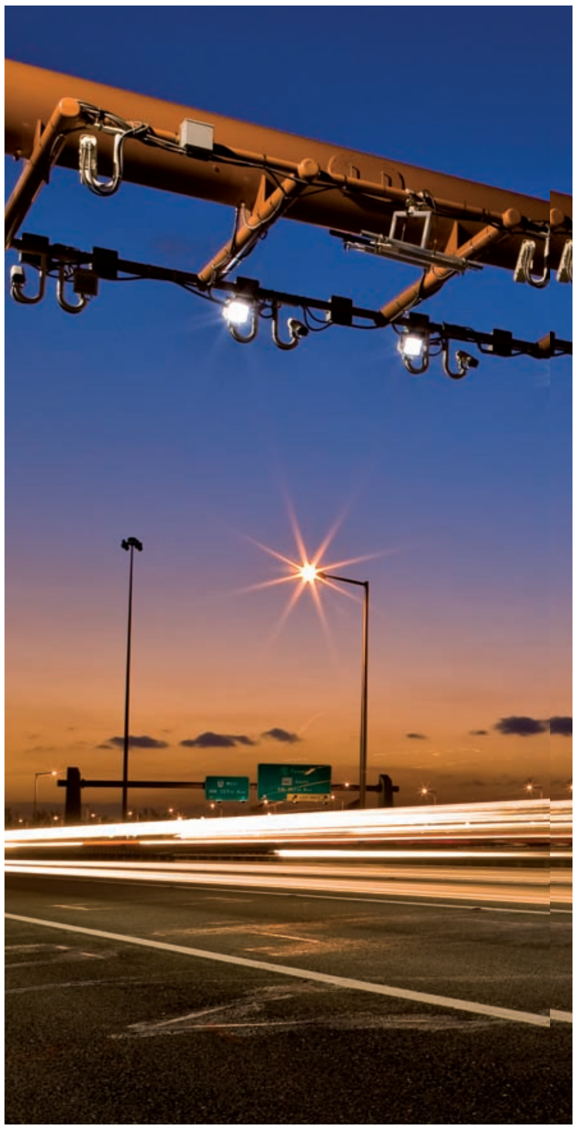
AVAILABLE OPTIONS

An electronic version of the ticket system, or a system-wide rate per mile? A rate per mile specific to each MDX corridor, or perhaps a revenue-neutral rate for the system where MDX collects yearly budgetary totals equal to what is collected today? (Remember, now 100% will pay a toll.) Maybe tolls could be indexed based on Consumer Price Index (CPI), but annually, triennially? All of these are very difficult options that MDX staff took into account in their recommendations to the MDX Governing Board for final decisions. Some of the MDX corridors can be converted quite easily. Others, not so.

The idea of an electronic version of the ticket system was discarded quickly for the simple reason that the amount of entry and exit points greatly increased the number of gantries, making it cost prohibitive – especially on a corridor such as Miami's Dolphin Expressway (SR 836). Also, trip matching in this urban environment when entry reads fail would be a nightmare at best.

A system-wide rate per mile was discarded as well. The vetoing of the entry-exit ticket system and the possibility for short distance movements on and off would have required a rate less than the cost to collect for these tolling points, in doing so skewing the system-wide rate. Deductive reasoning led MDX to regard a multiple barrier system as ideal. By systematically capturing 99% of the customers and charging them about the same as they pay today we would achieve our objective that all customers share the costs with the likelihood that many would pay less. Today, a customer who enters onto an expressway near a tolling point and travels through that tolling point pays the entire fare – US$1.00. Tomorrow, this same customer may only pay half or less for that same trip.

Gratigny Expressway (SR 924) is MDX's next expressway scheduled for conversion to AET around early 2010. This corridor provides commuters with direct access from Broward County to the north with the business centers in north Miami-Dade County. Currently, the Gratigny has one bi-directional conventional toll plaza on the eastern end, with only 50% or less of the

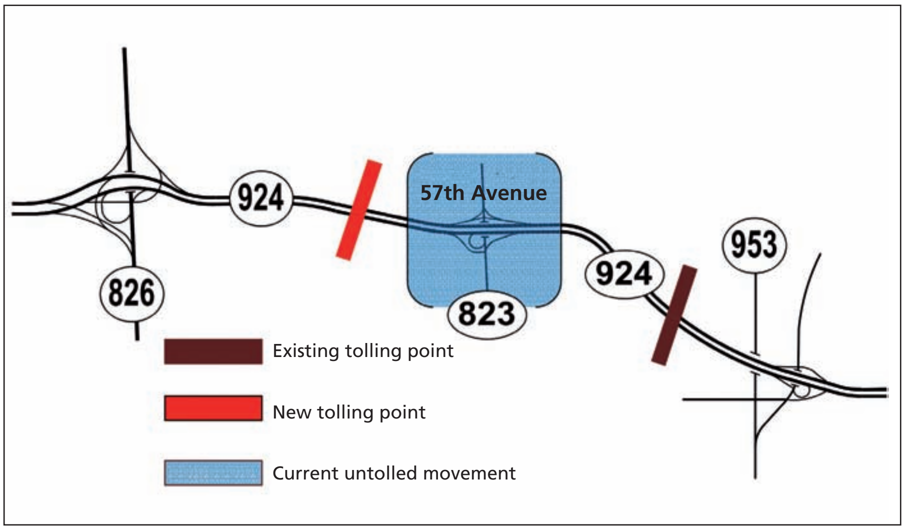


users paying a toll. SunPass, the electronic system operating in south Florida, is used by 75% of the Gratigny customers daily, with peak hours exceeding 80%. Having only one major interchange not covered by a toll, the Gratigny AET configuration was the least complicated to convert.

The Don Shula Expressway (SR 874) and the Snapper Creek Expressway (SR 878) are two expressways on the MDX system providing mobility in the southwestern portions of Miami-Dade County. Approximately 145,000 users from the south-west Miami-Dade areas travel on these corridors daily. On the Don Shula Expressway, only 54% of the users pay a toll and the Snapper Creek Expressway is currently not tolled. MDX has invested over US$30 million in new capacity and new movements on these expressways with additional improvements of over US$160 million planned in the next four years. These are tangible benefits for users that will provide travel-time savings, enhance safety, and improve traffic operations. SunPass usage in this corridor is also extremely high, exceeding 70% on a 24-hour average. These corridors, SR 874 and SR 878, will follow the Gratigny conversion to AET in late-2010/early 2011. Although a little more complicated than the Gratigny, with multiple interchanges currently not being tolled, a viable AET solution was nevertheless determined. In the pre-AET example (*p*90), you will see that the Don Shula Expressway has a bidirectional toll plaza near the southernmost end of the corridor. The current fare at that bidirectional plaza is US$1.00. Around 50% of the traffic traveling on the Don Shula Expressway enters north or exits just south of the Killian Parkway, never paying a toll. Under the AET example, you will see that the tolling point that exists today gets converted to an AET gantry with a rate of US$0.25 in each direction, which

"These are tangible benefits for users that will provide travel-time savings, enhance safety, and improve traffic operations"

The Miami-Dade Expressway Authority plans to convert to open roadway tolling and to become a cashless system by 2012



The above illustration shows the 2009/2010 plan for all-electronic tolling on the SR 924 in Florida

is a quarter of the current rate for the use of that segment. Additional mainline gantries are added north of Killian Parkway – one at US$0.25 and the other north of the SR 878 spur for US$0.50. The cost for those paying today remains the same (US$1.00 in each direction) with those only driving on shorter segments paying less. On the Snapper Creek Expressway, currently untolled, two mainline gantries are envisioned – one west of 87th Avenue and the other east of 87th Avenue – thereby closing the system and eliminating the free movements and reducing the cost for those who pay today but do not travel the entire distance. The SR 874 round trip pre-AET costs the existing paying customer US$2.00. The round trip cost post-ORT is US$2.00. The paying customer who today makes a round trip from Florida's Turnpike to Kendall Drive pays the same US$2.00, whereas post-AET that same trip will cost US$1.00. MDX is working closely with the Florida Turnpike Enterprise as it, too, looks to convert to AET in this area. This is a great example of agencies partnering for the good of the public to ensure a seamless customer base and successful conversion to all-electronic.

“Ultimately, all-electronic tolling will only be successful through the full automation of the operation and the back-office processes”

WHERE ARE WE NOW?

How is MDX going to place all of these gantries, have in-ground vehicle classification (MDX uses an axle-based classification system), protect equipment, monitor traffic, alert the drivers with signage and media? One of the most aggressive procurement campaigns ever has been launched. In June 2008, MDX held a toll industry review forum, with the intent to provide an open forum to discuss MDX's AET movement and the process that could be undertaken to get the job done. All aspects of the industry were invited: system integrators, toll equipment and construction suppliers, engineers, designers, and operators. Real feedback was required from these important entities regarding how MDX should move forward with procuring the services to design, build, operate and maintain this AET solution. Should the in-lane system be separated from the back-office solution or not? Should the civil work be included as part of the system integrator's responsibilities? Listening to the professional advice received during the forum, MDX continued to work toward the successful deployment of the procurements. Toll systems integration (in-lane)? Check. Account Management and Toll Enforcement System (AMTES)? Check. Public Communications – advertising? Check. Design and Construction for all the Civil work and infrastructure components? Check. System-wide ITS and system-wide fiber optic deployment? Currently getting installed, but check. Road Rangers? Check.

In addition to all of the other US$180 million MDX work program projects being implemented for construction, the above successful conversion to AET is expected to exceed US$50 million in contracts. The MDX Governing Board has taken this task very seriously, setting the stage for the future of transportation in Miami-Dade County.

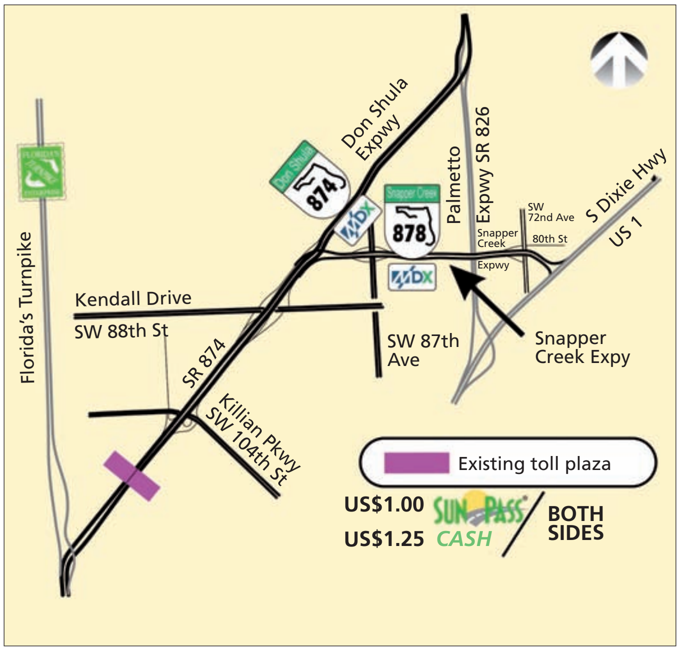
To support all the previously mentioned initiatives, MDX has engaged in an ITS program to actively monitor and respond to incidents more quickly. This ITS program includes the use of CCTV cameras to monitor traffic conditions, roadway detector systems to facilitate incident detection and a fiber-optic communication backbone to effectively support all communications needs for the agency, as well as interagency communications between MDX and other local transportation authorities. In addition, MDX users can benefit from an Advanced Traveler Information System (ATIS) as the result of participation in the South Florida 511 system. At the core of all of these systems – and in partnership with the Florida Department of Transportation (FDOT) – MDX uses the SunGuide Transportation Management Software to assist its TMC operators strategically co-located at the FDOT SunGuide Center. This co-location facilitates the interagency coordination and collaboration among FDOT, MDX and other local participating agencies, such as Florida Highway Patrol.

MDX oversees the county's five major east-west arteries: The Dolphin Expressway; The Airport Expressway; The Don Shula Expressway; The Snapper Creek Expressway; and The Gratigny Parkway

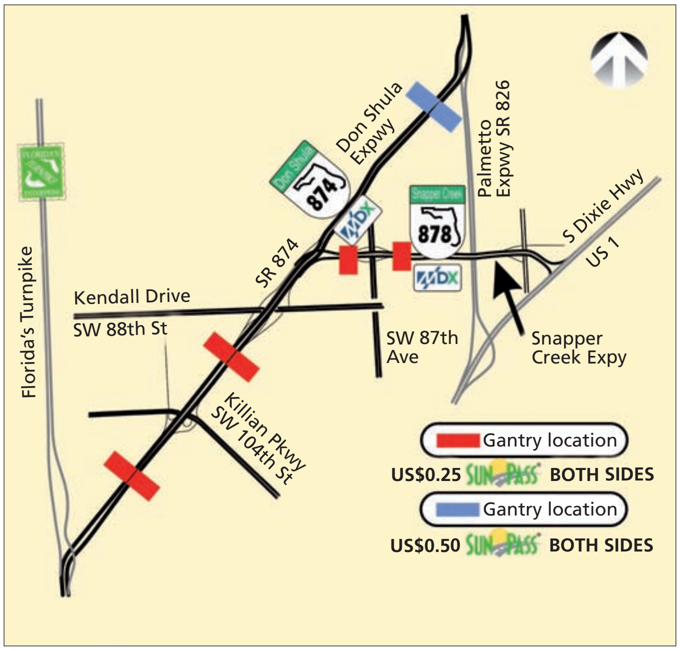
LIGHTS, CAMERA, VIOLATIONS...

When you start using 'electronic tolling-only' on a segment of roadway that has never been tolled before, you're going to have some violations, right? Without a doubt, yes. MDX's experience in opening an all-electronic section of roadway yielded violations upward of 20% within the first few days, although a steep drop-off in violations followed. The normalization of the violation rate to below 3% occurred within six weeks after the violation system was activated on these new all-electronic tolling points. Many commuters who were driving this expressway segment on a daily basis didn't know they were going through a tolling point and not paying the toll. Signage misunderstanding and confusing language on the signs were the primary excuses drivers gave for violating. After talking with many of these customers – and communicating to them that they had entered into an all electronic 'SunPass-only' zone – we discovered how complacent some became on their daily commute. Many telephoned back after their next commuting

Funded by tolls, MDX has been aggressively upgrading and updating its roads over the past decade



The above illustration shows the existing toll plaza location and rates for the Don Shula/SR 874-Snapper Creek/SR 878 Expressways



The above illustration shows the proposed AET location and toll rates for the Don Shula/SR 874-Snapper Creek/SR 878 Expressways

day and said, "Wow, I never paid attention to the signs. It was only after talking with you that I was more attentive when I drove through the next time, and I see now that this is a tolling point for SunPass-only vehicles." After this feedback, MDX took additional steps to capture the drivers' attention by painting 'SunPass ONLY' on the roadway prior to entering the electronic-only zones. The operator is continually improving the operational aspects of having all electronic segments on its system by drawing from peers in the tolling world – using their best practices and solutions, but tailored to meet the specific needs of South Florida.

"Many commuters who were driving this expressway segment on a daily basis didn't know they were going through a tolling point and not paying the toll"

MDX had a six-week grace period for toll violations when the first all-electronic section of roadway was opened. Toll violation notices or citations were not sent out for the first six weeks of operations. One lesson learned was that those drivers not paying attention violated for those six weeks. Once notices began to be mailed out, people woke up from their complacency and stopped violating. Dealing with these drivers became a customer service issue. We needed them to buy into the SunPass program and at the same time recoup the costs to process their violations. The solution – taken from other tolling entities in the country – was to convert the violator into a customer. Ultimately, if you opted into the program, the fines for all toll violations were reduced by 60% – a win-win for everyone. This program was a big success and registered ridership on these sections increased.

Another issue encountered was the increased load of citations being handled by the county court system. With the addition of these tolling points, MDX found itself writing more citations on a daily basis than all of the traffic citations written by all police jurisdictions in Miami-Dade County combined. The answer to this was to work with the courts and to fast-track a solution that was in the works called 'e-Citation'. Normally, Uniform Traffic Citations, or 'UTCs', were delivered by hand to the court, requiring them to scan each UTC into the system and then load the information into their case load computers for traffic court. With e-Citation, MDX would electronically file the UTCs with the court on a daily basis with little or no human intervention. This was a tremendous efficiency gain and a labor cost reduction for both the court and MDX.

The next step in the process is to consolidate cases by 'name', requiring someone to appear in court only once, despite the fact that they might have multiple citations. The test project for this process is under way and the preliminary findings again show gain in efficiency as well as a reduction in labor costs.

TECHNOLOGY AS THE BACKBONE

Technological advancements bring us to the future now. As MDX moves into the realm of converting its entire expressway system to all-electronic, we will encounter numerous operational challenges in the transition to remove the ability to pay cash on the system. We are very fortunate to be in an industry that has an extremely well-informed networking system where solutions and experiences of other tolling professionals are just a phonecall away. Ultimately, all-electronic tolling will only be successful through the full automation of the operation and the back-office processes. In particular, technology is demonstrating tremendous improvements in recognition systems that take digitized images and correctly identify license plate characteristics and extract the required information for registered owner correlations. These improvements, coupled with advancements in 'fingerprinting technology' – the technology that associates characteristics of a vehicle similar to the way a fingerprint is associated to a unique individual – is boosting the accuracy of the entire automated violation process into the more than 90th percentile realm. Truly, these technological advances are allowing us to leap into the future at lightning speed. ■

Alfred Lurigados, P.E., is the director of engineering at the Miami-Dade Expressway and is responsible for the MDX Five-Year Work Program and management of planning, design and construction projects. Stephan P. Andriuk, meanwhile, is the director of toll operations, with responsibilities including long-range planning, design, construction and integration of new toll plazas and equipment, and ITS. In addition he is also a direct advisor to the executive director on innovative technologies in tolling

by Thomas R. Biggs & Elizabeth Bent, SFCTA

BAY WATCH

FAIRNESS AND SOCIAL JUSTICE DICTATING SAN FRANCISCO'S WAY FORWARD

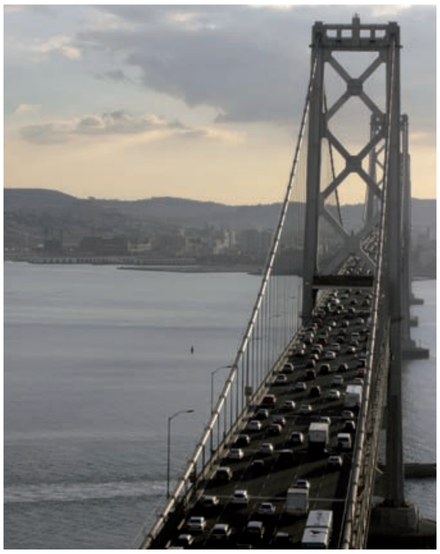
Although New York has received most of the headlines for its now defeated congestion pricing plan, authorities in San Francisco are quietly pursuing their own ideas. Public outreach will play a key role as the strategies are formulated

Many transportation planning professionals view congestion pricing as the most realistic way today to manage our choked roadways, and London and Stockholm are just two recent success stories. Although these examples hold out the promise of relief to other congested urban centers, planners know that success in one environment cannot be imposed upon another in the same form. A congestion pricing plan is not a one-size-fits-all model: it's an idea that, to work, must be adapted to the city in question – the habits and expectations of its residents, the tempos of its workday and night life.

In his inaugural remarks, Mayor Gavin Newsom recognized the environmental and quality-of-life benefits that a sensible congestion pricing plan might offer San Francisco. He also set the stage by noting that, if implemented, congestion pricing would need to be designed to meet the unique needs of this city on the hills.

With 750,000 residents, San Francisco itself is a medium-sized city, but it is the second most densely populated in the USA. In addition, it is the cultural, economic and financial centerpiece of the Greater Bay Area region, where nearly seven million people reside throughout nine counties. Within the region, San Francisco has the largest commuter and daytime population: on any given day, more than one million travel to the downtown area. Many (over 40%) use the various public transportation options that are available to commuters and residents alike.

To examine the possibility of implementing congestion pricing here, a feasibility study was commissioned, the purpose of which was to look at the economy, the environment, and the equity of a plan with respect to all potential users of the transportation system, in the light of several key questions. For instance, how much would congestion pricing improve the transportation system by reducing delay and improving travel options? How much would it enhance environmental quality, livability and sustainability by decreasing vehicle emissions and improving safety?



San Francisco city officials are considering charging a US$3.00 fee to enter the city center

Importantly, how would it support the economic vitality of the city by improving access to business and commercial activity, and by reducing the cost of congestion in terms of time lost and wasted fuel?

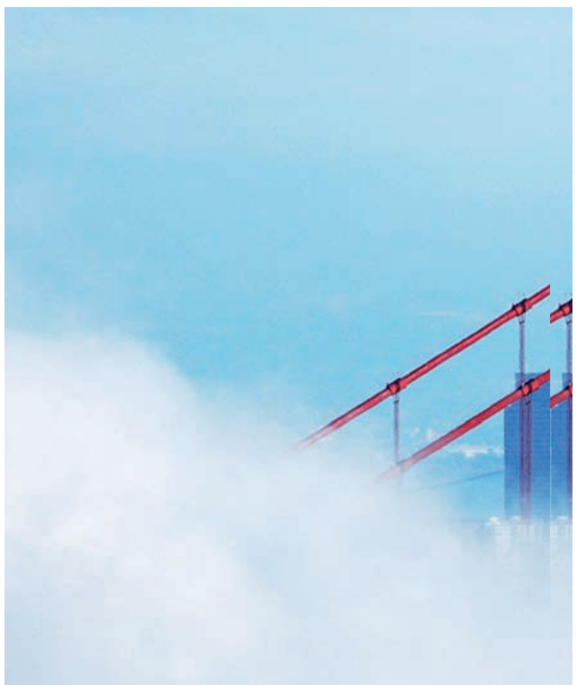
The study is scheduled to be completed in the first half of 2009 and should ascertain whether or not there is a feasible congestion pricing scenario. Subsequently, the question will need to be addressed: is congestion pricing right for San Francisco?

TECHNOLOGY ENABLES THEORY

Congestion pricing presents the promise of dual benefits: positive and effective demand management that can be fine-tuned to desired outcomes; and the establishment of a new revenue source for funding transportation operations and improvements. The underlying theory for congestion pricing has been studied since the 1920s, but it is the recent emergence of information and telecommunications technologies that has enlivened it. Now in place in Singapore, London, Stockholm, Rome and elsewhere, congestion pricing has proven practical and effective.

The stage for studying congestion pricing in the area was set first by the San Francisco Countywide Transportation Plan, published by the San Francisco County Transportation Authority (SFCTA) in 2004. In this plan the potential for congestion pricing was recognized as consistent with the city's 'Transit First' policy, as part of an approach to transportation that offers safe, attractive and equitable transportation choices for all users, within the overall goal of strengthening the city's diverse economy. The city's 'Climate Action Plan' also calls for exploring pricing as a demand management tool. Major local newspapers such as the *San Francisco Examiner* have also endorsed congestion pricing in concept.

The USDOT has also recognized the growing problem of congestion in the urban landscape and is actively encouraging



San Francisco's transportation officials are considering congestion pricing to discourage driving and encourage other modes of transportation metropolitan areas to explore pricing as a solution through its 'Value Pricing Pilot Program'. In 2005, at the governing board's direction, SFCTA applied for and was awarded a US$1 million grant to study congestion pricing within its environs.

The study began in late-2006 and is referred to as the San Francisco Mobility, Access and Pricing Study (or SFMAPS). It is the first comprehensive study in the USA to examine the feasibility of congestion pricing in the context of a medium-sized city. It includes a broad assessment of potential congestion pricing design options and associated costs, revenues, benefits and impacts. The main components of the study are policy development (goals formulation, evaluation framework), public communications, and technical analysis of the transportation system.

A TOP SAN FRANCISCO CONCERN

According to surveys conducted by the Bay Area Council, transportation consistently ranks as the number one problem in the region. In its *2007 Urban Mobility Report*, the Texas Transportation Institute placed the San Francisco urban area as the second most congested in the USA, surpassed only by Los Angeles. Each traveler in the Bay Area wastes 60 hours annually stopped in traffic, along with 57 gallons of fuel. The cost to the city alone totals US$2 billion per year, and transportation accounts for fully 50% of emissions.

The main image on *p*94 shows measured speed data collected by SFCTA for the streets and roadways that underperform as a result of congestion. Highlighted streets are operating at speeds of 10mph or less for auto traffic, and 8mph or less for public transportation. As can be seen in the figure, the highest concentration of congested, underperforming streets is located in and around the downtown business districts of the city, and on key routes leading to the Golden Gate and Oakland Bay Bridges.

The need to manage demand derives from a simple fact: the city has a mature street system that, if anything, is reducing and not increasing in supply. The demolition of the Embarcadero and Central Freeway double-decker freeways are recent examples of the withdrawal of road capacity. Fortunately for the city, its grid system offers good opportunities to distribute and manage traffic to support such changes to the network. However, with ever-growing demand by multiple modes of travel, the challenge of assigning road space and green-time grows each year.

There are 570,000 people working in the downtown areas of San Francisco. The majority (75%) are engaged in the service sectors, including those employed in finance, banking, IT, professional services,

San Francisco's cyclists could benefit greatly from the scheme, as have those in London

"The need to manage demand derives from a simple fact: the city has a mature street system that, if anything, is reducing and not increasing in supply"

hotels and food service. Most commute to downtown from other areas of San Francisco and other counties in the Bay Area. Even with a robust regional public transportation system that focuses on downtown San Francisco, for most commuting markets the dominant mode of transportation is the private automobile.

Public transportation systems for San Francisco and the Bay Area include the Bay Area Rapid Transit system (BART) and the San Francisco Municipal Transportation Agency (Muni). Regional express bus and ferry services, as well as commuter rail lines (Caltrain), round out the regional transit system. Public opinion surveys indicate that 80% of those who commute to the downtown areas of San Francisco have a viable public transportation option (although only half of them use it).

Moreover, many travel within the city by walking and cycling – indeed, San Francisco is considered one of the most walkable cities in the USA. Cycling is encouraged, and there is a very active community of cyclists.

As a result of all these options, there is heavy competition for street space. Automobiles, transit, couriers, cyclists and pedestrians vie for travel paths, and some of these contend with each other for spots in parking and delivery zones.

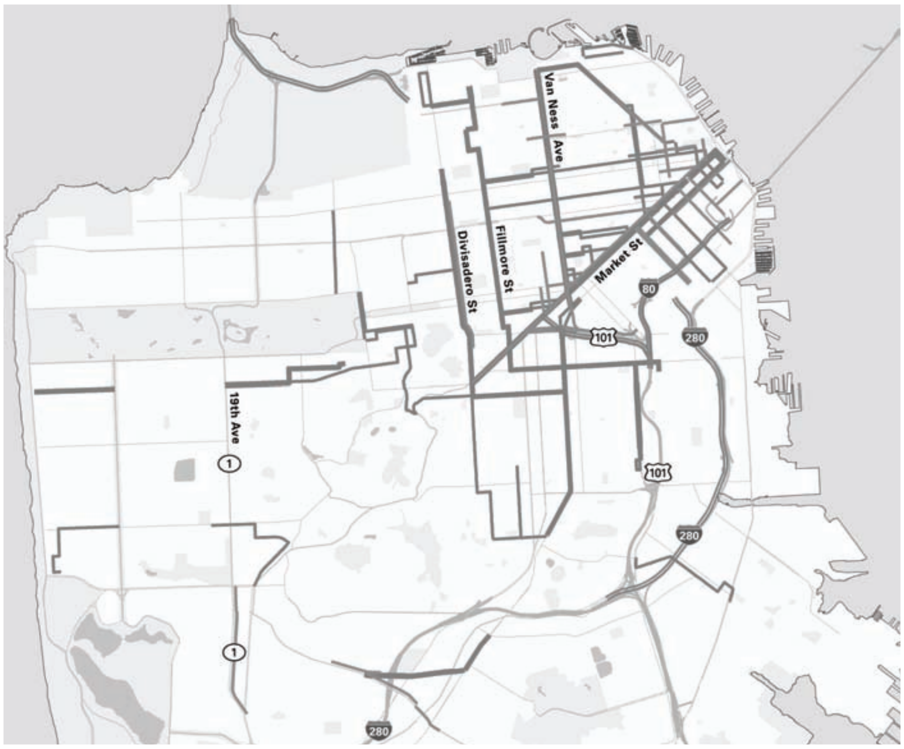
COMMUNITY INPUT SHAPES POLICY

The SFMAPS process incorporates an active public outreach program that includes public workshops, meetings with community and business stakeholders, focus groups and opinion polling. In addition, the public can access information about SFMAPS via the internet (www.sfmobility.org), newsletters, fact sheets and email subscriptions. The outreach activities solicit a broad and deep feedback throughout the Bay Area, to shape a feasible plan that meets the needs of residents and businesses as completely as possible.

The community has responded with an array of opinions, suggestions and ideas that give managers a clear idea of transportation needs for the city's varied constituencies, in each of its segments.

Residents and community groups often express concerns about the availability, reliability and cost of public transit services. They worry about traffic diversions around pricing areas and the impact to local neighborhoods outside of the pricing area. Alternatives are therefore being examined to increase transit supply, and various pricing area boundaries are being reviewed, with the goal of reducing boundary diversions and the associated impacts.

In addition, fairness and social justice are indeed big issues in San Francisco. Throughout the study, dialog with advocacy groups on a variety of concerns has been maintained to engage the public's assistance in shaping polices sensitive to disadvantaged populations. For example, SFMAPS



Congested streets and roadways in San Francisco are highlighted. If the plan goes ahead, the city would be the first in the USA to charge cars a fee to enter certain neighborhoods at certain times

URBAN PARTNERSHIPS

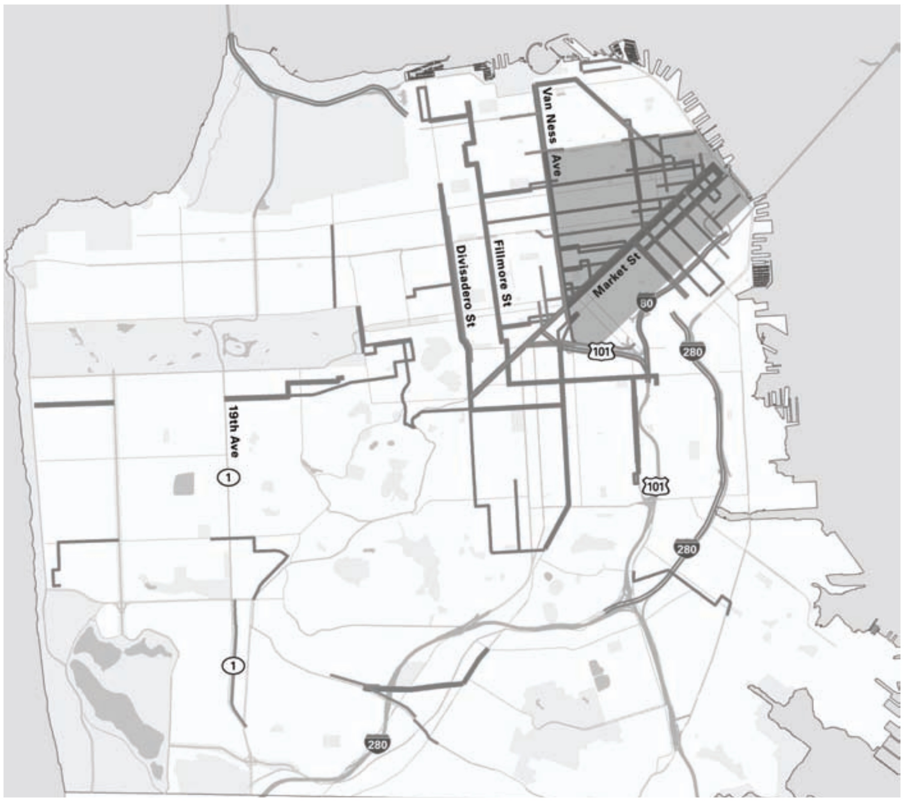
In 2006, USDOT announced the Urban Partnership Program (UPP) to encourage metropolitan cities to address the growing urban congestion problem through an integrated strategy of tolling, transit, technology and telecommuting. In 2007, the San Francisco Bay Area was one of five metropolitan areas awarded a federal grant under the program.

The original US$159 million grant proposed pricing the southern access to the Golden Gate Bridge, known as Doyle Drive. More recent developments have proposed refocus of the grant toward laying the groundwork for a potential citywide demonstration of pricing.

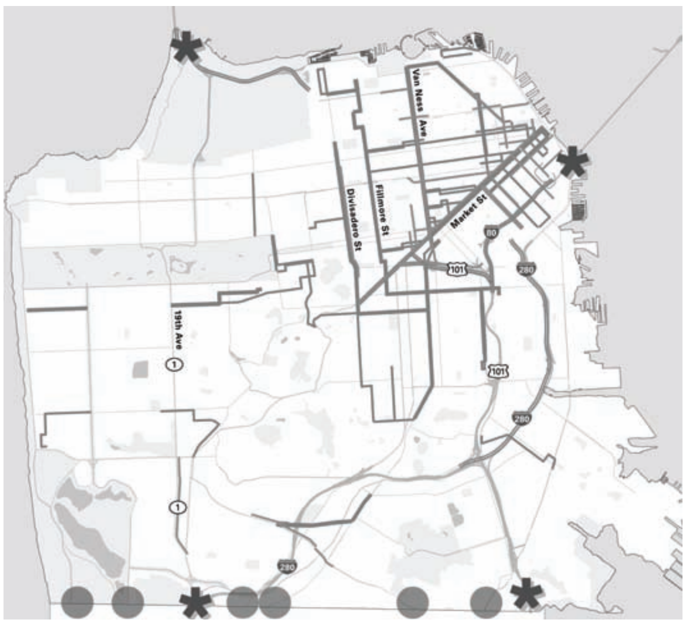
The new program features SFpark – a demonstration of variable parking pricing, parking guidance information and traveler information systems, as well as a potential VII (Vehicle Infrastructure Integration) demonstration. Other potential elements of the program include SFgo – a traffic management initiative that includes real-time incident management and a robust transit signal priority component that could complement the city's BRT (bus rapid transit) initiatives.

Whereas the SFMAPS congestion pricing project is a feasibility study funded by a federal Value Pricing Program Grant, the UPP grant gets projects "off the drawing boards and into action", according to former US Transportation Secretary Mary E. Peters. The UPP grant recipients will develop and implement a performance measurement system to assess the effectiveness of these congestion-mitigation strategies.

"Business owners and employers share a common goal with the city: if congestion pricing is implemented, it should support rather than hinder the economic vitality"



⬆ The city is located at the tip of the San Francisco peninsula, with the Pacific Ocean to the west, San Francisco Bay to the east, and the Golden Gate Bridge to the north



⬆ The area pricing scenario in San Francisco, which encompasses about two square miles in the financial district

⬅ The gateway pricing scenario, which could see motorists charged at key entry routes

is examining a wide range of possible discounts and/or exemptions for low-income drivers and mobility-impaired drivers. Each of these is being looked at in terms of fairness, administrative costs and revenues.

Business concerns are also paramount factors. Retail sales activity, conventions and tourism are important drivers of the local economy. What has emerged from discussions with business owners and employers is that they share a common goal with the city: if congestion pricing is implemented, it should support rather than hinder economic vitality. The *San Francisco Business Times* believes congestion pricing has promise and supports the exploration of possible implementation designs.

The business community wants predictable fleet rates for commercial vehicles where appropriate. They would like to see a program that minimizes impacts on discretionary travel for retail, dining and entertainment. Finally, the business community has encouraged the city to increase enforcement of parking and loading zones – particularly the double-parking that impedes bus and auto traffic downtown. Already, the city has listened to this constituency and is adding cameras to buses that aid in automatically identifying and enforcing double-parking violations. Transportation planners also point to the importance of reinvesting charge revenues to enhance downtown shopping districts. However, the business community is not yet sold on congestion pricing: there is general agreement among merchants and planners that congestion should be addressed in a way that is protective of the local economy. If congestion pricing is implemented, it must be done in a way that enhances San Francisco's attractiveness to visitors and commuters alike.

CONCEPTS BEING CONSIDERED

Drawing lessons from international examples and public input, planners have proposed two congestion pricing scenarios for evaluation. The first is a cordon (or area-wide) plan that would price travelers entering the downtown areas. This would include the Financial District – the site of the densest concentration of service-related (i.e. banking, legal, professional, insurance, technical and information technology) firms. It would also include the Civic Center area, with its concentration of public services. Lastly, it should also encompass a portion of the South of Market (SOMA) district which – while less dense than the Financial District – houses similar service enterprises. Although the boundary of this area is still being evaluated, in size it could encompass about two square miles – a modest portion of San Francisco's 49 square miles.

This downtown cordon or area is the most served in terms of local and regional public transportation. Market Street serves as the city's main organizing thoroughfare, under which four BART rail lines converge to the East Bay and the Peninsula, diverging on each end to service major residential and business concentrations. Muni also operates five light-rail lines that branch out into the western and southern neighborhoods. Many Muni bus lines and the historic 'F Line' operate at street level. The nearby Transbay Terminal (now under redevelopment) serves as a hub for regional bus services.

In the context of SFMAPS, cordon pricing refers to placing barrier-free detection and pricing infrastructure around the perimeter of the proposed pricing area, similar to the Stockholm congestion pricing system. The next phase of SFMAPS will evaluate pricing policies, business models, and technology options to determine the exact form of pricing that might be implemented.

The second pricing concept is referred to as the 'Gateway Concept', and prices key entry routes into San Francisco at its boundaries. (The city and county of San Francisco are contiguous). Key routes include roadways and freeway ramps that access the major commuting routes to the North Bay via the Golden Gate Bridge, the East Bay via the Oakland Bay Bridge, and the South Bay via I-280 and US Route 101.

In the Gateway plan, those traveling by automobile to and from San Francisco would be subject to the congestion charge, but those within the city would be unlikely to pay the charge. A thorny issue here is that about half of the vehicles driving to downtown destinations originate within San Francisco. There is a concern that pricing only half the drivers might not meaningfully reduce congestion – the desired outcome of the plan – and that it would be fundamentally unfair to regional travelers. Therefore, the Gateway option may need to be combined with the pricing of key routes within the city, or with the downtown cordon, to be most effective.

As mentioned, the business community has asked the study to examine pricing different permutations of peak periods only (either am-only, or directional fees during both am and pm peak periods). San Francisco does not experience the all-day, hyper-congestion characteristic of such larger cities as London or New York. Most of the measured and projected congestion occurs in the peak regional commuting periods. Market research conducted to support the analysis of congestion pricing indicates that Bay Area commuters are more likely to shift time in response to congestion pricing rather than shift mode. The form of peak period pricing will continue to be examined as SFMAPS proceeds.

FAIRNESS FOR THE PEOPLE

San Francisco is a diverse city and fairness, affordability and social justice are key themes being examined in the congestion pricing study. The goal is to protect those who would face a substantial burden or who otherwise cannot take advantage of transportation options if pricing is implemented. Discount policies need to consider performance objectives, account for administrative costs, be easily understood and, above all, be perceived as fair.

Existing programs are in place to assist low-income residents; discounts that could be administered through these programs are being considered. Similar to London, discounts for residents within the pricing area are also being examined, while fees will be waived for taxis.

Discounts for disabled drivers pose a challenge. Today, public parking is free for those who display the easily available 'Disabled' placard. Many believe this program is widely abused. Alternatives are being reviewed that would give discounts to mobility-impaired drivers who have little choice but to drive. If implemented, this program would need to be administered separately from the current disabled-placard program. Today the Golden Gate Bridge Authority operates a similar program.

Finally, there exists an equity question, driven by Bay Area geography. To enter the city, drivers from the North Bay and East Bay pay tolls on the Golden Gate and Oakland Bay Bridges, whereas travelers from the South Bay arrive overland and do not pay anything. An idea being explored is to cap the maximum daily amount of the sum of potential congestion price fees and bridge tolls.

"San Francisco does not experience the all-day, hyper-congestion characteristic of such larger cities as London or New York"

As the second most-congested region in the USA, San Francisco Bay Area businesses sacrificed over US$2 billion to congestion in 2005

GOING FORWARD

In July 2008, the Authority held multiple public workshops in San Francisco and the surrounding Bay Area communities, and launched an extensive second round of public outreach to find out what the public would like to see in a congestion pricing implementation. Interestingly, Bay Area residents who participated in these activities (including focus groups and opinion polls) mostly responded by asking 'how and when' congestion pricing might be implemented, rather than 'whether or why'. Not unsurprisingly, residents and commuters of the Bay Area are concerned about the environment, sustainable growth and making quantum improvements to the public transportation system.

The SFMAPS team is in the process of defining and detailing the options that merit detailed evaluation. Then, based on performance measures that have been vetted though public consultation, they will conduct technical evaluations of the alternatives. Items on the agenda include refinement of the boundaries, assessment of traffic technology options, an economic impacts analysis, and a plan to reinvest the congestion charge revenues. At that time, another cycle of public outreach will pose the question – Is congestion pricing right for San Francisco?

With congestion constantly on the rise, the looming bankruptcy of federal funding for transportation, and an historic challenge to reduce transportation's footprint on the environment, transportation planners view congestion pricing as a potential win-win-win strategy. And – with the feasibility of pricing dependent upon state-enabling legislation – the question is whether or not the public will agree. ■

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by Andreas Kossak

THE POLITICS OF TOLLING

THE POLITICAL WILLS AND WON'TS OF IMPLEMENTING PAY AS YOU DRIVE

The industry has been steadfast in its belief that distance-based charging is the way forward for certain tolling schemes. However, until there is the political backing to go with it – and certainly less ambiguity in the EC Directive – the already proven technology will lay around gathering dust and cobwebs

The idea of tolling heavy trucks (HGVs) on Germany's autobahn network was first mooted in the late 1980s, and in 1994 a test facility for tolling technologies was established near the city of Bonn (autobahn A 555). In 1995, Belgium, Denmark, Germany, and Luxembourg introduced the Eurovignette (a small sticker indicating a road toll has been paid) for time-based tolling of HGVs (laden weight of 12 tons or more) using autobahns/expressways and similar primary roads in the member states. The legal basis of the introduction was the EU Directive 93/89/EC, dated October 25, 1993. The Netherlands joined the Eurovignette alliance in 1996, and Sweden followed suit a year later. Eurovignettes are available with a validity of a year, a month, a week or a day – differentiated by numbers of axles and emission standards. Conventional vignettes are commonly known as a *pickerl*.

In early 1999, the German government decided that from January 1, 2003 distance-related tolling should be employed to charge HGVs using autobahns. In late 1999, the government appointed a High Commission on Financing the Federal Transport Infrastructure, the Paellmann Commission (named after its chairman). In its interim report dated February 2, 2000, the commission recommended a gradual comprehensive paradigm shift in financing the transport infrastructure, from the traditional financing based on the general budgets to financing by the user, the beneficiary and/or the 'causer' – "as far as possible under the different boundary conditions of each transport sector". The Commission was – and still is – convinced that a full conversion is possible and urgently necessary in the road sector, and explicitly named a variety of advantages, potential and options.

Germany has introduced a distance-based toll for all trucks of 12 tons gross vehicle weight or more

First and foremost, there should be a direct link between using the roads, paying the charge, and employment of the revenue. There should also be a fair and differentiated attachment of the costs with regard to its causation, as well as coverage of the real financing needs. There should be no dependency on the changing impacts on the general budgets, and any discussion about traffic-related taxes and infrastructure costs should be separated. All users, the Commission stated, should pay according to the same principles, using an efficient instrument of traffic management. Finally, public-private partnerships should be investigated (and sought) wherever possible.

In its final report (dated September 5, 2000), the Commission specified its recommendations in relation to the paradigm shift. An essential point was that the undisputed latent financing gap (concerning qualified maintenance and development of the Federal highways – 'maintenance crisis') should be closed first. Beginning at the time – and to amount to the respective financing gap (in comparison to the actual Federal budget and budget plans) – the net revenue from the user charging should be fully compensated for through traffic-related taxes (Figure 1).

With regard to tolling technology, from the outset the Commission recommended a vehicle positioning system (VPS)/global navigation satellite system (GNSS) so that the future expansion of the system to 'unlimited access' road networks wouldn't necessitate a change in the technology used. The Commission also recommended time-based tolling of light trucks and private cars that used the autobahns, and there were two main reasons for such a recommendation: it was deemed to be a suitable entry solution for the respective vehicles, with a comparably low financial burden; and it was considered to be a good interim solution until GNSS tolling of such vehicles could be achieved cost effectively.

At the time, the Commission's recommendations were fully accepted by all stakeholders, and its fastest possible implementation was urged – even the 'yellow press' applauded! Yet, three years later the vice-president of ADAC, the largest German automobile club, kicked off his speech during a parliamentary soiree regarding transport infrastructure financing with the words, "We need Paellmann 1:1," meaning tolling all kinds of vehicles on all types of roads and a full compensation on the tax side (minus the financing gap and transaction costs). The position of all lobbyist groups changed shortly after, due to a number of reasons.

Upon its introduction on January 1, 2005, only 50% of the net revenue gleaned from the distance-related tolling of those HGVs using autobahns was distributed to the road sector. The other 50% was distributed nominally to the rail sector (38%) and the inland waterways (12%). Not only that, the revenue was not used to compensate for the undisputed financing gap, but instead to further reduce the tax-financed budget for the transport sector. Additionally, revenue is not transferred to the transport sector directly, but via the Department of Finance (as if it has to be 'washed' before it is distributed). The political discussion regarding an extension of tolling (not least to private cars) focused exclusively on additional money for the general budget – meaning an additional burden for road users without any benefits.

Such a strategy violates almost every principle of user financing, and as a result the 'window of opportunity' for the paradigm shift was well and truly closed. The politicians at the time did not react to the barriers faced by altering their stance in respect of a real paradigm shift, but instead introduced yet another barrier. Ever since then, any discussions regarding possible expansion of tolling have been warded off by the stereotypical argument – it's not on the agenda. Even those politicians who were convinced of the advantages and the necessity of the paradigm shift admitted to themselves, 'We *should* do it, but how can you win elections with such a policy – moreover, could we lose them?' Ultimately, not jeopardizing the political position seemed to be more important than securing the urgently needed additional financial resources for the road infrastructure, as well as taking advantage of the much higher traffic management potential that road user charges have over traditional taxes.

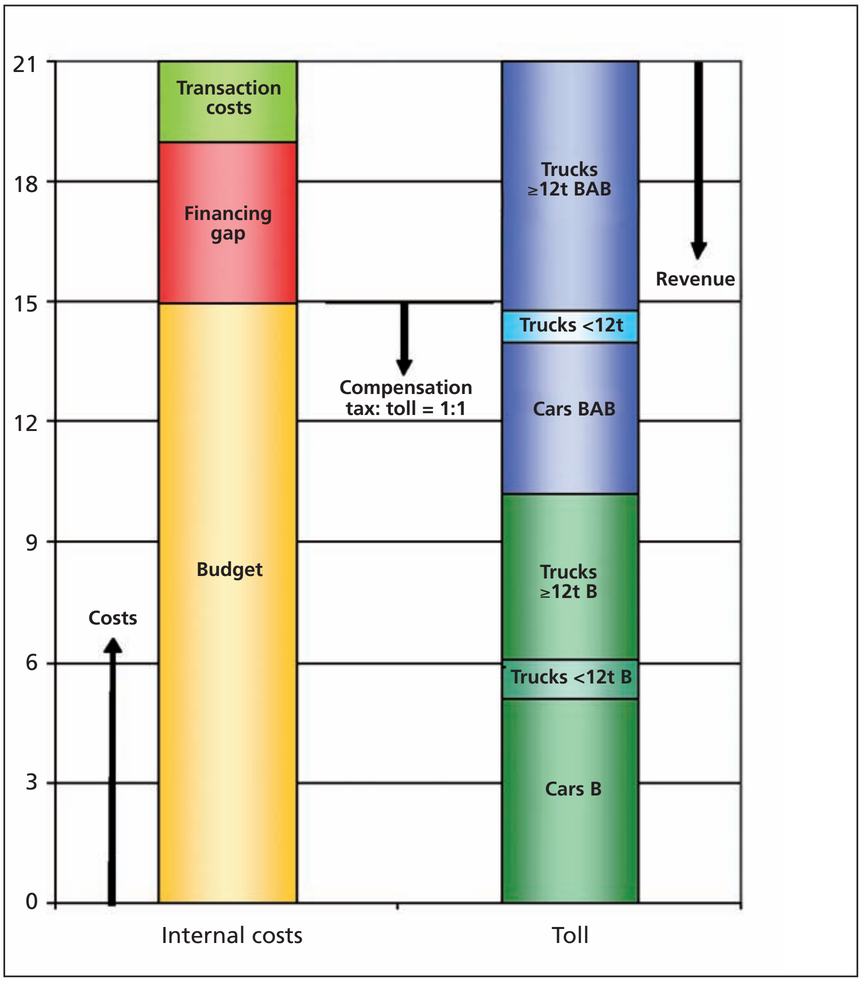

Figure 1: Germany, Federal highways from tax financing to user financing

THE SCENE ELSEWHERE

The scenario is not unique to Germany and is being played out across Europe. For instance, toward the start of this decade in the UK, preparations for the charging of heavy trucks using distance-related tolling had already reached an advanced stage. In May 2004, the procurement prospectus within the frame of The Lorry Road-User Charge Programme had been published by HM Revenue & Customs (HMRC). Around the same time, the government-appointed Commission for Integrated Transport recommended the prompt introduction of a revenue-neutral total change from tax financing to user financing (a supposed fairer attachment of the internal costs of the infrastructure), taking full advantage of the traffic management potential of user charges aimed at a massive reduction of congestion and therefore a better, more economic use of the available infrastructure. A study contracted by the Commission found that, based on a static variation of charges by time of day and parts of the network, it could be possible to reduce the overall time lost as a result of congestion by nearly 50%.

However, in response to the results of a privately initiated public internet petition (1.4 million votes against tolling), the issue has been shelved and is considered 'politically dead' – at least for the time being.

In the early 2000s in the Netherlands, a revenue-neutral switch from financing from taxes to user financing for all vehicles on all roads also reached an advanced stage (Mobimeter). Its realization was intended to be completed around 2008. After a policy change resulting from national elections, however, the plans were cancelled. Since then, a new approach has been initiated, and the introduction is now aimed for 2011 for HGVs and between 2016 and 2017 for cars.

In Sweden in 2004, a government-appointed road taxation commission

"Not jeopardizing the political position seemed to be more important than securing the urgently needed additional financial resources for the road infrastructure"

"There is no doubt that the technology for distance-related road user charging schemes on a small or large scale is available"

published its final report, which also recommended a gradual changeover to user financing. The introduction of distance-related charges for all trucks (laden weight of 3.5 tons or more) on all roads was considered to be possible by 2008. And from 2010, a variation of the toll level based on network location (according to the differences in the internal costs) was recommended. From about 2012 onward, the integration of private cars was considered economically feasible in a distance-related tolling scheme. Contracted by the Swedish government, a project was implemented to investigate the appropriate method (not least the appropriate technical solution) for the realization of the recommendations (ARENA). Although a final result is still to be announced, alternatives analyzed to date are not considered to be viable financially.

Global discussions and actions regarding the introduction of road user charging have for years been focused on the objective of distance-related charging of all kinds of roads and all types of vehicles as a final stage. Primarily, that means tolling of non-limited access roads/road networks, and tolling such roads/road networks by distance requires the use of VPS.

The schedules for the realization of nationwide distance-related road user charging under acceptable economic conditions based on the respective technology vary greatly. Although the majority of members of the US National Surface Transportation Policy and Revenue Study Commission, for example, are convinced that it is not realistic before 2025 (final report as of January 2008), certain system providers claim to be prepared to carry it out across the USA within four years, and with a cost-revenue ratio in the range of 1:15 to 1:20 (5% to 7% transaction costs compared to a net revenue based on the internal costs).

THE QUESTION OF TRANSITION

There is no doubt that the technology for distance-related road user charging schemes on a small or large scale is available and mature in relation to component development. However, road user charging is not primarily a question of technology. It is a question of policy, of trust in the credibility of politicians by the public, of political objectives and ideologies, and of acceptance by the various stakeholders. It is a question of real transaction costs in relation to the revenue, the use of the revenue, additional burden for the road user, or a compensation on the tax side within the frame of a systematic paradigm shift in financing the transport infrastructure. It is a question of efficiency and impacts in terms of traffic management and preserving the environment, of equity, privacy, administrative and legal conditions, (internal and external) interoperability, non-discrimination, and much more.

Even if the required technology is available and proven – and even if the cost:revenue ratio is acceptable – it could still take some time until a stable political decision can lead to its implementation. Even if such a decision is attained, the implementation may take considerably more time than expected. Proven technological components do not guarantee a fully functional complex tolling system on a large scale – an important lesson learned following the establishment of the German Toll Collect System.

THE ELECTRONIC VIGNETTE

As already detailed, the German Paellmann Commission recommended introducing vignettes as interim toll-charging solutions for small trucks and passenger cars for road use, at least until the cost of implementing distance-related tolling becomes acceptable. Effective from October 1, 2008, the Eurovignette became available in an electronic format. The electronic vignette (e-vignette) is based on electronically stored rights of use tied to a license plate number. Resulting from a public tender, the operator of the traditional (paper) Eurovignette, the German company AGES was awarded the contract to implement and operate the electronic Eurovignette. The e-vignette is a much better interim solution than the paper vignette, particularly as important components of operating the system can be integrated into the final stage of a distance-related solution, such as the back-office/control center, enforcement system, call centers, points of sale, other manual booking systems, etc.

Such an interim scheme represents an appropriate 'entry solution'. The burden to the road user associated with time-related tolling is in general much lower than that of distance-related tolling. For instance, the revenue from the Eurovignette in Germany was less than Euro 500 million for the last full year of operation (2002), whereas the revenue from distance-related tolling of the same kind of vehicles (HGV ≥12 tons maximum laden weight) on the same autobahn network was Euro 2.86 billion for the first year of operation (2005) – nearly six times as much! Indeed, 2007 figures would indicate around Euro 3.4 billion.

There are some notable benefits of introducing time-related tolling as an interim solution. On the one hand, politicians get the chance to prove their credibility in relation to the appropriate use of the revenue and the entrance into a systematic paradigm shift. On the flipside, users have the opportunity to experience the effects of tolling in terms of a reduction in traffic-related taxes and/or an improvement of the transport infrastructure.

The electronic version has reasonably better potential and more options for road user charging than the paper option. It allows the operation of the tolling system, as well as the toll enforcement, to be based on the vehicle license plates. As a result, it lends itself to a broad range of tolling schemes and environmental/low-emission zones using different technologies for booking and enforcement – in particular automatic license plate recognition (ALPR) systems.

Various schemes could be targeted, including time-based tolling of open-access roads/road networks, limited-access roads/road networks, cordon-based schemes,

↑ Within the Eurovignette system, the payment of user charges is recorded in real-time in an electronic database that is centralized by the member states that are a part of the overall Eurovignette system zone-based schemes, bridges, tunnels, and mountain passes. It could allow for distance-related tolling of limited access roads/road networks, as well as trip-based tolling of cordons, zones, bridges, tunnels, and mountain passes. It could cater for all scheme sizes, from a single facility (such as a bridge or a tunnel), to a central business district, inner city, regional, national, or even international program. In addition, tolls could be varied to a reasonable extent by time period and location, and such an interim solution could also allow for differentiation/access limitation based on emissions standards.

Over the past few years, ALPR has proved to be a mature and reliable technology, even when operating in difficult conditions (bad weather, dirt, at night, etc). Also, costing around 5-10% of revenues, the e-vignette is a very cost-efficient solution, can be introduced rapidly, and benefits from numerous purchasing avenues, including the internet, SMS, call centers, and points of sale (gas stations, etc). Of greater appeal, no onboard units or roadside equipment are required, and there is minimal risk – if any – of tampering, theft or forgery.

ALPR has for several years been successfully implemented and operated in road charging and parking schemes worldwide. London's Congestion Charging scheme, for example, is based on ALPR, as is the city tolling scheme in Sweden's Stockholm, the stationary enforcement system (in general) as well as the manual enforcement system (partly) of the German Toll Collect truck-tolling system, and Austria's Asfinag *Videomaut* (for certain mountain passes). The *Verkehrsclub Österreich* (Traffic Club Austria) recently called for a change from the traditional sticker to an electronic version, while in Hungary a national e-vignette was introduced on January 1, 2008. Similar plans are afoot in several other European countries, too.

THE DIRECTIVE

According to the actual valid Eurovignette Directive (Directive 2006/38/EC of May 17, 2006 on charging of heavy goods vehicles for the use of certain infrastructure), 'tolls and/or user charges shall be applied to all vehicles from 2012' (Article 7, paragraph 2, point b). The directive refers exclusively to heavy goods vehicles; 'all vehicles' in this context means trucks with a permissible laden weight of 3.5 tons or more. Article 7, paragraph 6, states that 'the arrangements for the collection of tolls and/or user charges shall not, financially or otherwise, place non-regular users of the road network at an unjustified disadvantage. In particular, where a member state collects tolls and/or user charges exclusively by means of a system that requires the use of a vehicle onboard unit, it shall make available the appropriate onboard units under reasonable administrative economic arrangements.'

Protesting truck drivers voice their concerns about fuel prices. Similar scenes greeted lorry charging

This justifies not including trucks in the range of 3.5 to less than 12 tons maximum permissible laden weight, if it does not fit into the political strategy of a member state.

The respective directive does not permit the imposition of a (time-based) toll and a (distance-related) user charge at the same time on the same part/segment of a network. Article 7, paragraph 4 states '…tolls and user charges may not discriminate, directly or indirectly, on the grounds of nationality of the haulier, the country or place of establishment of the haulier or of registration of the vehicle, or the origin and destination of the transport operation'. If one links paragraph 4 and 6 of article 7 with the passage regarding the prohibition of imposing tolls and user charges at the same time on the same segment of the network, a reasonable amount of uncertainties and opportunities to undermine the principles arise. This holds particularly true in the case of nationwide charging concepts for all kinds of motor vehicles (not only HGVs) on all types of roads. The respective uncertainties is realistic for all types of vehicles, on all kinds of roads and for all scheme sizes, may, with good reason, be questionable at this stage. However, the paradigm shift is not only a question of technology, of organization, of legal condition, etc. It is primarily a politically highly sensitive issue. As a result, a smooth and systematic transition is extremely important, and that includes appropriate entry/interim solutions.

The traditional vignette for time-based charging has proved to be an efficient and accepted solution in this regard. The modern version of an e-vignette combined with advanced ALPR is an even better solution – especially considering the added potential of variations by time period in the day, and particular segments of the road network. The actual valid Eurovignette Directive does not take into account stages of transition to the necessary extent, so allowing interim solutions is a crucial point in this context. The Directive contains footholds for (unintentional or otherwise) misinterpretations regarding

"A smooth and systematic transition is extremely important, and that includes appropriate entry/interim solutions"

and footholds for misunderstandings or (intentional) misinterpretations should be clarified as soon as possible. What is an unjustified disadvantage? What does 'excessive formalities' or 'barriers at internal borders' actually construe?

CONCLUSION

Shifting from traditional tax financing of the road infrastructure to the 'user pays/ pay-as-you-go' principle is gathering pace globally. The technology needed for strain- or distance-related charging of road use is available and technically mature. Whether or not an economically viable implementation some highly important aspects. It is valid only for HGVs, while most member states plan to introduce road user charges for all automobiles on nationwide levels. The next generation of the Directive (or – better – a new comprehensive one) should cover the paradigm shift as a whole in an appropriate and realistic manner, complying with the respective objectives stated in the White Paper, *European transport policy for 2010: time to decide*. ■

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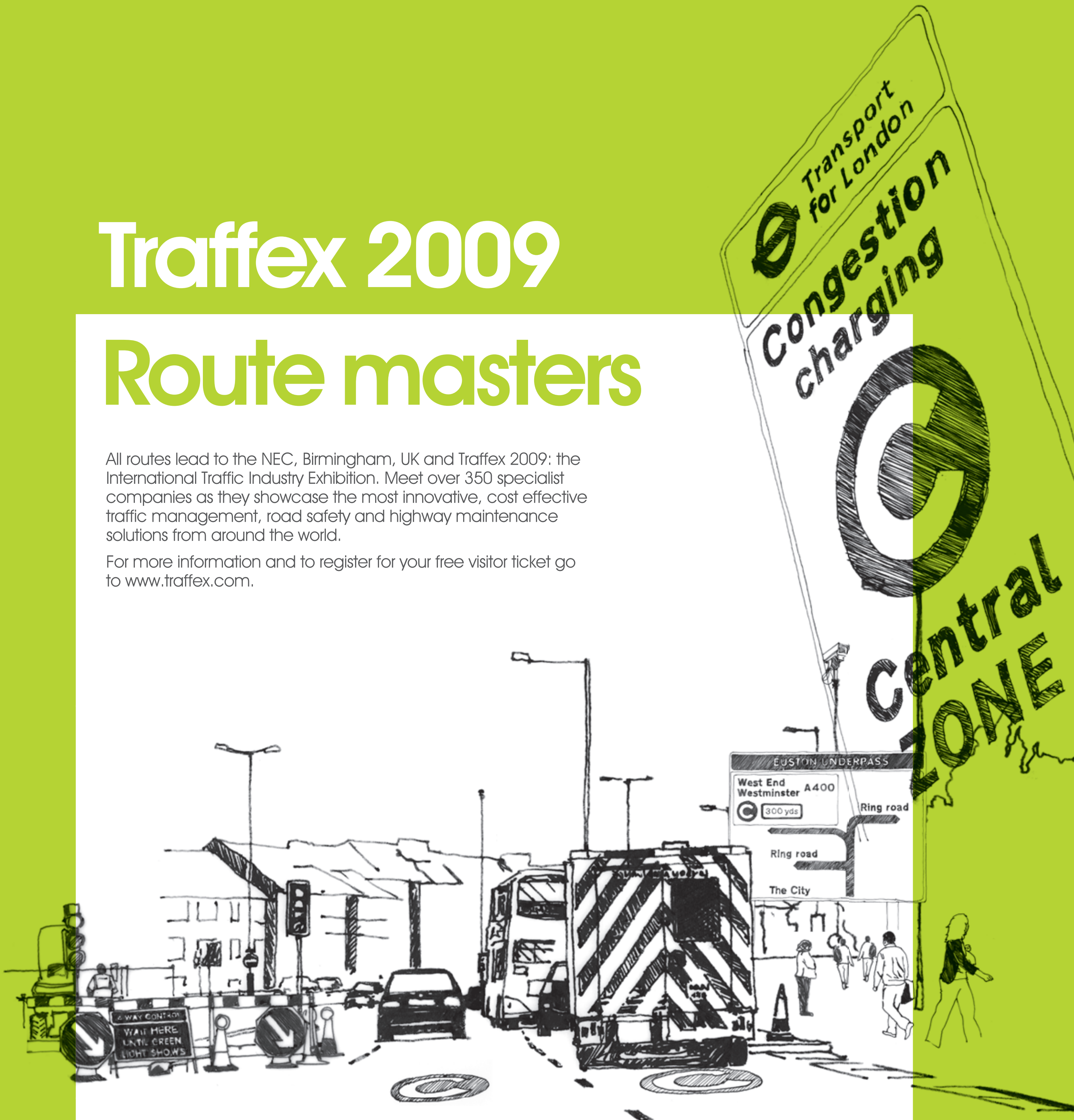

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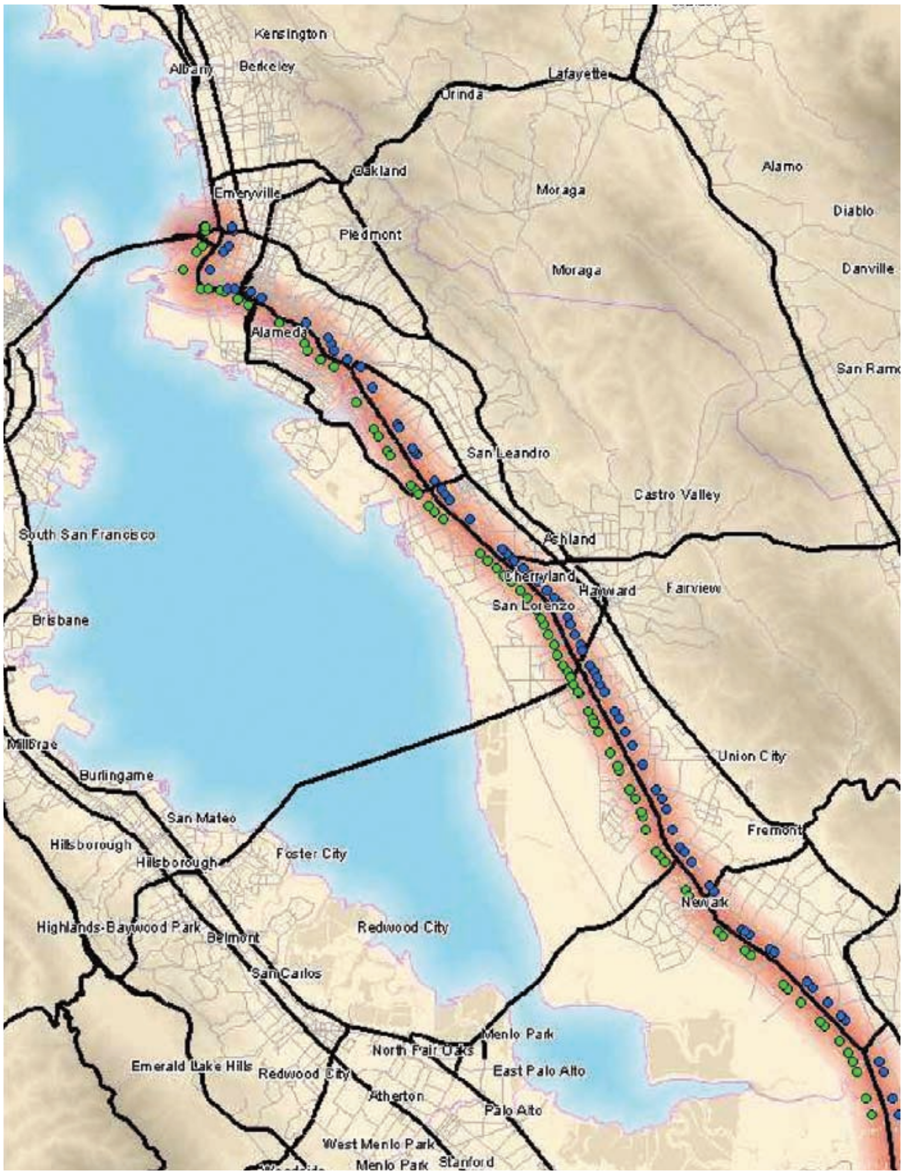
SECTION 4:
DETECTION/MEASUREMENT

by Hamed Benouar

RELEASE THE PRESSURE

PERFORMANCE-BASED MANAGEMENT USING REAL-TIME TRAFFIC DATA

Transportation agencies are always on the hunt for solutions to their traffic congestion conundrums. In the field of detection, finding solutions that are cost-effective, reliable and maintenance-free causes just as many headaches



The I-880 corridor was one of the first comprehensive applications of corridor management

Transportation system management requires the collaboration and cooperation of the institutions that have jurisdiction over the system. Subdivided into corridors, transportation systems include freeways, arterials, local street and transit properties. Managing a corridor also requires the collaboration and cooperation of the agencies having jurisdiction over the corridor, such as transportation agencies, law enforcement agencies, and transit properties. Real-time transportation management is vital to making the best use of the transportation infrastructure in relation to meeting actual demand. Measuring the performance of the infrastructure and managing based on the real-time performance of the corridor is an important element of meeting the needs of the corridor agencies. Accurate, reliable and cost effective real-time traffic data collection is essential for such real-time performance-based corridor management.

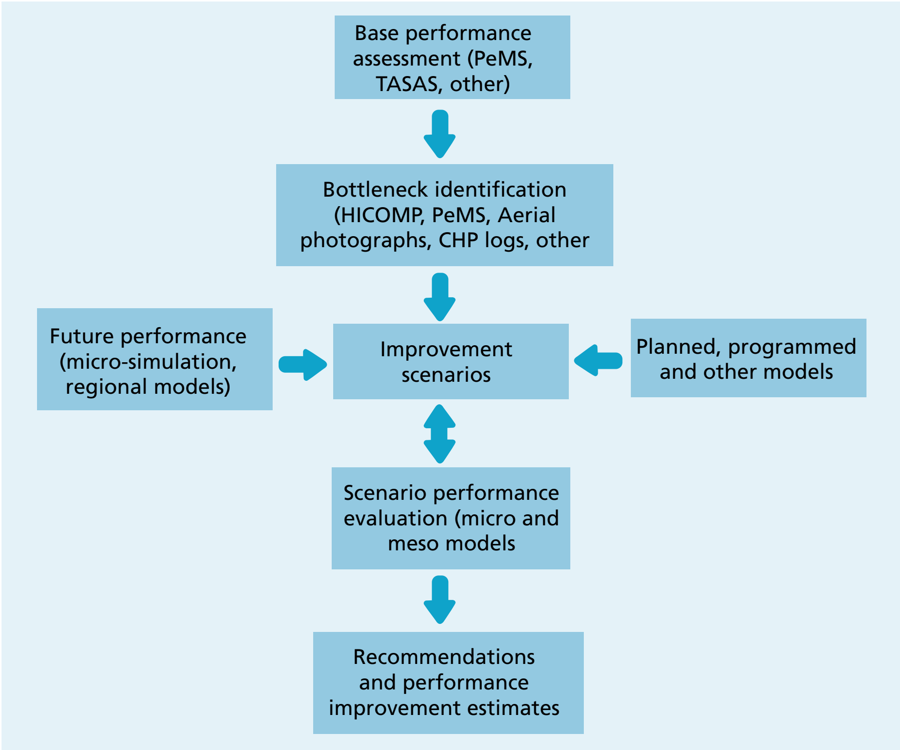
WHY CORRIDOR MANAGEMENT?

Traffic congestion continues to have a negative impact on people and the economy. In the USA, the top three most congested cities are Los Angeles, New York and Chicago. It is no surprise that those three cities are not only the most populated cities in the USA, but also major national financial centers. But congestion comes with economic growth, which is inevitable, and eliminating it is a very difficult task. Transportation agencies cannot keep up with increased demand through infrastructure expansion alone. Building additional facilities when physically possible takes a long time given environmental and funding constraints. Congestion should at least be managed to a level that is acceptable to commuters and the economy.

There are two types of congestion: recurring congestion due to excess demand

and the lack of adequate infrastructure to meet the demand; and non-recurring congestion resulting from incidents and more predictable but not recurring special events, such as sports games, and construction and maintenance activities. In all cases, agencies could achieve more with the use of new technologies to improve efficiency and make better use of existing infrastructure, and to plan and respond better to non-recurring congestion. In all cases, accurate real-time data is key to better corridor and overall transportation system management. In the case of recurring congestion, real-time traffic data can make use of ramp meters a lot more efficiently in managing demand on the freeway. Knowledge of real-time performance of arterials, such as travel time, could provide opportunities for balancing the system on a corridor basis by sharing capacity between freeways and arterials. Providing real-time accurate information to the motorist will encourage better use of existing infrastructure, as informed motorists will go to the least congested routes, thereby helping to balance the system and fulfilling the role of 'ultimate transportation manager'.

Since the inception of the USDOT led to new ITS initiatives, many agencies have been embarking on the use of new technology to improve the efficiency of their transportation systems. However, many find it very difficult to deploy technology due to lack of funding and a trained workforce to operate and maintain the new systems. In addition to the slow adoption of new technologies, many institutional issues come in the way of integrated corridor management and corridor mobility improvements. The San Francisco-Oakland Bay area in California, for example, includes more than seven million people, nine counties, more than 100 cities and more than 25 independent transit properties. Integrated corridor management in such an area needs the participation and cooperation of more than a dozen agencies having independent jurisdiction over part of the corridor – either a freeway, local streets, or a transit bus or train. Data collection and sharing is at best a challenge. However, many of these agencies have come to the conclusion that cooperation and collaboration improves overall transportation system management. The USDOT is sponsoring the Integrated Corridor Management (ICM) effort and California has been a leader over the past decade in improving corridor mobility through an integrated planning and operations effort 'Practicing the Pyramid'.

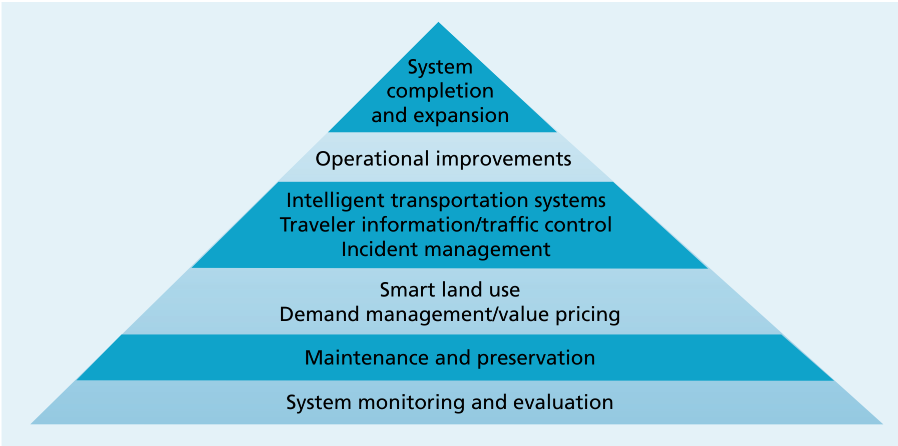


The chart shows the processes taken during the development of Corridor Management Plans (CMPs)

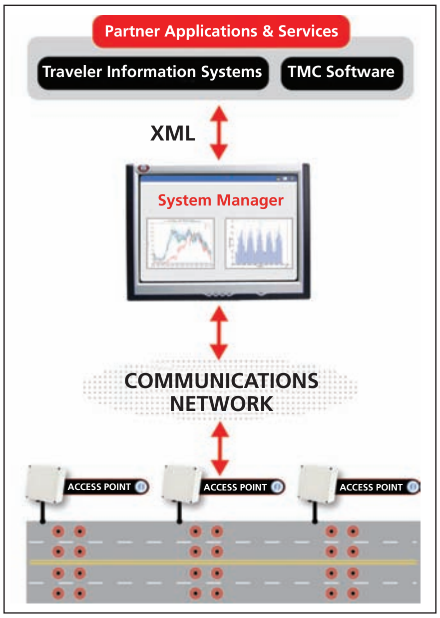
THE BEST PRACTICES

California is a leader in the concept of using data to monitor and manage the system. Such concepts were articulated in reports to the legislature in the late-1990s and received USDOT awards. Practicing the Pyramid is a concept led by the California DOT (Caltrans) Division of Traffic Operations in collaboration with the Division of Planning. Such concepts and vision helped put a transportation measure on the 2006 ballot for California voters to pass. In November 2006, voters approved Proposition 1B that provided nearly US$20 billion for transportation improvements, of which around US$4.5 billion was for corridor mobility improvements. Recognizing the need for good data collection as a basis for monitoring the system, measuring system performance as well measuring the benefits of new improvements, Caltrans allocated funding up front to fill detection gaps throughout the most congested corridors that were slated for improvement under the Corridor Mobility Improvement Account (CMIA). With approval by the California Transportation Commission (CTC), Caltrans manages the CMIA program and funded the new detection through its State Highway Operations and Preservation Program (SHOPP).

"Agencies find it difficult to deploy technology due to lack of funding and a trained workforce to operate and maintain the systems"



Measuring the system from planning through operations maintenance to improvement



The above shows an integrated traffic data system's components

The I-880 Corridor was one of the first comprehensive applications of corridor management. It included both the application of new technology and simulation and the participation and institutional cooperation of all the agencies that have jurisdiction over the corridor.

The study has been completed by the University of California Center for Innovative Transportation (CCIT) in collaboration with the System Metrics Group (SMG). The development of Corridor Management Plans (CMPs) had to include the collaboration and sharing of data from all agencies. The institutional work was just as demanding, if not more than the technological work. Data availability and accuracy was a major encountered problem, as it was hard to establish baselines and to validate the microsimulations. Three steps were followed by the group: first bring all agencies together, establish the charter and find out what data was available; then develop a data needs and acquisition plan; before finally performing system evaluation and scenario development and evaluation.

The process shown on the previous page was followed. The study concluded that reasonable data would allow corridor assessment and delay in more detail so that the impact of improvements can be evaluated. There are clear benefits to what good data can reveal as far as corridor performance is concerned.

For planning and cost benefit evaluation purposes, average vehicle hours of delay can be estimated before improvements are completed. The afterstudy using the data can therefore show benefits of the investments.

I-80 CORRIDOR MOBILITY IMPROVEMENT

Another corridor that has been identified as a major one for improvement is the I-80. One of the most congested in the state of California, I-80 runs from the Carquinez Bridge to the Oakland-San Francisco Bridge. The Alameda County Congestion Management Agency (ACCMA) has the lead in implementing the I-80 corridor mobility improvements. The I-80 ICM vision is shared by all of the agencies along the corridor, and will enhance the current Transportation Management System by using a State of the Practice solution to build an integrated, balanced, responsive and equitable system to monitor and maintain optimum traffic flow along the network to improve the safety and mobility for all users.

This corridor received more than US$80 million in Proposition 1B funds for improvements both on the freeway and arterials. Along this corridor, there is no physical room for roadway expansion so the managed lane concept will be employed to get more efficiency out of the existing infrastructure.

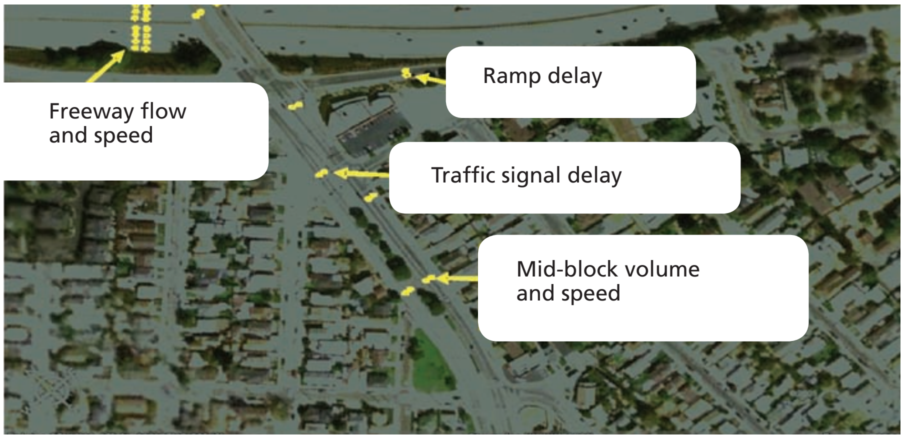
The key to effective corridor management and reducing congestion on arteries and freeways is accurate data. The only way to receive accurate data from these congested arteries is to use a dependable, accurate and cost-effective vehicle detection system. The key word used here is dependable. Metropolitan areas need to consider their Dependability Index when choosing a vehicle detection system. Suppliers of such systems tout their accuracy, but a more appropriate question to ask is how often they are available. A large number of technologies used in vehicle detection are either broken or in 'recall' most of the time. Cities need to consider a technology's dependability before implementing a detection system.

"WVDS can offer the missing link (accurate data) as a single platform for all corridor detection needs, including freeways, arterials and intersection actuation and control"

THE MISSING LINK

Inductive loop detectors have been used for the past 50 years for most traffic data collection, including traffic control at intersections and traffic count applications on the freeway and arterials. Many technologies that are perceived to be less intrusive and more cost effective have been introduced over the years to replace loop detectors. The most successful technologies introduced more than a decade ago include video detection, which is used mainly for traffic signal control, and side-fire microwave radar systems for freeway count stations. Today, loop detectors are still used in more than 70% of the applications as a result of their accuracy and because of the problems that both video and radar have had in their implementation over the past decade. Although both video and radar detection systems have evolved and improved over the years, they are still plagued with high maintenance and accuracy problems in all weather and traffic conditions. Advanced detection and system detection and any type of midblock detection continues to be dominated by loop detectors as both video and radar detection systems are not suitable due to obstacles, such as power requirements, occlusion and pole-mounting requirements.

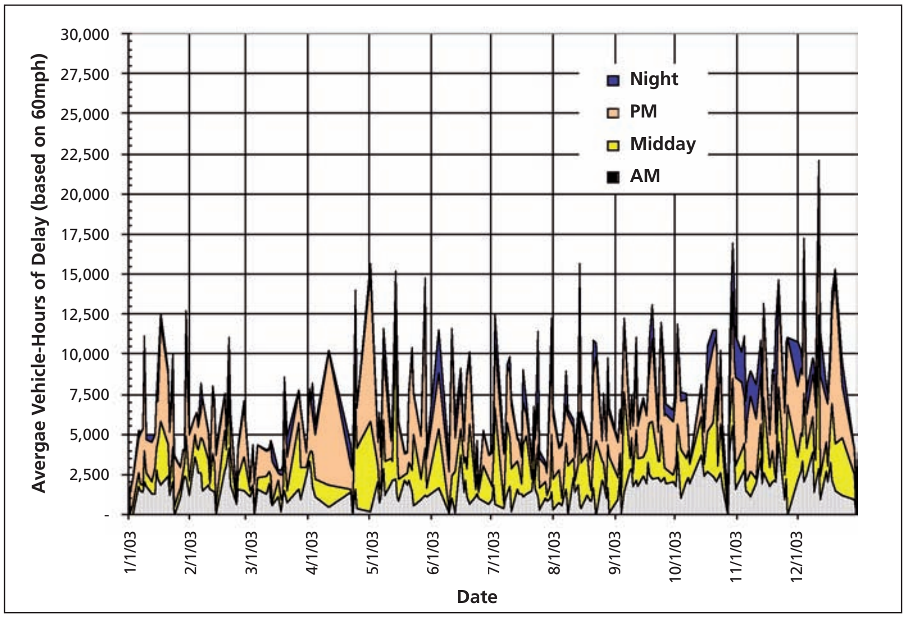
Recent developments in wireless vehicle detection systems (WVDS) provide a good alternative to loops detectors as a single detection platform for vehicle detection in all applications. Wireless sensors are



The chart shows an integrated data system for all traffic data needs especially cost effective for midblock vehicle detection applications, including advanced detection and system detection. Wireless detectors can be placed up to 1,000m from the intersection and can provide vehicle detection with accuracy comparable to loops, yet without the expensive and disruptive trenching that is required for installation of loops, conduit and wires. In addition, WVDS can be installed at a fraction of the cost of loops, enabling adaptive signal control, which was, until now, cost prohibitive. WVDS provides agencies that continue to use loop detectors today an excellent, less intrusive, as well as accurate and more reliable solution at a fraction of the lifecycle cost.

In addition, WVDS provides a flexible IP-based solution that can be integrated with existing controllers and detection system to fill the gap and provide the needed detection that is necessary to perform real-time performance-based corridor management and improvement. In areas where no detection is available, WVDS can offer the missing link (accurate data) as a single platform for all corridor detection needs, including freeways, arterials and intersection actuation and control.

Affordable vehicle detection systems with ease of installation and low maintenance/lifecycle costs is vital to real-time performance-based corridor management. The accurate data is needed in support of freeway and arterial travel-time information systems, alternate routing, local and system level performance measures, adaptive and traffic responsive signal control, ramp metering and freeway management. Moreover, accurate, flexible detector technology is the foundation for effective Integrated Corridor Congestion management. ■



Most traffic delays are random in nature and change on a daily basis. Accurate, real-time data from a dependable vehicle detection system is key to reducing congestion and effective traffic management

Hamed Benouar is vice president of business development at Sensys Networks. He previously served as director of UC-Berkeley's California Center for Innovative Transportation and was head of Caltrans' transportation operations program

Stefano Grandi & Antonella Nanetti

NUMERO UNO

AUTOMATED TRAFFIC FLOW MONITORING SYSTEM FOR EMILIA-ROMAGNA REGION

Italy's first automated traffic flow monitoring system is the result of a long technical and administrative process that involved the region, provinces and ANAS, the body that manages the road networks throughout the country

The system for automated monitoring of traffic flows in the Italian Emilia-Romagna region is the result of a long technical and administrative process carried out with the provincial authorities and ANAS (the organization that manages the national roads network in Italy).

Emilia-Romagna's 71,000 roads total 60,000km in length. As one of the most developed regions in Italy in terms of its industry, commerce and transport network, the region's strategic geographical location between northern and southern Italy makes it key within the Italian transport system. It is on major routes taking transit traffic north and south within Italy and international traffic on to other European countries. The result is a large flow of freight and passenger vehicles, from a combination of heavy local and transit traffic. This affects the entire road network and hits suburban roads in particular, as there is a high density of widespread human settlement in small- to medium-sized cities.

The usual traffic monitoring campaigns carried out along the suburban roads so far have not been performed systematically. Measurements were often initiated to answer specific needs and, at times, carried out using non-homogeneous procedures. Such monitoring fails to provide a seamless and dynamic vision of traffic flows and makes comparisons almost impossible. This is a big obstacle in creating a database guaranteed to provide the level of information required to deal with the severity of the traffic problems – accidents, pollution and congestion. There is a real need for better organization and better intervention plans.

This situation has led Emilia-Romagna, within the context of the *Piano Regionale Integrato dei Trasporti* (Regional Integrated Transport Plan), to aim to build a 'system that controls and monitors the actual trend of significant indicators to check over time the effectiveness of the interventions planned and the soundness of the approaches taken'. A program to create an automated regional traffic flow monitoring system has been launched as an essential step toward building a database to enable transport planning and programming, and to transform occasional information into official data to be shared and used by all of Emilia-Romagna's provinces.

"The system was devised by the region, together with the nine provincial authorities and by ANAS"

The system is also key to a much wider road information system (SIV) that the Emilia-Romagna region is currently completing – a set of data essential to managing mobility more successfully, containing information on crashes, traffic flows, geometric features, and workzones.

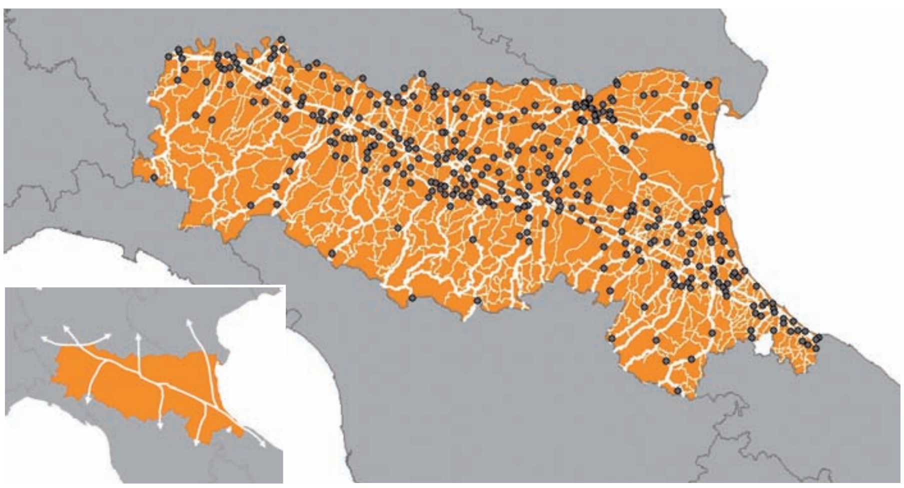
Despite the degree of awareness and commitment, the implementation has proved complex, due to some technical and especially administrative reasons – some related to the regional authorities. Unlike provinces and municipalities, these do not own the roads but are meant to plan, coordinate and finance their own activities.

When the program was launched, Italy did not have – and still does not have – automated traffic-flow detection systems over areas as large as entire regions shared by differing administrations. Most data actually focuses only on limited areas, such as city districts or motorway sections. For various reasons, these could not be applied to a suburban scenario and to such diverse geographical areas, nor could they meet such markedly different technical and administrative requirements.

PILOT PROJECTS

Given the system's complexity, its innovative aspects and technical and administrative characteristics, it was decided to create two pilot projects in the Ravenna and Ferrara provinces involving the provincial authorities, the main municipalities and ANAS. The experience gained and the tests carried out during – and at the end of the pilot projects – about the monitoring posts and data management phase, have defined the decisions taken and the layout planned for the regional project.

The automated regional traffic flow monitoring system project envisaged the



↑ Location of automated regional traffic flow monitoring system roadside posts in Emilia-Romagna installation of 231 stationary data-collection posts on the main and provincial suburban roads throughout the region remotely controlled by a regional control center.

The system was devised by the region, together with the nine provincial authorities and by ANAS. The costs were shared by all the authorities participating with over 60% covered by the region with the remaining 40% coming from the provinces and ANAS.

In its post-completion phase it is envisaged that the system may be extended to any other interested municipalities and to include additional functions relating to the environment, for example. At this time it is also intended to spread the number of monitoring posts and to apply new functions commissioned by the provinces and by ANAS or the region itself, without changing the system's parameters and its information sharing features.

IMPLEMENTATION

To implement the system, specific agreements have been reached between the region and the provinces, and also between the region and ANAS. A workgroup consisting of representatives of all of the partners involved in the projects has been established. The terms for the tendering process and the technical and functional specifications have all been discussed in the workgroup, and then ratified by each authority participating in the project.

The members of the workgroup have been nominated as executive directors and members of the supervising committee, taking an active part in all the steps required to complete the works. These include making numerous onsite inspections to identify road sections and land segments to install the posts and initiating all of the procedures required to obtain authorization and permits for roadworks. It also encompasses agreeing the technical decisions taken during the tendering process, and taking part in final testing.

Upon completion, the workgroup approved a set of regulations on using the system covering its maintenance, management and implementation, as well as the procedures to disseminate the data. The regulations define the maintenance program management carried out by Famas System, the lead company of the business association awarded the tender. A new workgroup has been nominated, once again comprised of representatives from ANAS and all the provinces involved. Its purpose is to guarantee the system continues to be shared and that any problems, such as any technical decisions, can be tackled collectively.

COMPOSITION

Currently the system consists of a regional control center (CCR) and 300 roadside detection posts. The award of the contract led to the implementation of the post model comprising loop sensors (fingerprint reader type, embedded in the tarmac at a depth

↑ Famas's Star C-500 can detect stationary and moving vehicles and classify traffic flows with an accuracy similar to an induction loop device

of about 9cm) connected to a roadside cabinet containing the detection and data transmission equipment, and storage batteries. Ten of the 268 posts installed under the contract are experimental, and feature innovative sensors installed above the traffic lanes (mono-microwave technology with signal processing) and connected to a specific data-concentration and communication module.

The sensor developed by Famas, STAR C-500, allows the same data to be detected by loop sensors using signal analysis technology, with the addition of stopped vehicle detection functions. The monitoring posts record the number of vehicles, speed, length, space between vehicles, and classification into 9+1 categories: motorcycles, cars, cars with trailer, vans, a variety of trucks, coaches and others.

The roadside cabinets have been marked with the Emilia-Romagna region logo, which identifies road network projects and the sponsors. A competition has been launched in the region's schools to develop a new logo to develop awareness and promote creativity among students about road systems and road and traffic safety issues. Each cabinet has also been marked with a sticker with a short sentence, in different languages, describing the system's purpose.

SYSTEM FUNCTIONS

In its basic configuration, the aim of the system is to create an updated and multifunctional information database that can be shared among all authorities. It should also be capable of allowing data collection for the development of processing for forecast models and to support transport planning, road accident data analysis, programming work on the road infrastructure, road network management, traffic censuses, and interfacing with national planning strategies and programs.

In its more evolved configurations, the system can be expanded to include functions such as checking traffic conditions, identification of routing policies for the management of commuter and commercial traffic, measurement of weather conditions and of road surface, and addition of data regarding air quality and concentration of pollutants.

"The sensor developed by Famas, STAR C-500, allows the same data to be detected by loop sensors using signal analysis technology"

Every post is powered autonomously using a photovoltaic panel installed on a 6m pole, saving energy and reducing air pollution. The collected traffic data is passed through a GPRS-based communication network on a detailed vehicle-per-vehicle basis to a single central server located at the regional control center, accessible by all authorities sharing the system.

Famas has designed specific data acquisition, storage (DB Oracle) and browsing (GIS ESRI) systems to manage the posts and the large amount of incoming data. The data is refreshed every 15 minutes with access via an intranet/internet network. The control center's software provides a WEB-GIS interface that helps users consult the system and select the data.

For simulation scenarios, each participating authority can use the most suitable modes to acquire all of the data, ranging from disaggregated data to the pre-set elaborations within the system. It also envisages free access to aggregated data, through the internet, by external users such as sector operators or citizens.

The data is used for various activities, and especially to help the local authorities share the system for programming and planning. Within this framework, the system's statistical traffic data is used as input data for mathematical models to run simulations for transport planning.

In a more advanced phase, it will be possible to envisage the use of data to update real-time road traffic bulletins as part of an information service for travelers to inform them of traffic jams, give travel time forecasts, and recommend the most convenient alternate routes.

The same service can be provided via a dedicated internet portal equipped with application software and information pages via various access channels. Ultimately, it will be possible to prepare specific bulletins to drivers on traffic conditions and the location of road2works. ■

Stefano Grandi and Antonella Nanetti are both from the Emilia-Romagna Region, Italy. For more information, please telephone Famas System on +39 0471 827100, email info@famassystem.it, or alternatively log on to www.famassystem.it

by Dave Johnson

SAFETY CENTRAL

DEVELOPING IMPROVED SOFTWARE SOLUTIONS FOR CENTRAL MANAGEMENT

Recent sophisticated advances in centralized software technology mean that emergency vehicle preemption and transit-signal priority are becoming easier and more efficient to control, secure, monitor, manage and maintain

Emergency vehicle preemption (EVP) is expanding rapidly in many communities across the USA and Canada, as speed is essential in emergency response, and accidents involving emergency vehicles are costly in terms of property and lives. In addition, the growing urgency to improve efficiencies of mass transit without additional investments in new routes or equipment has put transit-signal priority (TSP) on an equally rapid growth track.

There is a new facet to these systems that could make them even more universal at intersections the world over – new software from the maker of the Opticom infrared system for EVP and TSP. This software makes managing preemption almost as easy as managing an appointment calendar.

This infrared system has been used by communities for nearly 35 years and comprises three integrated components, including an emitter, a detector and phase selector, in addition to configuration and logging software.

The emitter is a small strobe or LED that is mounted on the emergency services or transit vehicle. It generates a uniquely coded infrared frequency light that is picked up by a detector at the intersection. The detector – usually mounted on the signal light or mast arm – relays the communication to a phase selector in the traffic cabinet. The phase selector contains circuitry and embedded software that reads the coded information contained in the emitter signal, validates and identifies which vehicle the signal came from and then, if it's an authorized vehicle, forwards a preemption or priority request to the controller.

ITS Link software supports the Opticom infrared system by providing the capability to do system configuration, security through code management, and log retrieval. ITS Link is usually used by a technician right at the intersection.

NEW SOFTWARE TOOL

The next advancement from Global Traffic Technologies (GTT) is Opticom central management software. It is designed to help users take full advantage of their EVP and TSP system deployment. The software works with a community's existing communication infrastructure to allow users central control and management of systems.

The infrared system already collects a wide range of data right at the intersection – data such as preemption request call times, the identification code of the vehicle that made the call, whether the preemption was requested, and so on. With the central management software, all of this data can be transformed into information that traffic officials can use to make important management decisions about their particular EVP and TSP systems.

The central management software is both a regional and jurisdictional tool. A region is defined as a metropolitan area comprised

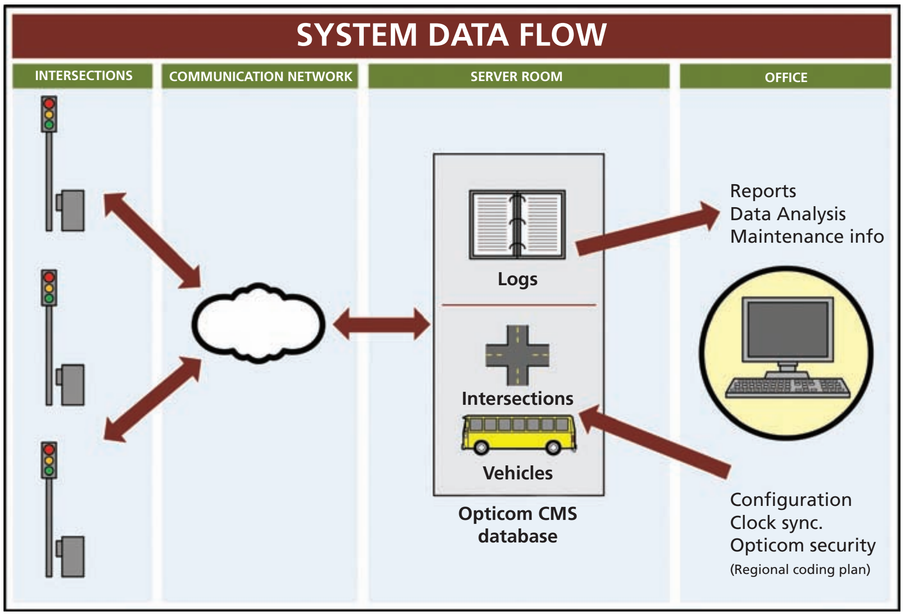


Diagram outlining system data flow. Log data from intersections equipped with the Opticom infrared system is collected by the Opticom central management software database through the existing communications network. The software allows traffic engineers to transform the raw log data into valuable reports and perform a variety of maintenance and management tasks

The software is a Windows application that is designed to be user-friendly and simple to comprehend

of several jurisdictions (the governmental units or organizations that control the intersections where Opticom equipment is installed). A jurisdiction is typically a city or county, but could be used to represent a corridor of intersections that have unique configuration or security requirements.

The software helps traffic officials sort out these layers of ownership and control, so they can find out how the Opticom system is being used and by whom. Within the central management software database, the logs collected from all the traffic cabinets across the region are categorized by the jurisdiction and region that manages the intersection.

Before the new software, technicians had to visit each intersection to collect this data, as well as to change the configuration of the system. Now traffic engineers can instantly identify all the equipment installed at each intersection in a jurisdiction, review the programmed parameters of each one, and then reconfigure the equipment to new settings. They can also manage the phase selector inventory and generate inventory reports – all without leaving their desks!

MANAGING VEHICLES

The system emitters feature coded frequency pulses that contain a unique identifier of the vehicle on which they're installed. Coded emitters help eliminate the problem of people using unauthorized emitters and changing lights for their own benefit.

The central management software allows traffic officials to easily create and manage a local or regional emitter code plan by jurisdiction and by agency within each jurisdiction. Once a coding plan is in place, it's entered into the central management software database, along with information about each vehicle in each agency participating in the regional plan. The coding plan can be deployed for both agencies using EVP and TSP.

With the agency and vehicle information in place, the software correlates the emitter code of every vehicle making a preemption request call with its own vehicle and agency information. This is so traffic engineers can quickly understand how the system is being used across the region, for any one jurisdiction's intersections, at a specific intersection, by any one agency's vehicles, or by a specific vehicle. And they can see this activity within the past few minutes or over the past several months, or even years.

"The central management software makes implementing, changing and managing the security plan easy"

Which vehicles are allowed access to the system is often one of the biggest decisions traffic engineers and community officials have to make. But once decided, the software makes implementing, changing and managing the security plan easy.

The software lets traffic engineers configure each jurisdiction in a region with a level of security appropriate for that jurisdiction, and even allows different jurisdictions within the region to deploy different security levels. By providing multiple levels of security, the software gives them the capability to evolve to the next level of security over time.

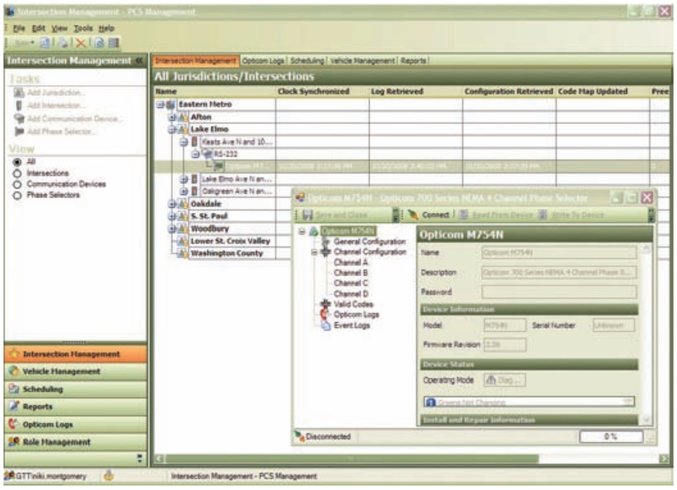
With the new software in place, traffic officials can easily and quickly block unauthorized vehicles from access to the EVP or TSP system, without sending a technician to each intersection in the system corridor. They can also monitor usage patterns, quickly detect system abusers, and find out whether and where vehicles have attempted to break into the system.

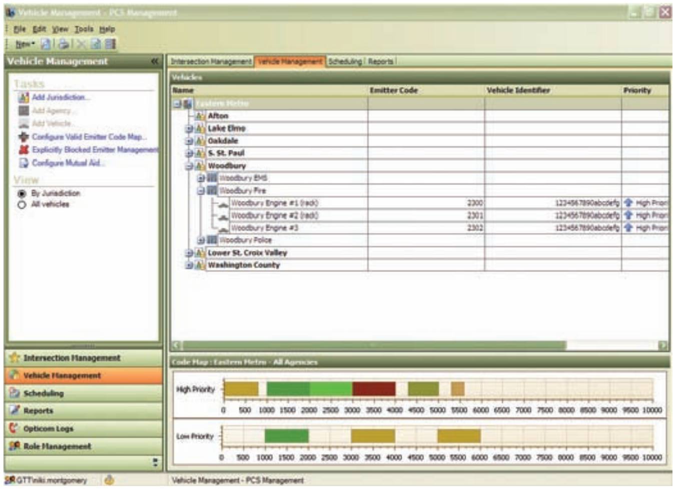
Traffic engineers can further strengthen system security by explicitly blocking certain emitter codes. For example, engineers may want to block emitter codes that appear in the intersection log reports but cannot be identified, or emitters that have been reported as missing or stolen or that are associated with registered vehicles that must be taken off the authorized use list.

In addition, the software can easily accommodate mutual aid agreements between jurisdictions. Whereas the agencies of a jurisdiction are by default granted access through that jurisdiction's Opticom systems, agencies from other jurisdictions are not. However, where mutual aid agreements are in place, enabling mutual aid is as simple as enabling it in the software, then running a job to update the authorized code maps in the intersections. Mutual aid can be one-way or reciprocal, depending on the agreement between the different agencies.

RETRIEVING LOGS

Emergencies are by definition stressful. They require people to make critical decisions





instantly, and the results of those decisions are sometimes tragic. So reconstructing the events leading to an incident is often of crucial importance to investigators.

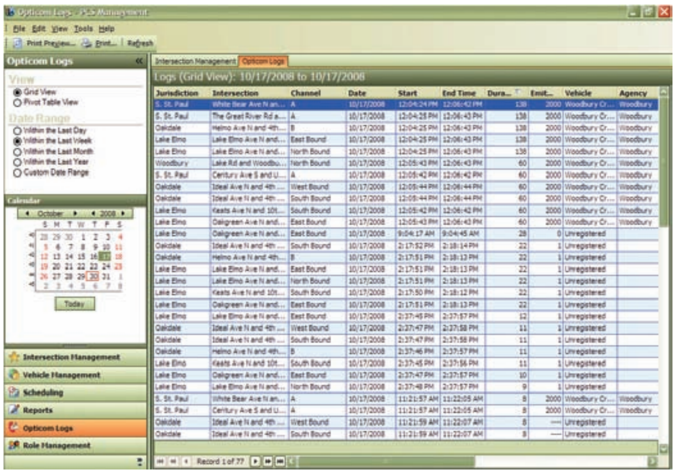
This is just one example of how the 'ad-hoc query' capability of the software (which allows instant retrieval of intersection log data) can be a valuable tool for finding out exactly when, and by whom, the system was used. With system log data in the software database, engineers or investigators can see the data by intersection, by approach, by agency jurisdiction, by vehicle, as well as several other parameters.

The software also makes it easy to download and manipulate log data, send raw logs or finished reports directly by email, and to schedule maintenance or other recurring tasks.

ANALYZING DATA

Reports that used to take a long time to gather and tabulate can now be generated almost instantly. This information is useful for traffic engineers, agency officials and community leaders, who have to make decisions about managing the systems or often have to justify the value of the system itself to constituents. These system-wide reports can provide valuable information quickly. This data can include intersections with the highest number of emergency vehicle preemptions or transit-signal priority calls, EVP calls by vehicle, and unusually long signal priority or preemption times, by either vehicle or intersection. In addition, valuable is information on intersections with no EVP or TSP calls and preemption or priority requests from unregistered or unauthorized vehicles.

The software allows traffic departments to complete proactive maintenance reviews of their system without traveling to the intersection. Receiving scheduled reports on system usage by intersection, approach and vehicle helps identify possible system issues and allows a targeted maintenance response rather than system-wide maintenance inspections. Traffic departments can also access the central management software for real-time information to immediately verify and address user feedback and concerns about system operation.



↑ Selection of screenshots from the Opticom central management software

"We can manage our entire Opticom systems from a central location with no additional investment"

EARLY ADOPTER EXPERIENCE

The city of Mesa, Arizona, with a population of 460,000, is one of the fastest growing cities in the USA and it is also the first municipality to install the new software. "In the first two weeks of using Opticom central management software, it identified potential maintenance issues and system improvements," explains Jeff Jenq, the city's ITS engineer. "This supports the reasons we were so interested in it in the first place: to help us identify system concerns, diagnose maintenance requirements, reduce maintenance costs and improve the overall operation of our system. The software will help ensure that the city of Mesa maximizes the benefit from our investment in the Opticom infrared system."

The city installed the system in 1987 and continues to upgrade it with the latest technology advancements from GTT. The system consistently supports the city of Mesa's goal of safer and faster emergency vehicle response. But the idea of greater centralized control over the system's functionality prompted Mesa officials to be the first user of the new software. "We can manage our entire Opticom systems from a central location with no additional investment in our communication network," continues Jenq. "We were able to use existing communication methods and multiport communications devices already installed in our traffic cabinets."

The first release of the central management software will be available from GTT in the first quarter of 2009 to support the Opticom system. Scheduled releases of the software through 2009 and 2010 will support advanced diagnostics and the Opticom GPS system. ■

Dave Johnson is a software engineer with Global Traffic Technologies (GTT), and is based at the company's headquarters in Minnesota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by Marcel Massana

DETECT TO PROTECT

NEW SYSTEM FOR AUTOMATIC DETECTION OF DANGEROUS GOODS

Impressive work is being conducted in Spain on improving the detection of vehicles transporting dangerous goods. Despite challenges, such as hard-to-read license plates and labels, a new system is making strong progress

The DAMP (Automatic Detection of Dangerous Goods) automatic recognition system has been designed by Spain's ACISA to satisfy the demand for information that might be needed by the country's various departments of traffic, roads and transport, such as the DGT (Dirección General de Tráfico in Spain), SCT (Servei Català de Trànsit in Catalonia), and Dirección de Tráfico from the Basque Country Government.

Firstly, the system detects vehicles with dangerous goods by recognizing the ADR orange-colored label. Both the ID Danger Number and UN codes of the label are then extracted, in addition to the license plate detail. Subsequently, the data is transmitted along with the location, lane, and a timestamp to a central server. Finally, the data is actively monitored and supervised while being logged into a database.

The management software follows the present distributed architecture standards and is made up of two distinct parts – a real-time data processing module and an historical data processing module. The first ensures operators are alerted in real time to a certain type of cargo via any of the points of detection. In addition, it also allows many other advanced operations via the vehicle and trailer plate data following data mining and cross-checking with other databases, such as technical inspection services (ITV in Spain), assurance companies, blacklists, and so on. The second module is dedicated to processing historical data. The system provides highly reliable data that is extremely useful to feed reports, graphs, movement density maps, etc, all of which eases the decision-making process of the various departments involved.

CHALLENGES TO OVERCOME

From a technical point of view, several challenges had to be resolved that were impacting the success of this implementation. The first aspect that needed to be taken into account was the selection of points to place equipment, such as main access routes and optimal closest points to the borders. A particular problem to overcome was the lack of infrastructure and services necessary for the system operation – structural supporting elements, AC power supply, communications, and so on. DAMP is an energy-saving solution that can be powered by solar energy with compact photovoltaic panes. Moreover, it can take advantage of low-bandwidth communication links, as the process of data extraction takes place within the equipment itself, so it is not compulsory to transfer images. Great efforts have been made by ACISA's engineering and R&D departments, resulting in a highly compact system that simplifies installation and maintenance.

Four key modules make up the main system. The first of these is the high-speed infrared light illuminator, which consists of high-power LEDs capable of delivering consecutive flashes of IR light that are invisible to drivers, thereby enabling the camera to collect details of all vehicles regardless of the light conditions.

The second is a high-performance camera, able to capture images at very high speeds (up to 1,000fps) and process

Aside from the difficulty of capturing three plates in one shot, lighting also poses a challenge them within its FPGA programmable logic devices. This device enables a high-throughput data process by means of parallel algorithms, allowing the equipment to have a similar response to a supercomputer, yet benefiting from a compact size and low cost.

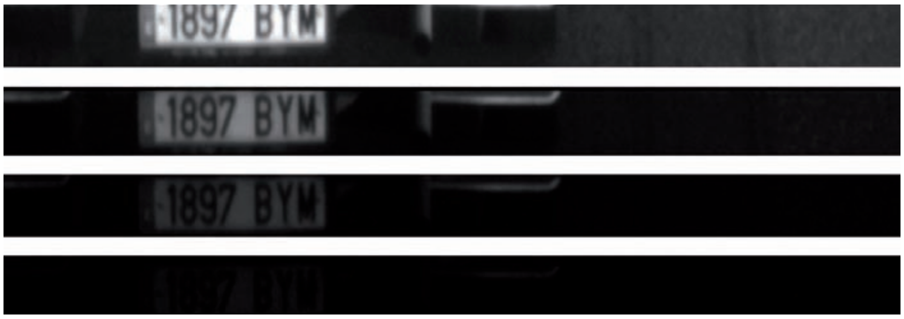
Third is the high-performance embedded computer – a single-board computer with low power consumption that runs the license plate recognition software.

Fourth is the air conditioner. The whole package is assembled in a box with IP65 protection for outdoor use. The air conditioner controls the internal temperature to ensure the correct operation regardless of weather conditions.

ACCURATE IN AN INSTANT

The detection method is the key process, as everything else depends on it. The detection has to be accurate enough to capture the vehicle in a precise instant. Although this can be conducted by means of intrusive systems (loops), DAMP incorporates a complex set of algorithms that enables non-intrusive detection. These work at very high speed inside the camera, capturing and processing up to 1,000 images per second – enough to accurately detect a vehicle regardless of its speed and the environmental conditions. According to ACISA's analysis, this detection method is able to detect vehicles on the road at up to 300km/h at any time of day or night. To improve system performance, the detection system eliminates non-domestic vehicles in such a way that makes the OCR process ignore these vehicles.

Images are cropped to reduce processing time



The DAMP system relies on a set of sophisticated algorithms to perform its detection processes

HIGH-SPEED VEHICLE DETECTION

The system must operate 24 hours a day, 365 days a year, in all kinds of lighting conditions. To do this, it has an infrared lighting device that adapts to different light conditions. A sensor for measuring the ambient light enables an auto-adjust feature in the camera and enforced illumination. This illumination is switched on intelligently, as the system optimizes power consumption to a minimum when solar power is needed. Therefore, the system has two running processes – detection and capture.

When in detection mode, lighting is lowered to the minimum needed by the camera to achieve a sharp enough image to ease accurate detection. For greater efficiency, the lighting system is synchronized with the frame rate to illuminate only when the camera is detecting. With regard to vehicle detection, the system automatically reconfigures to capture mode. This means increased lighting and increasing the resolution of the camera to obtain a valid image for the following processes to succeed. Tests results obtained in real situations have shown a very high dynamic range using this kind of scenario on roads with regular transportation of dangerous goods. The license plates of these kind of trucks (tractor ID, trailer ID, and cargo ID) produce extremely different levels of brightness.

To improve performance, a new technique for capturing images has been developed. This innovative process achieves a maximum contrast and, therefore, a maximum performance of the OCR on all truck license plates. It captures multiple images and processes them at very high speeds (up to 1,000fps), achieving an increased contrast by means of image redundancy. Furthermore, the images are taken with different exposure times to extract all useful information from the scene, regardless of environmental conditions, the orientation of the plates, their reflectivity, and so on. As a result of this development, a substantial increase in system efficiency has been realized.

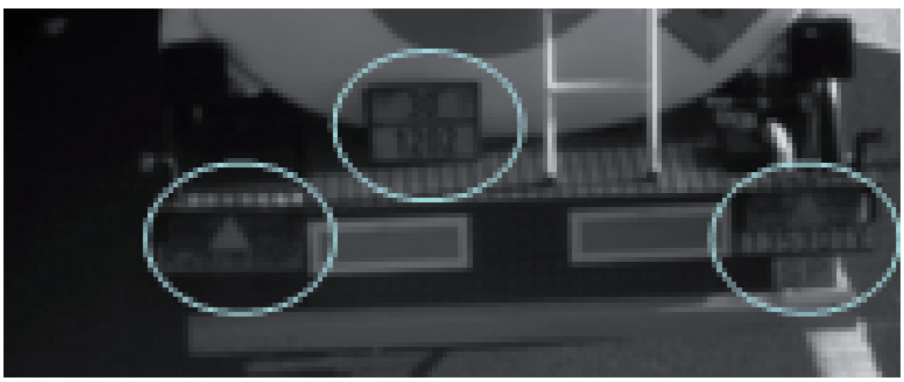
Before data extraction takes place, the images are cropped to highlight the specific area of interest where the ADR label and license plates are located, in doing so reducing processing time for data extraction. Once focused on the area of interest, the first thing for the system to verify is that it is actually confronted with a vehicle containing dangerous goods. If this is actually confirmed, further action can be taken. If not, the acquired image is discarded.

In addition to locating the cargo label, the next procedure is to locate the vehicle's license plate and extract the required data. The final task is to process the data, fulfill a log register with a timestamp, and then position and send it to the control center.

One of the main problems involves misinterpretation of the labels and data defining the goods and the danger level, which can sometimes be a result of dirty plates, and plates that are configurable to several different types of goods.

QUALITY CONTROL

Despite there being a convention that establishes the shape, form factor and layouts of these labels, as well as the codes that identify the goods, conversely no auditing procedure exists to assure label quality. This is why many carriers use interchangeable character plates, allowing them to easily adapt codes while loading the truck. These interchangeable characters – often simple pieces of vinyl stuck on the plate – are of completely arbitrary degrees of reflectivity and are often very difficult to read. This problem has no immediate solution. A single label can include characters with different levels of brightness, or irregularly placed on the label. Although it can be said that this is a problem that affects just a minority of trucks, it does also affect the system's average performance. ■



Before any data can be extracted for processing, the license plates and cargo label must be located

Marcel Massana is projects manager at ACISA and is based in Barcelona, Spain

by Dr Alan Hayes

FORWARD THINKING

FUTURE-PROOFING VIDEO TRANSMISSION FOR TRAFFIC APPLICATIONS

Software scene analysis of CCTV signals is an important tool for surveillance. But the video compression that is necessary can discard valuable scene information: could new forms of transmission networks be the solution?

CCTV is an invaluable tool in managing highway systems. Whether the cameras are used for incident detection and management, for license plate recognition, traffic regulation infringement, obstruction detection or for any of the many other applications, it is clear that the number of cameras at the roadside will continue to increase. The challenge for the transmission system has been how to get the camera signals from the roadside to a point where they can be used or processed. The development of video compression technologies and the resulting reduction of the information bandwidth required to be sent, has made possible the use of standards-based communication systems such as Ethernet or SDH for the transmission, thereby taking advantage of all the benefits associated with these types of network systems.

However, during the compression process, information within the video signal is discarded and cannot later be recovered. With the increasing use of video analytic software, which benefits from the maximum amount of video content information, the process of compressing a video signal just to make it more convenient for the transmission system starts to limit the future usefulness of the video signal delivered to the control room. Therefore, this approach requires the software analysis to be done at the roadside. This in turn can limit the system's capability and functionality to what is available at the time of installation and its ability to take advantage of future advancements in video software development is significantly reduced.

As video processing and scene analysis software gets more sophisticated – both for its intrinsic usefulness and to cope with the ever-increasing number of cameras – the limitations associated with using compressed video transmission threatens to become more and more significant. This in turn limits the future usefulness of the cameras for the management of the highway.

The challenge for the transmission system of the future is not only how to get the camera signals from the roadside to the point where they can be used or processed, but ensuring that vital video footage is not thrown away in the process.

The purpose here is to discuss whether this limiting of the possible future-proofing of the CCTV transmission for ITS can be avoided. This paper also discusses and illustrates how transmission networks now available can provide the benefits of Ethernet and SDH networks while simultaneously carrying uncompressed video signals. This type of transmission network not only allows all the video content to get to the point where it is going to be used or processed in a benign environment, but also ensures that no video scene information is lost in the process – effectively future-proofing the transmission network.

↑ AMG was selected by the Highways Agency in the UK to develop a new network – the Birmingham Digital Ring – that would cope with traffic flows now and in the future in the busy Midlands area

HIGHWAY MANAGEMENT CCTV

The number of cameras used on the roadside is increasing as CCTV becomes a more important tool for the management of a highway network. The cameras are used for a number of applications, including: incident detection and management; vehicle tracking; traffic flow control; and driver information systems.

Historically, the challenge for the transmission system was to get a picture from the camera to the user, who would view the video signal on a monitor. Traditional transmission systems designed specifically for video were in the main point-to-point, limited in transmission distance capabilities, non-resilient and unmanaged. This could be a significant drawback in the case of faults when used with a serious highway management system where information was required 24 hours a day and fast response was paramount. It also made the addition of further cameras

"The use of sophisticated scene analysis software is becoming a valuable tool for the processing of CCTV images"

The Guardian-Lite 3700 fiber-optic transmission was key to the UK Highways Agency's National Roads Telecommunications Services (NRTS) project – a single national approach to the future communications network on England's motorway and trunk network

and the moving of cameras difficult. With the introduction of video compression technologies, the bandwidth required for transmission could be markedly reduced by throwing video scene information away. This allowed the use of standard networks, such as Ethernet or SDH, and resulted in the ability to take advantage of the benefits associated with their capabilities. These benefits include: resilient networks – dual redundancy; drop and insert architectures; virtually unlimited transmission distance; integrated switching and routing; and simultaneous multisite viewing.

VIDEO COMPRESSION

An uncompressed video signal requires ~130Mps of bandwidth from the transmission network. To carry many video signals, compression has to be used for the cost-effective transmission of multiple video signals over an Ethernet or SDH network. Compression can bring the bandwidth requirement down to between 25-64kbps per camera signal, depending on the video quality requirement and the bandwidth available. Various compression standards are used in the CCTV market to fulfill this requirement. The primary standards are MPEG2, MPEG4, MPEG4-10, H263, H264, Wavelet, MJPEG and MJPEG 2000.

The choice of which technology to apply was typically determined not only by when the decision was made, but also by the cost and capabilities of the respective compression algorithms. The capabilities of the compression algorithms have improved with time in terms of reduced bandwidth requirement versus quality. However, backward compatibility has not been maintained. This continues to be a serious problem when selecting a specific technology. Some manufactures try to accommodate future improved technologies by using DSP-based non-algorithm specific

A tolling station in India, which features fiber-optic transmission equipment supplied by AMG

architectures. However, as the technology moves forward, so does the processing power requirement. Hence older DSP-based systems no longer have the capacity to move to the newer algorithms.

Video compression can use compression 'within the frame' as well as compression 'frame-to-frame'. A static, low-content video scene can be sent with a minimum of bandwidth. As the scene content increases with more detail, so the 'within the frame' bandwidth requirement is increased. As the motion within the scene is increased, so the 'frame-to-frame' bandwidth requirement is increased. The bandwidth requirement can be further compromised if low latency compression is required for Pan Tilt Zoom (PTZ) camera type systems. Therefore, choice of algorithm should include specifications for the worst anticipated case in terms of scene detail, activity, latency and resolution. These can then dictate the algorithm and the overall bandwidth requirement of the network.

It is important to note, however, that all these algorithms throw away video information that cannot be recovered. If the Ethernet or SDH networks could accommodate the uncompressed video bandwidth, then this would be the algorithm of choice.

LIMITATIONS OF COMPRESSION

The traditional limitations with the use of video compression associated with viewing quality and response latency are still an issue for some applications. Moreover, other issues are now coming to the fore. The more significant of these is the inability to take advantage of third-party scene analysis software at the time of installation, or more significantly at any time in the future, and the total loss of the system when the network crashes together with the skilled network support resource needed to reinstate and maintain the network. Other problems are the simultaneous multiple agency use of the video each with its own transmission limitations, and the issues associated with the creation of a National Operations Center bringing in signals from many regional control centers. System latency, frozen frames and the susceptibility to hacking are also worrying.

Scene analysis software: The use of sophisticated scene analysis software is becoming a valuable tool for the processing of CCTV images. This is not only because the number of cameras is increasing and the use of human operators becomes impractical, but also because the software capabilities are improving and becoming more successful. These software applications can be developed independently of the transmission system and their usefulness is dependent on the quality of the video scene information available to them.

It is important that the video transmission system does not compromise or limit future use of any such software packages. This effect can currently be demonstrated when using video processing software such as for smoke detection in tunnels. For a system that could raise an alarm within a few seconds of the first appearance of smoke when presented with

The UK's Highways Agency is replacing 33 independently managed police control rooms with seven linked Regional Control Centers to consolidate data for all 5,800 miles of strategic roads nationwide

a uncompressed video stream, this is delayed until virtually the whole scene is filled with smoke when presented with an MPEG4 video stream. It is also demonstrated with the inability of off-the-shelf commercial traffic flow software, even for the most simple functionality, to operate with a compressed video stream reduction – not to mention the reduction in the reliability of some ALPR video processing software when used with compressed video streams. The sophistication of scene analysis software and the requirement for more detail from the video stream is only going to increase in the future. The way to maximize the video scene information available is to avoid compressing the video prior to it being processed, so you need to process it at the camera or transmit it back to the control room in an uncompressed format. With the latter, it is clear that the system can be future-proofed against any incompatibility between any scene analysis software and the method used to transmit the signal to it. The former method is fine if the software has all the requirement capabilities.

Network capabilities: The use of a total IP-based system for the transmission of the video does put demands on the network above and beyond what would normally be required for a relatively 'simple' data network. These demands may only become apparent as the camera count increases. Large systems of more than 150 cameras, but sometimes smaller depending on the type of network, can require network work routing and quality of service protocols that are not available within low-cost 'simple' networks. The result of not having them can lead to a significant amount of network congestion, which, at the minor end of the spectrum, leads to non-access to certain signals, but can also lead to – with an incorrectly configured network – a network crash. This leads on to the other issue of a fully IP network-based system. IP networks do crash, for instance, due to a mistake from an engineer – the larger the system, the more likely this is to occur. Sometimes the cause is unknown. This would mean in the case of a fully IP network-based CCTV transmission system that none of the camera signals would be available. The use of a separate transmission system specifically designed for the collection of video to a distribution point, control room or processing point prior to being put onto an IP network ensures that the video will always be available at that location even in the event of a network crash. Another factor, which is not always taken into account, is the quality of the IP network support resource required to reinstate and maintain the network. This can be an expensive overhead associated with the operation of an IP network.

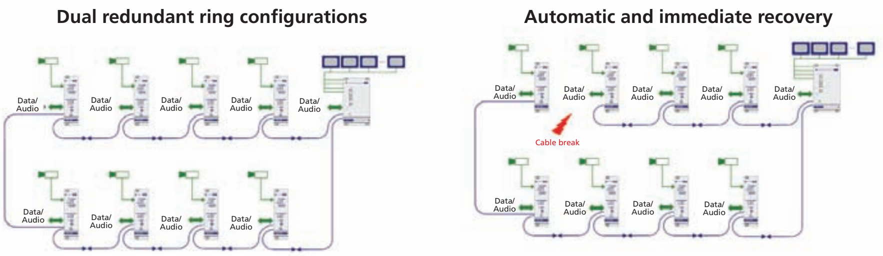
AMG Systems has recently supplied fiber-optic transmissions to road authorities in India

"When future-proofing CCTV transmission for ITS systems, consideration needs to be given to a number of key factors"

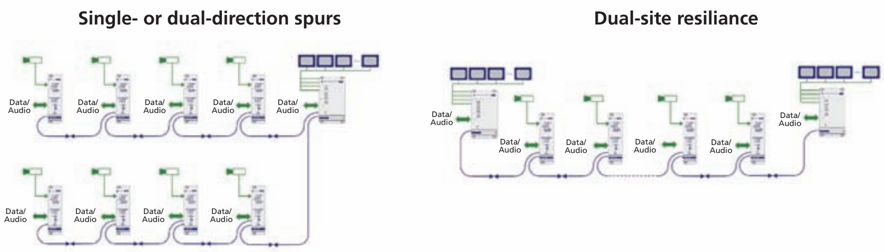
Multiple compression: Another limitation that can be caused by compression results from the requirement of multiple users to simultaneously view the same video signal. This is fine if all the agencies require the same quality of signal. However, if the collection of the video to a distribution point has used compression of one type and the onward routing also requires compression of another, the video signal may have to be brought back to an uncompressed format to do this. Recompression of a previously compressed signal can be problematic. The way to ensure that a video signal can be onward routed to any user from a distribution point is to transmit the signal to the distribution point in an uncompressed format.

Creation of a National Operations Center: An issue for many countries is when a few regional highway CCTV schemes coming back to a number of Regional Control Centers (RCCs) have been put together using compressed video on an IP network and then need to be consolidated to a National Operations Center (NOC). The local schemes will have been developed over time using different technologies and different manufacturers for the video compression. The NOC that will connect to the local CCTV is put together wanting feeds from each RCC using an IP network, again requiring compression of the video. Unless all the RCC schemes use the same manufacturer's product from day one – which is very risky because of the rate of change in compression technology – the video will have to be recompressed to bring it back to the NOC. This results in a video quality issue in the NOC. The preferable alternative is to collect the video to the RCCs uncompressed; in this way any compression technology can be used at this point to onward transmit to the NOC. It also has the benefit of allowing the analytics to be done in the RCC in a controlled environment, rather than at the roadside.

Latency: Latency is the delay between an operator trying to move a camera by, for example, moving a joystick, and the image on the viewing monitor actually moving. A figure of merit used by some agencies suggests that total latencies in excess of 250ms are unacceptable for a user to cope with over extended periods. An uncompressed transmission system does not have any significant latency. The transmission latency associated with the speed of light is 5ms for each kilometer traveled. Therefore, even a 1,000km transmission distance would only result in a 10ms delay to the camera and back, not noticeable in a CCTV system. Note that this latency is present regardless of whether the video is transmitted in an uncompressed format or a compressed format. However, for a compressed video system, if frame-to-frame compression is used, such as within



• IP transmission networks without video compression
• Retains valuable video picture content for future software scene analysis
• Minimal infrastructure requirements – daisy chain, ring or spur architectures



• Increase and move nodes without change to the infrastructure
• Future-proof approach with respect to technology and capacity
• SNMP compatible network management system
• Dual redundant and resilient network architectures
• Up to 64 video on a single optical fiber with Ethernet and 128 low-speed data/audio channels

Figure 1: Typical uncompressed video collection architectures

the MPEG standards, then the video has to be buffered at the encoder and at the decoder. This on top of possible network delays results in a latency target of 250ms being difficult to achieve in a real-life incident scenario, when the video image has the most information content within the frame and the most activity frame-to-frame. This scenario, when the video is needed most, puts the most demands on the video compression. A latency figure that is easy to achieve during ideal image conditions will always increase for the same video quality and same transmission bandwidth.

Frozen frames: A frozen frame is when the display shows a video image that suddenly freezes in time and does not update. The display can then mislead the operator, as it is not providing a current image from the camera. As a compressed video system has to buffer and store complete image frames, there is the possibility, albeit as a fault condition, that this frame store no longer becomes updated as it continues to put out the same frame all the time. In safety-critical applications, this can result in a 'fail to danger' situation. In uncompressed video transmission, there is no frame store, so it will never be able to mislead the operator by displaying an 'out of date' image – even in a fault condition.

Resilience to hacking: The only secure way to prevent hacking into an IP-based network is to prevent access to it. Having got access, ways of hacking into them are readily available on the internet. Here there are illustrations of not only how to access the network, but also how to 'jam' video streams, freeze video streams and even replace video streams. This issue is very worrying for real security environments. Taking the IP node to remote roadside locations allows for relatively easy access to the network. Using an uncompressed video transmission network to collect the video from the remote roadside locations and bring it back to a controlled environment prevents easy access to any IP network. The processing can take place where it can be processed or compressed and put onto an IP-based network.

UNCOMPRESSED NETWORKS

The range of AMG transmission equipment has been designed to replicate the benefits associated with the standard network capabilities, without compromising the video. The AMG transmission does not compress the video and is immune from the limitations listed above.

For the video collection, it is possible to collect channels of video and distribute Ethernet, low-speed data and audio signals on a single unit located at the roadside. These can be connected on a dual-redundant ring architecture with a single fiber daisy-chaining between each unit. The benefits of this approach are the minimal use of fiber, ease of camera addition (or other roadside service), the ability to drop off signals at multiple locations and the effectively unlimited transmission distance. The dual-redundant capability ensures that the operation is maintained in the case of a fiber break or in the case of loss of power at a unit. AMG3700 series units are the equipment to be used for all the collection of all the cameras (approximately 1,400) on the UK highways within the NRTS project.

The system can be fully managed via industry-standard SNMP or via a proprietary GUI to highlight any faults in the fiber, while full operation is maintained. It also monitors video availability and loss of power.

When it comes to future-proofing CCTV transmission for ITS systems, it is clear that careful consideration needs to be given to a number of key factors. This paper has highlighted the problems relating to the use of compressed video alongside scene analysis software and also the backward compatibility and inconsistency issues with the various compression standards. We also know that from an operational point of view, there is trade-off between response latency and video quality, which can affect the manageability of CCTV systems.

Products do exist that have all the benefits of standards-based networks without the compromise associated with video compression. It is clear that any organization planning the development of a new highway surveillance system needs to give due consideration to the method chosen for transportation of the video signal. The wrong choice made at the outset could seriously limit the effectiveness of the system as well as restrict the ability of future upgrades to take advantage of the expected advances in the capabilities of important tools such as scene analysis software. ■

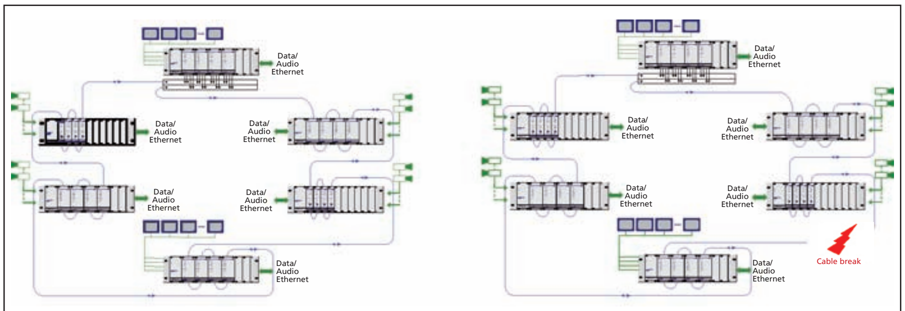


Figure 2: Typical uncompressed video distribution architecture

Dr Alan Hayes is the founder and managing director of AMG Systems and is based at the company's headquarters in Bedfordshire, UK

by Toshi Wada

IN THE DARK?

ISSUES FACING NIGHT-TIME SURVEILLANCE

Most users conducting traffic surveillance understand the importance of having a camera that is able to cope with varying conditions of light. But using the right lens also needs close attention, as it is crucial to a system's success

Even in low light or in dark situations, surveillance cameras are expected to perform the same as they do in daylight. With the help of IR illumination, it is possible for surveillance cameras to work 24/7 to capture the desired images. To work continuously in bright light and in dark conditions, a Day/Night (D/N) camera is a must. A D/N camera changes in color to black and white when switching from day to night, and vice versa when switching from night to day. These types of cameras are abundant in traffic applications, and are especially popular for ALPR. One issue that is often less understood by the users of these cameras is that a lens tailored for D/N cameras is necessary in order to avoid focusing problems.

ON THE RIGHT WAVELENGTH

Visible light and near-IR light have different wavelengths. Visible light (i.e. what a human can see) is from 400-700nm. Near-IR light has a wavelength from 700-1,000nm, which is invisible to the human eye but can be caught by a D/N camera. As a result of this wavelength difference, a focus shift occurs, and the lens must be refocused when the D/N camera switches from day to night, or vice versa. In license plate recognition applications, this focus shift problem is critical because it can lead to misreading numbers for other similar letters, especially '1' and 'l' and '0' and 'O'.

To prevent this problem, a D/N lens (or IR corrective lens) is necessary. IR corrective lenses can compensate for the wavelength difference and maintain the correct focus position, even when switching from day to night. IR corrective lenses usually have a special coating to cope with this problem, and some manufacturers also employ a combination of special glass materials – such as low dispersion glasses – to achieve better transmission and contrast. Most of the IR corrective lenses on the market also possess a different design inside the lens barrel when compared to conventional lenses (although the outlook is similar).

RIGHT TOOL FOR THE JOB

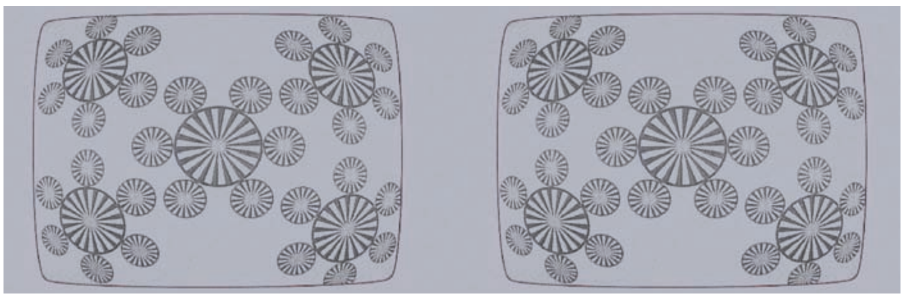
Once potential users get to grips with why a specialized lens is necessary, the next question they must ask is, 'which IR corrective lens should I use?' Choosing the correct lens is an important process to ensure the application works effectively. The first step is to decide the focal length (represented by a small f) to obtain the correct angle of view. If you want a wide angle that can cover a broad area, choose a short focal length (such as f/2.8mm). If you need a tele angle, choose a long focal length to cover a certain distance (such as f/50 or 100mm). ALPR cameras are usually installed some distance away from vehicles, so for these applications a telephoto lens is needed. And to change the angle of view occasionally, a varifocal lens is highly recommended. Also, as the light environment changes periodically, a DC iris lens is essential for traffic applications so that the lens can adjust the amount of light to maintain the utmost position of the iris.

Related to the iris selection is the need to choose a lens that has enough brightness. The brightness of the lens is represented by a large F, and the smaller the number the brighter the lens will be. For instance, F/1.0 is twice the brightness of F/1.4, so if you use a F/1.4 lens in a 1.0 lux camera, you can make the minimum lux to 0.5 lux while using a F/1.0 lens.

Another concern that must be addressed is to ensure there is enough transmission to the wavelength. In traffic applications, the most used wavelength should be 850nm, and most IR corrective lenses are designed to match this wavelength. However, if the application uses longer wavelengths, such as 950nm or 1,000nm, an IR corrective lens that has enough transmission among longer wavelengths is necessary.

In the CCTV and traffic markets, there are numerous types of lenses, several of which have the same specifications (the same focal length, F number, IR correction, etc). Although the specifications are identical, the picture quality, sensitivity and contrast differ greatly. It is important to remember that the lens can maximize camera performance, but it also has the potential to minimize performance. For a 540TVL high-resolution camera, a good lens that can cope with this resolution is not just the ideal – it is essential. In the future, megapixel technology will be delivered to the traffic market, and manufacturers are already hard at work developing lenses to satisfy this growing market. ■

Toshi Wada is in charge of CCTV sales and marketing at Tamron Europe and is based at the company's facilities in Germany



↑ Images with IR light (wavelength of 850nm, with a floodlight), which is invisible to the human eye

by Stijn Vandebuerie

GLOBAL TREND

HOW AUTOMATIC INCIDENT DETECTION IS HELPING TO CONQUER CONGESTION

The huge popularity of AID is testament to its high quality. The systems make journeys smoother and safer, while assisting traffic managers in monitoring roads. Although a well-proven technology, the best may be yet to come

Freeway incidents cause injury, traffic congestion, increased environmental pollution, and cost millions of dollars every year in delay and damage. When there is an incident, minimizing the response time – the time from when an incident occurs to the time that emergency crews arrive on the scene – is crucial. A fast response time increases the survival rate of those with serious injuries and minimizes traffic jams and potential secondary incidents. Current video detection systems set the standard in quick detection and are seen today as a necessary tool for intelligent traffic management. Automatic Incident Detection (AID) technology, however, is proving its effectiveness day in, day out, all around the globe.

In the field of CCTV systems with AID, a great deal has changed over the past couple of decades, although many more changes are yet to come. Various technological evolutions have led to products that 20 years ago would have sounded like science fiction. Not only has video detection matured tremendously, but the supporting technologies such as video networks, cameras and compression techniques have also helped a great deal in developing intelligent CCTV systems to what they are today – a widely accepted and indispensable tool for traffic operators. In many situations, one operator has to monitor several hundred cameras installed throughout several sites. To be able to detect incidents on all cameras simultaneously, an AID system is a prerequisite.

Clockwise from top left: detecting stopped vehicles and pedestrians on the hard shoulder; camera deployment in Malaysia; detection on the A73 in Erlangen, Germany; Traficon's VIP-T board

Traficon's VIP-T range of products is being deployed for AID in countries around the world

Traffic applications using AID are deployed all around the world. The systems alert traffic control centers to a wide range of events, such as stalled vehicles, crashes, and stopped traffic. The detection is conducted through real-time analysis of video cameras. By monitoring these devices using artificial intelligence, stopped vehicles, slow-moving traffic and crashes can be quickly identified. When an incident occurs, the operator can see what has happened, how many vehicles are involved, if there are casualties, how the general traffic situation is at that point, and so on. This combination of data and images facilitates verification of alarms and the swift detection leads to the fast intervention of rescue teams. This goes a long way in helping avoid secondary accidents and the closure of lanes. With early notification, authorities can respond quickly to events, allowing traffic to return to normal sooner.

No other detection system reacts faster than video detection. Fast response time is however one thing – reliable alerting is another. A workable detection system is one that provides exact and correct information in a very short amount of time.

THE PALM PROJECT

In 2006, Traficon was selected to provide incident detection and traffic data collection along the main arterial road of the world's first artificial island – the iconic Palm Jumeirah in Dubai. The technology included 18 detection units and the contract was won alongside Siemens Building Technology.

Traficon also won the contract for the Palm Jumeirah tunnel (26 detection units) in cooperation with the Japanese Kinden Corp. "The Palm Jumeirah vehicular tunnel is, in fact, the third tunnel to be equipped with Traficon's incident detection system," explains field project manager Steven Van Caet. "The two others are the airport tunnel and Al Shindagha Tunnel, which is part of the 'Falcon' project."

The Palm project is famously ambitious. The island anticipates 20,000 visitors a day, to be transported from the mainland via the 1.4km, six-lane highway. Key components of the system include traffic incident detection and flow monitoring, traffic data collection and pedestrian detection, an IP-addressable board for communication, a software platform for collection, and storage of traffic events in a relational database.

Traficon's T-Port software platform for the collection and storage of data and video sequences serves as the operator's interface for continuous and real-time monitoring. It comes equipped with a powerful event alerting and reporting function. Data and events are provided to the server and the system is integrated and networked into the larger TMS.

TRENDS IN AID

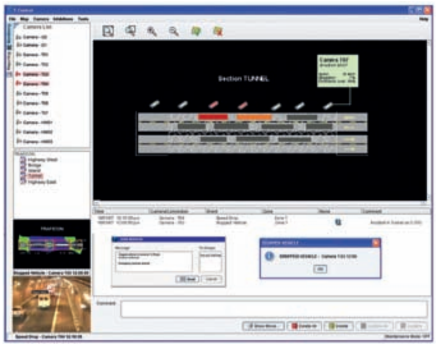
It is clear that, in the future, intelligent CCTV systems will continue to mature and that increasingly complicated detection tasks will have to be carried out. Many applications are very interesting, but are still in the research phase and are far from being ready to be brought to market.

Depending on customer demand and the maturity of the technology, most of these applications will eventually find their way to the market. A new AID application that is now receiving more and more attention is hard shoulder monitoring.

As traffic congestion increasingly affects our economy, quality of life and environment, highway agencies need to find new solutions. As we know, simply building new roads does not cut congestion. A solution that is being viewed as an efficient, quick and reasonably priced way to substantially improve the congestion problem is using the hard shoulder as a traffic lane during peak hours, which reduces accidents, travel time and pollution.

To implement this solution, however, a monitoring system capable of detecting obstructions and incidents – breakdowns, reversing vehicles, pedestrians and debris – must be put in place. The operators situated in the regional control center have to be 100% sure that the hard shoulder is clear of any obstructions, and this is where outdoor AID comes in.

Municipalities are also launching a variety of campaigns to promote public transport and convince people to abandon their cars at home and opt for the bus. The rationale is twofold: using public transport leads to less traffic, and it is also good for



Alerts are presented in a user-friendly format that is thorough and comprehensible in a hurry

"Automatic Incident Detection can help manage traffic, prevent secondary accidents, and save lives"

the environment. However, until now, few of these campaigns have had much impact, and people continue to prefer to go to work in their car. The main problem here is that they do not see 'direct' benefits from using public transport. But what if you could get to work faster by taking the bus instead of the car? In Grenoble, France, a new solution that involves using the hard shoulder as a privileged lane for public transport is being tested. Buses simply avoid traffic queues by driving on the hard shoulder, thereby vastly improving their punctuality and reliability. Will this system be able to change drivers' mindsets and lead to greater use of public transport? The results are eagerly awaited.

The aim of schemes such as this is to give priority to certain road users during prescribed hours: in this instance, the emergency lane must be kept clear for buses during rush-hour traffic. To do this, CCTV cameras are installed for remote monitoring, while the AID system assists operators in detecting obstructions by continuously analyzing the camera pictures to look for objects/vehicles that stop in the detection zones. The system alerts operators to any event that it determines warrants further manual checking. It also allows the police to warn all following buses that there is an obstruction ahead, and to dispatch rescue services to clear the lane expeditiously.

Depending on the stretch of road to be monitored, the AID system comprises a number of static cameras, each typically 12m above the bus lane. Each camera is capable of detecting stopped vehicles over a distance of approximately 180m (the actual camera separation varies due to bridges and curves obscuring the hard shoulder). Video is fed over the existing fiber network to the control room, where video processing and alarm generation take place.

The system monitors each camera continuously, supplementing the operator's eye to detect any abnormal situations. This hard shoulder safety system is capable of detecting stopped vehicles within 10 seconds of their occurrence. Based on the pre- and post-event images that are captured, an operator can determine the nature of the incident and enable a timely and appropriate response. By quickly alerting the controlling authority, AID can help manage traffic, prevent secondary accidents, and save lives.

THE A73 PROJECT

Since mid-2008, drivers have been able to use the hard shoulder on the A73 in Germany. The A73 section at Erlangen is the main commuter feeder for the Nürnberg and Erlangen region, and the shoulder lane is opened for traffic during peak hours. Between Möhrendorf and Erlangen-Bruck, an extra lane becomes available to provide smoother and safer journeys. With the help of a Traficon AID system, the operator is able to efficiently control this 9km-long section.

The VIP-T module detects all incidents within 10 seconds of them occurring. Pre- and post-incident image sequences are generated automatically, while analog video is digitally encoded and available in the control center as MPEG-4 video stream.

The VIP-T boards are mounted at route stations. The video images from the cameras serve as the input for VIP-T to generate relevant incident detection information. Communication of events and alarms to the route station go via the VIP-T I/O Expansion module. VIP-T also compresses the analog video signals and provides real-time streaming video. All events, alarms and images are transmitted to the subcenter at Erlangen to the T-Control server. At the central control room in Fischbach (30km from Erlangen), the T-Control client is installed, which provides a graphical user interface for real-time monitoring to the operator. Drivers are informed of updates via VMS and lane-change signals.

With new AID projects on the horizon all over the world – including in France, Norway, Chile, Croatia, Australia, China and Saudi Arabia – Traficon thrives on rising to challenges. "We are continuously investing in manpower and technology in order to stay ahead of what the traffic market will demand," concludes Traficon's managing director Jo Versavel. "Traffic problems are a global phenomenon, and we are ready to tackle these by focusing on new applications and advanced algorithms." ■

Stijn Vandebuerie is Traficon's marketing and communications manager by Mike Post

LIFE BEHIND THE LENS

HOW ADDED INTELLIGENCE IS PUTTING THE 'SMART' BACK INTO TRAFFIC CAMERAS

Traffic control devices are increasingly sophisticated pieces of equipment, as users request more and more advanced detection capabilities. Luckily for them, technical experts are heeding these demands and pushing for progress

Living in a time when technology advances at a meteoric rate, keeping informed of critical changes is becoming continually more difficult. Read any newspaper or technology magazine and you will discover that computers, cameras, telephones, music players and vehicles are newer, faster, easier to use and have improved features. The same also applies to traffic control devices. Each year, enhancements to traffic control equipment yield more efficient transportation management systems.

VersiCam offers a cost-effective alternative to the inductive loop and other presence-detection sensor technologies

Traffic signal controller standards vary by country, region, province or state. In addition, each agency may require specific variations of standards to meet local needs. Control cabinet standards for North America alone, for instance, include Type 170 and 2070, ATC, NEMA TS1, NEMA TS2 Type 1, and NEMA TS2 Type 2. All standards specify interface protocols for traffic control devices.

The Santa Ana, California-based company Iteris boasts a range of flexible and value-driven solutions to meet these standards, among which is the new Edge2 series processor. Edge2 operates with either 12V DC or 24V DC power and provides controller inputs designed specifically to meet all these standards. NEMA TS2 defines the interface to the controller, conflict monitor, signal bus and detection devices using a communication interface identified as a Bus Interface Unit (BIU). Detector devices are mounted in racks and each rack of eight detector slots provides 16 controller inputs and requires one BIU to interface with the controller. The Edge2 processors communicate with the BIU using the NEMA TS2 standard protocol.

GOING THE EXTRA MILE

The need to collect more information from roads and highways is pushing the demand for more detection capabilities. End users are requesting lane-by-lane counts, turning movement counts, system inputs, red light violation counts, and even bicycle detection and counts. As the number of detectors per location increases, the size of the control cabinets and the equipment needed to house these detectors may increase.

A space- and cost-saving design was created for the TS2 interface module, known as the TS2-IM, which maximizes the use of existing cabinets and minimizes future expense by limiting the detection rack capacity needed to meet large detection requirements. The TS2-IM fits into the BIU space in the cabinet, eliminating the need for a separate BIU, and communicates with Edge2 series processors, providing up to 16 cameras of detection and up to 384 detectors. The value to the user is 64 controller inputs from one eight-slot rack, which negates the need for four BIU units and three additional detection racks. To increase flexibility, the TS2-IM also communicates with existing detection devices already present in the rack.

Video detection technology provides exceptional directional vehicle detection schemes. Iteris Vantage systems provide the ability to determine the direction that a vehicle is traveling and decide whether to detect a vehicle based not only on its presence but also the direction of travel. In doing so, video detection can ignore vehicles

"The impetus to relieve traffic congestion will drive the need for better, more advanced detection systems"

The Vantage Edge2 processor is a key component in the family of Vantage video detection solutions

eAccess sends high-quality MPEG-2 streaming video over IP-based networks

that cross turning lanes from a different approach, or vehicles going in a direction that the user is not monitoring.

Iteris also uses its directional capability to accurately count vehicles. A detection zone drawn far away from the camera lens will have a more difficult time counting vehicles. It is often difficult to count vehicles at the stop bar due to vehicles that are stacked-up and also slow acceleration transitions. Iteris uses directional capability to count only vehicles traveling in the desired direction of travel from the optimal location close to or in front of the stop bar. Users can also choose to detect only during the green phase, or count only when the approach is 'not green' (clearance plus red intervals).

Video detection is a cost-effective solution for intersections with two lanes or more and Iteris has developed a low-cost, low-feature product just for the job. VersiCam has a small footprint and just enough detection capability to detect even the smallest intersections economically, while the interface to the controller cabinet meets the requirements of NEMA TS1, NEMA TS2, 170, 2070, as well as ATC.

EXTRA VALUE SERVICE

But the value provided by video detection does not stop with detecting vehicles. It provides two useful byproducts: the capability to remotely manage the detection zones; and the ability to view the video image. A series of Iteris products allow end users to manage vehicle detection and view video from a centralized traffic control center or other remote locations over several communication systems. The Access module acts as a central switch for several Edge2 processors and has a built-in dial-up modem and an EIA232 interface for detection management and viewing snapshot video. The eAccess and the new EdgeConnect module act as a switch for up to four Edge2 processors and have built-in IP connectivity. eAccess and EdgeConnect can interface with fiber, telephone, wireless and DSL communication networks. EdgeConnect – which can manage up to 16 cameras – streams up to 16 live video images and provides access for detectors and intersection programming.

To optimize the use of the video returned via the communication infrastructure, a good video image is required from the camera. As part of an ongoing effort to achieve a complete solution, Iteris continues to improve its cameras. Enhancements include implementation of a very high-quality color imager, which helps to provide a crisp and clear color image. An efficient heater even decreases power consumption while keeping the camera free of ice or condensation. Another recent addition is a simple design for power, image, zoom and focus of the camera. Iteris utilizes a connection design using simple electrical tools: cables can be pulled and installed using standard tools – no custom tools or pre-made cables are required.

The industry is changing and the impetus to relieve traffic congestion will drive the need for better, more advanced detection systems. The need to not only 'see' roadway conditions but also to quickly and easily manage those systems to improve traffic flow will become standard. Video detection technology has come a long way since its inception and as systems continue to improve, further increases in terms of cost-effectiveness will be realized, therefore expanding the scope within the intelligent traffic management market. ■

The VersiCam from Iteris offers remote zoom and focus functions to simplify setup and includes a high-sensitivity color imager (CCD) to ensure accurate vehicle detection in all lighting conditions

Mike Post is national sales manager for Iteris and has 24 years' experience in providing, designing and integrating traffic control solutions

by Juha Leskinen & Matti Tervaskanto

LASER GUIDANCE

SMART ADVICE ON TRAFFIC MEASUREMENT

The versatility of fast laser measurement technology is not always fully appreciated. Offering an unrivaled flexibility – especially when compared with traditional methods – lasers will play a key role in the future of traffic control

One single measurement technology rarely offers perfect solutions for a variety of applications. Each will have its own special requirements and therefore demands optimization to fulfill the needs of the measurement task in question. This is not, however, the case *per se*: sometimes a single technology is able to offer competitive solutions for several different measurement duties, and one such example is laser technology.

There are a number of different types of measurement in the field of traffic control – and up to 20 different roles should easily spring to mind. But due to its versatility, laser technology offers the capability to measure many variables with a single short laser pulse or a burst of pulses. Among such measurements are accurate triggering of vehicle, speed measurement, profile measurement, over-height measurement, distance between vehicles (for tailgating detection), vehicle counting, and a variety of intersection control measurements.

DISTANCE MEASUREMENT

Laser technology today has myriad applications and is an ideal technology for developing advanced and small measurement units for calculating geometrical variables such as distances. The technology uses narrow laser pulses sent to an object from a laser source, which is reflected back to the receiver, and more commonly known as pulsed time-of-flight (TOF) measurement. A good way to understand the complexity of the technology is to consider the time that the laser pulse takes to travel to the target and back again. Laser moves at the speed of light at a speed of approximately 300,000km/sec. To reach a single pulse resolution of about 5mm means measurement of pulse flight time with an accuracy of 10 picoseconds [a picosecond is one trillionth of a second].

Although a highly complex technology, laser has nevertheless been well mastered by a handful of companies around the world, and is used in many demanding applications that require fast distance measurement to poorly reflecting surfaces. In traffic control, the measurement is used for many applications that require easy installation and non-intrusive measurement of traffic.

A portable speed measurement unit utilizing a more accurate and reliable laser technology can calculate the speed of vehicles over multiple lanes

One of the world's leading beacons for the research of this technology is the University of Oulu in Finland, at which the technology has been studied since the 1970s and has been the subject of a number of doctoral theses. Based on these studies and resulting research and development, the technology has been adapted to many products used in industrial and traffic applications. Indeed, the Finnish company Noptel utilizes it in many of its traffic control sensors – products that are in use across all continents in various deployments.

APPLICATIONS

One of the best features of pulsed TOF technology is the ability to accurately detect and measure the distance to practically any object without using a cooperative target, such as a reflector (one form of target can be a vehicle, for example). One basic problem of obtaining a sharp picture from a license plate is to get the timing right. In a poorly lit environment, the distance to the object must be accurate enough, regardless of the speed of the vehicle. Sometimes a distance window of 10-20cm is required, although often 20-30cm is enough. But what is the most reliable way to catch the vehicle in that position? One way is with a pulsed laser. With a pulsing rate of 4kHz, the unit can measure distance to the object driving 200km/h (56m/sec) with an accuracy of less than 1.5cm. Taking into account errors coming from the varying shapes of the vehicle and using multiple pulses for the detection to have better reliability, the triggering accuracy is still around 10cm.

In license plate recognition, there are two basic principles; take the photo from the front of the vehicle or the rear. In both cases, a single laser unit can detect the vehicle with the same level of accuracy. When adding a little more intelligence to the measurement and measuring at the same level as the vehicles, a single unit can measure several lanes by analyzing the triggering distance from the object.

Today, it is quite easy to add further intelligence – even into small sensors – due to increased performance and supply of processor technology. Combining this intelligence with advanced laser technology can make the sensors useful for many difficult measurement tasks, and makes the laser technology competitive with loops and other traditional technologies.

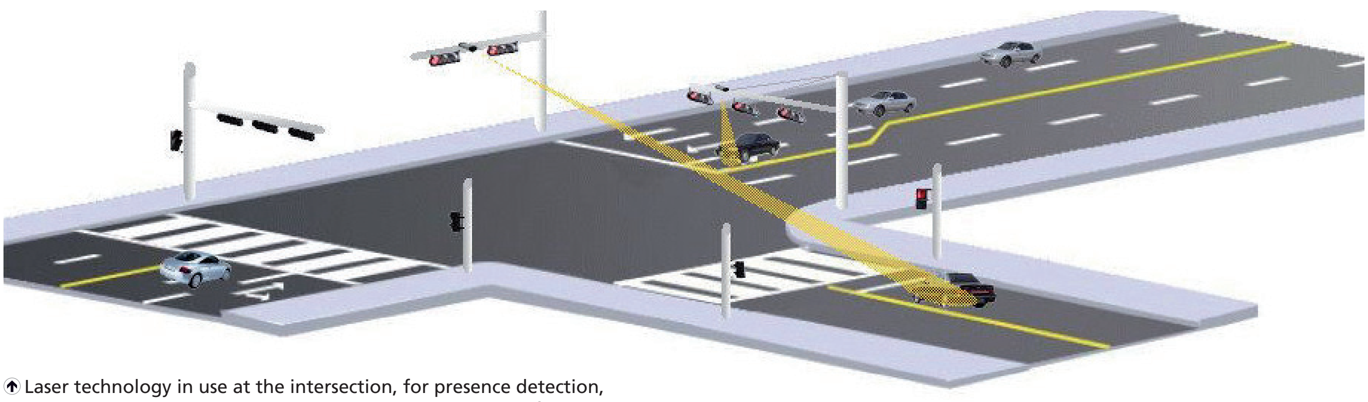
Another widely used measurement in traffic control is the speed of vehicles. Main roads, streets, intersections, queues, and multiple lanes can all be controlled by laser.

There are four main types of measurement setups and installations: vehicle installation, portable measurement stations from the tripod, fixed measurement systems on the pole or gantry, and light port-type measurements. Laser can be utilized in all of these setups.

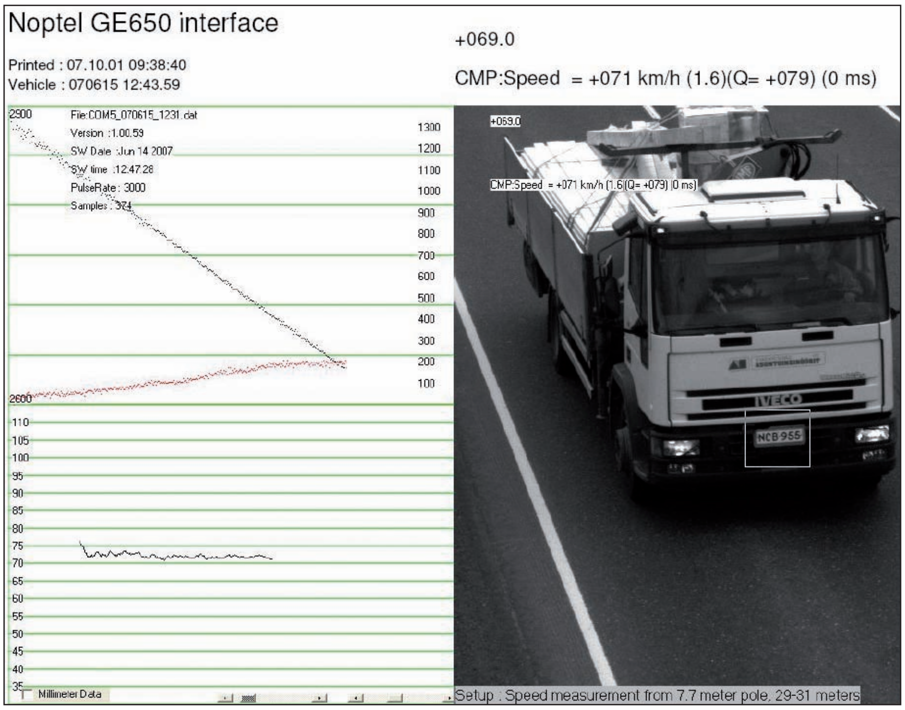
There are several measurement principles and technologies within the field of laser technology, one of which is based on fast-pulsed TOF measurement. With this technology, the speed is measured based on a number of successive distance measurements from the object. When the distance measurement is fast, for instance 2-4kHz, the unit takes 200-400 measurements in only 0.1 seconds, which is more than enough to calculate accurate speed value.

The time delay of 0.1 seconds is not fast enough to trigger the camera in an optimal place for taking a sharp picture in the event of speeding. For that purpose, a laser unit can calculate a quick speed value using 20-40 measurements. In such a scenario, the unit can give a triggering pulse to a camera 10ms after having detected the vehicle. If a vehicle is driving at 100km/h, the triggering pulse comes 30cm after the detection point. The same values and detection of vehicle can be conducted for both approaching and departing vehicles.

"Today, it is quite easy to add further intelligence – even into small sensors – due to increased performance and supply of processor technology"



↑ Laser technology in use at the intersection, for presence detection, controlling lights, red light violation detection, and speed enforcement



Typical raw measurement values taken from a laser sensor during an enforcement application

The speed value comes in a fraction of a second

Accurate triggering ensures a sharp picture

Depending on the installation geometry and measuring setup, accuracy can even be 1-2%, but is typically 2-5% of the speed. As a distance measurement unit will measure distances at high speed, it will also collect distance information from the shape of the vehicle. That information can be used in accordance with the speed information to calculate the height and length of the vehicle and in this way can also be used to measure the distance between the vehicles.

PROFILE MEASUREMENT

Another main application is to measure vehicle profiles, a principle that allows the measurement of vehicle types, shapes and sizes, and allows the use of that information for accurate height and length measurement, as well as vehicle classification. The accuracy is typically less than 1cm, which provides quite an accurate vehicle profile. What users then want to do with that information depends on their needs. Although today the processing capacity of even small embedded controllers is rather high, it is possible, for example, to leave that job to the measurement unit and take out the ready-analyzed classification information.

Another interesting measurement task is the control of overheight vehicles entering a tunnel or other area with limited access. There are two basic solutions and also two basic problems involved. First, the detection device must detect even small parts of the overheight vehicle. Second, those parts must be detected at all speeds. The two solutions are to measure it vertically from the top of the lane, or horizontally from the side of the lane. When measuring from the side, on occasions when it is possible to install the cooperative part on the opposite side of the road, a light port can be used. If a more advanced solution is required, a high-speed laser distance measurement unit can measure without the cooperative part, and can even automatically select the vehicles on separate lanes. If a measurement speed of 6kHz is used, the smallest part to detect at 100km/h speed is 0.5cm. This gives a practical minimum size for the detected pole or part of about 2cm. When measuring from the side of the road, the installation must be made to the selected maximum height. In this case, the profile of the vehicle cannot be measured, but the measurement unit will detect all overheight parts.

If the profile of the vehicle is vital, it should be measured from the top. In this case, a potential issue is that the laser beam is pointing to a small area in the lane and not detecting all the highest parts of the vehicle. Of course, these two setups can be combined to measure both the type of the vehicle and the exceeding of the height limit.

INTERSECTION CONTROL

In the intersection control field, several tasks can be performed: control of lights, vehicle presence detection, red light violation control, and also speed measurement. One widely identified problem with using inductive loops for control of lights – especially in large cities – is that vehicles do not get any turning light in crowded traffic. This is due to the fact that the loops detect the vehicle when they arrive but can easily forget them. Laser distance measurement works differently: as the measurement is continuous, it detects the vehicle continuously when it is waiting for the lights to change. At problematic intersections, this principle makes the traffic flow smoother by always giving the green light for vehicles that are waiting.

TRAFFIC INFORMATION SYSTEMS

A final example of what laser technology can offer the traffic market relates to real-time information, which can help make traffic flow smoother. The requirement for such information is constantly increasing and even if it is not used to directly control the traffic, it can be disseminated to drivers to help them make educated choices when selecting an optimal route.

ITS is a catchphrase that forms the subject of many projects targeted to making driving a pleasant experience. To achieve that goal, not only are advanced systems needed to bring information to drivers, but a comprehensive gathering of information from different sectors of traffic is also required. For that task, laser technology can play a big role, by supplying information such as vehicle speed, type, size, length, height, count, flow rate, gap between vehicles, occupancy, and classification.

Laser cannot perform everything, but it is a great source of information for many traffic control and information systems. In a proper and innovative design, the same basic measurement and technology can serve in many different measurement tasks, meaning the same unit can be produced in large quantities and tested in different environments to make both the measurement and the device reliable. ■

Juha Leskinen is an electronic engineer and project manager at Noptel. His specialty is the design of hardware and software for highly demanding industrial and traffic control applications, using pulsed time-of-flight measurement technology. Matti Tervaskanto is responsible for traffic control systems marketing at Noptel and is based at the Finland HQ

2009/2010 Eve

MARCH 2009

MARCH 3-5
MUNICH SATELLITE NAVIGATION SUMMIT
Munich, Germany
The Munich Satellite Navigation Summit has been established as the European and International conference with global impact, featuring invited high-ranking worldwide speakers from industry, science and governments dealing with the directions of satellite navigation now and in the future.
www.munich-satellite-navigation-summit.org

MARCH 3-8
CEBIT
Hannover, Germany
CeBIT is the world's largest trade fair showcasing digital IT and telecommunications solutions. CeBIT offers an international platform for comparing notes on current industry trends, networking, and product presentations.
www.cebit.de

MARCH 11-12
INCIDENT MANAGEMENT CONFERENCE
Niagara Falls, Ontario & New York
Incident Management in the Fast Lane offers solutions to today's transportation and emergency response leaders by delivering a series of major incident presentations, training sessions and peer networking opportunities.
www.nittec.org/imconference09/

MARCH 15-18
TOLL ROAD SUMMIT OF AUSTRALIA, NEW ZEALAND & THE ASIA PACIFIC RIM
Sydney, Australia
This is IBTTA's first event in Australia, and will tap into the growth of tolling in Australia, New Zealand and other in the Asia Pacific countries. A major focus will be the Australian experience in toll concessions and operations, including the political, regulatory, public affairs and customer service aspects of startup and mature facilities.
www.ibtta.org

MARCH 18-20
INTERTRAFFIC CHINA
Shanghai, China
This offers an established and prominent platform for the traffic and transport industry. After two successful shows in Beijing, the 2009 event will take place in Shanghai to ensure the nationwide profile of the event is further enhanced. Exhibitors from around the world will present the latest innovations.
www.intertraffic.com

MARCH 22-25
ITE 2009 CONFERENCE AND EXHIBIT
Arizona, USA
Join more than 1,000 transportation professionals as they exchange ideas on operations. Highlights include two plenary sessions by well-renowned transportation experts and numerous technical sessions.
www.ite.org

MARCH 24-25
5TH ITS SOUTH AFRICA INTERNATIONAL CONFERENCE & EXHIBITION
Johannesburg, South Africa
The theme for the 5th biennial ITS Conference and Exhibition is "Moving People Smartly". It will bring together local and international experts and systems, while products and services will be on show at the exhibition.
www.itssa.org

MARCH 24-25
6th INTERNATIONAL WORKSHOP ON ITS
Hamburg, Germany
This workshop provides an outstanding forum for experts in the fields of transportation, communication and sensor technologies. It gives an excellent opportunity to present latest research results and discuss technical experiences as well as new ideas.
http://wit.tu-harburg.de

MARCH 26
17TH INTERNATIONAL SYMPOSIUM ON ELECTRONICS IN TRANSPORT
Ljubljana, Slovenia
This event promotes the strategic objective of integrating and strengthening the European research areas in Slovenia as well as in the new EU member states, accession states, and nearby countries in the field of sustainable transport.
www.ezs-zveza.si/isep2009

APRIL 2009

APRIL 21-23
TRAFFEX 2009
Birmingham, UK
A visit to Traffex is the perfect opportunity to meet the entire industry all under one roof and be able to obtain expert advice, research and compare the latest products and services from world-class companies. Traffex 2009 will see the launch of the Street Design exhibition, a new event that will showcase the latest products and services used for all aspects of creating and planning the built urban environment.
www.traffex.com

MAY 2009

MAY 10-13
ITS CANADA ANNUAL CONFERENCE AND GENERAL MEETING
Edmonton, Canada
The theme of the Conference is "ITS – Transportation Solutions for Growth and Sustainability." Included in the event will be an exhibit area, as well as technical tours and social events. Topics that will be covered include: use and integration of ATMS; advanced traveler information systems; congestion pricing and other ITS economic models/strategies.
www.itscanada.ca/edmonton2009

MAY 17-20
IPI CONFERENCE AND EXHIBITION
Colorado, USA
The International Parking Institute (IPI) 2009 Conference & Exposition is the largest conference of its kind, and there are ample opportunities to connect with over 2,500 attendees to develop new business prospects and invigorate existing relationships with current customers.
www.goeshow.com/parking/2009

MAY 26-27
ITS POLISH CONGRESS
Warsaw, Poland
The second Polish Congress dedicated to ITS will enable cooperation between the industry and representatives of governmental organizations, councils and cities. It will encourage an exchange of expertise between domestic product and service providers and international firms.
www.pkits.pl

MAY 26-29
INTERNATIONAL TRANSPORT FORUM
Leipzig, Germany
The Ministers of Transport of 51 Forum member countries and guest countries will again be meeting in Leipzig with key leaders from industry, the research sector and civil society to discuss the challenges of globalisation for the transport sector and consider what transport can do to respond to the needs for global economic and social development.
www.internationaltransportforum.org

MAY 27-29
INTERTRAFFIC ISTANBUL 2009
Istanbul, Turkey
The fifth edition of Intertraffic Istanbul will feature exhibits from manufacturers, importers and agents of products and services within the fields of infrastructure, traffic management, safety and parking. Visitors will include decision-makers, consultants, contractors, and representatives from private companies, municipalities and Ministries of Transport.
www.intertraffic.com

traffic technology INTERNATIONAL

Traffic Technology International **magazine publishes an updated list of diary dates in the bi-monthly edition, as well as on** *www.traffictechnologytoday.com* **Keep an eye out for further news.**

nts Calendar

JUNE 2009

JUNE 1-3
ITS AMERICA ANNUAL MEETING
Maryland, USA
ITS America's 2009 Annual Meeting & Exposition is a three-day learning and networking event which will attract the most diverse transportation audience from across the country. The event will feature panel sessions, poster sessions, interactive seminars, renowned industry speakers, informative exhibits and technology demonstrations, and technical tours.
www.itsa.org/annualmeeting.html

JUNE 2-4
9TH SPANISH CONGRESS ON ITS
Andorra La Vella, Spain
ITS Spain is organizing the 9th Spanish Congress and Exhibition on ITS. Simultaneous translation will be provided. Many topics will be covered, including traffic safety, ETC, tunnels, and intelligent vehicles.
www.itsspain.com

JUNE 8-10
CANADIAN MULTIDISCIPLINARY ROAD SAFETY CONFERENCE
Saskatchewan, Canada
A variety of key topics will be addressed such as biomechanics of injury, highway design, collision avoidance, as well as human factors and driver behavior.
www.carsp.ca/cmrsc.htm

JUNE 21-24
2ND INTERNATIONAL SYMPOSIUM FREEWAY OPERATIONS (ISFO)
Honolulu, Hawaii
This second iteration of a very successful first ever symposium held in June 2006 in Athens, Greece has 'Active management of expressway facilities' as its core theme. The event will bring together freeway and tollway operators, practitioners and researchers specializing in freeway, highway toll operations and capacity analysis to explore the hot topics in this field.
http://2isfo.eng.hawaii.edu/

JULY 2009

JULY 8-10
10TH ITS ASIA PACIFIC FORUM AND EXHIBITION
Bangkok, Thailand
This year's conference and exhibition has the theme "Smart Move", which will feature the application of ITS technologies for smart modes of transport. Several research projects will be presented, related to Bangkok vehicle usage, traffic information exchange, traffic control systems and radio traffic transmission technology. There will also be a state-of-the-art ITS technology exhibition.
www.its-ap2009.in.th/

AUGUST 2009

AUGUST 23-27
NATIONAL RURAL ITS CONFERENCE (NRITS)
Oregon, USA
The 2009 National Rural ITS Conference (NRITS) promises to provide a variety of networking opportunities and time with vendors and decision makers. Topics covered will include: incident management and emergency response, evacuation preparedness and response, as well as alternative energy applications.
www.nritsconference.org

SEPTEMBER 2009

SEPTEMBER 13-16
IBTTA'S 77TH ANNUAL MEETING AND EXPO
Chicago, USA
IBTTA's Annual Meeting and Exhibition is the most significant gathering of toll industry professionals and business partners in the world. Chicago in 2009 will bring together more than 1,000 toll agency professionals for three days of networking, best practices and critical innovations in toll industry finance, marketing, technology, customer service, environmental stewardship, operations, maintenance and a variety of other related issues.
www.ibtta.org

SEPTEMBER 2009

SEPTEMBER 21-25
ITS WORLD CONGRESS
Stockholm, Sweden
ITS World Congresses gather some 5,000 participants from around the world looking to share experiences and build networks. Delegates will include representatives from: international organizations and national governments; regional, local and municipal authorities; security and safety organizations; equipment manufacturers and suppliers; and ITS users and members organizations.
www.itsworldcongress.com

NOVEMBER 2009

NOVEMBER 9-11
2ND MIDDLE EAST PARKING SYMPOSIUM
Abu Dhabi, UAE
Following the success of the first Middle East Parking Symposium in 2008, parking professionals from across the world will once again be gathering in Abu Dhabi for the second edition of this event. As well as featuring an extensive conference covering a variety of issues, there will be an exhibit of the latest products and services from the parking sector.
www.parking-me.com

NOVEMBER 15-17
TOLL ROAD SUMMIT OF THE AMERICAS
São Paulo, Brazil
This is IBTTA's third conference in South America. The summit will examine an array of methods to design, finance, operate, and maintain user financed surface transportation facilities. Main topics include tolling techniques and interoperability, managing in a tough economic climate, and VII.
www.ibtta.org

NOVEMBER 17-19
TRANSPOQUIP
São Paulo, Brazil
TranspoQuip Latin America is the biggest event for the transportation infrastructure industries in Latin America. The exhibition and conference bring together decision makers from the infrastructure industries for roads, highways, railways, metro, ports, waterways and airports. The event's three main themes are: management and operations; safety and security; and user comfort.
www.transpoquip.com

DECEMBER 2009

DECEMBER 13-15
TRANSPORTATION FINANCE SUMMIT
Washington, DC, USA
Experts from around the world will present practical, real-world solutions to the difficult challenge of creating new revenues to fund surface transportation infrastructure in a fiscal environment that is seriously constrained. Presenters will explore public-private partnerships, leveraging public agencies, toll road start-ups, innovative public financing programs, debt and equity financing, congestion charging, the concession model, and creating public and political support for user-financed transportation services.
www.ibtta.org

FEBRUARY 2010

FEBRUARY 24-26
IT-TRANS
Karlsruhe, Germany
In 2008, the first specialist conference and trade fair on IT solutions for public transport turned out to be an international information and communication platform for the industry. More than 800 visitors from 41 nations attended IT-TRANS 2008. Over 80 exhibitors from 19 countries participated in the first event, with 2010 looking set to be even more successful.
www.it-trans.org

MARCH 2010

MARCH 23-26
INTERTRAFFIC AMSTERDAM
Amsterdam, The Netherlands
Intertraffic was established in 1972 and has since evolved into the largest platform for the transportation infrastructure, traffic management, safety and parking sectors. 2010 sees the 20th edition of the event. Intertraffic is the place where more than 25,000 professional visitors and exhibitors meet and do business.
www.intertraffic.com

OUR ADVERTISEMENT IS ON **p113**

Since it was founded in 1978, **ACISA** has provided services in electronics and electricity. Although initially created to provide runway markers and lighting in airports, the company has diversified its activities to fields such as traffic, street lighting, sign posting, and access control. It has also entered into the traffic control systems sector, winning a number of significant installation and maintenance

email: gmolina@acisa.es

www.acisa.es

OUR ADVERTISEMENT IS ON **p71**

Advantech Europe is a global ePlatform services provider integrating web-based technology, computing platforms and customization services. The company cooperates closely with system integrators to provide complete solutions for a wide array of applications in various industries. In the traffic sector, Advantech specializes in integrating communication between various facets of intelligent transportation networks, offering a range of customized products.

email: sjoerd.vanunen@advantech.nl

www.advantech.nl

OUR ADVERTISEMENT IS ON **p59**

TSS-Transport Simulation Systems develops Aimsun, the transport modeling software with over 1,100 users in 54 countries. Aimsun fuses analytical, mesoscopic and microsimulation transport models in a single application. In December 2008, the company launched Aimsun 6.0.2, the latest version of this popular tool, equipped with a variety of enhancements. TSS also markets Aimsun Online: a unique simulation-based solution for real-time traffic management.

email: agerodimos@aimsun.com

www.aimsun.com

OUR ADVERTISEMENT IS ON **p31**

The Finland-based **Decatur Electronics Europe** markets speed measurement products and traffic safety equipment worldwide. Amongst its extensive radar range are speed display signs, speed display radars, speed guns and moving radars. The company's radar products are used for law enforcement, sports, industrial and scientific applications. Decatur has been in the radar industry for more than 50 years and its technology is among the most advanced available.

email: jani.andersson@decatureruope.com

www.decatureurope.com

OUR ADVERTISEMENT IS ON **p63**

For the traffic industry, **DT srl** offers a range of products and services in two key areas: tolling and parking. It is well versed in applications ranging from highways to tunnels and bridges and encompassing a range of technologies, including tolling enforcement and cash toll money management. For the parking sector, DT offers a range of services starting from conducting feasibility studies all the way through to managing live parking projects.

email: info@dtsrl.it

www.dtsrl.it

OUR ADVERTISEMENT IS ON THE **BACK COVER**

Econolite Control Products is a leading transportation solution provider and manufacturer of advanced traffic controllers, traffic management systems, video vehicle detection systems, arterial systems masters, vehicle and pedestrian signals, traffic control cabinets, data collection and management services, intelligent intersection technology, and a full line of maintenance services. The company offers a unique and established blend of capabilities and experience.

email: ddonovan@econolite.com

www.econolite.com

OUR ADVERTISEMENT IS ON **p72**

The **eSafety Challenge** focuses on smart vehicle safety technologies and the potential lives to be saved on the roads through increased deployment of these technologies. A big obstacle for deployment is the lack of awareness among both policy-makers and end users, which is affecting policy support, user expectations and readiness for change. These demos are designed to highlight original concepts or applications that will enable considerable progress in road safety.

email: j.bangsgaard@fiafoundation.com

www.esafetychallenge.eu

OUR ADVERTISEMENT IS ON **p51**

Offering state-of-the-art customized solutions for the traffic, environmental and meteorological control sectors is the philosophy behind **Famas System**. The company manufactures telematic products and systems for remote data transmission and processing, including large intergrated networks for the monitoring and analysis of road infrastructures in urban, out-of-town and motorway areas. The overall aim is to be informed about traffic situations in real time.

email: roland.k@famassystem.it

www.famassystem.it

OUR ADVERTISEMENT IS ON **p113**

Formed from 3M's Intelligent Transportation Systems, **Global Traffic Technologies** is setting out to improve traffic management, emergency vehicle preemption and transit signal priority across the globe. The company offers proven, integrated and specially tailored solutions, combined with dedicated and experienced staff; all designed to reduce emergency response times, improve intersection safety, keep buses running on time and streamline traffic management.

email: larry.yee@gtt.com

www.gtt.com

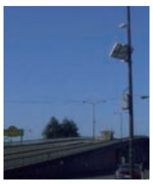
OUR ADVERTISEMENTS ARE ON **p97 & p81**

Intertraffic Amsterdam is a leading exhibition for infrastructure, traffic management, safety and parking. The Intertraffic Amsterdam 2006 event attracted 23,890 visitors from no less than 110 different countries. Its international character was reinforced on the exhibitor side as well, with 690 exhibitors from 41 different different countries. The 19th outing of Intertraffic will take place in Amsterdam RAI the Netherlands from Tuesday 1 April to Friday 4 April 2008.

email: intertraffic@rai.nl

www.amsterdam.intertraffic.com

OUR ADVERTISEMENT IS ON **p21**



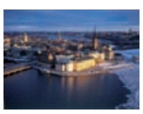
ISS Canada offers sophisticated radar technology solutions for ITS applications to improve traffic flow, efficiency and safety.

The choice provider of innovative, reliable, cost-effective and field-proven traffic management solutions around the world, its comprehensive product portfolio is designed to meet specific needs in traffic counting, freeway management, urban traffic control, workzone safety warning, and also real-time incident detection.

email: zsafa@eistraffic.com

www.eistraffic.com

OUR ADVERTISEMENT IS ON **p32**



The 16th **ITS World Congress** is taking place in Stockholm, Sweden. ITS World Congresses represent the largest events in the world for ITS leaders, policy makers and other industry professionals. Registrants will have access to both the large exhibition hall featuring the latest products and services on offer to the market, as well as conference sessions, technical tours and limitless opportunities to connect with an international audience.

a.morley@hgluk.com

www.itsworldcongress.org

OUR ADVERTISEMENT IS ON THE **IBC**

Gulf Traffic was launched in 2002 in response to demand across the region for an event that brings together international manufacturers and suppliers who offer products, services and technology for the traffic industry. It attracts government officials, police, contractors, planners and distributors – senior decision-makers in the industry. Exhibiting at and visiting will allow you to network with existing clients as well as forge valuable new business relationships.

email: Alexandrea.Jones@iirme.com

www.gulftraffic.com

OUR ADVERTISEMENT IS ON **p63**

Swedish organization **Info24** is a neutral Information and Media Exchange (IMX) for the collection, transformation, processing, trading, presentation and distribution of real-time information. This information includes Machine-to-Machine (M2M), telematics, traffic information, environmental data, electricity and water consumption, alarms, financial transactions and GPS-tracking of vehicle and goods. The goal is for systems and machines to effectively communicate with each other.

email: bjorn.sabel@info24.se

www.info24.se

OUR ADVERTISEMENT IS ON THE **IFC**

Iteris applies advanced engineering, best industry practices, experience and imagination to create ITS. These are solutions that solve today's problems and allow future growth and flexibility, providing information to improve the travelers' commute and experience. The Roadway Sensors division of Iteris offers Vantage video detection systems for traffic control at intersections, which gives traffic managers a tool to mitigate traffic congestion by modifying traffic signal timing.

email: ksm@iteris.com

www.iteris.com

OUR ADVERTISEMENT IS ON **p4**

Monash University's Accident Research Centre is Australia's largest multi-disciplinary research center specializing in the study of injury and injury prevention. It undertakes applied research contracts for government and industry clients throughout Australia and internationally. More fundamental research is undertaken through research grants. MUARC has clients both national and international, but maintains relationships with a number of bodies in its home state of Victoria.

email: enquire@muarc.monash.edu.au

www.monash.edu.au/muarc

OUR ADVERTISEMENT IS ON **p129**

Noptel specializes in the design and manufacture of applied optoelectronic devices to perform a wide range of geometrical measurements. The quality of the products and services is one of the key principles of Noptel's strategy. Products incorporate the latest technology, as well as comprehensive, long-term user support to help customers gain full satisfaction. For the traffic control market, Noptel offers a wide range of speed classification and measurement products.

email: matti.tervaskanto@noptel.fi

www.noptel.fi

OUR ADVERTISEMENTS ARE ON **p9 & p13**

Robot Visual Systems is a pioneer in the field of traffic safety and offers innovative products that considerably help in raising road safety worldwide. Police and public authorities globally take confidence from the company's many years of experience. A part of the JENOPTIK Group since 1999, the ISO 9001:2000-certified company's vast product range and the comprehensive service offer guarantees of a reliable and tailor-made application of its units and systems.

email: sandra.horlitz@robot.de

www.robot.de

OUR ADVERTISEMENT IS ON **p26**

For more than 20 years, **Telegra Europe** has been establishing itself as a leading worldwide supplier of advanced traffic management systems for highways and tunnels. The company offers a full range of products and integration services. It has more than 30 large systems in operation worldwide. The company offers its own core traffic management products as well as highly trained staff providing expertise in all aspects of hardware, software and system design.

email: robert.ryslavy@telegra-europe.com

www.telegra-europe.com

OUR ADVERTISEMENT IS ON **p17**

Traficon's aim is to be the worldwide market leader in video image processing for traffic analysis. The company has more than 25 years of experience in the video detection field. Traficon's headquarters is located in Belgium, and it has subsidiaries in Europe, USA and Asia. The company has more than 60,000 detectors operational worldwide and has installations in more than 300 tunnels. More than 600km of tunnels worldwide are equipped with a Traficon system.

email: stv@traficon.com

www.traficon.com

OUR ADVERTISEMENT IS ON **p121**

From **Quixote Transportation Technologies** is a variety of offerings in the Nu-Metrics range. This line consists of permanent and portable traffic-sensing and -analysis systems, distance-measuring and safety solutions for transportation professionals. The company's products include the Groundhog permanent traffic analyzer, the Hi-Star portable traffic analyzer, the NiteStar distance measuring instrument and the trans-Q radar traffic classifier.

email: jon.tarleton@quixotecorp.com

www.qttinc.com

OUR ADVERTISEMENT IS ON **p121**

Since 1950, **Tamron** has emphasized creativity and originality as a manufacturer of precision optical equipment. This has guided every facet of its activities, from R&D and production engineering to quality assurance. The company is determined to create new products and services by integrating the optical technology that it has accumulated over the years with today's electronic and precision engineering technology, specifically to meet the needs of the multimedia era.

email: t.wada@tamron.de

www.tamron.de

OUR ADVERTISEMENT IS ON **p102**

A visit to **Traffex** at the NEC in Birmingham (21-23 April 2009) is the perfect opportunity to meet the entire industry all under one roof and be able to obtain expert advice, research and compare the latest products and services from world-class companies. Traffex 2009 will see the launch of the Street Design exhibition, a new event that will showcase the latest products and services used for all aspects of creating and planning the built urban environment.

email: a.morley@hgluk.com

www.traffex.com

OUR ADVERTISEMENT IS ON **p71**

With offices from Midrand, South Africa to Middlesex, UK, **Truvelo** has gone from strength to strength since 1966. The company designs, develops and maintains a range of equipment and products, including traffic law enforcement and vehicle data gathering/analyzing instrumentation, as well as weigh-in-motion technology. The company's popular D-Cam is proven to be a versatile, modern, accurate and cost-effective solution that offers built in automatic verification.

email: products@truvelo.co.za

www.truvelo.co.za

THE LAST WORD

…goes to ITS(UK)'s chairman, a true veteran of transportation management, who feels the benefits of ITS won't be fully realized until *all* systems can be integrated and connected

by Eric Sampson, chairman, ITS(UK), UK

Years ago I worked for one of the Research Councils and was involved in the office equipment purchases. We viewed ourselves as a modern organization – after all, we were supporting the UK's cutting-edge research in science and engineering – and had invested in electric typewriters that stored a page of text on paper tape, considerably boosting typists' productivity. We then heard about the 'word processor'. It, too, stored documents, but permitted endless editing, spaced the words on a line for perfectly justified text, allowed different fonts on the same page, gave a screen preview of how the job would look printed – and it even had a built-in spellchecker.

We also invested heavily in the new 'personal computers' – so expensive they had to be shared.

> **"The need for connectivity tends to emerge after you've made the investment so you must keep open all options"**

It didn't occur to us that within the word processor there was a computer, until we were on the point of buying a second batch and our attention was drawn to word processing software for PCs. We joined the dots to see a picture of flexibility – each user could modify the computer to suit the task: typing, financial calculations using 'spreadsheets', sorting databases. Without realizing it, we started to be part of an integrated office information environment.

So, why all this reminiscing about the 1980s in a serious transport journal? Quite simply, we are not doing very well about moving toward an integrated transport management environment. We have too many dedicated systems comparable with the old word processors and aren't doing enough to deploy systems that, while specialized, are built to open standards so that they can sit on common platforms.

In many respects it's understandable. Why might the bus information service I'm about to buy for the city center need to link to the traffic management network run by the Highways Agency just outside the boundary? Why might we need to export data about the running of our local trams to motoring organizations or commercial suppliers of road conditions? Why connect my out-of-town park-and-ride to the M25 control center 100km away? The need for connectivity tends to emerge after you've made the investment so you must keep open all options. So, like the word processors, don't buy dedicated single-function stuff: buy standard platforms and then configure them for the current tasks. We're moving increasingly quickly to a world of network management of supply and demand, rather than small independent areas of traffic control; a world of connectivity meaning shared information to enable everyone to gain some better quality, some reduced emissions, some reduced congestion, some cheaper and more consistent public transport.

I don't know exactly how quickly this will happen – or anyone who does know – but I'm certain it will. Achieving new accident reduction targets will demand the use of ITS services that link the roadside infrastructure to the vehicle. Efficient traffic management to squeeze the last drop of productivity from the networks will require city center UTMCs to link closely to the HA's national control framework. Management of demand for road space will require motorists to interact more closely with network managers and be prepared to notify destinations and trip plans in return for regular and reliable travel information, including advice about when to park the car and continue by public transport.

All of this rests on a few key decisions that come into the 'surely that's blindingly obvious' category. Local Authorities (LA) that haven't got an ITS deployment plan will need to write one to get the productivity gains and the expenditure savings. ITS(UK) is about to issue guidance for Elected Members, showing what can be gained with little pain, but incentives for the LAs to work as a large group rather than individually are almost non-existent. The HA national network will need to be coupled to a large number of LA traffic management systems – there's research under way now to plan how this should happen. Linking the majority of systems will be straightforward and affordable when a nationally accepted framework for connectivity is ready (a 'system architecture') – DfT, the HA, TfL are all active here but as yet there's no clear plan with firm dates. Connectivity costs initially but it repays quite quickly. As the recent POSTnote stated, "If subsystems were shared, costs could be reduced significantly." So I hope someone is listening to my plea to wake up at the back – it's time to integrate! ■

Newcastle University's Professor Eric Sampson previously headed the DfT's Transport Technology and Standards Division, and was also instrumental in setting up ITS(UK) in 1992

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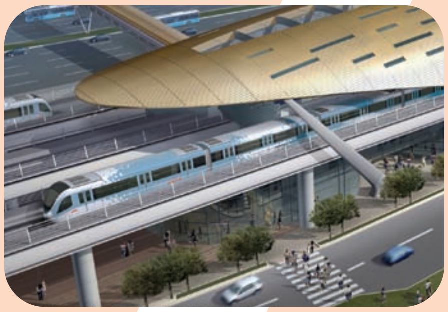

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